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MONUMENTAL-IT: A 'ROBOTIC-WIKI' MONUMENT FOR EMBODIED INTERACTION IN THE INFORMATION WORLD

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MONUMENTAL-IT: A "ROBOTIC-WIKI" MONUMENT FOR EMBODIED
INTERACTION IN THE INFORMATION WORLD

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by
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ABSTRACT

Conventional monuments are concrete manifestations of memories without the capacity to reflect individual interpretations of history. In an increasingly digital society, however, there is a need for configurable monuments reflecting our contemporary, open and complex community. "Monumental-IT" reflects the dynamic and inclusive character of our time. Rather than static, Monumental-IT is a dynamic, robotic, intelligent environment reconfigured or "retuned" by citizens and by historical information accumulating on the World Wide Web. This information is periodically "coded," altering the multi-sensorial physical-digital "Robotic-Wiki" components of Monumental-IT. Monumental-IT is designed to embody a new form of human-robotic interaction evolving from the monument typology.

This research is a response to three questions: *What is the monument for a world that is increasingly digital and "free"?*; *How can intelligent systems "creatively" reconcile current conceptualizations of history with monument-making?*; and, *What role can intelligent systems and Human Centered Computing (HCC) play in creating significant, meaningful, physical, urban places for collective memories?*.

This research involves designing, prototyping, and empirically evaluating Monumental-IT. The research employs a mixed-methodological research design which includes: quasi-experimental design, usability, heuristic evaluations, and cognitive walkthroughs as its research methods; and multivariate statistics to validate significance and usability with real users and experts in the domain fields of "architectural-robotics" and human factors psychology.

Results strongly suggest that the four distinct configurations of the robotic, multi-sensorial Monumental-IT evoke four distinct emotions in users. As well, users interacting with the Monumental-IT prototype evaluate the design as strongly aiding their recollection of human events (here, the history of slavery in the testbed, Charleston, South Carolina, USA). Finally, users overwhelmingly evaluated the Monumental-IT design to be more apt for our increasingly digital society than conventional monument design.

Key contributions are: the identification of metrics for evaluating complex digital-physical environments; the advancement of human-robotic interaction via environmental-scaled robotics and multi-sensorial features (colors, sounds and motions); and, the conceptualization of the monument as a cybernetic system.

DEDICATION

This dissertation is dedicated to my wife and son, Sara and Youssef, to whom I am grateful for helping to support my academic aspirations over the past three years; for their patience on my limited availability and hard times that they faced to help me in finishing this work; for taking care of me and helping me all the time. Their love, patience, and understanding have made this work possible. I would also like to thank my Mom and Dad, for their continuous support and love, for their care and patience on me, and for believing in my talents from early days. I am eternally grateful to them for their unstinting support.

ACKNOWLEDGMENTS

"Perhaps the mission of those who love mankind is to make people laugh at the truth, <u>to make truth laugh</u>, because the only truth lies in learning to free ourselves from insane passion for the truth."
-- Umberto Eco, The Name Of The Rose

In my ongoing search for truth, there will always be one thing I cannot forget, is to acknowledge all who supported me in my journey, and before all Allah (God) who gave me the power and passion: "*He Who taught (the use of) the pen,- Taught man that which he knew not*" (96:4 and 96:5 "Al-Alaq," The Clot, Quran).

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TABLE OF CONTENTS

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

LIST OF TABLES

LIST OF FIGURES

List of Figures (Continued)

List of Figures (Continued)

xiv

List of Figures (Continued)

List of Figures (Continued)

xvi

List of Figures (Continued)

List of Figures (Continued)

CHAPTER ONE

INTRODUCTION

*"This will kill that … Alas! Alas! Small things come at the end of great
things; a tooth triumphs over a mass. The Nile rat kills the crocodile, the
swordfish kills the whale, and the book will kill the edifice"*
-- Victor Hugo, The Hunchback of Notre Dame

At the beginning of the 19th century, Victor Hugo prophesized that new technologies, the printing press at that time, will kill architecture, leaving architects with no tools for edifying history (Lienhard, 2006). In the 21st century, evidence that small things have killed great things include information technologies, embedded in our daily lives and everywhere as "Ubiquitous Computing" (Weiser and Seely, 1997). Information technology has become an essential part of our social and environmental lives that include, but are not limited to, the internet, personal computers, laptops, smart cards, cellphones, and personal digital assistants (PDA's). What if these seemingly small technologies were embedded into our environments to shape physical architectural spaces? Computing and architecture share a common basis which gives architects of the 21st century the impetus to retune their approaches to accommodate the psychological, sociological, and environmental needs of human beings.

This thesis envisions architecture embedded with information technologies (IT); that the small things of IT will become part of our physical and social environments. Admittedly, an architecture comprised of "hardware" and "software" is no longer capable of satisfying our increasingly social and environmental needs. Architecture in the informational world should not be only concerned about hardware and software, but more

with the situation – the human event – in which it performs – "Embodied Interaction."
Architecture shapes people's behaviors according to their habitual and continuous needs.
The emerging development of information technology and robotics, Weiser's dream of
"invisible calm technology" (Weiser and Seely, 1997), is increasingly interested into the
environment where architecture exists. "Ubiquitous Computing" not only dissolves into
the environment, but also dissolves into humans' behaviors (Greenfield, 2006). Research
on ubiquitous environments promises to change our static built environments – an
important step towards intelligent and interactive environments.

This dissertation is focused on such intelligent environments, which demands in
its design the inputs of architects, psychologists, roboticists, information technologists,
computer scientists, sociologists, and others.

To understand the importance of the role this ubiquitous computing has on
humans' today lives is to understand how it shapes our behaviors in public spaces. How
does the use of this technology change the way we see the world? Where does collective
memory exist?

The human propensity for "monumentality," the impulse to edify and
commemorate history in a durable, physical form, persists. People continue to be drawn
to monuments as they are to books and other printed media. The advent of new
technologies to help convey human history has not managed to "kill," as Victor Hugo
prophesied, the long-standing means of communication that is architecture. In an
increasingly digital, mobile and global society, monuments continue to capture our
imagination, define our cities and, broadly, "speak" to us.

At its core, "architectural-robotics" leverages the idea of using hardware and software in the design of architectural spaces to be capable of real-time situational responses (Embodied Interaction). Architecture has mostly been unprepared for the importance of hybrid digital-physical systems in the digital informational era . Moreover, current research on architectural-robotics is still on the scale of components (walls, ceilings, floors, and furniture) but not yet at the scale of buildings and large spaces. Monumental-IT postulates that the dynamic, non-static cultural dimension of collective memory is significant in shaping our public spaces.

This dissertation aims to establish principles for designing an interactive monument for human differences in interpreting and understanding history and memory. To demonstrate these concepts, I present a prototype of Monumental-IT, a "robotic-wiki" monument for embodied interaction, describing its hardware, software, and its real-time changing modes, with a full evaluation of the system. Monumental-IT has been designed, prototyped and evaluated using an iterative-design process and human-centered design methods.

1.1 Context of the research

The resistance to monuments as described by the architectural historian Kirk Savage had deep roots in history: "Pericles famously claimed that the most distinguished monument was 'planted in the heart rather than graven on stone'" (Savage, 2009, p.1). Americans are still skeptical about monumental practices (Gass, 1982; Savage, 2009; Critical Art Ensemble, 1994). The challenges that contemporary architects are confronting exceed the ideological problems of monumental practices. Current collective

memory environments are confronting the challenges of scarcity of spaces, natural disasters (Donadio and Povoledo, 2009), expensiveness, and heaviness. Yet, we are still designing monuments.

The literature on monuments/memory defines the context of this research, describing the current condition for monuments' key aspects:

a. Monuments are considered one of the important resources for nations' revenues. In 2005, in the US, there has been estimated revenue of eleven billion and 547 million dollars in museums, and historical sites, including monuments and memorials (U.S. Census Bureau - Official Website, 2009).

b. Monuments are facing the scarcity of spaces. In 2009, there were more than 1,300 public monuments in New York (Tao, 2009). While, in 2006, Mr. Cogbill of the national planning commission, described that there were a limited number of places left for memorials in Washington (Barringer, 2006).

c. Monuments are still very expensive. The high cost of designing and constructing monuments, along with the expectation that the investment pay-offs financially, in terms of increased tourism. This was incentive enough for Washington D.C. to commission "star architect," Frank Gehry, to design its Eisenhower Memorial at a cost of $110 million (Hughes, 2009). While Gehry's monument promises to be an exuberant artistic statement by a leading architect of our day, the significance of this singular artistic statement at a remarkable cost is not yet clear.

1.2 Basic definitions

What are monuments? Monuments are landmarks of societies which state, we had done this, and we can do more; or, this is our past we appreciate this, and/or we disagree with that. Monuments are spatial, multi-sensorial placeholders of collective memories. They are the "carnal echoes" of human memory in public spaces. William Gass in "Monumentality/Mentality," defines monuments as images that translate time into space. According to Gass, a monument has five main characteristics:

    a.   It is not a sign.

    b.   It does not rely on relics, reminders, or resemblances.

    c.   It is not a narrative.

    d.   It is the imposing symbol of itself.

    e.   Forgetfulness is the first rule of memory, and distortion is the last rule of representing such memory (Gass, 1982).

Historically defined, the monument "expresses the soul of the society, and is, consequently, a simple sign of a transcendent reality" (Hollier, 1989, p.47). The monument is "time turned to stone" (Gass, 1982, p.142) and "a guide to … our actions in the years to come" (Gass, 1982, p.142).

In the early twentieth century, the surrealist Bataille characterized the monument as more threatening: a rather sinister instrument of Church and State that "speaks to the multitudes and imposes silence upon them" (Hollier, 1989, p.47). Today, however, "with our vast libraries and powerful electronic database able to store huge amounts of

information, the use of architecture as a memory aid may seem quaint" (Fisher, 1998, p.20).

The monument elaborated in this research, "Monumental-IT," is a "robotic-wiki" monument for embodied interaction in the information world. In addition to defining "monuments" in the context of this research, it is therefore to define "robotics," "wiki," and "embodied interaction."

Robotics is the branch of science that deals with designing and engineering robots. A robot, as described by Maja Mataric, "is an autonomous system which exists in the physical world, can sense its environment, and can act on it to achieve some goals" (Mataric, 2007, p.2). Frederic Kaplan described the "robot" as "an object that possesses the three following properties: It is a physical object (P), it is functioning in an autonomous (A) and situated (S) manner" (Kaplan, 2005, p.61). Generally, robotics is based on control theory, cybernetics, and artificial intelligence (AI) (Mataric, 2005, p.17).

"Wiki," as described by Phoebe Ayers et al., "is a type of website that anyone can edit, [i.e., collective and reconfigurable]. Most Wikis record the changes that are made to them, keep previous versions of pages [i.e., history]. Openness is a key feature of most wikis as well" (Ayers, Mattews, and Yates, 2008, p.41). Wikis are the evolution of open-source environments, as people are able to share and edit their thoughts about any topic, have the ability to record, and keep them as long as they choose. Similar to YouTube, Facebook, Twitter, and Wikipedia, Wikis are free and open for anyone to use. According to Wikipedia definition of Wikis,

> "Wikis typically have a set of rules governing user behavior. Wikipedia, for instance, has an intricate set of policies and guidelines summed up in

its five pillars: Wikipedia is an encyclopedia; Wikipedia has *a neutral point of view*; Wikipedia *is free content*; Wikipedians should *interact in a respectful and civil manner*; and Wikipedia *does not have firm rules*. One teacher instituted a commandment for a class wiki, 'Wiki unto others as you would have them wiki unto you'" (Wikipedia Website, emphasis added).

Embodied Interaction is based on research in embodied cognition, "a movement afoot in cognitive science to grant the body a central role in shaping the mind" (Wilson, 2002, p.625). 'Embodied Interaction' is "not simply a form of interaction that is embodied, but rather an approach to the design and analysis of interaction that takes embodiment to be central to the whole phenomenon," (Dourish, 2001, p.102). Embodied cognition is described in relation to the following claims:

> "(1) *Cognition is situated*. Cognitive activity takes place in the context of a real-world environment, and it inherently involves perception and action. (2) *Cognition is time pressured*…must be understood in terms of how it functions under the pressure of real-time interaction with the environment. (3) *We off-load cognitive work onto the environment*. We exploit the environment to reduce the cognitive workload. We make the environment hold or even manipulate information for us. (4) *Cognition is for action*. The function of the mind is to guide action" (Wilson, 2002, p.626, emphasis added).

From a technological perspective, 'embodied interaction' relates to the previous claims in relation to technological gadgets, objects, and robotics, which must be seen as integral to our environment (Green et al., 2005; Walker et al., 2009). Embodied interaction is about developing technological objects for human beings at the center of the design and development processes, focusing on human beings' relationships with their environments in real-time and real-physical space, situational contexts.

7

1.3 State-of-the-art of monuments

Monuments are paradoxical: they are closed vessels of memory commissioned by institutions and organizations, shaped by their architects. Monuments are icons above critical examination; societies have little right to claim them as true reflections of society or not. Monuments have no power in themselves to accommodate different interpretations; however, "history" differs from time to time and according to the socio-physical context of the monument.

1.4 Research questions

- What is the monument for a world that is increasingly digital and "free"?

- How can intelligent systems "creatively" reconcile current conceptualizations of history with monument-making?

- What role can intelligent systems and Human Centered Computing (HCC) play in creating significant, meaningful, physical, urban places for collective memories?

1.5 Research Goals and Hypothesis

In an increasingly digital society, the hybridization of the physical and digital is merging into a hybrid "physical-digital" world. The hybrid physical-digital world promises an evolution in architecture defined as "architectural-robotics" (Green et al., 2005; Walker et al., 2009). "Architectural-robotics" is defined by advancements in both architecture and robotics, to create intelligent responsive spaces.

The main goal of this research is to design a physical-digital monument in an increasingly digital society, which promises to accommodate the desired goal of

embodying the different interpretations of people though shaping their monument, calling

it **Monumental-IT**. The research hypothesis is *to design Monumental-IT*, in which:

- *Monumental-IT* is an evolutionary typology for monumental practices;

- *Monumental-IT* is designed with the goal of "opening" the monument for citizens to continuously configure and retune;

- *Monumental-IT* is characterized as "open," "reconfigurable," multi-sensorial," and "dynamic," partially designed by the architect, and left open to historians, families carrying forth the events' memory, and lay citizens to reconfigure the monument;

- *Monumental-IT* brings to life our collective past as redefined for the "open source" informational world.

1.6 Theoretical bases

The main theoretical bases for this research are: the Cybernetics theory of Architecture, Conversation theory, and Interactionism.

(a) Cybernetic theory of architecture and conversation theory

Arguably, the interrelations between humans, spaces, and technology have created some of the most vibrant arguments for designers and architects from Vitruvius until now (Morgan, 1960). Pask's "conversation theory" is "essentially a model … in which architects interpreted spaces and users as complete feedback system; interactive feedback systems related to adaptability" (Fox, 2010, p.6).

Gordon Pask introduced "architectural cybernetics, the cybernetic theory of architecture" as the "mutualism between structures and men or societies" and an

architectural system that interacts and responds to humans' exploration of its spaces (Pask, 1969). Figure 1.1 presents the historical change in our understanding of "interaction," from the idea of cause and effect; to relativity and uncertainty; and finally to "cybernetics," where human beings and surrounding systems are intelligent to the point that they interact, i.e., a mutual relationship between perception (sensing) and action (actuation) of both systems. Marshall McLuhan described this cybernetic culture by arguing that "the medium is the message," where "all media extend our bodies, creating new systems that have effects that return to us. This feedback loop ultimately alters us" (McGrath and Gradner, 2007, p.28).
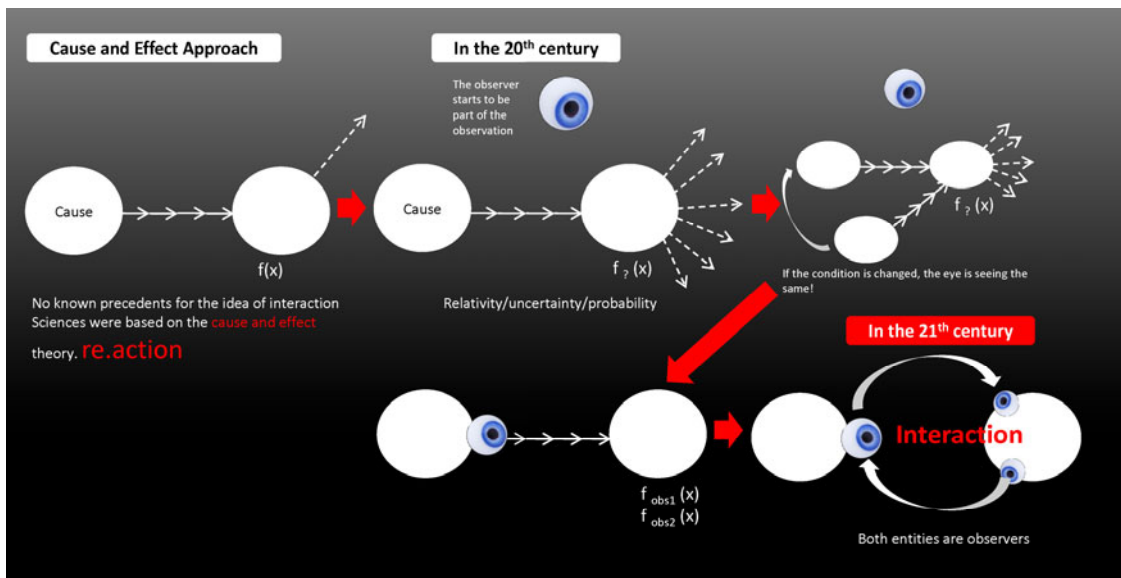
Figure 1.1 History of interaction toward "cybernetics" and "conversation theory"

Cybernetics, as described by Gordon Pask, has been defined by the underpinnings of adaptive control systems. *Adaptive control systems* are comprised of "controllers" and "sub-controllers" that interact with the environment. If "the environment is non-stationary, the controller *must* continuously relearn about it. Hence, the imitative

controller, learning P_1, P_2, …. is adaptive," Pask described (Pask, 1961, p.61). In *adaptive systems*, the learning processes are guided by built-in rules, "the controller" or its sub systems of "sub-controllers," perform selective activities all the time to select the "reward variable Ө," (Figure 1.2).Thus, if the system is designed using "hill climbers" or "optimizers," a certain value is reached (e.g., a threshold), the system learns that it has reached the specified peak and will respond accordingly (Pask, 1961, pp.61-66).
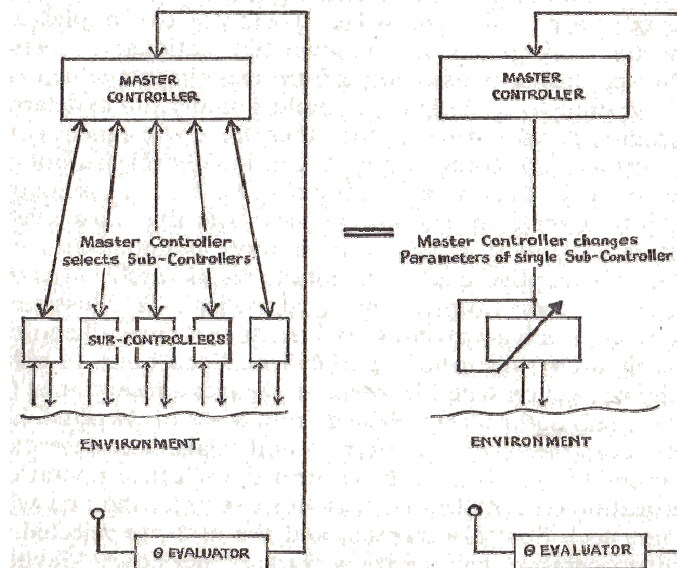
Figure1.2 Equivalent views of an adaptive controller (Source: Pask, 1961, p.62)

In biological systems, Pask describes that "an organism is a *control system* with its own survival as its objective," thus by using an analogous approach, we will be able to develop a better understanding of how to design mechanical *adaptive systems* (Pask, 1961, p.72).   According to Pask, all biological control systems share four main characteristics:

(1) <u>Survival</u>: an organism "shall survive in a physical assembly that determines the environment of the system" (Pask, 1961, p.71);

11

(2) <u>Adaptation</u>: an organism "must be an adaptive control system…the most flexible adaptation is learning. The least flexible occurs in evolution [as] animals are designed to *alternate behavioral stereotypes according to the state of their environment*. Thus the hedgehog hibernates in winter" (Pask, 1961, pp.70-73), also noted in Oke's thesis "Boundary Layer Climates", who presents piglets' relationship change, i.e., adaptation, when changing room temperature, (Figure 1.3). Ultimately, from one side in Oke's thesis, it presents the importance of the "software" of space (Shute, 2009), temperature in this example, for inhabitants' relationships; while on the other side it presents the animal-space-relationship as a feedback loop, mechanical adaptive system (Oke, 1978, p.167);
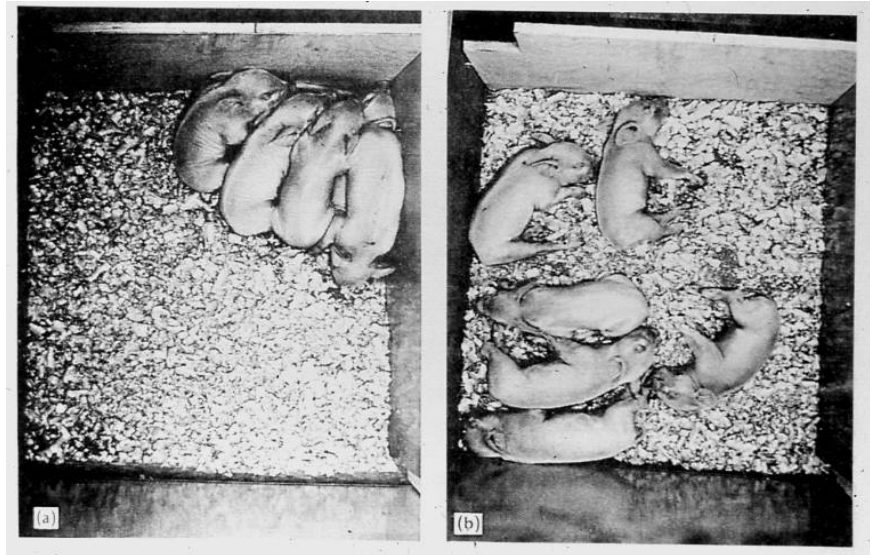
Figure 1.3 Response of newborn piglets to contrasting thermal environments, i.e., adaptation: (left) decreasing the temperature at 15oc, (right) increasing the temperature (Source: Oke, 1978, p.167)

(3) <u>Homeostasis</u> or internal equilibrium: an organism shall be able to stabilize the "complex many-to-many relations between structure and function … McCulloch calls [it] the 'redundancy of mechanism'" " (Pask, 1961, p.73);

(4) <u>Communication</u>: an organism shall be able to communicate senses and motor actions "…and we cannot be dogmatic about where they end" (Pask, 1961, p.75). According to Oke, in describing the effect of the atmosphere on animals' responses and thus how they adapt their bodies in relation to their environments, the animals adapt their bodies in accordance with: (a) energy and water balances; (b) thermoregulation; (c) metabolism; and (d) the effect of animal sizes. These are all evidence of control systems and the adaptation of intelligent systems in animals and human beings as they relate to their environments.

Mechanical systems (e.g. architecture) that survive, adapt, stabilize, and communicate partially imitate biological systems. From a cybernetic perspective, *a stable interactive system should allow "in a certain sense, a 'conversational,' man/machine relationship"* (Pask, 1961, p.89, emphasis added). A "conversational system" has the ability to interact with its users, a relationship between man and machine (i.e., a "cybernetic" system,) following inputs, rather than a preconfigured condition or a "fixed program teaching machines [i.e.] 'automatic controllers'." A "conversational system" learns over time and can make decisions accordingly. In a cybernetic conversational system, "a controller is aiming to: (1) keep the student's [user's] attention; [and] (2) adapt the object language" (Pask, 1961, pp.93-94).

13

Using the cybernetic analysis, imitating biological systems that interact and adapt will help architects create interactive-system "environments" capable of communicating and interacting with diverse human populations. The interrelation between man and machine/architectural environments are "conversational" if biological intelligent systems employ "sensory memory" to encode and recall stimuli/senses; and if "motor memory" recalls and prepares actions (Kandel, 2006).

(b) *Interactionism*

From a social science perspective, "Interactionism" shares concepts with cybernetics. "Interactionism" is based on the idea that the self and the other are not separate entities in the spectrum of the social life. Indeed, "the self is bound up with its relation to the other" (Fay, 1996, p.228), interchanging and interacting. Interactionism "encourages a dynamic commingling in which parties constantly change" (Fay, 1996, p.234). In encounters between selves and others, "the choice is not to adopt one or the other, but to hold them in dynamic tension" (Fay, 1996, p.234). Brian Fay represents this relationship (Figure 1.4) as "the dynamic character of the self and other through time in which interaction among selves and others" (Fay, 1996, p.233).
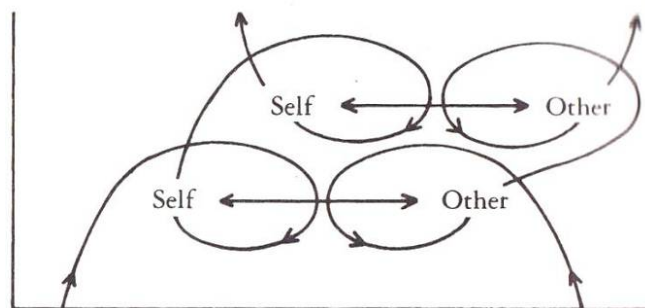
Figure 1.4 The dynamic flaw between the self and other through time (Source: Fay, 1996, p.232)

Ultimately, this research is based on the theories of cybernetics and interactionism, in which the interaction between users and systems (e.g. architecture) can be seen as a complete feedback system. The responsiveness of the environment to users' inputs can help in providing an example of such systems. Yet, the interactions between the users and the environment are not only based on their mutual relationships, but also on the medium. The monument for an increasingly digital society, Monumental-IT, employs IT and robotics to create an embodied interactional space. This medium of embodied interaction is merging the digital into the physical using the "Internet of Things" platform (Pachube Community), and creating an intelligent platform that embody the interactions between the users and the monument, see Chapter Three and Chapter Four.

CHAPTER TWO

LITERATURE REVIEW ON MONUMENTALITY/MEMORY

"Remembering the past is a form of mental time travel; it frees us from the constraints of time and space and allows us to move freely along completely different dimensions"
-- Eric R. Kandel, In search of Memory

The research on Monumental-IT is based on the cybernetic theory of architecture, Interactionism, and an understanding of the mutual relationships that connects architecture, memory, and Information Technology (IT). The literature review on "Monumentality/Memory" describes the state-of-the-art of all research components, presents research gaps, defines research's constructs and intervening variables, key concepts, and operational definitions, and suggests the research contribution.

2.1 Memory and architecture

Historically, monuments are vessels of collective "memory" as described in architectural treatises, older and more recent. Ancient Egyptians were highly connected with the use of stone in architecture: the stone is a kind of magic that conceals memories (Fletcher, 1987; Caponigro, 1986). On the Egyptian oxyrhynchus papyrus, the interrelation between stone and memory is described as a process of uncovering, "lift up the stone and you will find me there" (Caponigro, 1986, n.d.).

In Roman Treatises, the author of Ad Herennium advised his fellows to use a memory palace to remind people of things (Yates, 1966; Lyndon, 1994). Indeed, the idea of "memorizing" goes back to the Greeks in Cicero De Oratore (Yates, 1966). A leading architectural theorist of the Enlightenment, John Ruskin in "The Seven Lamps of

Architecture" argues for the importance of memory in architecture. In the sixth lamp, "The Lamp of Memory," Ruskin explains that Architecture is a vessel for human memories, "we may live without her, and worship without her, but we cannot remember without her. How cold is all history, how lifeless all imagery, compared to that which the living nation writes, and the uncorrupted marble bears! – How many pages of doubtful record might we not often spare, for a few stones left one upon another!" (Ruskin, 1989/1880, p.178).

In 1831, Victor Hugo argues for the importance of architecture in embodying human memories. According to Hugo, "in the 'age of architecture', before the printing press, the building was not merely the building of the sacred book; it was the sacred book itself" (Levine, 1982, n.d.). Additionally, Alberti in his book "On the Art of Building in Ten Books," argues for the importance of memory inherited in the meaning of forms not in the shape or the figure represented (Rykwert, Leach, and Tavernor, 1988). A more contemporary architect, Aldo Rossi described memory in architecture as the beauty of imitation of past memories reflected in architectural "events" (Rossi, 1981).

Collective memory is at the center of the interaction across people and things. As Malcolm McCullough describes it, collective memory is "an interaction design practice that provide affordance for history; use enduringly legible elements; commemorates events; and leave traces" (McCullough, 2005, p.159). The modern experiences of continuous changes led thinkers to the importance and appreciation of monuments as "the recognition of age value" (Forster, 1982, p.8). Described by Riegl as "contemporary perception of the past [in which] everything was of the past, however recent" (Forster,

17

1982, p.8). The function of a monument is to return an idea to consciousness; to remind, and hence, restore a thought to life (Gass, 1982). In Italo Calvino's dream for "Invisible Cities," memory is a city of hope and desire, a unique relationship between the space and the past in a context full of imagination, the "city of memory" (Calvino, 1997).

Thus, the literature concerning memory in architecture gives credence to the importance of architectural practices in forming the collective mnemonic devices for collective societal memory; however the act of such practices, or even the characteristics, are not formed by the plurality and the publicity of the openness of a free society (Eco, 1989).

From memory in architecture to monumental practices, I categorized "monuments" into four main types: (1) *The Platonic Monument*: the monument of the obelisk and platonic forms, as in ancient Egyptian, Greek, Roman civilizations and are still used till now; (2) *The Figurative Monument*: the monument as a snap shot of history, a sculpture of a significant person, or even a landmark; (3) *The Abstract Monument*: the monument that reflects architect's interpretation of collective memory – past history – using abstractions as a way to leave visitors to bring their own memories to it. Yet this type of monuments is static and only reflects the architect's formal and interpretive vision of past memories; and (4) *The Electronic Monument*: the monument which is moving from the physical state to the electronic state, represented in the practices of virtual environments and virtual gadgets that use technology to memorize information about places, events or people and can be used as a memory aid for later retrieval, mnemonic electronic devices.

A different way of categorizing monuments developed by William Gass can also be of importance to the literature, the American monument and the European one. According to Gass, the "monument" in American thought is fundamentally different from that of the European one. The American monument is about a futuristic vision of the past, the monument speaks to a community through information that is interactive. According to Jackson: "the monument, in short, is a guide to the future… it determines our actions in the years to come" (Gass, 1982, p.142). On the contrary, the European monument is "made of time turned to stone and stood still… hence (in the US), the monument is space turned into daily life and set moving like a road" (Gass, 1982, p.142). This is clearly illustrated in Eero Saarinen's iconic St Louis arch which aspires to a futuristic vision for a country. Built of stainless steel, not of old stones, the Saint Louis arch is abstract, not figurative.

Another challenge to monumentality is the scarcity of suitable building sites. In New York City alone, monuments number over 1,300 (Tao, 2009). As early as 1857, the U.S. National Planning Commission began "to realize that there are limited number of places left for memorials" in the nation's capitol (Barringer, 2006). Where can we continue to build monuments when spaces for memorials are limited? There is also the challenge of the high cost of designing and constructing monuments, as described in chapter one.

Indeed, statue monuments are becoming less attractive, as "it becomes increasingly evident that fewer and fewer people were actually looking at them; became merely 'an obstruction to traffic'" (Savage, 2009, p.195). The transformation that Savage,

an architectural historian, describes as an important change in the history of monuments is from the "Hero Monument" – Statue Monument – to what he calls the "spatial monument" – a "*space to be experienced rather than an object to be revered, the physical space of the monument would also become a mental and emotional space of engagement, with physical traumas as well as triumphs*" (Savage, 2009, p.197, emphasis added).

Monuments are however still closed silent vessels of memory commissioned by institutions and organizations, and shaped by their architects. The Oklahoma City national fence is open for the public to leave tokens on the memorial, "spanning the downtown block where the April 19, 1995, terror bombing occurred" (Oklahoma City National Memorial and Museum Website), Figure 2.1.

Figure 2.1 Oklahoma City national memorial fence left open for people to share their memories

The Liberty Monument in New Orleans is another example of an open public space which was not intentionally used as a space for protesting, but has become one of the most attractive spaces for protesting in New Orleans. The Liberty Monument commemorates the "White power:" through the inclusion of "the names of those White Leaguers who gave their lives in attacking the hated mixed-race government, as well as the names of some of the League leaders" (Levinson, 1996, p.3), Figure 2.2. African

Americans have long opposed this racist symbol in New Orleans. The monument's existence has made it the target of repeated attacks.

Figure 2.2 The Liberty Monument in New Orleans has two faces: before (left) and after protesting (right)
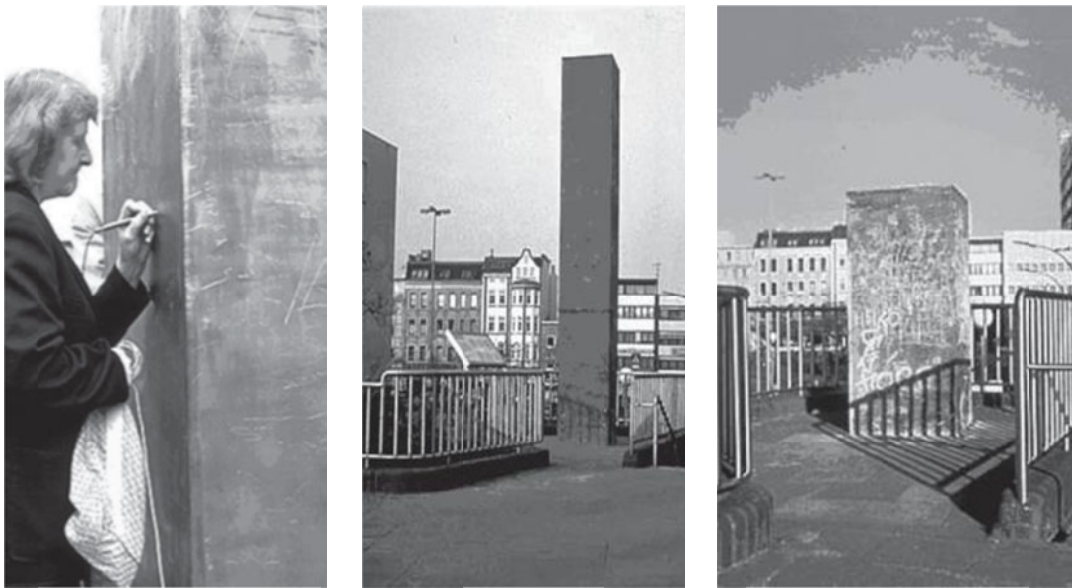
Figure 2.3 Harburg Monument against fascism sinks to the ground as more citizens participate

Another example is the Harburg Monument against fascism in Germany, comprised of a moving column allowing citizens to write on it and represent their voices in opposition to fascism. Over time, the column sinks to the ground as more citizens participate! "The monument would become neutralized, anti-monumental, while its

presence would still remain in the minds of those who participated in the memory formation process: Denkmal-Arbeit in its truest form. The monument was lowered eight times from November 10, 1986 to November 10, 1993. All that exists today is the original plaque on top of the pillar" (Mulholland, 2007, p.22), Figure 2.3.

While these examples represent spaces for people to share their voices, the monument is still not "intelligent" enough to understand its users, and thus react. Intelligence in this context is defined as a system that must be able to survive, adapt, stabilize, and communicate with its users, a cybernetic system. Moreover, the aforementioned monuments are still closed to one representation imposed by the architect/designer. Even the Hurburg Monument offers only one way of interacting with it; and by time the monument sinks, no more citizens will be able to engage it, resulting in no further interactions between the monument and the public.

Figure 2.4 Vietnam Veterans Memorial, Washington D.C. (left to right): "The Wall," "Three Servicemen Statue" and "Vietnam Women's Memorial"

Additionally, contemporary typologies of monuments are hotly debated and criticized. Savage argues that, "Americans were holding the public monument in suspicion. Monuments, the skeptics thought, were mere gestures by a powerful few rather than spontaneous outpourings of [the collective] popular feeling. True memory lay in the hearts and minds of the people" (Savage, 2009, p.1). The Vietnam Veterans

Memorial represents an example of such a debate in the United States, as there are three compositional representations of it:

(1) "The Wall," is comprised of an abstract black granite wall inscribed with the names of all who died or remain missing in the war, (Figure 2.4, left);

(2) The "Three Servicemen Statue," (Figure 2.4, middle), is another representation of the Vietnam War memory. "Many historical and veterans groups protested the unorthodox design [of the Wall] and wanted to add a more traditional statue and an American Flag" (Messmore, 2002, webpage); and

(3) The "Vietnam Women's Memorial" is incorporated "to promote the healing of Vietnam women veterans through the placement of the Vietnam Women's Memorial on the grounds of the Vietnam Veterans Memorial in Washington, D.C.; to identify the military and civilian women who served during the Vietnam war" (Figure 2.4, right).

In this example, on commemorating the event of Vietnam War, there are many perspectives to recall such memory, with many interpretations and representations in the various forms of the monument. Literally, there is no one representation capable of satisfying people's needs to recall and represent their memories.

Historically, the need for changing the characteristics of the medium that embody people's representations, e.g. monuments, can be traced back to the Greek historian Herodotus in "The Persian Wars." Herodotus described the characteristics of that change when Scythians, agrarian-based nomadic tribes in ancient Iran, was able to change the political and cultural power that dominated Asia for twenty seven years, through their

nomadic culture and movement, "thereby preventing the enemy from constructing a theater of operation" (CAE, 1994, p.15; The Circle of Ancient Iranian Studies, 1998-2009). Scythians presented an example of how to disturb the closed, silent structures of power.

On one hand, according to the Critical Art Ensemble (CAE) critics, the Electronic era should be the evolution of the Scythians as a territory for change and resistance, an "Electronic Disturbance." On the other hand, architectural monuments are mere representations of power, which repress people's freedom and resistance, "as with all monumental architecture, [monuments] silence resistance and resentment by the signs of resolution, continuity, commodification, and nostalgia…in its cloak of silence, the monument can easily repress contradiction" (CAE, 1994, p.49). Also, "at the monument, the complicit are not burdened with alienation arising from diversity of opinion, nor with the anxiety of moral contradiction, [but] they are safe from the disturbance of reflection" (CAE, 1994, p.49). Thus, the literature emphasizes a need for creating a monument which is able to embody contradictions and diversity of opinions and to be the evolution of historical nomadic power.

2.2 Memory and Information Technology (IT)

The literature concerning memory and IT in today's increasingly digital society is vast (e.g. Berman, 2008; Berzowska and Coelho, 2006; Damazio and Dias, 2003; Durrant, 2007; Frohlich and Murphy, 2000; Mugellini, 2007; Petrelli, Whittaker, and Brockmeier, 2008; Petrelli, van den Hoven, and Whittaker, 2009; Schneider, Kroner, and Wasinger, 2006; Stevens, Vollmer, and Abowd, 2003; Stevens et al., 2002; Uriu et al.,

2009; Wilson, 1994; Hoven and Eggen, 2006); the literature on IT supporting collective memory is substantial (e.g. Bachimont and Blanchette, 2006; Engeli, 2006; Kientz and Abowd, 2006; Livingston, 2006; Rice, Lawyer, and Skousen, 2006; Richter, 2006; Sas et al., 2006; Sas and Dix, 2006; Walldius, 2006; Whittaker, 2006); and the literature on the use of technology in public places (Dalsgaard, 2008; Katzeff et al., 2006; Robertson, Mansfield, and Loke, 2006; Ruffaldi et al., 2008) and interactive environments (e.g. Crawford, 2005; Gemeinboeck, 2005; Zhao and Moere, 2008) is growing; nevertheless, the literature for creative, intelligent monuments augmenting memory has not yet emerged.

In our complex social, technological, and cultural world, embedded with all sorts of digital technologies that affect us at work, home and social loci, we do not have to remember all of our daily complex records, but we will depend more and more on the digital technology to record, analyze, and recall events and memories whenever needed (Bell, 2009). The e-memory (electronic memory), which is based on using digital technologies for encoding and retrieving memory, is essential to our current smart technologies and the developing cloud computing practices, that instead of having sensors and systems carried with us all the time, cloud computing allows world records to be updated and stored for users whenever and wherever they go, providing access to digital memory everywhere (Bell, 2009). Electronic memory is becoming a contemporary mnemonic device in augmenting the physical human memory. Thus, a need to define our current memory usage and its representations will affect the future of research in the use of digital technology on the personal, community, and societal levels

25

(Berman, 2008). Berman's research describes that "the world we live in [is] awash in digital data—an estimated 281 exabytes (2.25×10^{21} bits) in 2007. This is equivalent to 281 trillion digitized novels" (Berman, 2008, p.51) and keeps growing; motivation for developing the Data Cyber-Infrastructure (CI) according to trends that evolves from our usage of data. While the use of digital technology as mnemonic tools is growing, researchers are trying to understand the different ways of using it to encode and retrieve memory. Digital technology augmenting memory is developing at many representational scales, from physical clothing and artifacts to virtual websites and gadgets.
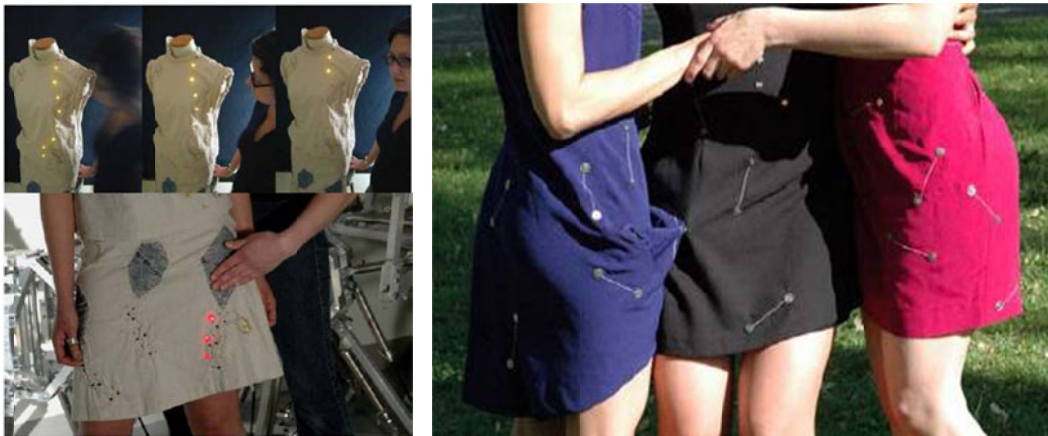
Figure 2.5 Memory-rich clothing. "Indication of time in the Intimate Memory Shirt. The skirt illuminates when someone touches, or gropes, the leaves" (left); "Constellation dresses promote touch and physical contact through simple electronic circuits" (right) (Source: Berzowska and Coelho, 2006, pp. 276, 277)

In clothes, Berzowska and Coelho have developed a memory-rich clothing that records and visualizes the "history of use" to present how people move through space or where and when they have last met (Berzowska and Coelho, 2006). On the scale of artifacts, Damazio and Dias state that "designers design objects and give them a physical shape. People use objects and give them a "social shape," (Damazio and Dias, 2006, p. 139). The main conclusion to be drawn from Damazio and Dias's research is that

26

personal artifacts play an important role in augmenting people's memory; that personal artifacts "are like mirrors where people recognize themselves, revive experiences, update feelings" (Damazio and Dias, 2006, p.139). Damazio and Dias designed a website for collecting images and recording statements about artifacts as a transcultural environment of everyday memories, presenting early findings "which indicate that memory artifacts play emotional roles" (Damazio and Dias, 2006, p.139). Frohlich and Fennell suggest the use of digital audio and photography as a mean to recall memory, they attach them to artifacts for later retrieval and the stories (memory) will be played back – memorabilia (Frohlich and Fennell, 2007), see Figure 2.6.

Figure 2.6 Audio-photographs and memory: The memory shelf (left); The audio-photo desk (right) (Source: Frolich and Fennell, 2007, pp. 114, 112)
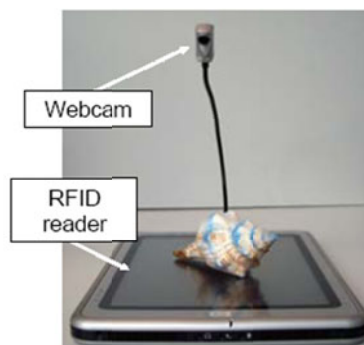
Figure 2.7 Memodules lay and play (Source: Mugellini et al., 2007, p.236)

Similarly, "Memodules" is a Tangible User Interface (TUI) study of Mugellini, connecting artifacts with memories, comprised of a webcam and an RFID reader that take a picture of the objects and read the objects' IDs. The "Memodules" research is based on the importance of cues in remembering, as "the process of 'remembering' usually consists [of] associating something with a sensory cue. For example, we may see a picture of a place visited in our childhood and the image recalls memories associated [with] the same time" (Mugellini, 2007, p.232), see Figure 2.7.

The "Making History" study found that people prefer to associate long-term memories through a variety of media: photos, essay, things, craftwork, ephemera, video, and publications; embodying memories in time capsules – objects which have "a set of cues whose meaning has to be actively reconstructed" and "oriented towards supporting the creative reconstruction of autobiographical memo" (Petrelli, van den Hoven, and Whittaker, 2009, p.1730).

At the scale of personal digital assistance devices (PDA's), the "Open Personal Memories" system consists of a software (SPECTER) used on a PDA that captures information from both the physical and the digital worlds, and secures them for later retrieval (Schneider, Kroner, and Wasinger, 2006).

On "Design Recommendations for Augmented Memory Systems," Van Den Hoven et al. provide a review of the current practices of memory systems used for autobiographical memory (AM) – ''memory for the events in one's life,'' where four categories of systems are presented: (1) recording life systems – systems used for recollecting memories; (2) reminding tasks – systems which helps people remember

things they have to do; (3) creating cues – using cues to help people to remember, for instance the Memory Palace project is as software used as mnemonic device by placing memories in an imagined house that is used as a cue to help recalling memories; and (4) augmented memory systems – devices used to help people recollect their autobiographical memories. The projects presented vary in the type of media used as cues for helping people to recollect memories (i.e., photo, text, sound, video and external artifacts). Nevertheless, most of the projects are focusing on recording memories, not on retrieving them (Van Den Hoven et al., 2008).

Van Den Hoven et al.'s review of the literature concludes that "most studies, do not (explicitly) identify that cues are important for recollecting, nor do they use the different levels of specificity of memories." This review also emphasizes the importance of cuing and reconstructing memories in the retrieval process with the use of media, as "all media types can be used as memory cues in an augmented memory system, although none of the papers explicitly mentions cuing as such" (Van Den Hoven et al., 2008, p.439).

After reviewing the literature on autobiographical memory, and the systems used for augmenting them, The Van Den Hoven et al. review suggest that an augmented memory system should: (1) support memory cuing; (2) use souvenirs as memory cues; (3) include tangible interactions to tangible artifacts (souvenirs); (4) choose explicitly which functions of autobiographical memory should support; (5) should not present recorded material as the "only" instantiation of what really happened, which interfere

with the actual recollection of the user; and (6) create a meta-data system that can be changed easily by the user.

Augmented memory system benefits most from context-dependent memory cues, and the most influential type of cue is text. There are, however, many other dimensions that affect recollection which has not been tested, such as: "pleasure while recollecting, the ability to change the user's mood, the intensity of the memory, the effect of cues a long time after the memory creation, the speed of the memory-recall and perhaps personal preferences for certain cue types" (Van Den Hoven et al., 2008, p.442). Areas of research that may require further studies, include "how the different functions of autobiographical memory can be supported by dedicated augmented memory systems, and what the relations are between memory cues used and the (kind and strength of the) memories that are recollected (e.g., do the cues become memories?)" (Van Den Hoven et al., 2008, p.442).

One major finding identified in this literature review is that "memories do not stay the same over time; they are, just as photos, not per se a carbon-copy of reality. People's beliefs and contexts change and therefore the reconstruction of memories can change as well" (Van Den Hoven et al., 2008, p.441).

Concerning *IT supporting collective memory*, Uriu et al. have developed "CaraClock," an "interactive photo viewing device which allows for the sharing of 'Collective Memory' among family members," and "when multiple CaraClock devices are synchronized, they display related photos according to the settings" (Uriu et al., 2009, p.3205), see Figure 2.8.
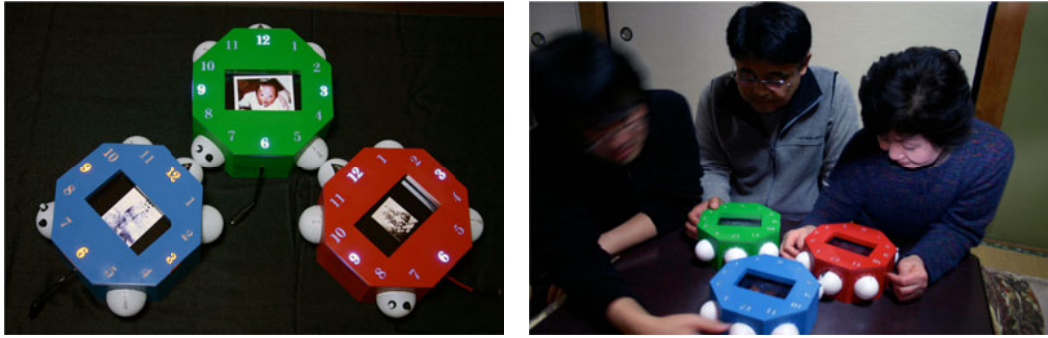
Figure 2.8 CaraClock is an interactive photo-viewing device designed to recall memories of the family members, when they connect their devices together (Source: Uriu et al., 2009)

Figure 2.9 Dreamscape (left); The Room Scheme exemplified with the [roomz]+[connectionz] example (Source: Engeli, 2006)

"Digital Traces" are virtual systems designed to leave traces of past memories in digital environments; the main idea of such systems is that they build traces for the location of memories using visual arts. A "Digital Trace" is, "a place in space and time, reflecting the moment the memory was generated," (Engeli, 2006, p.2). Examples of digital traces include: *Dreamscape,* a carpet of patches that are drawn by users and then linked to websites that represent users' daydreams; *Room Scheme*: based on Bernard Tschumi's theory of "architecture and events," in which spaces are seen as containers of events or stories, and thus the space doesn't grow in size but, instead, in the number of stories following the number of experiences occurring inside it, (Figure 2.9).

"Abrias" is a digital interface for collective memory. As observed by Kientz and Abowd, therapists interpreting data rely on their memories to make judgments on the progress of children with autism. "Abrias" instead employs video technology to capture sessions of different therapists assigned to one case. The video can be accessed by the therapists when needed. Abrias assigns timestamps on video frames to help therapists recall. A digital pen is used by therapists to assign grades, and consequently, all data for a case can be recalled digitally for the entire group of therapists (Kientz and Abowd, 2006).

Another example of the use of digital interfaces for collective memory is described by Rice et al. in their research on the Church of Jesus Christ of Latter-day Saints for preserving histories of families (Rice, Lawyer, and Skousen, 2006). Rice et al. describe the importance of such research for many reasons:

(1) the need to have a growing activity, as "family history has become one of the most popular pastimes in America and one of the top activities on the Internet;"

(2) the need to socially connect people together, especially in the US as "people in the United States lack a sense of roots and connection with the past as they have no culturally established tradition of passing on stories and heritage—social memories" (Corbett, 1997); and

(3) the need to find the truth about the histories of families, as they are all about interpretations where differences occur, "even if not entirely correct, the collective memories created by descendants discussing these stories also contain the elements of truth (Halbwach) which may provide clues for researchers" (Rice, Lawyer, and Skousen, 2006, p.1).

On "Designing for Collective Remembering," Sas and Dix consider the growing importance of collective memories in the last two decades. Sas and Dix suggest that "when memories relate to significant events impacting on an entire group or community and are shared amongst that group, they become collective" (Sas and Dix, 2006, p.1). Sas also studied digital memorabilia for WWII memories which consists of a "video diary" input, allowing visitors to record their war memories (Sas, Lawyer, and Skousen, 2006). The diaries, along with other images and film content, are displayed using projectors in an exhibition room. A website presenting the exhibit can be accessed anytime, anywhere, (Figure 2.10).

Figure 2.10 Video diary recording corner (left); Multi-screen projector (right) (Sas et al., 2006, p.3)

Figure 2.11 IT in public spaces. Visitors experience Balder's Funeral Pyre (left); Diagram of Balder's Funeral Pyre (right) (Source: Dalsgaard, 2008, p.26)

Concerning *Information Technology in public spaces*, Balder's Funeral Pyre has been designed using pressure sensors in the floor to "arouse children's interest in literature by introducing them to Norse mythology" by activating two projectors that

33

simulate fire (Dalsgaard, 2008, p.26), Figure 2.11. "Silence and Whispers" is an installation that, "when visitors step inside the cave, they hear audio fragments of ominous stories and folklore from Suomenlinna …[which] served as a naval fortress from 1748 until the end of World War I" (Dalsgaard, 2008, p.26), see Figure 2.12.
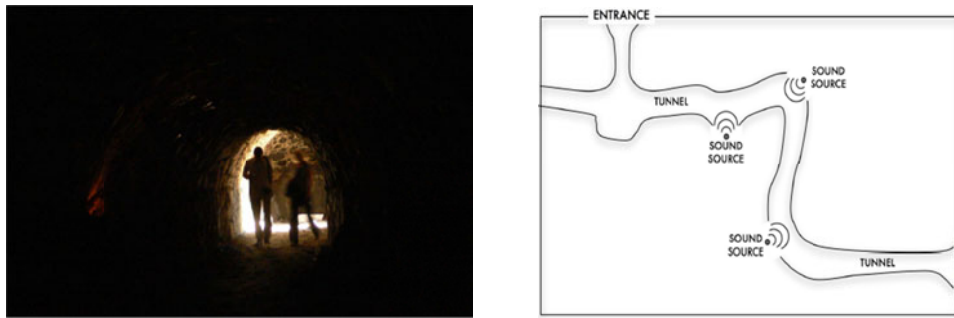
Figure 2.12 IT in public spaces. Visitors explore "Silence and Whispers" (left); Diagram of Silence and Whispers (right) (Source: Dalsgaard, 2008, p.27)

Figure 2.13 IT in public spaces. Exterior view of "The Well" an installation at the music festival organization in Sweden (left); the animation shown on the screen while the video is recorded (middle); interior view of The Well (right) (Source: Katzeff et al., 2006, pp.315-316)

"The Well," a video storytelling booth (Katzeff et al., 2006), is another example for using IT in public spaces. In this example, the key concept is for people to share experiences in a "confession booth" in which "the user watches herself communicating with the monkey on the screen. The role of the monkey (named "Appo") was to induce a

playful atmosphere and to fill the part of a neutral partner to direct confessions. While the user talks and moves, she is filmed by a video camera attached above the screen" (Katzeff et al., 2006, p.315), see Figure, 2.13.
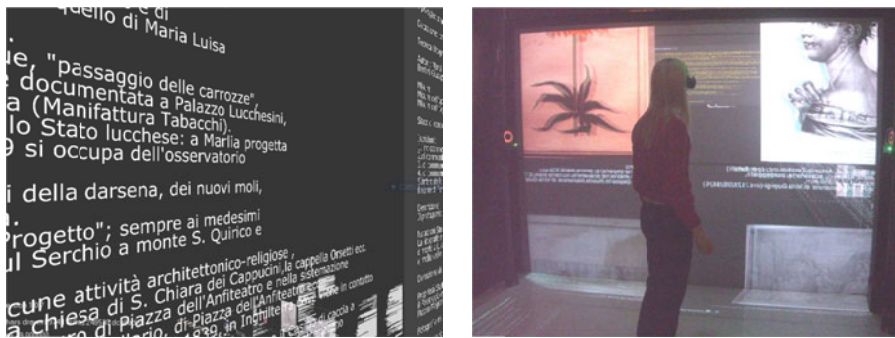
Figure 2.14 Ruffaldi's et al. system using IT in a museum setting. xVR text projected on a wall(left); a user interacting with the xVR environment by managing text and images projected on a wall (right) (Source: Ruffaldi et al., 2008, pp.117-118)

Figure 2.15 Impossible Geographies 01: Memory. "IG 01: Memory: the installation at Soto gallery" (left); IG 01: Memory: the past seeping into the present (right) (Source: Gemeinboeck and Krell, 2005, p.1066)

Another example of the use of IT in public spaces is an interacting system using xVR (Xtreme Virtual Reality) technology[1] for advanced image and text rendering, to design a VR environment that simulate "Information Landscapes for Cultural Heritage"

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[1] "XVR is a new technology to develop advanced multimedia content. It's focused mainly on 3D graphics and sound, but many forms of media are supported. XVR is a tiny ActiveX component developed by VRMedia so, for example, all you need to integrate an XVR content in a web page, is a computer with a decent video card installed and Internet Explorer (but an unofficial version for Firefox is already floating around the net). XVR applications are based on a very efficient byte-code and virtual machine combination. Applications are written in a sophisticate development environment called XVR Development Studio, that integrates an advanced editor with an high speed compiler" (VRmedia Website: http://www.vrmedia.it/Xvr.htm)

(Ruffaldi et al., 2008); integrating motion capturing system and interaction through the use of a joystick in a museum setting. In this interactive system, the users are engaged with the xVR environment using the joystick to change and manage text and images in a CAVE-like environment, see Figure 2.14.

Additionally, there have been many studies concerning the use of robots in museum settings. As described in the "robots in exhibitions" workshop's proceedings, of the the International Conference on Intelligent Robots and Systems (IROS 2002), "so far, robots have done the following tasks in exhibitions: tour-giving (Rhino, Minerva, Mobot museum robots, Museomobile, Expo.02); entertainment and animation (Museum of Communication Berlin, Diligent, Blacky); education (Mobot museum robots, Museum of Communication Berlin); picture taking (Expo.02); tele-presence (Kapros, Tourbot, Webfair); interactive art object (Expo 2000); demonstrations (Hermes)" (Arras et al., 2002).

Concerning the use of *interactive technology*, David Crawford has designed "Stop Motion Studies," a number of interactive installations that have been designed for Sweden, the United Kingdom, France, the United States, and Japan. The main idea, described as net art, is to experience being photographed in a subway, which then is projected on a wall in the subway (Crawford, 2009). "Impossible Geographies 01: Memory" (Gemeinboeck and Krell, 2005) is another interactive installation that connects its visitors with past visitors and fictional/performed events in the same space. In the "Impossible Geographies" exhibit, users are tracked and photographed by cameras over time; the software merges visitors' photos with fictional performances which have been

36

recorded over other times and in different places. The merged visitors' photos and the changing geographies in scenes are projected after a six-week period in the same space, with the aim of offering the visitors an opportunity to experience the "slippery relationship between fictive and 'real' memories," and "exploring memory as a metaphor for the fluid boundaries between the physical and the virtual" (Gemeinboeck and Krell, 2005, p.1065), see Figure 2.15.

"HHHM," a handheld PDA "hyper-monument," uses text, audio and images along with GPS technology, to locate history wherever users find themselves – a virtual digital tour guide (Karasic, Gelder, and Coshow, 2007). This "hyper-monument" is confined to a small 2D display – hardly the physical, spatial embodiment of memory – the monument – persisting through human history since the ancient Greeks.

The "Anne Frank Tree: an interactive monument for peace" is another example of a 2-dimensional (2D) website augmenting memory (http://www.annefranktree.com/). As is the "Make History Project," is a 2D website for "collective telling [of] the events of 9/11 through the eyes of those who experienced it, both at the attack sites and around the world" (http://makehistory.national911memorial.org/). These examples are all confined to 2D displays.

Ultimately, the physicality of monuments, even in an increasingly digital society, has not ceased to capture the human imagination, emotion, and curiosity. Moreover, the literature for creative, intelligent monuments augmenting memory has not yet emerged.

2.3 Architecture and Information Technology (IT)

The human need for communication has been a key foundation for structuring the physical and digital worlds. These two worlds are, today, hybridizing (Mitchell, 1999; McCullough, 2004; Negroponte, 1995). While the digital world is expanding, the hybrid digital-physical world is still unfolding. Since the beginning of the 21st Century, researchers' focus has shifted from computers to computation, as "the critical focus in the very near future will be on ubiquitous access to pervasive and largely invisible computing resources" (McCullough, 2004, p.7). This suggests the need for embedding technologies into the physical world. William Mitchell, Hiroshi Ishii, Usman Haque, and many others envisioned many technological platforms defined by such hybridization (McCullough, 2004; Moggridge, 2007; Ishii and Ullmer, 1997; Bratton, 2008).

Architecture in its hardware, software and situational platforms (i.e., as spaces of interaction where events exist,) promises such a hybridization between the digital and the physical worlds (Mitchell, 1999; McCullough, 2004; Negroponte, 1975; Fox and Kemp, 2009, Greenfield, 2006). Nevertheless, new technologies are not intended to "kill architecture" as Victor Hugo prophesied, but to augment human capacities in our current complex lives.

Historically, architecture serves as an interface for physical-human engagement supporting memory, socializing, protecting, working, and so on. Sociologist, and media and design theorist Benjamin Bratton considers how people "program" architecture, as "a set of designed or designable scripts that organize organization itself, [and] how things [people and architecture] will play out, and stage their interrelations accordingly"

(Bratton, 2007, p.20). These "programs" implicitly utilize the function of "architectural software," (i.e., thinking "about how and why physical things are moving as they are through urban space…to consider how architecture relates to human-machine interaction" [Bratton, 2007, p.20]), and hardware, (i.e., the digital and the physical). This hybrid "program" "is the framing script for how inhabitants will engage with a spatial system over time, or over a day, or simply from one place to the next" (Bratton, 2007, p.21). In a "hypermodern" society that is increasingly mobile, the use of information technology for physical interaction may help us design a hybrid digital-physical world that can comingle humans complex relations with physical spaces. Such architectural programs are defined today as the practices of interaction design and "architectural robotics".

Recently, "architectural robotics," an emerging research focus partnering architecture, IT, robotics, social sciences, and psychology, pursues the hybridization of our physical-digital worlds (Green et al., 2005; Fox, 2010; Weller et al., 2007). Theoretically, cybernetics in architecture (Pask, 1969), conversation theory (Pask, 1969; Fox, 2010), and interactionism (Fay, 1996) are the main theoretical bases for the development of the interactive and intelligent environments, architectural-robotics. These theories can be summed up in Pask's "conversation theory" as "essentially a model … in which architects interpreted spaces and users as complete feedback system; interactive feedback systems related to adaptability" (Fox, 2010, p.6).

Architectural-robotics is categorized as two distinguishable ways of interaction: (1) sensing physical interaction through processing and actuation; in which robotics is

embedded into the built environment. Robotics in this realm is comprised of sensing, processing, and actuating technologies, by which the physical environments intelligently sense and understand users, (e.g., presence, contact, distance, light, smell, temperature, audio, and proximity,) and effectuate and actuate to "enable the robot[/environments] to take action, to do physical things" (Mataric, 2007, p.24), allowing the environments to respond accordingly (Green et al., 2008), see Figure 2.16; (2) Internet interaction, through processing and engagement, in which virtual and digital interfaces, (i.e., internet and websites,) are used as the main platform for users' engagement with the world.

Figure 2.16 Animated Work Environment as an example for sensing physical interaction. "Developing prototype of the robotic "wall" showing four of its eight panels" (left); two different configurations for the robotic wall after physical interaction with its sensors (middle and right) (Source: Green et al., 2008)

Figure 2.17 The Muscle Projects by Kas Oosterhuis. Three different installations comprised of Festo muscles and proximity/pressure sensors (Source: Oosterhuis and Biloria, 2008)

For sensing physical interaction, architects including Oosterhuis, Fox, nArchitects, and Keith Green are embedding robotics into the built environment. Kas Oosterhuis, of the Technical University at Delft (TU-Delft) employs robotics for sensing through physical interaction, develops many platforms, and helps to identify opportunities in robotic technology embedded in the physical world (Oosterhuis and Biloria, 2008; Oosterhuis, 2003; Fox and Kemp, 2009).

Ossterhuis's Hyperbody group designed the "muscle projects," comprised of Festo muscles, a system of air compression and air pressure regulators to control pneumatic muscles, via proximity sensors and/or pressure sensors to signal the presence of users. The users' proximity causes variable compression and expansion of the muscles, resulting in changes in form (Oosterhuis and Biloria, 2008), see Figure 2.17.

Figure 2.18 The Interactive Bubbles project by Michael Fox. Interactive webcam from the D-tower website (Source: Fox and Kemp, 2009)

Examples of physical interactions embedded in the built environment include: Michael Fox's, "Bubbles" project in California, Figure 2.18; nArchitects's, "Party Wall" project (Hoang and Bunge, 2005) which embeds proximity sensors and motors between layers of foam that vibrates and changes form, (i.e., compresses and expands, when users

are close to its proximity sensors,) Figure 2.19; and Keith Green's "AWE –Animated Work Environment" (Green et al., 2006, 2008, 2009), which uses infrared sensors and motors to rotate eight rigid panels so as to provide six pre-configurations for work and play: collaborating, composing, presenting, viewing, lounging, and gaming, Figure 2.16.
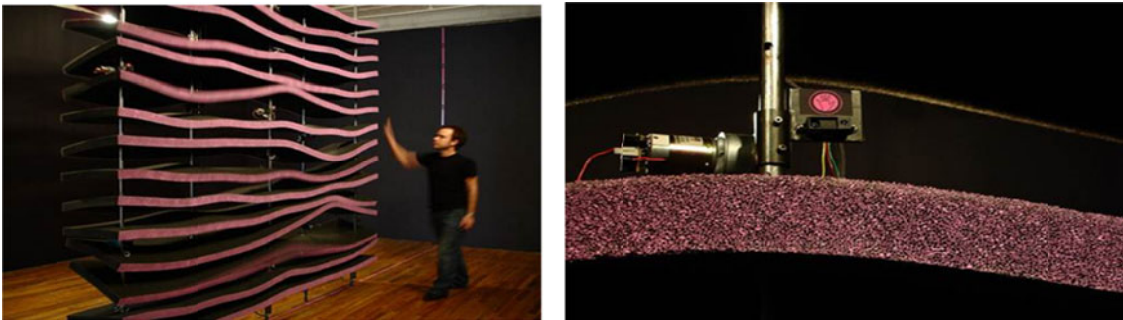
Figure 2.19 "Part Wall" by nArchitects in motion (left); "detail of a node with both a motor and proximity sensor embedded between two layers of foam" (Right) (Source: Hoang and Bunge, 2005)

Figure 2.20 The D-tower by Lars Spuybroek/NOX. Interactive webcam from the D-tower website, (http://www.d-toren.nl/app/) (left); four configurations for the D-tower: red stands for love, blue stands for happiness, yellow stands for fear, green stands for hate (right) (Source: Karssenberg, 2008)

Via internet interaction, the D-tower by Lars Spuybroek/NOX, is an example in which inhabitants of the city of Doetinchem in the Netherlands engage with the virtual world, (i.e., websites,) which accordingly change the physical world (Karssenberg, 2008). The D-tower measures citizens' degree of happiness, love, fear and hate. The results of the online questionnaires are represented visually on the website in the form of emotional landscapes, Figure 2.20. The findings are translated into peaks and dips: a lot of

happiness, little happiness, a huge amount of hatred, scarcely any hatred, barely any love, some love; then, these registered emotions are translated into changes of colors in the physical environment (Bullivant, 2005; Nox and Partners, 2003). "Emotional Cities" by Erik Krikortz offers an example of "internet interaction" in which citizens visit a website and respond to questionnaires representing their emotions about the city. The outcome of the current emotional state of the city is projected on the facades of large buildings (Iaspis et al., 2007). The combined use of physical and internet interactions together in one physical environment has not yet emerged.

The hybrid world of physical-digital interactions is promising for the development of intelligent environments. In the last five years, internet interactions are developing from being reactive using graphical user interfaces (GUI) into being "interactive" using gestural user interfaces; e.g., smart phones and PDA's. While these virtual environments are growing in complexity and interactivity, they remain confined to virtual internet interfaces within small gadgets, outside of the spatial environmental dimensions. If the digital and physical worlds can be hybridized, the promise of intelligent and open environments can be realized in different spatial applications such as architectural-robotics.

2.4 Memory and humans

Cognitive psychologists and neuroscientists profoundly and empirically studied how people encode and retrieve memories. The most important findings entail encoding specificity, Hierarchical Temporal Memory (HTM) theory, K-lines theory, and "Gists."

The environment affects the way we encode and retrieve memories, specifically the level of processing and encoding specificity. The mechanism for the "encoding specificity" principle is to encode information in organized form, including contextual cues that provide "access routes" for later retrieval (Murnane, Phelps, and Malmberg, 1999; Brown et. al.; Smith and Vela, 2001; Nairne, 2005; Tulving and Rosenbaum, 2006; Treib, 2009; Eich, 1995; Roediger and Guynn, 1996; Matlin, 2009; Kandel, 2006). Moreover, "the research on "encoding specificity" emphasizes that memory often requires problem solving" (Matlin, 2009, p.130). "The brain knows about the world through a set of senses … to create a model of the world…hold it in memory" (Wilson, 1994, p.1). As the spatial context is an effective component in the way we encode and retrieve memories, by employing the different contextual cues in our collective memory environments for the different ways people encode memories, (i.e., visually, auditory, and olfactory,) we should be able to enhance our physical environments for embodying cultural memory.

We encode and retrieve memories through *patterns*, according to the Hierarchal Temporal Memory theory (HTM) (Hawkins and Blakeslee, 2005), and the K-lines theory (Minsky, 1988), by Jeff Hawkins and Marvin Minsky. Memory works as spatial and temporal patterns in the neocortex. Humans encode these patterns through the use of their five senses: sight, hearing, touch, smell, and taste. We really have more. Vision is reportedly more like three senses: motion, color, and luminance (black-white contrast). The sense of Touch, likewise, has pressure, temperature, pain, and vibration. The sensory message enters our brain as streams of spatial patterns, flowing through time on axons

(Hawkins and Blakeslee, 2005, p.59). "The most important property [of long-term memory] is that you don't have to have the entire pattern you want to retrieve in order to retrieve it. You might have only part of the pattern, or have some messed-up pattern" (Hawkins and Blakeslee, 2005, p.30). These references in the study of memory point to the importance of *constructing and recalling patterns* in the processes of encoding and retrieving memories, which can help in designing collective memory environments, especially monuments. Monuments are not artifacts of the past, but are interpretations of it; thus, it is convenient to encode people's interpretations of that past as abstract forms, instead of literal ones. If we employ abstract contextual cues in new monuments, these monuments will be accessible to different people in encoding memory the way they find it useful for later retrieval. It may be useful for collective memory environments to use different sensorial dimensions to open the possibilities of accommodating the different ways people encode and retrieve memory – "multi-sensorial environments".

Human beings do not remember things or events in their entirety, but by way of important cues from such events, summarized as "Gists" (Larson and Loschky, 2009; Sampanes, Tseng, and Bridgeman, 2008). "Gists" can be described as a property of humans' memory, comprised of tiny layers in the neocortex where "memories are stored in a form that captures the essence of relationships, not the details of the moment" (Hawkins and Blakeslee, 2005, p.82). The research on "Gists" provide an evidence for the idea of using abstract forms instead of literal detailed forms in enhancing our collective memory environments, without the need to re-narrate stories of the past.

2.5 Interpretations of historical documents

A growing body of research on history and memory, has emphasized the ways in which monuments valorize specific historical meanings and interpretations (Crowe, 1998; Kachun, 2003; Lima, 1998; Wertsch, 2002). Perhaps the most perplexing challenge is the confusion concerning the interpretation of "history" and its embodiment in a physical structure (Dimitripoulos, 1998; Patrick, 2009; Struken, 1997).

In contemporary literary practices, Franco Moretti suggests the need to shift from the "close reading" of individual texts to the construction of abstract models as a "distant reading;" a shift to make explanations before interpretations for the aim of having a "more rational literary history" (Eakin, 2004; Moretti, 2000; Moretti, 2005; McGray, 2009). Moretti's idea seeks to solve the current paradox of literary practices, whereby "for any given period scholars focus on a select group of mere few hundred texts: the canon. As a result, they have allowed a narrow, distorting slice of literary history to pass for the total picture" (Eakin, 2004, p.B9). Moretti's suggested model is called "Graphs, Maps and Trees," in which "the text undergoes a process of deliberate reduction and abstraction. 'Distant Reading,' not an obstacle, but a specific form of knowledge: fewer elements, hence a sharper sense of their overall interconnection" (Moretti, 2005, p.1).

Similarly, Pierre Bayard describes and completes the arguments of Robert Musil, Paul Valery, Umberto Eco, Montaigne, and Balzac on reading books using different techniques in what he called "ways of not-reading:" processes used to describe effective ways of talking about "books you don't know," "books you have skimmed," "books you have heard of," and "books you have forgotten" (Bayard, 2007). Bayard aims to "not

depend on an image of books as fixed objects, but instead assumes that the participants are in a fast-moving discussion... can change the text itself" (Bayard, 2007, p.132), which "confers great freedom to impose our judgments of books on others" (Bayard, 2007, pp.148-149).

Umberto Eco, in his latest work, "The Infinity of Lists," describes the crisis of current literary practices which are dependent on certain cultural "islands" that are "limiting the possibility to know more" (Eco, 2009, n.d.). Suggesting the need to open the works of literature for people to reflect and complete, Eco states that he is "not in a position to tell you everything, so you must come by the rest by your own" (Eco, 2009, n.d.).

Bayard's and Eco's arguments suggest "openness" in the work of art and literature for people to interpret, similar to Moretti's idea of "distant reading." These concepts are promising for this research; in the digital age, it is possible to use the internet as an open media for people to share their memories of the past. And using Moretti's model of the text that undergoes a process of deliberate reduction and abstraction, (i.e., text-mining,) will aid in designing an open interface for people to share their interpretations on history.

2.6 Gaps in the literature

From the review of literature, the following gaps have been discovered:

▪ Monuments remain mostly *closed, silent vessels* of past memory, commissioned by institutions and organizations, and shaped by their architects;

▪ Monuments *tend to not have the power to accommodate different interpretations*;

47

- Monuments *tend to be immobile, heavy, and expensive.* Monuments are "finite," in construction of the their internal and external forms;

- In technology, the literature regarding *creative intelligent monuments augmenting memory has not yet emerged*;

- The scope of scholarship used to interpret history (collective memories) has *historically been limited to a few close reading, thus forming icons that are above critical examination.* Hence, societies have little right to claim whether the icon is true for themselves or not;

- The research concerning history and its interpretations shows *confusion concerning the interpretation of "history" and its embodiment in a physical structure.*

This research shall focus on designing monuments that are open vehicles for people to use to criticize and share their memories. The monument will make it possible for lay-citizens to shape and retune their environment. The architect shall design the monument to be accommodating to reconfiguration by people. The monument of the near future shall be a vehicle to collectively represent historical text (relatively more than the few close reading) providing lay-citizens to incorporate individual interpretations of their unique memories.

2.7 Supportive theories

This research is motivated by theoretical and philosophical arguments, as well as technological and informational ones, of the "Non-Finito," the "incomplete" work of art as conceived by the Italian artist Michelangelo (Buonarroti, 2009). Michelangelo and,

more recently, Eco attempted to find an answer for "the absolute truth in art." Eco, notes in "Opera Aperta," that "it is not the duty of the artist to name things or form them, I am not in a position to tell you everything…So you must come by the rest by your own" (Eco, 2009).   Art is principally concerned with reflections and interpretations, an "'honest' entertainment [that] acknowledges the complexity, the problematic character of the historical circumstances in which we live, because it allows for the possibility of change and serves as a stimulus to reflection and criticism" (Eco, 1989/1962, p.xvii). Moreover, art aims "to disclose a field of possibilities, to create operative choices and "ambiguous" situations open to all sort of interpretations" (Eco, 1989/1962, p.44).

We perceive architecture through its multi-sensorial dimensions, phenomenologically. Phenomenology, as described by Merleau-Ponty, is a relation between the self and the world: "my perception is not a sum of visual, tactile and audible givens; I perceive in a total way with my whole being; I grasp a unique structure of the thing, a unique way of being, which speaks to all my senses at once" (Pallasmaa, 2005, p.21). For Nietzsche 'the dancer has his ear in his toes' (Pallasmaa, 2005, p.14); and for Merleau-Ponty, 'through the vision we touch the sun and the stars' (Pallasmaa, 2005, p.42).

Another inspiration for this research is Post-phenomenology. Post-phenomenology is a hybridization of pragmatism and phenomenology, an empirical approach for understanding perception. Post-phenomenology, as defined by Don Ihde, is "a hybrid phenomenology" that "recognizes the role of pragmatism as a way to avoid the problems and misunderstandings of phenomenology as a subjectivist philosophy" (Ihde,

2009, p.23). Post-Phenomenology "sees in the history of phenomenology a rigorous style of analysis through the use of Variational Theory, the deeper understanding of embodiment and human active bodily perception" (Ihde, 2009, p.23). Post-phenomenology uses empirical methods to produce a new way of bringing something that is both spatially and perceptually distant – literally, produce an evidence for embodiment.

As described earlier, "distant reading" is another approach to interpret historical texts, a shift from "close reading" of individual texts to the construction of abstract models or what Moretti calls "distant reading". Distant reading "allows you to focus on units that are much smaller or much larger than the text: devices, themes, tropes—or genres and systems" (Moretti, 2000, p.57). Moretti posits the need for "distant reading" because, "a canon of two hundred novels, for instance, sounds very large for nineteenth-century Britain, but is still less than one per cent of the novels that were actually published: twenty thousand, thirty, more, no one really knows – and close reading won't help here, a novel a day, every day of the year would take a century or so" (Moretti, 2005, p.4).

Overall, this research is informed by the theory of "Embodied Interaction". "Embodied Interaction" is "not simply a form of interaction that is embodied, but rather an approach to the design and analysis of interaction that takes embodiment to be central to the whole phenomenon" (Dourish, 2001, p.102). Embodied Interaction is a hybrid system of "tangible computing" and "social computing" so as to create "smart environments." Embodied Interaction focuses on: (1) practice which is "not just what people do, but with what they mean by what they do, and with how what they do is

50

meaningful to them" (Dourish, 2001, p.204); and (2) an appropriation which is "[the] evolution of working practices, and their relation to the settings-technical, organizational, physical" (Dourish, 2001, p.205).

These theories of "phenomenology," "embodied interaction," "distant reading," memory, and "non finito" inform Monumental-IT in the following ways. First, the theory of "phenomenology" informs the idea of employing multi-sensorial cues (i.e., form, sound, color, shades and shadows, smell, and touch) in designing monuments. These different cues will provide means that can help each person (i.e., visitor) to encode and retrieve memory according to his/her mental model(s). Second, the "embodied interaction" theory informs the idea of connecting the virtual world (i.e., the wiki platform) with the physical structure of the monument, providing meaningful practices which are connected to social and physical worlds. Also, the "embodied interaction" theory suggests employing IT and robotics in monuments by providing tangible and social platform for interaction with the physical environment (Monumental-IT). Third, the "distant reading" theory informs the idea of data-mining historical texts. Fourth, theories of "encoding specificity," K-lines, and HTM inform the idea of designing multi-sensorial environment which will help people to encode and retrieve memory through spatial and phenomenological cues to build patterns for later retrieval. Fifth, the "incompletion" or the "non finito" theory informs the idea of opening the art work (i.e. monuments) for different representations. These different representations can be manifested by employing IT and robotics in designing the monument, a changeable kinematic structure.

CHAPTER THREE

CONCEPTUAL FOUNDATIONS

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

-- Mark Weiser, The Computer for the 21st Century

This chapter defines key research concepts, dimensions, operational definitions, and operational measures, as well as responses to the gaps in the literature review presented in Chapter One. This chapter as well introduces an iterative design process for Monumental-IT, a citizen configurable robotic monument, beginning with the definition of Personas (i.e., fictional user-profiles that represent the intended users); generating the research conceptual designs; and selecting the appropriate research design according to the criteria of conceptual design and Human-Centered Design. Finally, developing research methods for testing, evaluating, and analyzing Monumental-IT.

3.1 Key concepts, dimensions, operational definitions, and operational measures

The key research concepts of this research are: the design of monuments, "architectural robotics" and "Human-Robotic Interaction (HRI)," (Figure 3.1). Concerning the research dimensions for "designing monuments" and "encoding and retrieving memories," "formal and contextual cues" have been selected as dimensions that affect users' interactions within architectural/monumental systems. For Human-Robotic Interaction (HRI), "usability" and "effectiveness" have been selected as two dimensions for understanding the positive and negative human-interactions to the selected monument, described in-detail in the next sections.

For the research operational definitions, smell, sound, and motion have been selected as indicators for "contextual cues"; color and shape have been selected as indicators of "formal cues"; and "severity ratings of violated heuristics" has been selected as an indicator for the "usable and effective" dimension. On the research operational measures, verbal and observations have been selected for all previous operational definitions, including a set of questionnaires, heuristic evaluation sheets, paper prototyping, and lab observations, (Figure 3.1).

3.2 Responses to the gaps in the literature

In response to the gaps in the literature on Monumentality/Memory described in the previous chapter, I have developed philosophical and conceptual foundations for designing a monument using the supporting theories: post-phenomenology by Ihde, cybernetics, data-mining and wiki, contextual cues and level of processing, the "non-finito" of Michelangelo and Eco, and "distant reading" by Moretti, Bayard and Eco.

3.2.1 Philosophical foundations

Following from historically "closed" monuments to 'open' and "free" monuments, 'free' is defined as the freedom of speech, freedom of resistance, freedom to share knowledge, and freedom to participate in decision-making. Of the nomadic flow of information in the IT age, the architect should share in the ambition to resist the role of social institutions and organizations in manipulating human collective memories and the physical spaces which accommodate them.
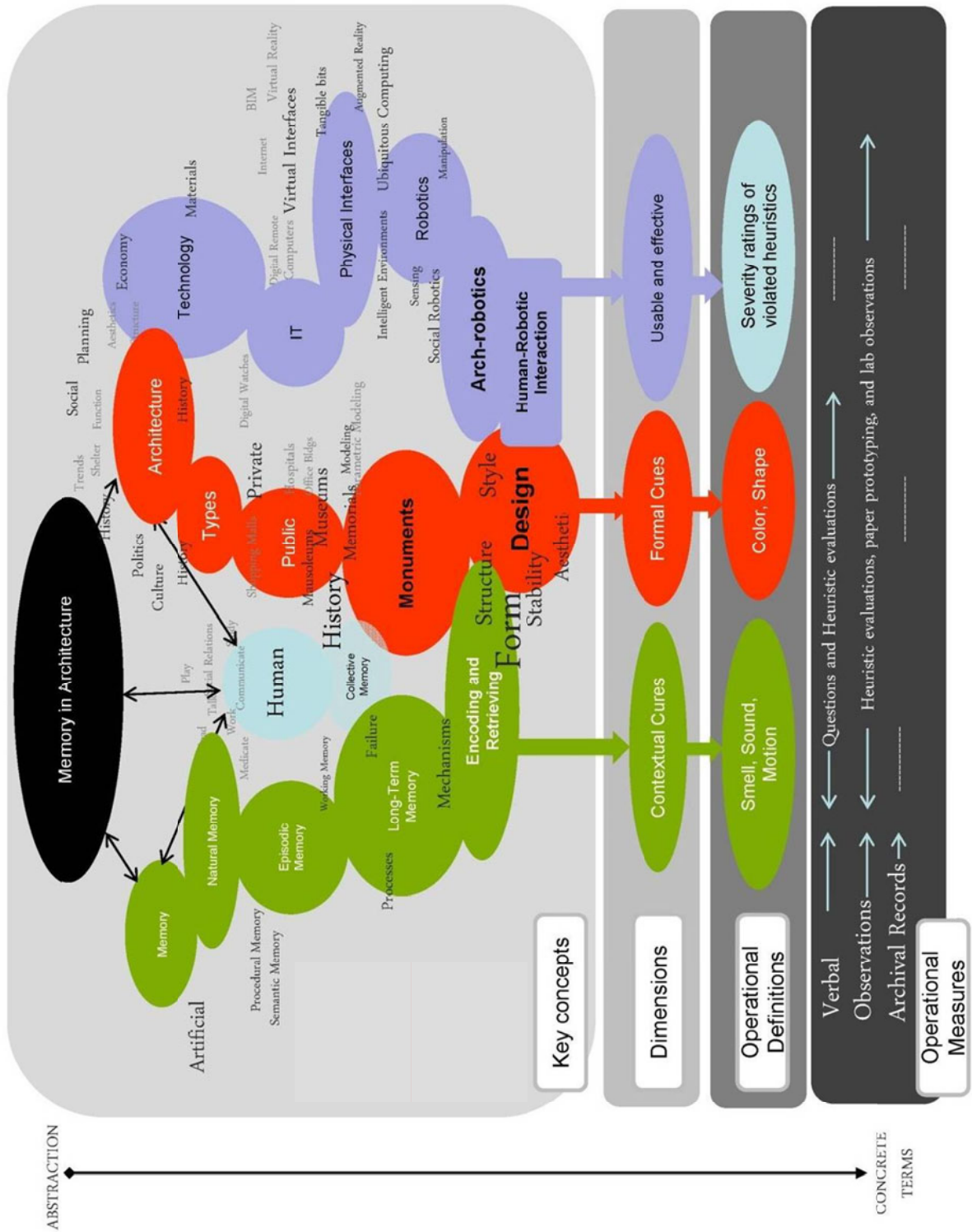
Figure 3.1 Diagram showing the research key concepts, dimensions, operational definitions, and operational measures

Architects must refuse to sacrifice the subjectivity of the viewer and leave people to represent memories the way they feel, free of any manipulation. It is this freedom that lets people represent themselves, they will be invisible in the sense of their nomadic structure, as Herodotus described when he talked about Scythians, "Scythians had the option of remaining invisible, and thereby preventing the enemy from constructing a theater of operation" (CAE, 1994, p.15).

In the process of recalling memory, it is important to consider it as a non-existing phenomenon within current space-time. The process of recalling memory involves people's interpretation of the experiences they had in the "past," or opinions about an event or a person they only read about. Recalling a memory is not a way to bring the past to life after an event passes, even if that "past" had occurred a year or thousands of years ago. Ultimately, *recalling "memory" is a kind of time travel*, as the Nobel prize winner Eric Kandel described in his thesis "In Search of Memory:"

> "[In recalling memory] you are not only recalling the event, *you are also experiencing the atmosphere in which it occurred – the sights, sounds, and smells, the social setting, the time of day, the conversations, the emotional tone.* Remembering the past is a form of mental time travel; it frees us from the constraints of time and space and allows us to move freely along completely different dimensions," (Kandel, 2006, p.3, emphasis added).

Nevertheless, the monument is still a spatial petrified form of an interpreted past, assuming that we all have the same voice and interpretation of memory. In response to these positions, "Monumental-IT" aims to provide a multi-sensorial space capable of being reconfigured by citizens, open to the diverse interpretations amongst a population. Monumental.IT allows users to interact and engage with its space. Also, the monument should be able to differentiate between interpretations of past events, and leave visitors to

partially shape the memory in the way that better fits their beliefs and experiences about the past, using the language of architecture, through formal and contextual cues, as shall be described in-detail in Chapter Four.

Formally, Monumental-IT is inspired by the idea of "skin and structure" of the human body. The human body is comprised of "skin," the envelope that defines the formal identity; and the "structure or skeleton," the core of the body that is slightly different from person to person.

> "While there are several differences between male and female skeletons on average, all the differences are relative so it is nearly impossible to identify gender from skeletal measurements alone. The majority of people will fall into the average ranges of bone size for their gender…it is important to remember that male and female skeletons are much more alike than different" (Main, 2011, p.1).

Analogously, understanding that skeletons are only slightly different, and that the skin differentiates human figures; in the language of architecture, the structure or skeleton of the monument can be seen as a ghost (i.e., a placeholder) of the true memory, the memory as it was, static. The skin can be seen as a representation of people's diverse interpretations of the intangible past, dynamic and reconfigurable. Additionally, the "site" in which the event occurred can be seen as the only true remaining memory (artifact) – the observable memory.

Robert Venturi's "Ghost Structures," a monument to Benjamin Franklin's demolished house, is an example of the idea of memory as ghost structure, a trace of what was. The physical remains of the site can be seen as the only true memory of this place, (Figure 3.2). Monumental-IT proposes to employ a similar analogy of skin and ghost

structures, which will be described in detail in the following chapters after generating design concepts, and selecting the appropriate design.

Figure 3.2 A monument to Benjamin Franklin on the site of his long-demolished house, designed by Robert Venturi in 1976, (Sullivan, 2008)

3.2.2 Conceptual foundations

Monumental-IT is motivated by many theoretical and philosophical arguments that will affect the conceptual foundation. Motivated by the Italian artist Michelangelo's thesis of the "non-finito," Monumental-IT can be left open: *internally*, through a reconfigurable Wiki website, that is open and available to all internet users to share their thoughts, memories, and interpretation of the past; *externally*, through a reconfigurable robotic body, that is open and available to people to retune it "collectively". Additionally, by opening the form to a field of possibilities, the monument's space will be an experience of ambiguity, which will be open to all sorts of interpretations.

As Kandel described before, memory is not only the event recalled, but also the recall of the whole of an experience. Architecture phenomenologists might agree with this position but recognize, as well, designed spaces as sensorial phenomena experienced

through the whole body, not only through the eyes. Monumental-IT will employ many sensorial dimensions to aid in the process of recalling memories, and will fully engage its visitors with the aura of the place, "carnal echoes" of our body in the monument, "embodiment." Instead of using the form of the monument, as in the figurative type, Monumental-IT will use form, color, sound, texture, shade and shadows, motion, and texture as its multi-sensorial changeable and reconfigurable dimensions. By empirically designing and evaluating human interactions using these phenomenological dimensions, "post-phenomenology," we will be able to understand the effect of the multi-sensorial dimensions on our experiences.

From a cognitive-psychology perspective, the use of multi-sensorial dimensions in the physical environment as contextual and formal cues can help in human processing and memory (i.e., enhancing the encoding and retrieving processes) (Murnane, Phelps, and Malmberg, 1999; Brown et al.; Smith and Vela, 2001; Nairne, 2005; Tulving and Rosenbaum, 2006; Treib, 2009; Eich, 1995; Roediger and Guynn, 1996; Matlin, 2009; Kandel, 2006).

Monumental-IT will be based on Moretti's thesis of "distant reading," on two scales: the first, is through the use of "data-mining" to extract patterns of words that can help in differentiating users' interpretations on a wiki website, calling it WikiMonument; and second, through the physical, robotic-monument's recognition of people's interpretations on real and virtual sites, thus providing an abstract perspective on the memory not a literal one, i.e., figurative and platonic monumental types.

58

"Embodied Interaction" is based on a human-centered design approach that drives the concept and design of Monumental-IT. Monumental-IT will be a hybrid system for employing mind-body and thought-action relationships. "Embodied Interaction" will be used to help understand human experiences with information technologies in real-time and real-space, situational experiences. If architects are able to understand how people interact with each other and with the technology they are using, then we will be able to embody our interactions and make the system human-oriented, instead of our long-lasting environments of technology-oriented systems. "Embodied Interaction" can be employed through the use of appropriate methods for designing and evaluating Monumental-IT's system with real users, i.e., iterative design process, heuristic evaluations, and usability engineering techniques.

The conceptual foundations for "Monumental-IT" seek to fill the previous literature review gaps by focusing on how a robotic environment on a monumental scale can augment collective memory of historical significance. Monumental-IT holds the promise of harnessing the capacity of the physical and digital in a physical-digital "Robotic-Wiki" hybrid, satisfying our need to engage physical, spatial things in the world and featuring, as well, the capacity of information technologies to network, adapt and reconfigure.

3.3 An iterative design process

According to usability experts, good designs should target end-users and support them, a system "that is developed without a good knowledge of the users and what they want to do with the system may be usable in that it can be used to do *something*, but it

may not do what the users want to do in order to achieve their goals. The system will be *usable* but not necessarily *useful*" (Stone et al., 2005, p.15). Thus, the need for human-centered design approach is critical in developing and designing usable and useful systems where "the user should be involved throughout the design life cycle" or what is called an "iterative design process" (Stone et al., 2005, p.17).

The iterative design process for Monumental-IT follows four steps: (1) defining the targeted users in the form of *personas* so as to help in designing; (2) *generating twelve design concepts* which undergo *a selection process* to arrive at the design(s) that fulfill the goals of the stated philosophical and conceptual foundations, fulfill usability properties, and fulfill usable system's heuristics; (3) *prototyping* the selected design(s) by employing low-fidelity prototyping materials as paper and soft-wood, with a semi-working robotic technology; and finally (4) *testing* and evaluating the selected systems using heuristic evaluations and usability surveys.

3.3.1 Personas

A "persona," is a fictional user-profile that can be used as a design and communication tools – "a user archetype [behavioral model] you can use to guide decisions about product features, interactions, and even visual design. By designing for the archetype, whose goals and behavior patterns can be understood, it is possible to satisfy the broader group of people represented by that archetype" (Goodwin, 2005, p.1).

Each persona "is a narrative that describes the flow of someone's day, as well as their skills, attitudes, environments, and goals…[a] persona must be specific to the design problem;" it may also have a fictional photo but at the end it is a design tool, that's why

60

we need to "focus first on the behavior patterns, goals, environment, and attitudes of the persona" (Goodwin, 2005, p.2-3).

For Monumental-IT, there are two personas representing the targeted users, "Megan B. Ross" and "George A. Smith," (Figure 3.3 and 3.4). Monumental-IT employs interactive technology and cybernetics as means to engage users with its spatial qualities in a conversational dialogues, inspired by conversational theory and interactionism. Monumental-IT should accommodate all users, and attracts underserved populations and those who have a higher interest in visiting monumental sites. Monumental-IT's goal is to convey an interactive conversation with users. Monumental-IT's design will be focused on specific end-users or personas which will help in designing usable and useful system.

3.3.2 Concept generation

After understanding Megan's and George's behaviors and attitudes when interacting with Monumental-IT, these two personas have been used as a guide within the research team's discussions on the appropriate designs, conveying Monumental-IT's goals. According to Karl Ulrich, a concept generation is "an approximate description of the technology, working principles, and form of the product" (Ulrich, 2000, p.108).

Monumental-IT is proposed for historic Charleston, South Carolina, with its history of slave trading, the primary testbed which will be described in-detail in the following chapter.

The philosophical and conceptual foundations motivate and guide the research. The main conceptual problem for designing Monumental-IT is the configurability of its structure, especially given that there are few examples of dynamic structures in the

history of architecture (Zuk and Clark, 1970). Motivated by the concept of having two entities, the skin and the structure, I developed more than 30 design sketches for this monument that has been narrowed down to 12 designs for further consideration.

Megan B. Ross is a 24-year-old graduate student, researcher, and teaching assistant. She has a M.A. in History. She has a busy lifestyle with work and school, taking a course load of ten hours. She is socially active and keeps up with all the latest trends. Megan really cares about stuff looking "cool."

Prof. John Scott is asking Megan to work on a project for her thesis. The project is to represent the history of slavery from lay citizens' opinions. Megan decided to use Monumental-IT (M.IT) as the main source, a distant-reading record for the history of slavery in the south. She planned to stay in Charleston for six months. Every day of this period, she visits M.IT twice a day for 2 hours; seated and watching M.IT. Using ethnographic methods of recording contexts, she starts to draw and write what is going on. Amazingly, she starts to build patterns every week; she is proud of her research findings. Now, she will present her research in TED, Ideas worth Spreading conference at New York!

Name	Megan B. Ross
Age	24-year-old
Educational Background	M.A. in History
Job	Student at Clemson University
Technology	iPhone, and PC user
Goals	She would like to know more about the history of Slavery in the US. Megan knows many friends who would like to say something about that , but they have no voice yet in publications.

Figure 3.3 Megan B. Ross is a fictional persona representing the first targeted user for Monumental-IT's design

George Smith is a 54-year-old sociology professor and researcher of Yale University. He has a B.S. and M.S. in Psychology. He has a busy lifestyle with teaching and research, has a teaching load of 20 hours/week. Freedom is very important to him, which is why he has always taught a graduate course, HIST809, Ethics of Freedom in the History of the United States. He would first like to share ideas and thoughts with others. He is proud of his strong time analytical skills. He is very studious, and because of the amount of work on his plate, often very busy.

Dr. Smith has been scheduling a trip to visit Monumental-IT in Charleston. He planned to do so because he heard about it from his dearest friend, Mr. Adams; who always visit M.IT to see how the time changes peoples' understanding of the history of slavery. Smith is now with his friends in front of M.IT. "Is this a monument? It must be," thought Smith, and these are the pictures of those slaves who had passed in Charleston. The monument slowly reconfigures its physical elements whenever more people come to visit it, as if it were translating, an imprecise language of monuments and architecture. Smith enjoys the "openness" and "freedom" of M.IT.

Name	George A. Smith
Age	54-year-old
Educational Background	PhD. in Sociology
Job	Professor at Yale University
Technology	Palm Pilot, and PC user
Goals	He admires history; read many books about the history of slavery, but he likes to visit a place of that past memory.

Figure 3.4 George A. Smith is a fictional persona representing the second targeted user for Monumental-IT's design

Each design alternative has been named according to its external features for simplifying the concept selection phase: the Rotating Tube, Fan Leaves, the Waving Strips, Solid and Void, Flower Leaves, Rotating Gears, Spider Arms, The Mesh, Hydraulic Plates, Strip Wall, Skin Wall, and the "Skeleton and Skin," (Figure 3.5). In the following table, the twelve design concepts are described according to their underlying kinematics, working principles, and form, (Table 3.1).
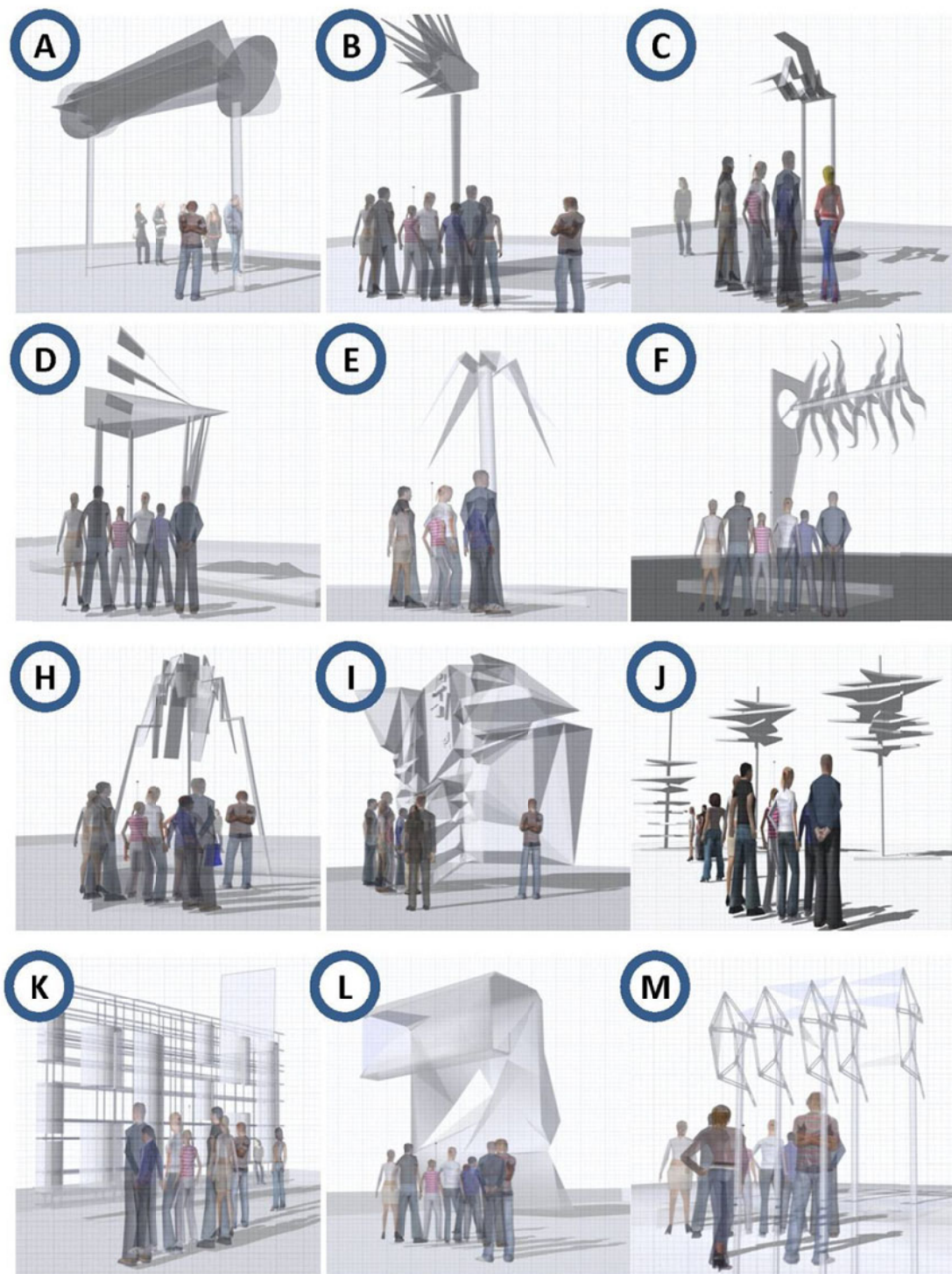
Figure 3.5 Concept generation phase: twelve 3d models for Monumental-IT

Concept	Description		
	Underlying Kinematics	**Working Principles**	**Form**
A: Rotating Tube	Rotational motion of the main tube, while the branches will move on steel tracks separately, with different actuation velocities	Each configuration will have a different rotational angle and different positions of the branches	A cylindrical shape structure with two vertical supports
B: Fan Leaves	Rotational motion of the leaves around a horizontal axe on the top of the post	Each configuration will have a different rotational angle	A fan shape structure with one vertical support and seven leaves which are hinged to a horizontal axe
C: Waving Strips	Horizontal and rotational motion	The four strips will have different folding angles and rotational position for each configuration	Four folded strips with two vertical supports and a horizontal axe
D: Solid and Void	Rotational motion	One top surface that will be rotating on a horizontal axe to close the top of the structure, the four configurations are: closed, semi-opened, 3/4 opened, and fully opened.	A wedge shaped structure with a top rotational surface, and three posts
E: Flower Leaves	Rotational motion	Four leaves will be rotating to form the live and death of a flower, by moving up and down; with many other possible configurations	Four flower pedals on one vertical post
F: Rotating Gears	Rotational and horizontal motion	Twelve gears will be rotating and moving horizontally to form many configurations with a different gears' positions	Twelve gear-like shapes rotating on a horizontal beam which is supported on a vertical frame

Table 3.1 Concepts description: Underlying Kinematics, Working Principles, and Form (continued)

Concept	Description		
	Underlying Kinematics	Working Principles	Form
H: Spider Arms	Rotational and horizontal motion	Eight folded arms will have different folding angles and rotational positions for each configuration	Eight folded arms supported on a ring beam, the ring beam is the top of a cone mesh structure which is supported on three posts
I: The Mesh	Vertical and horizontal motion	Polygonal pieces will open and close the holes in the mesh by moving horizontally and vertically forming many configurations	NURB structure with many polygonal holes in it; small pieces (a puzzle-like pieces) that will move to close the holes in the structure
J: Hydraulic Plates	Vertical and rotational motion	Polygonal pieces that will rotate and move up and down to form many configurations for Monumental-IT	Eight polygonal pieces sliding vertically and rotating on a vertical post
K: Strip Wall	Horizontal motion	Shape memory alloys (solid parts) that will be actuated using pulleys and motors, while expanding and shrinking horizontally, this solid parts will close and open the mesh	A mesh structure (horizontal and vertical members) with an inner dynamic vertical solid metal pieces which expand and shrink; as if it is a heart beating inside the monument's skeleton

Table 3.1 Concepts description: Underlying Kinematics, Working Principles, and Form (continued)

Concept	Description		
	Underlying Kinematics	**Working Principles**	**Form**
L: Skin Wall	Horizontal and vertical motion	The fabric (skin) is actuated using many pulleys and strings which are attached to motors, forming a skin which is trying to match the skeleton underneath it	Z-shape structure covered with a fabric (skin) which expands and contracts forming a living skin covering a static body
M: Skeleton and Skin	Closed loop kinematic chains	The closed-loop chains are actuated by servo motors which form different configuration by changing motor's speed, rotational angle, and the direction of rotation	Five skeleton structures composed of twelve members connected by hinges, and each skeleton is supported on vertical post; the five skeletons will be connected using a stretchy skin that deform whenever the skeleton rotates

Table 3.1 Concepts description: Underlying Kinematics, Working Principles, and Form

3.3.3 Concept selection

Ulrich et al.'s "concept selection methodology" has been used in this phase of the research, which is called *concept screening* (Ulrich and Eppinger, 2000, pp.137-147). According to Ulrich et al., "during concept screening, rough initial concepts are evaluated relative to a common reference concept[1] using the *screening matrix*," (Ulrich and

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[1] The reference concept as described by Ulrich et al. is "generally either an industry standard or straightforward concept with which the team members are very familiar. It can be a commercially available product, a best-in-class benchmark product which the team has studied, an earlier generation of the product,

Eppinger, 2000, p.144). The reference concept that has been selected for comparison is the "Muscle Project" by Kas Oosterhuis, (Figure 2.17) for the following reasons: (1) The Muscle Project is an interactive installation employing the same technology as does Monumental-IT; (2) The Muscle Project is an installation for public use; (3) The Muscle Project is well known by the design team; and (4) The Muscle Project shares with Monumental-IT the same design properties (e.g., openness, configurability, technological applicability, etc).

In *concept screening*, I have prepared the *selection matrix,* employing design and human-centered design criteria that follows the philosophical and conceptual foundations of this research, as well as the lessons learned from my previous research on interactive monuments (Mokhtar et al., 2010). The design criteria are as follows: openness, configurability, structural stability (a major problem in designing kinetic structures), aesthetics, technological applicability, ease of understanding, and ease of memorization. In the concept screening matrix, the previous twelve concepts have been listed at the top of the table, and the criteria are listed on the left-hand side. The concepts are rated against the reference concept (The Muscle Project) using the following code: (+) for "better than," (0) for "same as," and (-) for "worse than" in order to identify some concepts for further consideration, (Table 3.2).

After calculating the sum of the "better than," "same as," and "worse than," attributes, a net score is calculated by subtracting the "worse than" from the "better than" ratings, to rank the concepts, "those concepts with more pluses and fewer minuses are

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any one of the concepts under consideration, or a combination of subsystems assembled to represent the best features of different products," (Ulrich et al., 2000, p.146).

ranked higher," (Ulrich and Eppinger, 2000, p.147). The selected concepts are "M": "Skeleton and Skin" and "L": "Skin Wall," both of which are considered for further analyses, via develop scaled low-fidelity prototypes for testing user interaction, and to understand the technological applicability and usability.

Concepts

	Selection Criteria	A Rotating Tube	B Fan Leaves	C Waving Strips	D Solid & Void	E Flower Leaves	F Rotating Gears	G (Reference) Muscle Projects	H Spider Arms	I The Mesh	J Hydraulic Plates	K Strip Wall	L Skin Wall	M Skeleton & Skin
Design	Openness	-	-	0	-	0	0	0	+	+	+	0	0	+
	Configurability	-	+	+	-	+	0	0	+	0	-	0	0	0
	Structural Stability	+	-	-	+	-	+	0	-	+	+	+	+	+
	Aesthetics	-	0	0	0	-	0	0	0	0	-	0	0	0
	Technological Applicability	0	0	0	0	-	0	0	-	0	+	-	+	0
Human-Centered Design	Ease of Understanding	-	-	+	+	0	0	0	+	-	0	+	0	+
	Ease of Memorization	+	+	0	0	+	+	0	+	-	-	+	+	+
Sum	Sum +'s	2	2	2	2	2	2	0	4	2	3	3	3	4
	Sum 0'S	1	2	4	3	2	5	7	2	3	1	3	5	3
	Sum -'s	4	3	1	2	3	0	0	2	2	3	1	0	0
Score and Ranking	Net Score	-2	-1	1	0	-1	2	0	2	0	0	2	3	4
	Rank	7	6	4	5	6	3	5	3	5	5	3	2	1
	Continue?	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes

Table 3.2 Concept screening matrix for Monumental-IT

3.3.4 Concept resolution

At this phase, many questions have emerged:

- How do people represent themselves collectively in public spaces?

- What are the multi-sensorial dimensions for Monumental-IT?

- What materials should be used for next step, prototyping?

- How to test the proposed concept?

- What sensors and actuators are the most appropriate for use?

In the last decade, "Hot Cognition" has been a growing research in Psychology, delving into the importance of emotions in human communications. According to Thagard, "cold cognition" or "cognitive psychology" is the branch of psychology which deals with the understanding of human learning, memorizing, and responding to the world; by not including emotions in its equation, this mainstay of psychology, is questionable (Thagard, 2006). Thagard argues for the significant influence of emotions upon group decision-making: "psychologists and neuroscientists have increasingly recognized the inherently emotional nature of decision making…[leading to our understanding of] emotional communication which communicates and shape peoples decisions by transmitting emotional information" (Thagard, 2006, p.69). Hot Cognition emphasizes the importance of emotions in understanding people's cognitive and social abilities, which affect our understanding of human communication and representation abilities.

In their seminal work "Wired for Speech," Nass and Brave discuss the effect of speech on people's understanding of emotions and the use of the humans' voice as a

reliable instrument for the advances of human-computer interaction (Nass and Brave, 2005). Research on emotions in synthetic speech, Murray and Arnott suggest the importance of speech technology in simulating vocal emotions (Murray and Arnott, 1993). Lang in his research on human affective reactions to emotionally evocative pictures, argues that "researchers need to know more about responses to moving pictures, *emotional sounds*, and reactions when reading narrative text" (Lang, 1995). Kessens et al. also emphasize the importance of speech in expressing emotions for humanoids dealing with kids using recordings from the Belfast Naturalistic Database to represent the different "basic" emotions: anger, fear, sad, and happy (Kessens et al., 2009).

Ultimately, the use of speech technology in human-machine interaction helps in differentiating humans' emotions (Murray and Arnott, 1993, Nass and Brave, 2005) which can be used in Monumental-IT's environment to differentiate peoples' inputs (i.e., their emotions on memories). Moreover, the "emotional communication" promises to be an effective tool for having the collective public shape their monuments "together."

From its philosophical and conceptual foundations, Monumental-IT is comprised of multi-sensorial dimensions: smell, sound, color, texture, shade and shadow, and motion. For colors, Monumental-IT will focus on basic colors, blue, red, yellow, and green, to represent people's different emotions. According to Rudolf Arnheim, D'Andrade et al. and Finlay, "colors and emotions" are interconnected but their discriminating associations can hardly be theorized (Arnheim, 1974; D'Andrade, 1974; Finlay, 2007). Ludwig Wittgenstein in his book "Remarks on Colour" "despaired that the logic of color perceptions could be clarified: 'there is merely an inability to bring the

concepts into some kind of order. We stand there like the ox in front of the newly-painted stall door'" (Finlay, 2007, p.383). Arnheim argues that there are "hardly any attempts has been made to group the various colors in terms of their general expressive qualities" (Arnheim, 1975, p.369). While there is common agreement on the effect of warm and cold colors, e.g. red and blue, for having a temperature effect, saturation, purity, luminosity, darkness and lightness, among many other color qualities affect our perceptional understanding of colors, but this effect is difficult to measure in dynamic settings, as is for architecture. Additionally, Arnheim argues that there is "nothing of general validity emerged" on people preferences on colors (Arnheim, 1975, p.371). Hence, the design team selected, based upon the complexity of measurements and the lack of theoretical foundations for connecting colors and emotions, warm and cold colors that can be tested in a pilot study and thus changed as needed. "Red" represents warm and anger, "blue" represents cold and fear, "multi-color" (Red, Yellow, Green, and Blue) represents happy, and "white" represents cold and sad.

In order for sound to evoke emotions, I have selected four different pieces of melodies that have been tested through an email survey of 45 participants. The email survey included four audio files, numbered 1 to 4, and participants were asked to select the emotion/(s) that each melody conveys. The responses were as follows: 100% agreement on Kevin Macleod's soundtrack of "The House of Leaves" to convey "fear;" 100% agreement on Ji PyeongKeyon's soundtrack of "Over The Green Fields" to convey "sadness;" 93.3% agreement on the French electronic music pioneer Pierre Henry's music "Psyché Rock" on 1967 to convey "anger;" and 97.8% agreement on Johann

Strauss II's music "Perpetuum Mobile - A Musical Joke" to convey "happiness." To evoke emotions, the design team proposed to project pictures and textures on the monument's structure associated with the remembered event which the monument is designed to convey.

Concerning which physical materials should be employed in the next step, prototyping, I have chosen to use rapid prototyping materials (i.e., paper/soft-wood) prototyped using the Laser Cutters and CNC machines. These prototypes were realized for the purpose of empirically testing users' responses to the suggested concepts and also to examine their validity of employing the technological means of Monumental-IT. The suggested concepts will undergo human-centered design methods for evaluating usability and understanding of the monument's different components. The two evaluation methods are heuristic evaluations, using experts in the domain fields of usability engineering, arch-robotics, and architecture; and usability surveys, see Chapters Five and Six.

Regarding the question of the type of sensors and actuators to be used, Monumental-IT will utilize one type of actuator, a continuous rotation servo motors, which provides 360-degree-rotation geared motors; and speech recognition system for sensing people's different vocal emotions. In research on speech recognition, "speech" is defined as "a natural, hands-free mode of communication between humans, and potentially between robots and humans" (Gibilisco, 2003, p1328). The use of microphones as sensors for speech recognition and vocal emotion recognition have some technical limitations, due to "sources of noise, such as the robot's motors and air flow in the environment, [which can be compensated] by using multiple microphones and

multimodal cues" (Gibilisco, 2003, p.1328). Gibilisco describes speech recognition system in his diagram of Figure 3.7, (Gibilisco, 2003).

To make use of the speech recognition system, the microphones need to be able to differentiate between individual's distinct vocal emotions and speeches. Gibilisco in the "Encyclopedia of Robotics" describes speech according to frequencies, which he categorizes into three frequency ranges, calling them "formants": f1 for frequencies less than 1000Hz, f2 for ranges from 1600Hz to 2000Hz, and f3 which ranges from 2600Hz to 3000Hz.
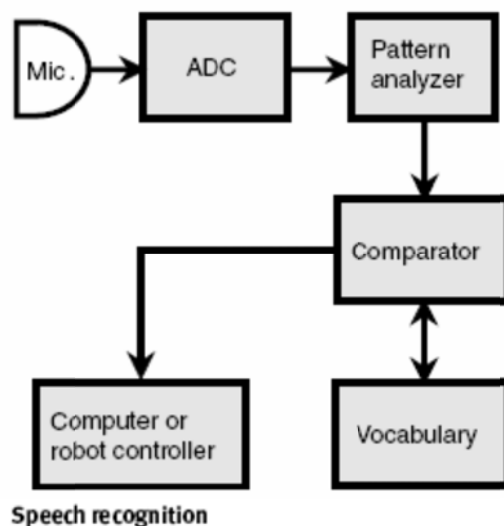
Figure 3.6 Speech recognition system for humanoids (Source: Gibilisco, 2003, p.293)

In theory as Gibilisco described, we can differentiate voices using formants, but in practical terms the use of "formants" to differentiate vocal emotions is not a simple matter. From a '"Social Robotics" perspective, Cynthia Breazeal describes a branch of research called "Expressive Emotion-Based Interaction," where sound pitch (frequency) and energy is used to differentiate vocal emotions in Kismet, "the first autonomous robot

explicitly designed to explore socio-emotive face-to-face interactions with people" (Breazeal, Takanishi, and Kobayashi, 2008, p.1356). Murray represents different attributes of sound and their vocal effects associated with several basic emotions, as in Table 3.3, which can help in the process of recognizing the differences between voices when people interact with Monumental-IT's microphones. These technologies, both in hardware and software, need further study outside the scope of the research.

Vocal effects associated with several basic emotions

	Fear	Anger	Sadness	Happiness	Disgust
Speech rate	Much faster	Slightly faster	Slightly slower	Faster or slower	Very much slower
Pitch average	Very much higher	Very much higher	Slightly lower	Much higher	Very much lower
Pitch range	Much wider	Much wider	Slightly narrower	Much wider	Slightly wider
Intensity	Normal	Higher	Lower	Higher	Lower
Voice quality	Irregular voicing	Breathy chest tone	Resonant	Breathy blaring	Grumbled chest tone
Pitch changes	Normal	Abrupt on stressed syllables	Downward inflections	Smooth upward inflections	Wide downward terminal inflections
Articulation	Precise	Tense	Slurring	Normal	Normal

Table 3.3 Speech recognition system, vocal effects with the different basic emotions (source: Murray et al., 1993, pp.1097-1108)

3.3.5 Prototyping

As described in the next chapter focused on the Research Prototype, Monumental-IT is proposed for Charleston, SC as a testbed, representing the history of slavery in the 19th century in the US. The pilot site is Chalmers Street, fronting the Old Slave Mart, where the jail and slave trades occurred, (nps.gov Website, 2010). In the prototyping

phase, the goal will be focused in guiding and recommending design solutions that will

be implemented in Monumental-IT.
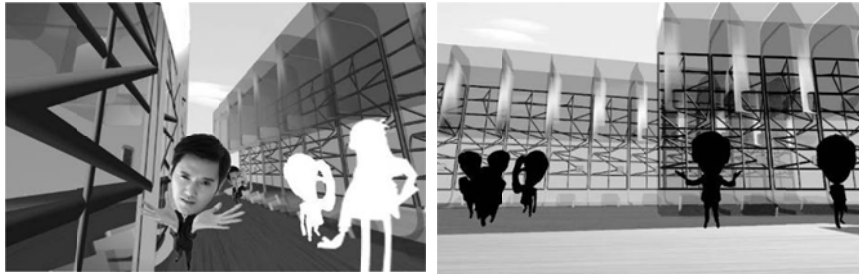
Figure 3.7 Sketches of Monumental-IT's Concept L, the "Skin Wall"
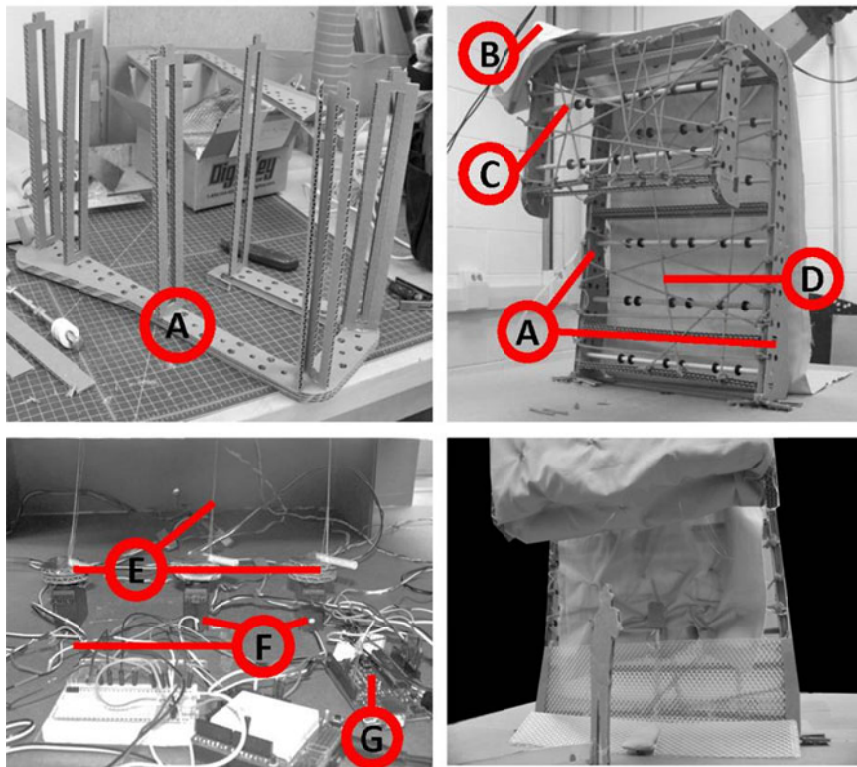
Figure 3.8 Concept Design L: the "Skin Wall" (bottom left). The Skin Wall is comprised of: (A)supporting frames; (B)Skin; (C)wooden spacers at 20cm intervals attached to them the string's guiding gears; (D)frame's mesh (strings); (E)anchoring Nylon strings; (F)three servo motors; and the (G)microcontroller

The first prototype implemented is design concept "L", "Skin Wall," (Figure 3.7),

employing paper prototyping via Laser Cutter. The structure, 60 cm width and 80cm

height, is made of corrugated sheets; the skin is made of soft fabrics (Lycra). The skin is

actuated using Nylon strings anchored at different points on the fabrics at 15cm intervals. The strings are attached to three servo motors controlled by a microcontroller, programmed using C language, (Figure 3.8).
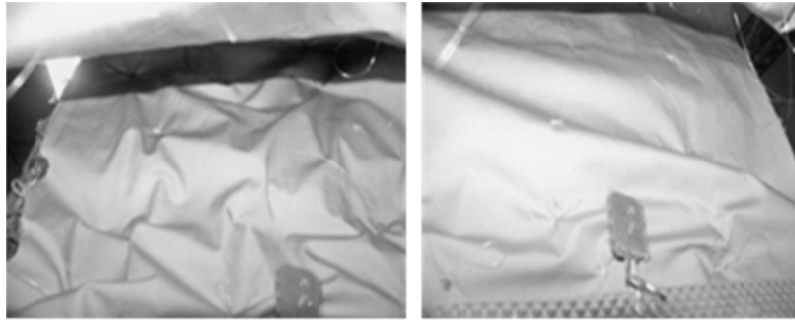
Figure 3.9 Two different deformations for Monumental-IT's skin

After initially testing the "Skin Wall," the following conclusions were formed: (1) the skin can be deformed using strings at unlimited anchoring distances showing different deformations, (Figure 3.9); (2) while the skin patterns produce different densities of wrinkles, the architectural forms will not be as distinguishable as needed to differentiate between the various representative emotion configurations; (3) the intended configurations are affected by variable weather conditions (i.e., wind directions and speed); and (4) the skeleton is hidden, which contradicts the "philosophical foundations" for having the skeleton as a "ghost" of true memory. Thus, concept "L" has been excluded.

The second prototype that has been tested is concept "M:" the "Skeleton and Skin" structure. This prototype is comprised of the following components: (A) microphones to recognize people's speech on site; (B) closed-loop kinematic chain structures actuated by servo motors; (C) skin (e.g. elastic textile fabrics attached to the physical structure); (D) servo motors; (E) LEDs; and (F) microcontroller (Figure 3.10).
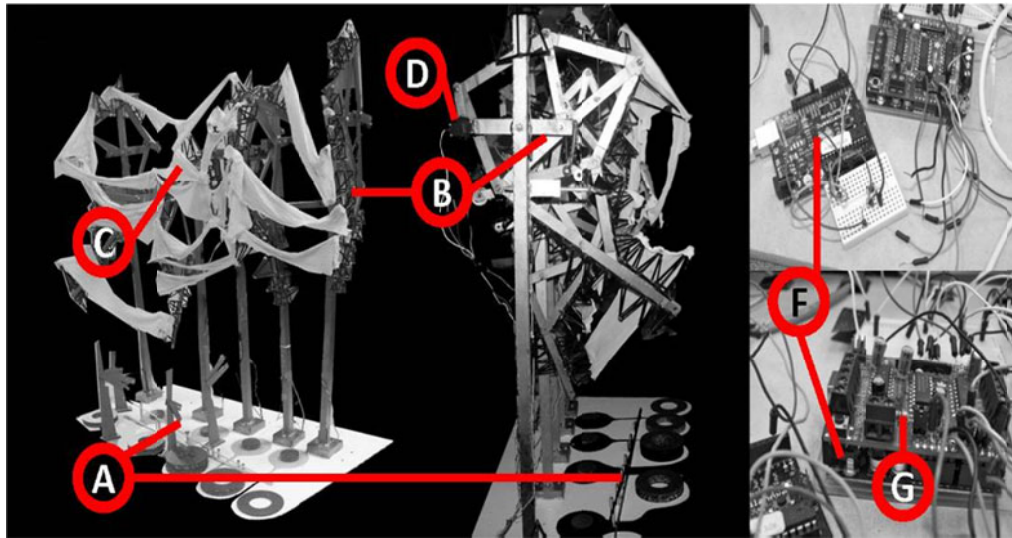
Figure 3.10 Monumental-IT's components as described in the text

In the process of prototyping the "Skeleton and Skin" concept, the design of the dynamic skeleton has gone through an iterative design process so as to solve some technical limitations, (i.e., designing the closed-loop kinematic chain structures; see Chapter Four for more details). The iterative design process was initiated by designing the linkages and their kinematics. I constructed the linkages using plastic tubes (Figure 3.11-left), which failed to work well due to lack of prefabricated connections that can make the linkages rotate without hitting the nearest linkage in the chain. The chains must be designed to have a clear path for full rotation around all axes of rotation.

A second structure was constructed using corrugated paper (Figure 3.11-middle), which has been easy to fully rotate, and readily comprehensible for visualizing the different configurations, (Figure 3.12). Yet, this prototype also has its weaknesses, as the joints between the linkages hindered the structure from rotating due to the structure's weight, and the weak linkages tended to collapse after many rotation cycles.

The structure was finally made using stiff linkages, soft-wood, with joints made of bolts and nuts, (Figure 3.11-right). This third iteration works well, but with two minor challenges. First, the structure rotation is slow, due to the bolt's frictional forces with the linkages and the heaviness of the bolts and the structure. The rotation speed was improved in subsequent iterations through the implementation of smaller bolts and lighter material for the linkages and the joints. Second, the structure was not stable due to the motors' rotations. The motors add momentum to the structure, which affect the posts' connections with the base. Further studies are needed to study the connection of the base of the model that may provide additional improvement to the speed and smooth function of the model.
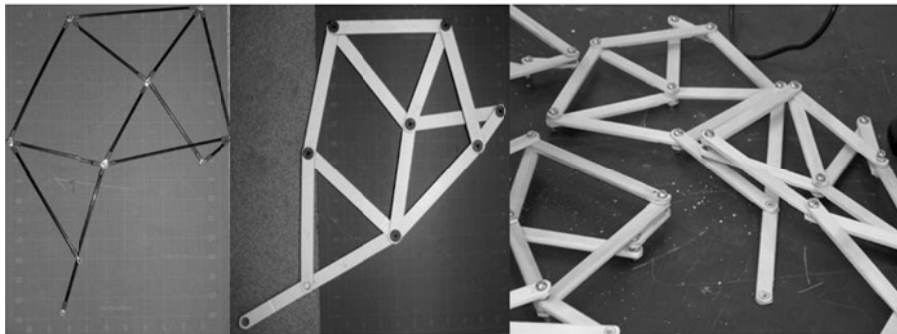
Figure 3.11 An iterative design process for Monumental-IT's skeleton – closed-loop kinematic chain structures
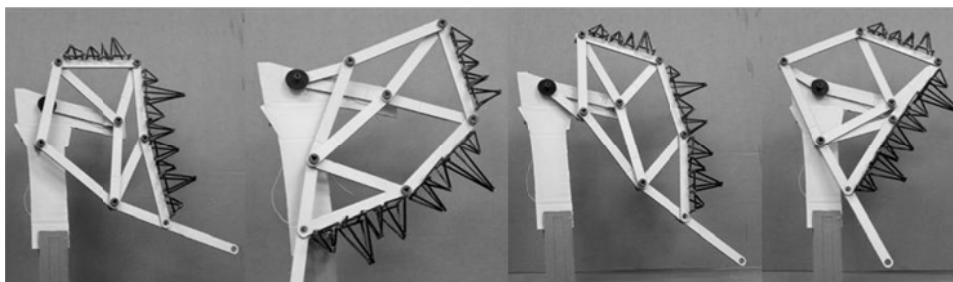
Figure 3.12 Monumental-IT's corrugated paper prototype in different configurations

In this phase, I developed a working skeleton that performs as desired, with the

skin attached, and the installation of the robotic technology. The robotic technology included the microcontroller and servos. Also, I used external red, blue, green, and yellow LEDs configured manually. Finally, the microcontroller was programmed to represent four different modes:

(1) Fear Mode: the blue LEDs turn on, and the first, third and the fifth structural elements actuate, one after the other, at a very slow speed – just a quarter rotation of the kinematic loop;

(2) Angry Mode: the red LEDs turn on, and all the structural elements actuate together at full speed;

(3) Happy Mode: the different LED colors randomly turn on and off, and the structural elements actuate one after the other at normal speed; and

(4) Sad Mode: all LEDs turn off, and the structural elements actuate one after the other in full rotations of the kinematic loops, but at slow speed, (Figure 3.13).

Figure 3.13 Monumental-IT pilot study representing the four different configurations

3.4 Concept evaluations and analysis

Two types of evaluations were used for evaluating Monumental-IT's concept: "heuristic evaluations," (see appendix A and Chapter Five for more details); and "usability evaluation techniques" (i.e. using surveys with lab observations; see Appendix B and Chapter Six for more details).

Five usability and architectural-robotics experts evaluated the system using "heuristic evaluations." Then, I collated, summarized and prepared a complete set of usability problems that the experts identified, (see Table 3.4). Finally, I asked the experts to rate the severity of each problem using Nielsen's five Severity Rating Scale: (0) no usability problem, (1) cosmetic, (2) minor, (3) major, or (4) catastrophic problem (Nielsen, 1993). The average severity ratings for discovered usability problems were used to identify priorities in the process of enhancing Monumental-IT's design, as summarized in table 3.4.

Heuristic(s) Violated	Descriptions	Severity Ratings
Visibility Of System Status	How do users know that the monument is waiting for their inputs?	2.6
	The users need priming to start getting involved.	2.2
	The skin is only a cursory sketch.	1.6
Aesthetic And Minimalist Design	Users don't know what to do next after speaking to the microphones or stepping on the footsteps	2.2
	The speaker and the footsteps are not integrated in the design of the monument.	3
	There is no need for an acoustic beep to indicate formal physical cue.	2.2
	Some people are allergic to odors/smell.	3.6
User Control And Freedom	The users do not know if the system accepts their voices or not.	2.2
	Do people need to reset a button after speaking to the microphones?	1
	The skin is only a cursory sketch.	2
Differentiate Monumental-IT's Configurations	The skin is only a cursory sketch.	1.6

Table 3.4 Severity ratings of usability problems

The following heuristic violations have been identified by the experts:

"recognition rather than recall," "visibility of system status," "user control and freedom,"

"aesthetic and minimalist design," and category-specific heuristics: "differentiate

Monumental-IT's configurations," and "response rate to human monument interaction."
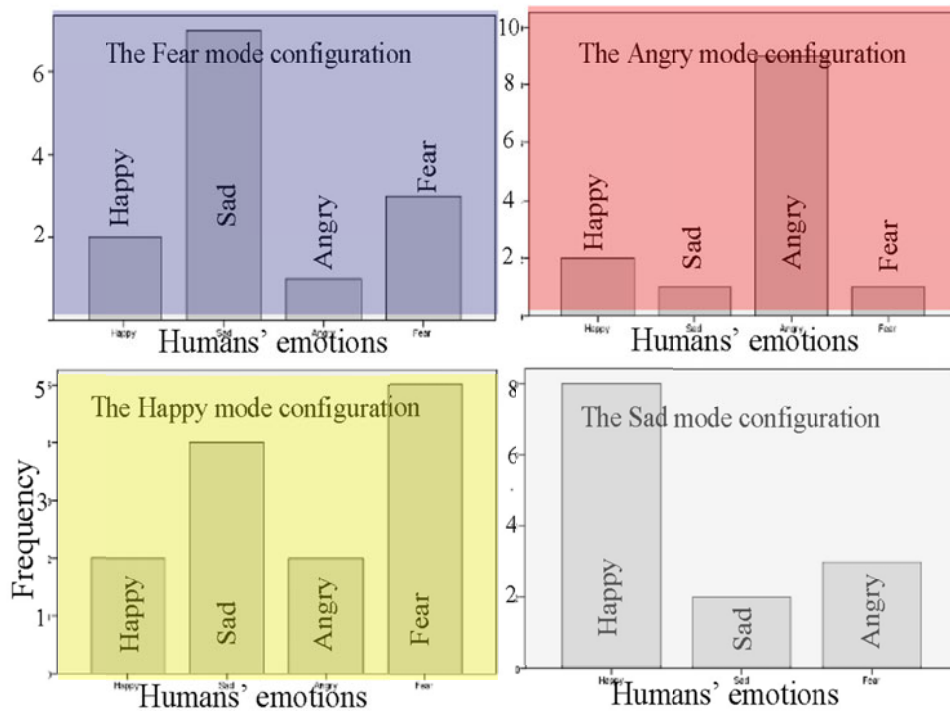
Figure 3.14 Users' answers to Monumental-IT's configurations

Additionally, sixteen users, representing the two personas described previously

(Ross and Smith), have conducted a survey in a lab setting. After I analyzed the collected

data on motion, form, and the different configurations of Monumental-IT, the suggested

design showed significant effects on peoples' emotions, as described in Figure 3.14.

However, the configurations did not all match the intended emotion modes, the responses

rate and percentages showed that the effect of these phenomenological dimensions, using

robotic technology to form Monumental-IT's architectural space, are having significant effects on people and their understanding of monumental spaces.

The survey questions regarding "colors and emotions" showed that colors have also an interesting effects on peoples' emotions, (Figure 3.15). The findings suggest that the robotic monument has the capacity to convey peoples' emotions concerning a human event of historical significance – a novel human-space-interaction.
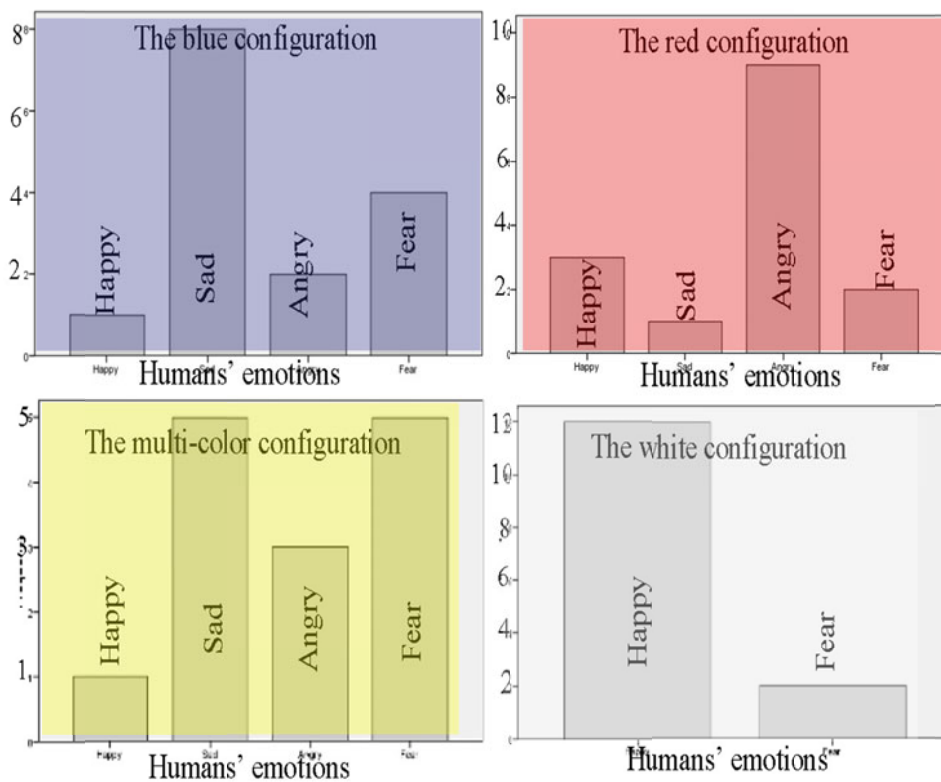
Figure 3.15 Users' answers to Monumental-IT's colors and emotions

The analysis of the qualitative component of the survey related to the question, "how would you describe Monumental-IT in one sentence?", is as follow. The positive responses received were: "Making history interactive," "Interesting, struggle under the bone, story of slavery," "Evolving and changing humans' identities in a way of

representation," "Interesting and very interactive," "An interactive monument," "Futuristic," "It mechanically represents emotions through color/sound/smell," "Making history interactive," "Interesting and very interactive," "Interactive monument." The negative responses received were: "This was very hard for me to comprehend," "A gigantic confusing whirling monster;" and one response that can be interpreted as both positive and negative was: "shredded, shroud, torn."

The responses indicate that users overall have a positive attitude and appreciation of the concept of a citizen-reconfigurable monument. Responses suggest the interest in, and importance of continuing the research on Monumental-IT. The learned lessons from this pilot are the need to:

- Change Monumental-IT's configurations and colors according to users opinions by redesigning and implementing the concept at 1:6 scale physical prototype.

- Change Monumental-IT's design to eliminate discovered violated heuristics (minor and major violations).

- Include sound in subsequent prototypes, and evaluate its effect on user-robotic interaction and the usability of Monumental-IT.

- Exclude the smell component from Monumental-IT's design.

- Conduct testing on the physical prototype of Monumental-IT, and evaluate the human-robotic interaction with its multi-sensorial features.

- Refine Monumental-IT's overall design (aesthetically, technically, and technologically) using physical prototyping.

CHAPTER FOUR

RESEARCH PROTOTYPE: A CITIZEN-CONFIGURABLE
ROBOTIC MONUMENT

Monuments, as cultural products of history and culture, should encourage people to look to the future, stimulating people to engage and share, and to motivating people to ponder and interpret. As Goethe presciently noted, "moreover, I hate everything that only instructs me without increasing or immediately stimulating my own activity," (Nietzsche, 1980, p.7). Monumental-IT is an evolutionary typology which is formed by users, as interactive and intelligent, to aid people in interacting openly with the architecture machine; to stimulate people's thoughts and memories; to stimulate people to share and engage in a collective experience. Monumental-IT is an open platform for future generations to change their interpretations whenever a new truth is unveiled.

4.1 Definition and description with scenario

Open and interactive Monumental-IT, expands the typology of current monumental practices (i.e. the platonic, the figurative, the abstract, and the electronic monuments). Monumental-IT is comprised of two platforms: (1) the robotic physical platform; and (2) the internet virtual platform. Both platforms are connected to provide different means for sharing thoughts about memory. The robotic platform is a real-time interactive installation, comprised of sensors and actuators, controlled using a programmed microcontroller that intelligently senses and responds to visitor inputs and interactions with the monument. The internet platform is a wiki type website, i.e. that anyone can edit and change, with the aim to open the space of interaction to a wider

population who cannot otherwise travel to the physical robotic platform (i.e., a WikiMonument). The "robotic-wiki" platform exchanges data via the internet, allowing any internet user the ability to change the physical robotic platform through the internet.

The selected concept, concept "M," as described in Chapter Three, was investigated in a pilot study, using "heuristic evaluations" by an expert panel and by "usability evaluation techniques" via user surveys with lab observations. The two evaluations lead to a number of recommendations that informed iterations in the Monumental-IT design. The proposed concept has been developed to respond to user recommendations, and the need to better understand and interact with the monument. Additional developments included software changes (described in the "Software" section); and the refinement of the physical body (Figure 4.2). Refinements in the physical body include: making the skin as an inclusionary space, not a cursory sketch; integrating the microphones into the design of the monument; adding signage on the microphones to aid visitors in understanding how to interact with the monument; and integrating the monument into the site of Charleston's Old Slave Mart (detailed in the following section).

Two scenarios follow of how Monumental-IT and WikiMonument might operate, focusing on the testbed of historic Charleston, South Carolina and the slave trade that occurred there. Monumental-IT utilizes peoples' voices and a series of slave narratives as the vehicle for its reconfiguration, the physical-digital interaction, or "robotic-wiki" monument, (Monumental-IT, http://www.youtube.com/watch?v=KXA9I_0cPJc).

Megan Fox and Lauren will present a scenario of how visitors of the physical platform "Monumental-IT" might interact with it. George Smith will also present a scenario but of how the virtual platform "WikiMonument" might operate, and how his input will affect (i.e., retune) the physical "Monumental-IT." These scenarios will present the idea of the "robotic-wiki" monument and how the physical-digital platform will embody interaction (i.e., "embodied interaction") in the information world.

Megan Fox from Clemson, and her best-friend Lauren, who traveled from New York, decide to spend a weekend together in historic Charleston, South Carolina. On their highly ranked "to-do-lists," is a visit to the Old Slave Mart, the only known existing building used as slave auction gallery in South Carolina. When Megan and Lauren are having their first quick tour of the site at 7pm on Friday, they gain a sense of history in the city's buildings and urban structure; but, surprisingly they stop at Chalmers Street to watch a strange metallic structure, impressive, oddly new. They discover a sign: "Monumental-IT".

"Monumental-IT is a 'must-see' tomorrow," says Lauren. "Yes, I am curious to find out what this is," Megan responds. On Saturday, Megan and her friend are in front of Monumental-IT, watching the changes in its form and color. What was not obvious to them at the beginning, becomes apparent after a time, highlighted by what Lauren tells Megan: "see, people are getting close to this thing and talking to it!" "What? Are you kidding Lauren?," Megan says. They both walk close to it and realize that the monument is like a microphone, waiting for people to talk into its mouthpiece. There is a metallic plate placed at each microphone on the monument which states: "Monumental-IT is your

space for recalling the history of slavery. Please talk to it; it understands you and will respond to you. You have the freedom to share your voice about the human history. Monumental-IT is for you to shape!"
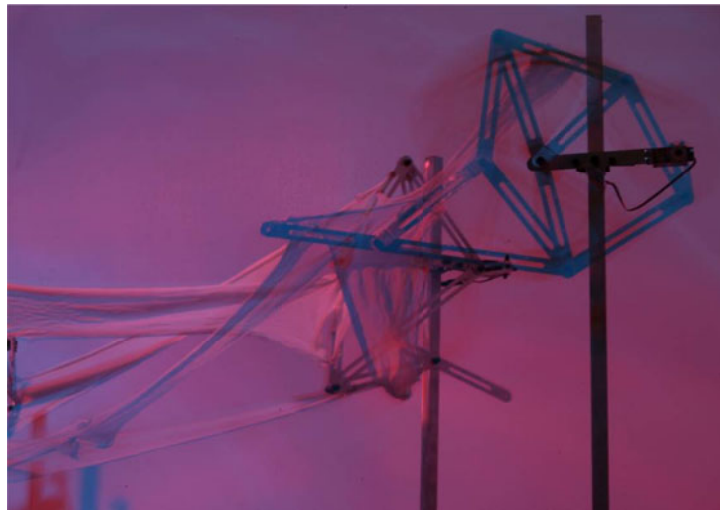
Figure 4.1 Monumental-IT in the transitional state from red to blue

Megan moves closer to one of the microphones. Lauren follows her friend. Megan begins to talk and she gets excited, especially when she feels her voice has affected the form of the monument. The monument becomes red from blue. The monument starts to move frenetically (Figure 4.1). It rotates very fast, producing a harsh sound. The sound initially frightens Lauren, but Megan keeps her close and says, "My friend, is it true? Our lives are different now, right?" Both Lauren and Megan left the place of Monumental.IT with many feelings about that past. This experience should last long in their minds.

When no visitors are present on Monumental-IT's site, another scenario follows of how the virtual website, the "WikiMonument," might operate. The WikiMonument as described later, is an online platform where visitors can share their voices about the

history of slavery and a database for historical text via a link to an online database. The WikiMonument utilizes peoples' voices via sharing, speaking, and writing (elaborated later as "Internet Interaction Mode") and a series of slave narratives as the vehicle for its reconfiguration via an online database (elaborated later as "Data-mining Mode"), which will directly retune the physical structure in Charleston, (Monumental-IT, http://www.youtube.com/watch?v=KXA9I_0cPJc).

George Smith from New Haven, Connecticut, does not have the time to visit Monumental-IT in Charleston. George decides to visit the WikiMonument website to share his voice about the history of slavery. George is now searching the internet (i.e., on Google) for "WikiMonument," "it is the first link. How easy is the internet!," he says. After logging into the website, he finds an icon: "About WikiMonument". By hovering over the icon, a window opens: "…WikiMonument is the virtual/internet platform of Monumental-IT," so "WikiMonument is connected to Monumental-IT in Charleston. Yes, that's what I am looking for," says George. On the same popup window: "How it Works?," a paragraph which provides George with all steps needed to share his voice. After he read the instructions of how the website works, "I should have my own account to track records in the future… Here we go!," says George. George is able to create an account via "Log in / create account" icon.

George is now connected to the WikiMonument platform by having a secure account with his own password. George starts to share his voice by using the text window, he writes: "…it is hurting me as anyone who read all the books that I had on slavery. The slaves were the victims of…" By accepting his text (i.e., click on "Accept",)

90

George is one step away from watching a live webcam of how his text is affecting Monumental-IT's form.

After he clicked on "Watch it Live," "I can't believe this! Harsh Sound, red color, moving thing!" George is surprised. It takes him a while to understand the meaning of Monumental-IT's multi-sensorial components, in this Live Window. Then, he starts to gain a sense of what he wrote, which represented emotions of anger about that history. "It is what I said but in color, sound, and motion! I should go there, the harsh sound and the red color are unique to this thing. I should go there and see it in my next summer. Sure, I should!," says George.

The main idea of how the WikiMonument works is based on data-mining visitors' inputs and historical text accumulating on the database. To elaborate on how the data-mining might operate, we begin below with a fragment from a sample slave narrative drawn from the on-line database, "Documents of the American South: North American Slave Narratives". The data-mining activity seeks concurrences of words identified in the given written text and the "sensory database" of Table 4.1, marked here in bold:

> "You see, I have such a **hurtin'** in my back en such a drawin' in my knees en seems like de sun does just help me along to bear de **pain**" (Source: Documenting the American South).

The impressions marked above (in bold) are the attributes that represent Anger, which will accordingly change the configuration of Monumental-IT as seen in Figure 4.13. Monumental-IT not only challenges notions of monumentality, public history, and robotics in civic space, it also reinvents ways in which history itself can be imagined. For while the data-mining of the WikiMonument will draw upon empirical and objective

data, it will also draw upon the ineffable and tumultuous human voices that shape our world. To properly reflect the significance of such "messy data," Monumental-IT will respond in semiotic and aesthetic terms, as well as terms that are figurative rather than literal. Instead of flashing texts in order to educate, much as one might see in a traditional museum display, Monumental-IT will have the capacity to enact, embody, and represent such knowledge in sensorial dimensions as much as by factorial artifacts. By seeking to inspire and reflect as much as to educate or elucidate, Monumental-IT reinvents the very notion of how a monument might best serve the public sphere. Monumental-IT is designed as in the following figures.
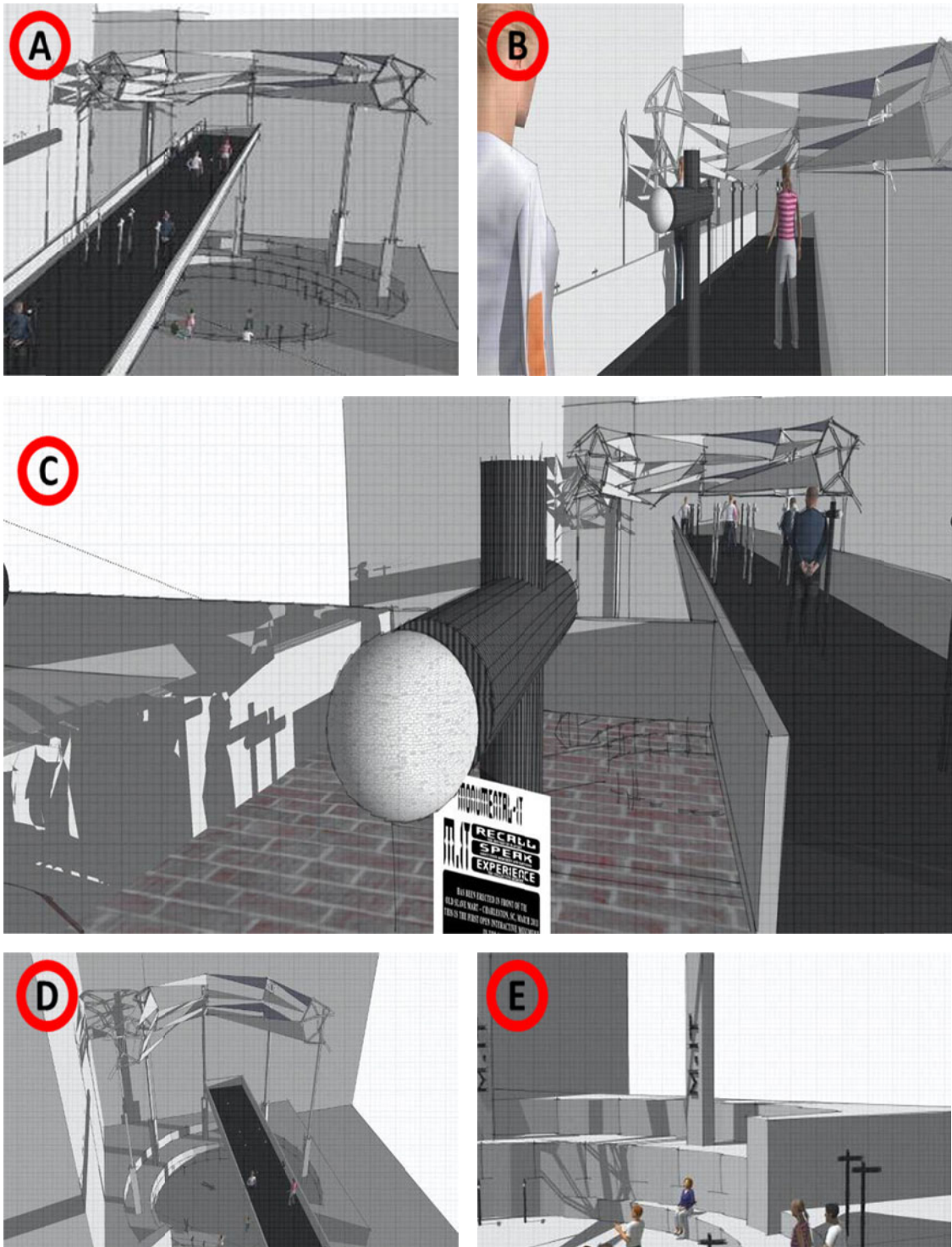
Figure 4.2 A- A perceptional image of Monumental-IT; B- an affective image showing visitors on the bridge; C- Monumental-IT's mouthpiece and signage; D- Monumental-IT's inclusionary space; and E- Monumental-IT's street level view, (continue)
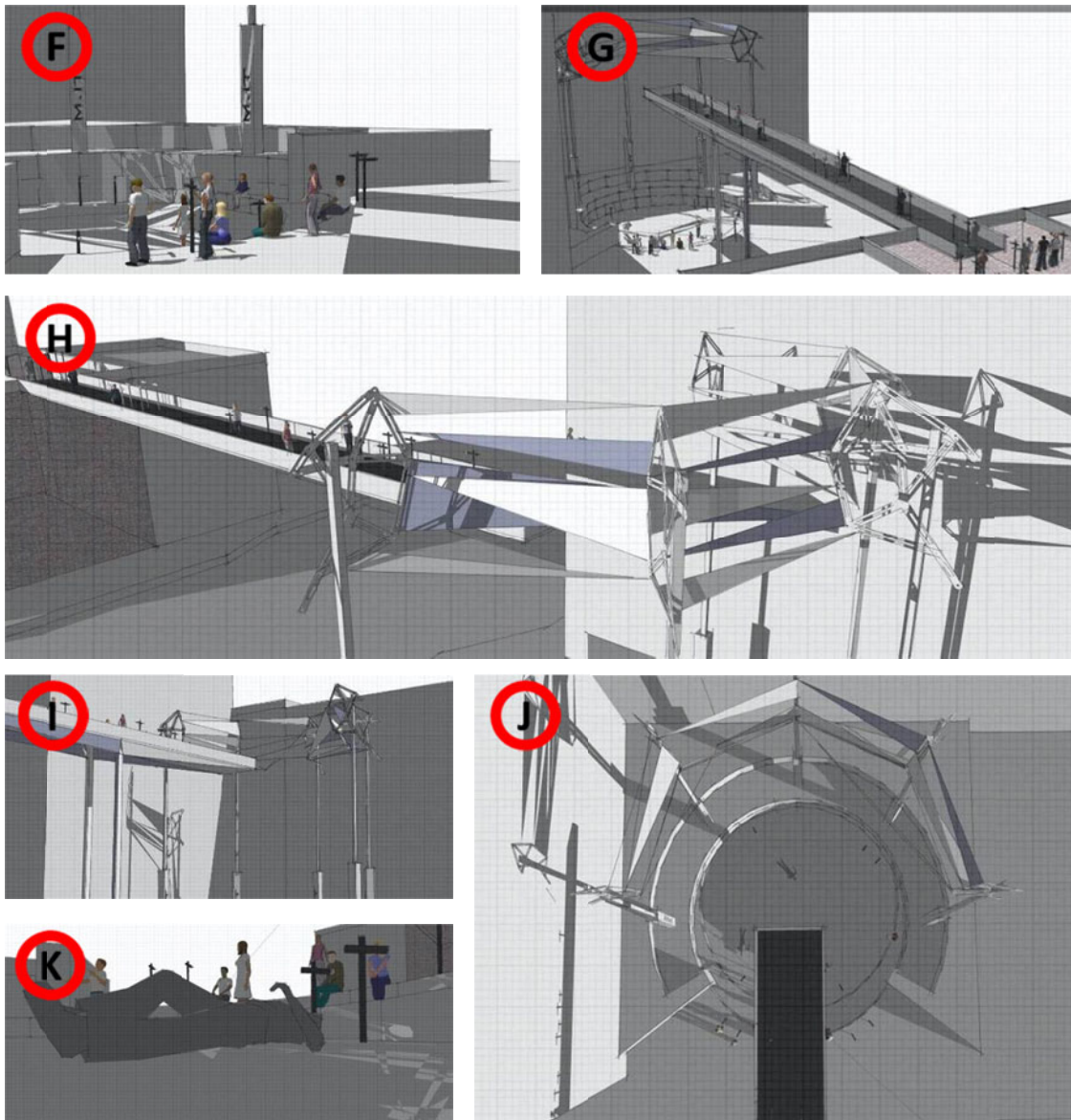
Figure 4.2 F- Visitors are sitting and standing to watch Monumental-IT; G- Monumental-IT's perspective from the North-East (State Street); H- Monumental-IT in front of the Old Slave Mart Museum, Charleston, SC; I- Monumental-IT's bridge; J- Monumental-IT's layout; and K- a visitor is lying down to watch Monumental-IT.

4.2 Context

Monumental-IT is proposed as a monument for recalling the history of slavery in

the US in the 19th century. The history of slavery is one of the most sensitive memories in

the American history because of its connection with many political and social dimensions

(i.e., human rights and systems of discrimination); as

> "[in the 19 century, the] white racism became the driving force of southern race relations. The culture of racism sanctioned and supported the whole range of discrimination that has characterized white supremacy in its successive stages." (Documenting the American South Website: http://docsouth.unc.edu/neh/intro.html).

The historical context on slavery is rich with debates about race, identity, and representation (Crowe, 1998; Kachun, 2003; Lima, 1998; Wertsch, 2002). This context is ideal for Monumental-IT that should be able to represent people's diverse voices on history. Monumental-IT is proposed for historic Charleston, South Carolina, with its history of slave trading – the primary testbed. The specific site will be in front of the Old Slave Mart Museum in Chalmers Street. The Chalmers Street location was the site of the historical slave market, Ryan's Mart, later the Old Slave Mart and present day museum. Historian Nancy Curtis, describes that "the Old Slave Mart in Charleston's historic district is a commercial building that was used for slave trading and auctions before the Civil War"(Curtis, 1996, p.196).

The National Park Service (NPS) and the Planning Department of the City of Charleston described the historic slave market as "possibly the only known building used as a slave auction gallery in South Carolina still in existence. The Old Slave Mart was once part of a complex of buildings known as Ryan's Mart that occupied the land between Chalmers and Queen Streets. The complex consisted of a yard enclosed by a brick wall and contained three additional buildings: a four-story brick building partially

containing a "barracoon" [slave barracks], a kitchen, and a "dead house" or morgue" (The

National Park Services, http://www.nps.gov/nr/travel/charleston/osm.htm).

Figure 4.3 Monumental-IT's context. The Old Slave Mart (top left); Monumental-IT's site (top right); Front elevation of Monumental-IT's site (bottom left); attached site to Monumental-IT (bottom right)
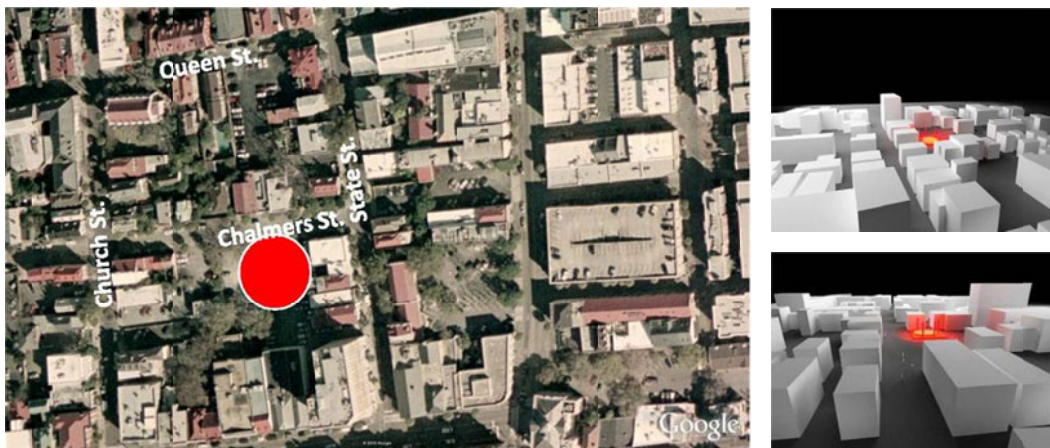
Figure 4.4 Monumental-IT proposed site. Image from Google Maps for Chalmers street (left); 3d-mass model showing Monumental-IT in front of the Old Slave Mart Museum

The proposed site, a square-shaped site about 15meters in length (49'2.551"), is accessible from the east on State Street; from the west on Church Street; and from the north on Queen Street to the back yard of the Old Slave Mart Museum, (Figure 4.3 and 4.4). Monumental-IT visitors are intended to be drawn from the Old Slave Mart Museum, and that is one reason why the monument has been designed to be accessed through a bridge (C) from the roof of the Old Slave Mart, in addition to its street access from Chalmers Street, (Figure 4.5).

The monument, benefiting from being adjacent to the Old Slave Mart Museum, the only "true" artifact left in place, shall complete the theme of the skin and structure (the ghost for the memory of slavery). The monument will dynamically and continuously change, according to people's inputs to it, while the "true" past (i.e. the Mart,) is static. In other words, Monumental-IT tries to approximate people's interpretations of the past to the true memory, but that will not ever be a flashback of the true memory. The only thing that can be seen is people's interpretation, the skin that continuously change.
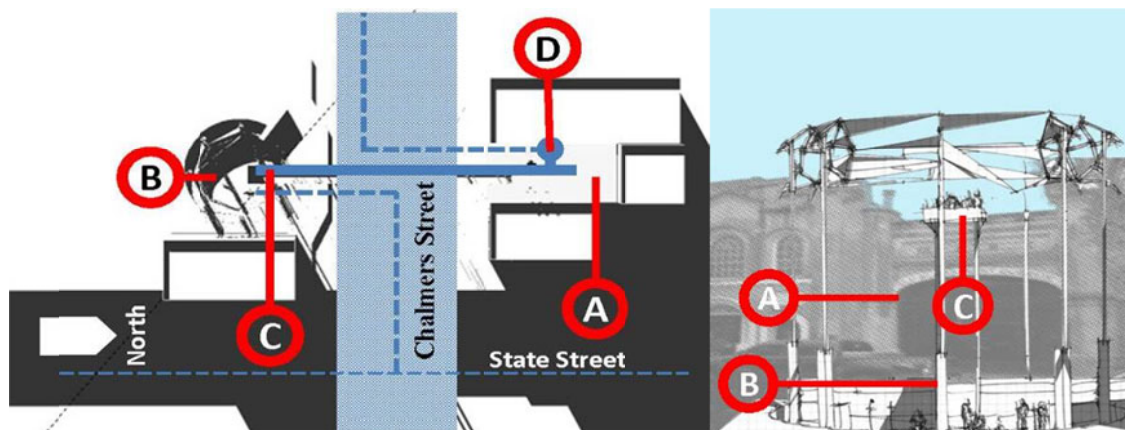
Figure 4.5 Monumental-IT in front of the Old Slave Mart. A: Old Slave Mart; B: Monumental-IT; C: A bridge crossing Chalmers St. from the third floor (roof) of the Museum; D: vertical circulation to the roof (Elevator)

4.3 Technical design

The structural system of the scaled prototype was drawn using AutoCAD and fabricated using Computer-Numerical Control machines (CNC), automated by CAM programs that convert CAD files into G-code to drive the CNC machines. The monument is scaled at 1:6, with the following dimensions: A: the square base is 2.44 meters length, and the height of the monument is 1.6 meters. Materials used for prototyping are: two 49"x97"x3/4" MDF sheets for the base ("A" in Figure 4.6); ¼" Pine Plywood for the body of Monumental-IT ("B" in Figure 4.6); five columns at 3/4"x3/4"x6' square ultra-corrosion-resistant architectural Aluminum (Alloy 6063) 1/8" wall thickness ("C" in Figure 4.6); linkages [D] of five 36"x36"x.08" Multipurpose Aluminum bars (Alloy 6061) ("D" in Figure 4.6); and 5x8mm flanged ball bearings for servo motors-linkages connections.
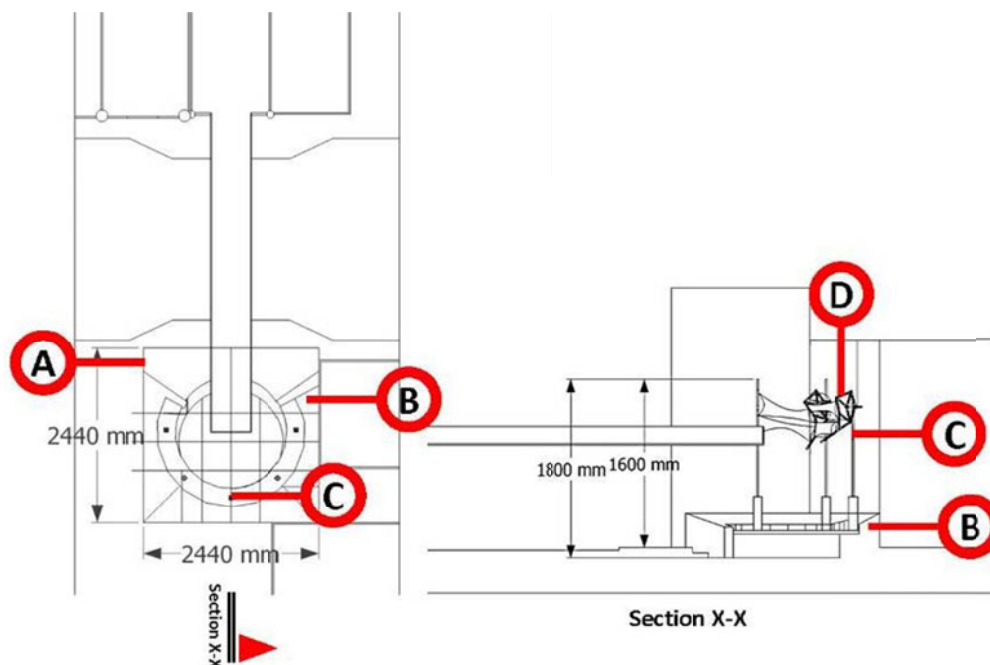
Figure 4.6 Monumental-IT CAD drawings showing the prototype dimensions. A: Square MDF base; B: Pine Plywood for the body; C: five Aluminum (Alloy 6063) columns; D: Aluminum (Alloy 6061) linkages

After designing the linkages (see following section), an AutoCAD drawing was created,(Appendix C and D), and a Multipurpose Aluminum sheet (Alloy 6061) was fabricated using the MultiCUT CNC milling machine, (Figure 4.7 - left).
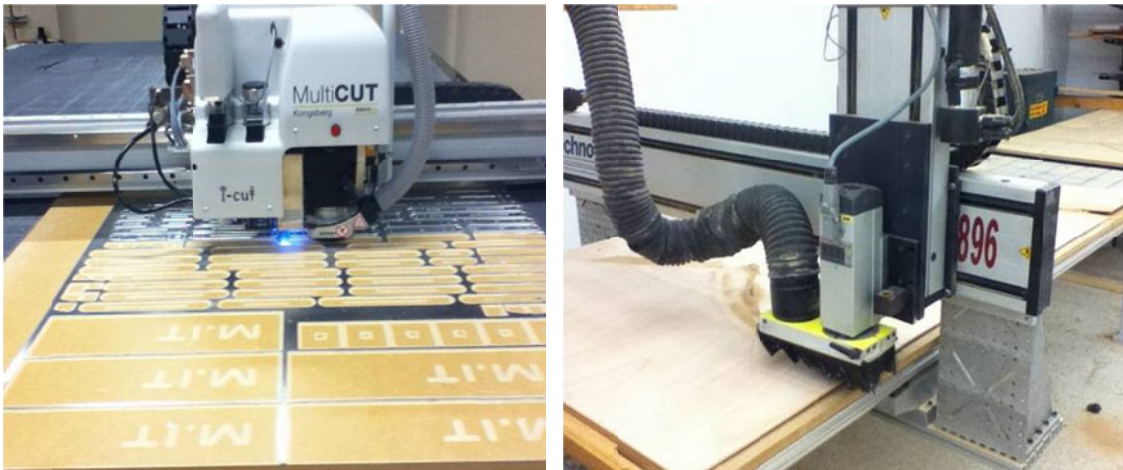
Figure 4.7 The process of fabrication of the Aluminum Linkages using the MultiCUT milling CNC machine (left); the MDF and Pine Plywood have been fabricated using a Techno's LC Series CNC Router (right)

For this machine to cut the Aluminum (Alloy 6061), a 2mm Solid Carbide Upcut Spiral O Flute bit was used on a spindle speed of 14,000 rpm, at a travel speed of 30"/minute under nine paths at Multi-Pass depth of 0.0076". The entire CNC operation took 24 hours to cut the pieces (shown in Appendix E). The Pine Plywood and the MDF sheets were fabricated using a Techno LC Series CNC Router, (Figure 4.7 - right).

After fabricating the body (the base and the bottom of the structure) and the structure of the scaled prototype, the prototype was assembled (Figure 4.8 - left). The Aluminum structure was polished. The wood was stained and polyurethaned, applied in layers to the entire body, (Figure 4.8 - right). Then, the skin was connected to the structure, (Figure 4.8 - right).
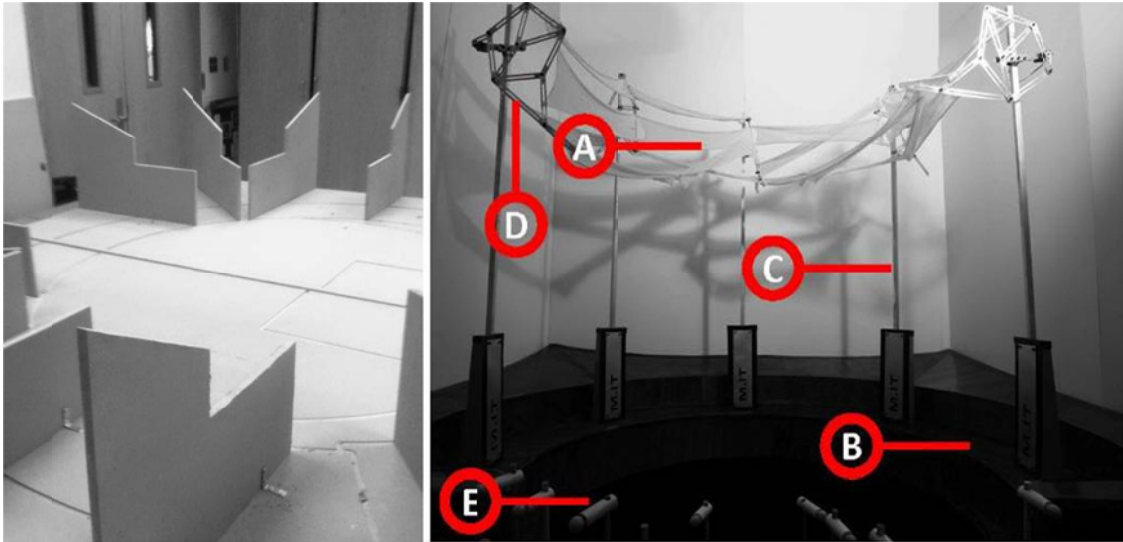
Figure 4.8 Assembling the base for Monumental-IT (left); Monumental-IT components are: A-the Skin; B-the body; C-the Columns; D-the Linkages; E-the Microphones (right)

4.3.1 Hardware
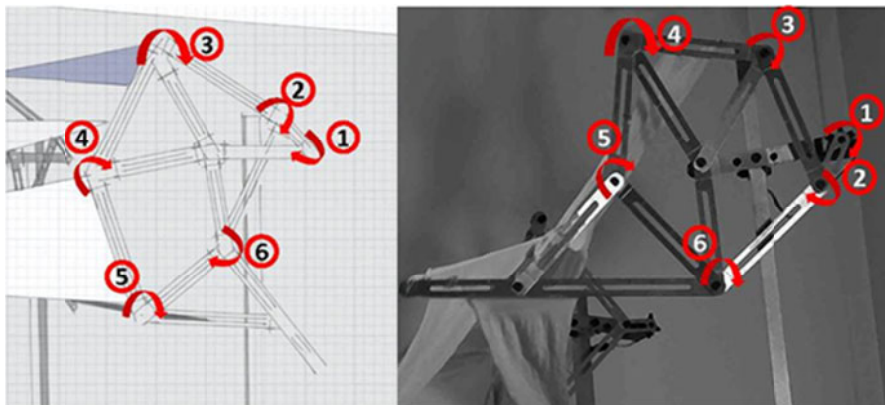
Figure 4.9 A sketch and an image of the two types of linkages showing Monumental-IT's six degrees of freedom

The linkages structure of Monumental-IT was inspired by the Theo Jensen Mechanism developed by Dutch artist and Kinetic sculptor Theo Jansen. According to Jensen, "the walls between art and engineering exist only in our minds" (A., 2009, p.1). For Monumental-IT, two different types of linkages were developed in order to produce

different configurations when connected to the servomotors. The linkages were selected from the five structures tested in the pilot study described previously.
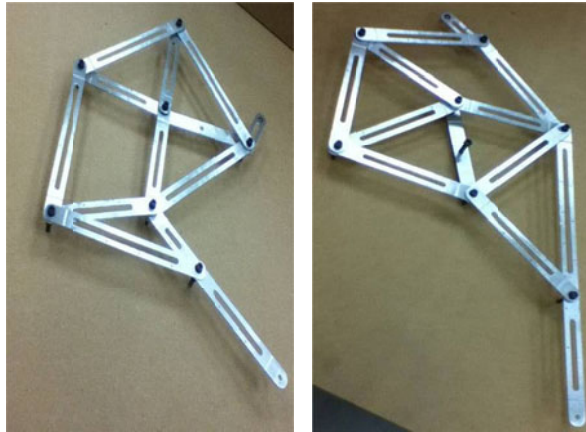
Figure 4.10 Two types of linkages for Monumental-IT's structure

My interpretation of the "Theo Jensen Mechanism" is a closed-loop kinematic chain structure, also called parallel robots, which has six degrees of freedom for six joints of the structure (Figure 4.9 and 4.10). The dimensions of the linkages are presented in Appendices C and D. The two selected structures are comprised of twelve linkages connected with joints (practically speaking, bolts).

The robotic hardware of Monumental-IT is comprised of nine components (see Figure 4.11): A: An Arduino microcontroller – a microcontroller board based on the ATmega328 which has 14 digital input/output pins and 6 analog input pins, 32 KB flash memory and 2 KB SRAM; B: A Motor Shield – to drive Monumental-IT's five servo motors; C: A Relay Shield – which is a four photo-coupled channel relay that has been connected to the Arduino's analog pins to control four LEDs, equivalent to a 75-watts Incandescent bulb. The LEDs have a separate 120 V source, while the Relay uses the Arduino's 5V, ground and Vin; D: An MP3 Player Shield – which has a TTL serial host

connection from 2400 to 460800 bps, and controls up to 127 sounds. The MP3 Player Shield has been used to play the selected audio tracks described in Chapter Three; E: five Continuous Rotation Servos – with an average speed 60 rpm, connected to the linkages using ball bearings; F: four LEDs – red, yellow, blue, and green; G: four pushbuttons; H: A digital projector – connected to a computer to project ten selected images on the skin of Monumental-IT (see Appendix F and G); and I: two loud speakers.
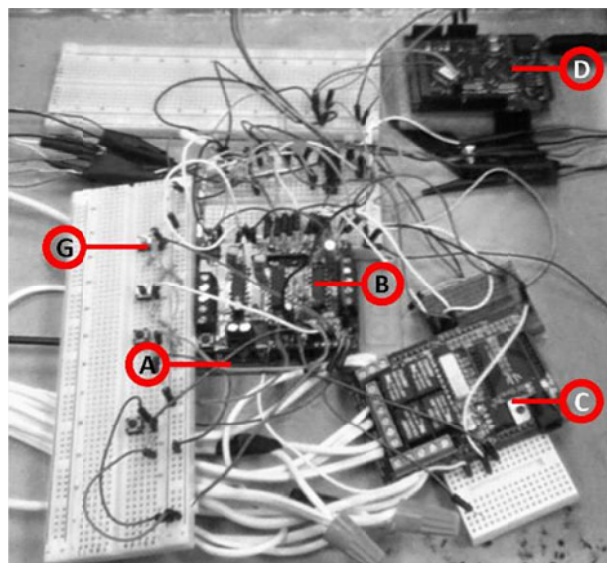
Figure 4.11 Monumental-IT's hardware: A- Arduino Microcontroller; B- Motor Shield; C: Relay Shield; D- Mp3 Player Shield; and G: four pushbuttons

Microphones are an integral part of the conceptual foundations for Monumental-IT, but they were not used in this study because, as shown in Breazeal's and Nass's studies referenced earlier, sound recognition is a branch of science that necessitates further study beyond the scope of this research. The research team decided not to expand the scope of research to include microphones in this study, but recommends that future researchers implement and test the use of microphones on Monumental-IT.

4.3.2 Software

As Monumental-IT has two platforms for interaction – the physical and the virtual – this section considers the software design for both the physical platform and the WikiMonument virtual website. The physical platform is designed with the intention to distinguish human emotions by employing a speech recognition system as described in the "Research Resolution" section. In the current "most developed" prototype, the system will use the four pushbuttons to activate the different configurations of Monumental-IT rather than by microphones. Monumental-IT is designed to distinguish the four basic emotions: happy, anger, sadness, and fear. The microcontroller was programed to represent these four different modes, (see Appendix H for the wiring code).

Figure 4.12 Monumental-IT's Happy Mode, the harmonious dancing structure

The Happy Mode is designed so that, when the third pushbutton is activated, the yellow LED turns on, images are projected on the skin, Johann Strauss II's music "Perpetuum Mobile – A Musical Joke" begins to play, and the structural elements actuate one after the other at normal speed, representing interactive formal gestures for a dynamic, harmonious choreography of architectural tectonics, (Figure 4.12).
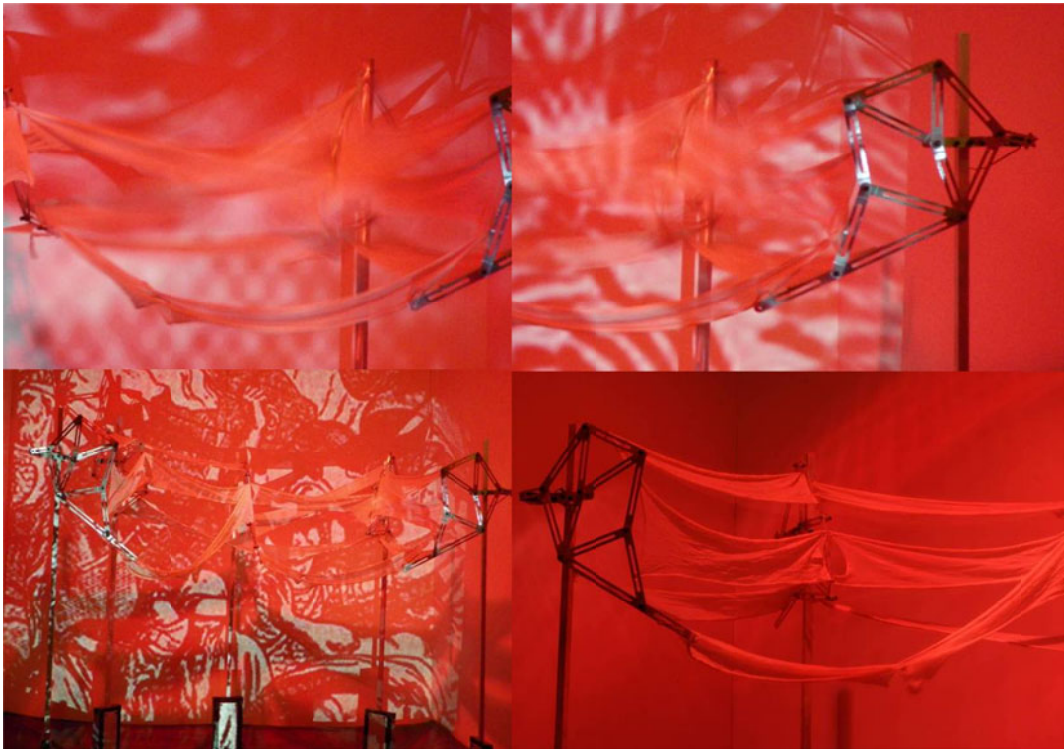
Figure 4.13 Monumental-IT's Anger Mode, a dynamic discordant choreography

The Anger Mode is designed so that, when the second pushbutton is activated, the red LED turns on, images are projected on the skin, Pierre Henry's music "Psyche Rock" begins to play, and all the structural elements actuate together after the first and third structure translocate at full speed, representing interactive formal gestures for a dynamic, discordant choreography of architectural tectonics. In this instance, the skin is stretched

to its maximum limit, a visual interpretation of the sufferings of slaves, subject to tension and stress, (Figure 4.13).
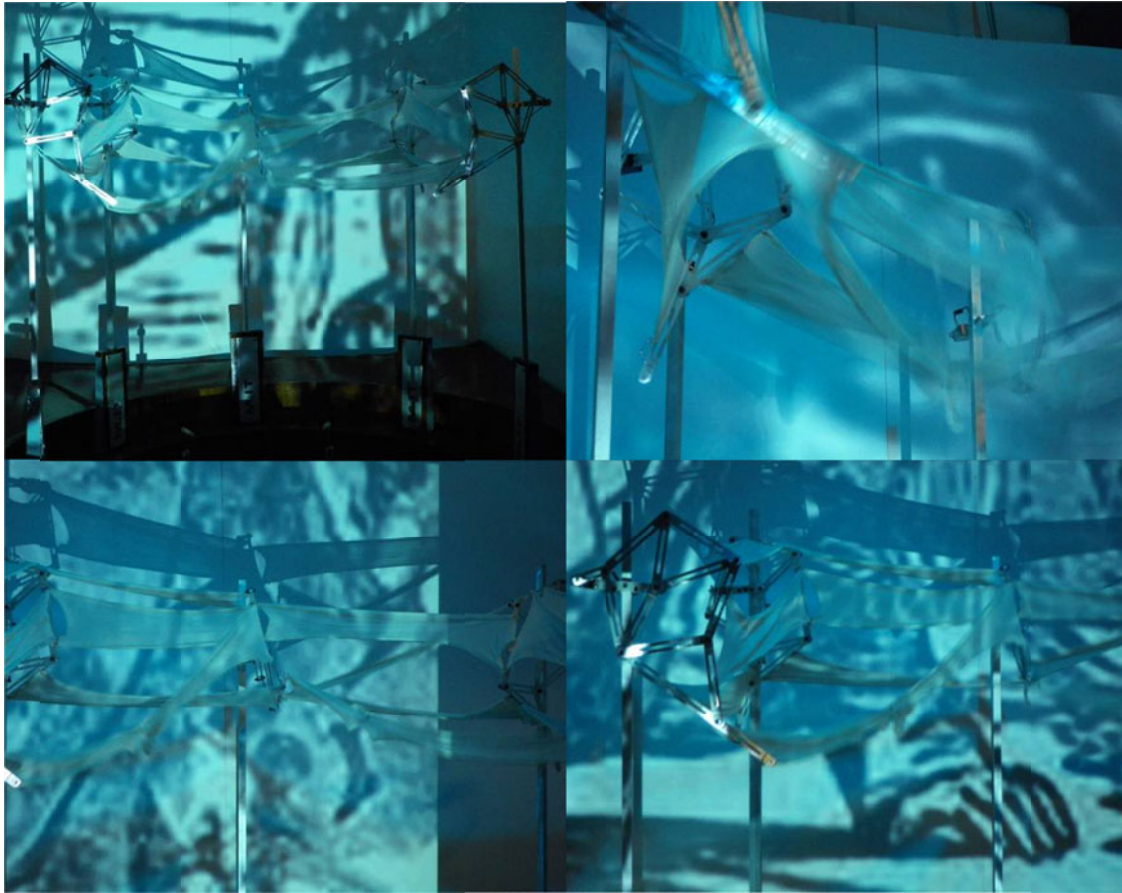
Figure 4.14 Monumental-IT's Sad Mode, a dynamic slow and sad choreography

The Sadness Mode is designed so that, when the fourth pushbutton is activated, the blue LED turns on, images are projected on the skin, Ji PyeongKeyon's soundtrack of "Over the Green Fields" begins to play, and the middle structure (i.e., the third,) starts the symphony at slow speed, representing interactive formal gestures for a dynamic slow-and-sad choreography of architectural tectonics. For this occurrence, the skin will move at a slow pace, as if the structure does not have enough power to continue rotating, (Figure 4.14).
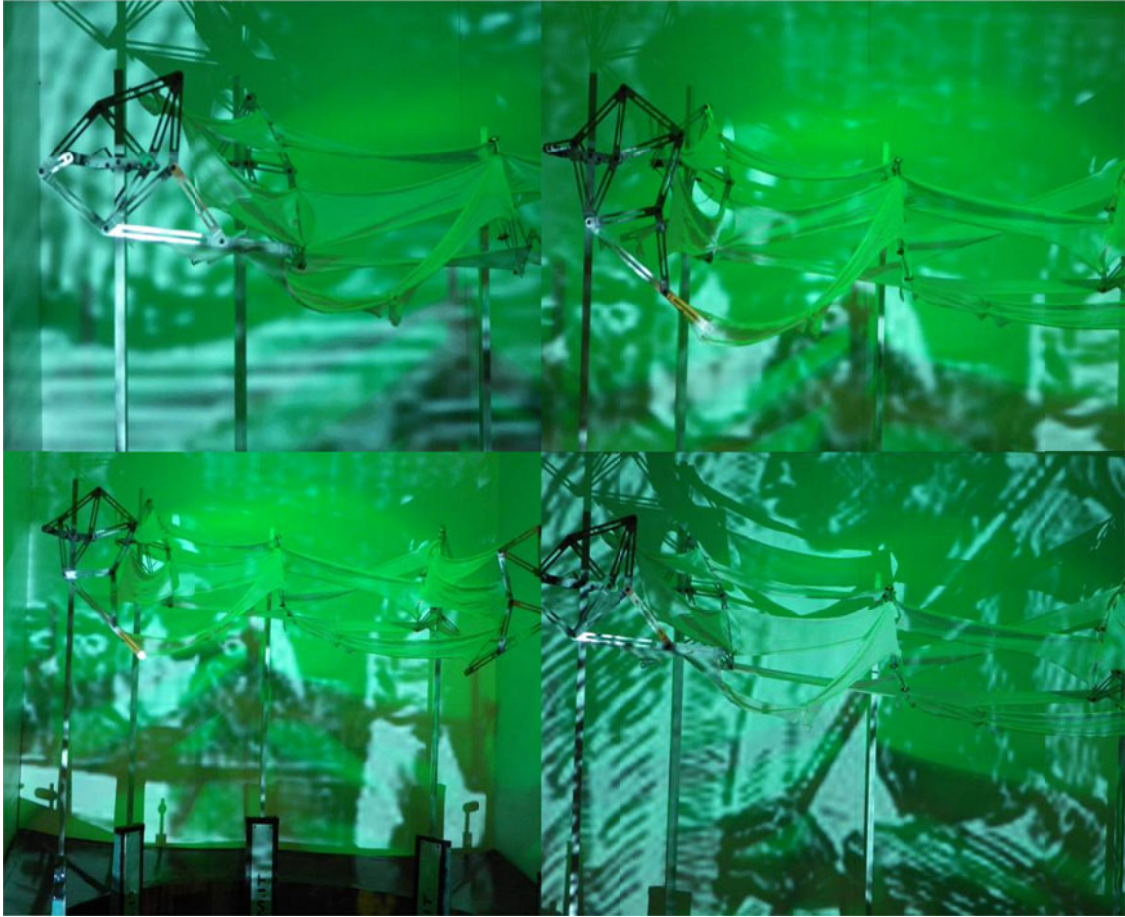
Figure 4.15 Monumental-IT's Fear Mode, a dynamic hesitant and slow choreography

The Fear Mode is designed so that, when the first pushbutton is activated, the green LED turns on, images are projected on the skin, Kevin Macleod's soundtrack of "The House of Leaves" begins to play, and the third, the second, and the first structures start at quarter rotation, on a slow speed representing interactive formal gestures for a dynamic hesitant-and-slow choreography of architectural tectonics. In this final representation, the structure initially appears to be advancing, but suddenly stops, as if something is preventing it (as for the slaves) from continuing its motion, (Figure 4.15).

The "Wiki" website, which is an open source environment that anyone can edit,

track and record the history of visitors' interaction with the site, will serve as the virtual platform of Monumental-IT, a "WikiMonument". According to Ayers et al.'s "How Wikipedia Works," "a wiki expresses the views of a community with some common interest and brings people together in a shared space for discussing ideas and building resources" (Ayers et al., 2009, p.42). In developing the wiki platform of Monumental-IT, the website was designed and prototyped in a PowerPoint, hyperlinked interface, then printed as a paper prototype for usability testing (this is elaborated later).

The aim of the "WikiMonument" is to offer citizens not in the physical space of Monumental-IT, to nevertheless interact with it through three types of online interactions:

(1) "*Share*" their feelings about the history of slavery, selecting one of the four basic emotions, each represented as an icon in the form of facial expressions (Figure 4.16);
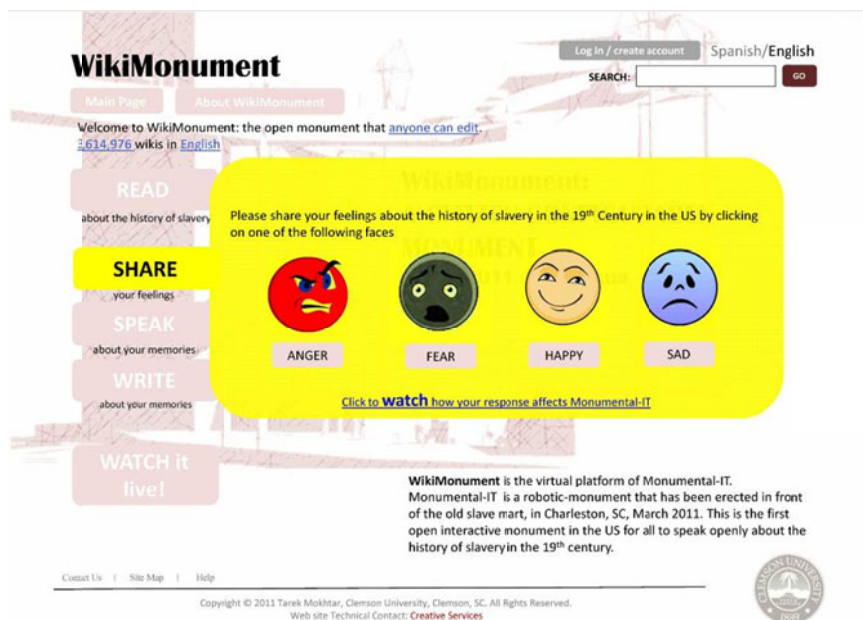
Figure 4.16 WikiMonument website representing the Share Mode

Figure 4.17 WikiMonument website representing the Speak Mode

(2) "*Speak*" into an online microphone to record perspectives about the history of
slavery as an audio file (e.g. mp3 or wav formats). Users can also track their
records, modify them, delete them, and review them (Figure 4.17); or
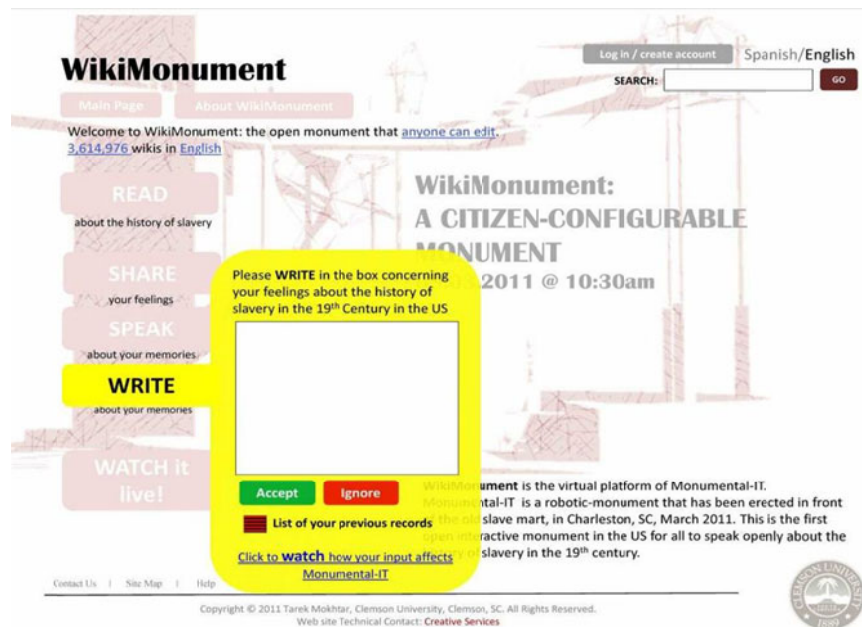
Figure 4.18 WikiMonument website representing the Write Mode

(3) "*Write*" their opinions and interpretations about the history of slavery, in the form of an online text in a wiki format that can be retuned, edited or deleted at will (Figure 4.18).

WikiMonument is using data-mining environment to reconfigure Monumental-IT based on the evolving collection of documents from visitors of WikiMonument and "Documenting the American South" database (see Appendix F). "Documenting the American South" database is one of the largest databases of primary and secondary sources concerning the history of slavery in North America. The data accumulated throughout the WikiMonument website, the three types of interactions (share, speak, and write), and the historical data will be distinguished using data-mining software (e.g. TAPoR (Text Analysis Portal for Research)[1], Weka[2], RapidMiner[3] (formerly "Yale")). The extracted information is periodically "coded," altering the multi-sensorial digital-physical components of Monumental-IT.

In the most basic terms, data-mining is the process of extracting patterns from data. The main idea is that WikiMonument will go through a process of data-mining text documents for specific attributes that are emotional, given that Monumental-IT is itself a multi-sensorial monument, (Table 4.1). The texts that will be data-mined can be categorized as: (1) primary sources (written accounts of individual slaves who passed through Charleston, as found in "Documents of the American South" database); and (2) secondary sources (scholarship pertaining to Slavery in Charleston).

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[1] TAPoR (Text Analysis Portal for Research) is an open online environment where users can use to analyze and data-mine text websites by importing the weblinks and use the online environment to analyze text.
[2] Weka, http://www.cs.waikato.ac.nz/~ml/weka/
[3] RapidMiner, http://rapid-i.com/component/option,com_frontpage/Itemid,1/lang,en/

Monumental-IT sensory database for text mining					
Fear	**Angry**		**Sad**	**Happy**	
Fear	Pain	rage	Despair	Hope	Calm
terror	misery	antagonism	sadness	optimism	peace
dread	depression	resentment	grief	cheerfulness	tranquil
horror	desolation	edgy	sorrow	sanguinity	quiet
fright	distress		unhappiness	happiness	cool
panic	agonize		wretchedness	joyfulness	unruffled
alarm	hurt		melancholy	jollity	serene
trepidation	soreness		gloom	exuberance	relaxed
dismay	sting		despondency	gladness	
shock	ache		dejection	pleasure	
Anxiety	harm		woe	contentment	
Worry	injure		upset	gladness	
Concern	wound		lament	glee	
Unease	Anger		mourn	bliss	
Apprehension	Hate		grieve over	delight	
Disquiet	nervousness		panicky	exhilaration	
fretfulness	annoyance			satisfaction	,
angst	fury			enjoyment	
Bother	irritation			gratification	

Table 4.1 WikiMonument database of emotional attributes for text "data-mining"

Table 4.1 presents the WikiMonument's emotional attributes for the data-mining exercise. Concurrences of these attributes data-mine the text to produce the four different configurations described in the previous section, i.e., Happy, Anger, Sad, and Fear Modes. The data-mining actuates the robot when no visitors are detected by Monumental-IT.

The virtual WikiMonument platform is connected to the microcontroller using the "Internet of Things" platform, "Pachube." According to Casaleggio Associati's thesis on "The Evolution of Internet of Things," the "Internet of Things" is "a gradual revolution that will lead to all the objects surrounding us being connected to the Internet in some

way" (Casaleggio, 2011, P.5), (Figure 4.19). The interaction with Monumental-IT and connectivity is described in detail in the following section.

4.3.3 Embodied Interaction (real-time and real-space)

In "Embodied Interaction," former Xerox PARC researcher Paul Dourish emphasizes the importance of communication across human beings, and objects in the real world. When human beings use objects to communicate, such as computers or cellphones, both humans and artifacts share the same space of interaction. In essence, such objects become extensions of ourselves, or prosthetics that enable us to augment our human capabilities. Dourish notes that artificial systems and human beings are essentially embedded in the same, "real" space; even the internet is a real space of communication between humans and their personal computers, not a virtual-space interaction. It is important to point out the importance of time in (i.e., real-time) communications: the quicker and faster the response, the higher bandwidth for communications. Consequently, real-time and real-space are factors in bettering communications. Monumental-IT takes inspiration in Dourish's theory of "Embodied Interaction" in the design of this communicative system that employs real-time and real-space interactions, thus overcoming the limitations of virtual reality and cyber-space interactions. Ultimately, communication between human beings and objects, like Monumental-IT should be seen as a cybernetic loop.

By using the "Internet of Things" platform (i.e. Pachube,) and connecting the Ethernet Shield to the Arduino board and the internet, communications between the "WikiMonument" and the physical robotic platform "Monumental-IT" can be established

(Figure 4.19). With Monumental-IT using microphones in real-space and WikiMonument using a webcam to communicate in real-time with Monumental-IT, a real-time and real-space communication is established, even for those visitors who are not on the real site of Monumental-IT – embodied interactional system or a "robotic-wiki" system.

Figure 4.19 shows a scenario and a connectivity circuit on how the robotic platform is connected to the wiki platform, a "robotic-wiki" monument. In "A" of Figure 4.19, George Smith, the research persona, is in his office using the WikiMonument website to share his thoughts and opinions on the history of slavery. After George's interaction with WikiMonument, a data-mining tool "B," e.g. TAPoR, extracts the emotional pattern from George's input and send it directly to Pachube website "C." Then, the data which has been sent to Pachube website is located on the server "D," which means that the data is in the "cloud" to be sent to the microcontroller using the Ethernet Shield "E" through an internet cable. Finally, Monumental-IT's program is directly reconfiguring Monumental-IT after defining the highest accumulated emotion on its database.
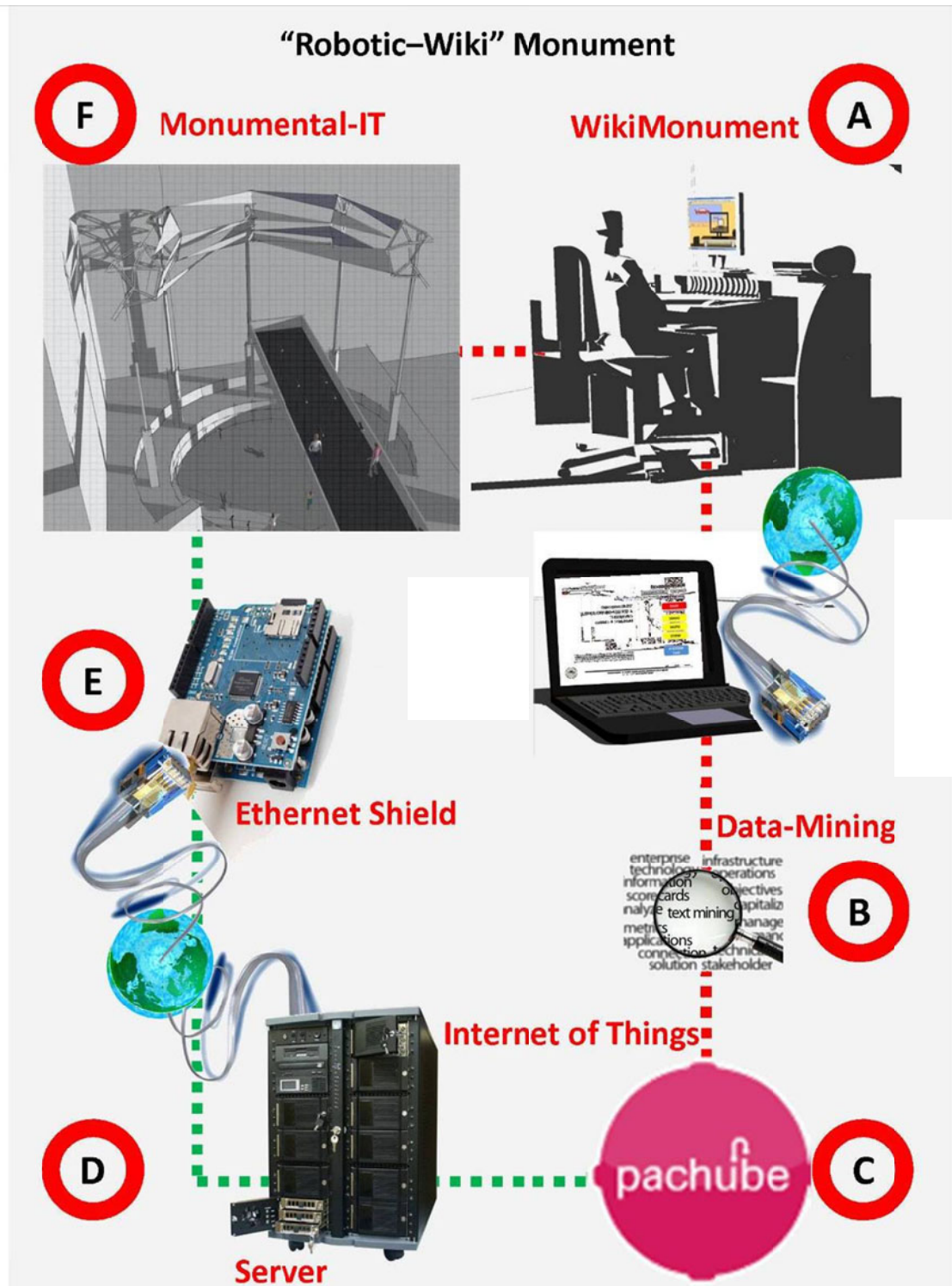
Figure 4.19 Monumental-IT, a "Robotic-Wiki" monument for embodied interaction

4.4 Modes of operation

As described previously, Monumental-IT, and its virtual offspring WikiMonument, operate simultaneously. The human interactions with Monumental-IT can be classified into three modes of operations:

(1) Physical Interaction (Real Space-Time Mode);

(2) Internet Interaction Mode; and

(3) Historical information accumulating on the Web (Data-mining Mode).

These modes are defined as follows:

(1) Real Space-Time Mode is defined as interaction occurring on-site, as users engage with Monumental-IT's microphones or the pushbuttons in this study. The interactions afforded by Monumental-IT oscillate between past and present, virtual and real spaces, as well as in real-time and time-lapse. The usability evaluations and heuristic evaluations of the scaled physical prototype in the next chapters will evaluate the effectiveness for real-time, on-site human-robotic interaction.

(2) *Internet Interaction Mode* is defined as interaction with remote users exercising their own voices using online microphones, selecting one of the predefined four emotional facial expressions, or even to "fine-tune" the monument via entry of text into the internet website. This mode of interaction is being prototyped using a low fidelity prototyping technique, paper prototyping, and evaluated using cognitive walkthroughs with real users to enhance website usability (see next chapter for evaluations). While the website connectivity and functionality with the robotic monument is part of the conceptual foundations for this research, programming the website (not designing it) and

114

Pachube is outside the scope of this research, with recommendations for future researchers to implement and test the use of the website on Monumental-IT.

(3) *Data-mining Mode* is defined as the interaction with codified historical information accumulating in real-time on the Internet, as a vehicle for Monumental-IT's reconfiguration. The text undergoes a "coding" process by identifying concurrences of the emotional attributes in the text. After coding the text, the data-mining software extracts patterns of emotions, altering the multi-sensorial digital-physical components of Monumental-IT. The data-mining mode is outside the scope of this research and thus not evaluated in this study.

CHAPTER FIVE

HEURISTIC EVALUATIONS AND COGNITIVE WALKTHROUGHS

Recently, User-Centered Design (UCD) methods have been widely employed in interactive design development and analysis, including, but not limited to the research activities of: concept generation, concept selection, design decisions, experts' feedback and evaluation, and end users evaluation of products (Ulrich, 2000/1995; Brown, 2009; IDEO, 2011). User-Centered Design (UCD) is "an [iterative] approach to user interface design and development that involves users throughout the design and development process" (Stone et al., 2005, p.15).

The four essential activities of UCD or Human-Centered Design (HCD) (International Organization for Standardization ISO 13407), Human-Centered Design Processes for Interactive Systems (International Organization for Standardization ISO 9241-210, 2010), are: "(1) [to] understand and specify context of use; (2) [to] specify the user and organizational requirements; (3) [to prototype] product design solutions (prototypes); and (4) [to] evaluate designs with users against requirements" (Stone et al., 2005, p.15).

UCD has been applied at all stages of Monumental-IT iterative design cycle. This chapter will consider two UCD evaluation methods of the "discount usability techniques" applied in the iterative design of Monumental-IT: (1) "cognitive walkthroughs" (CW) used to evaluate the interface of the WikiMonument with real-users; and (2) "heuristic evaluations" (HE) used to evaluate the Monumental-IT scaled prototype as a response to

feedback from experts who participate in the HE pilot study as part of the iterative design process (see Chapter Three, Section 3.4).

5.1 Defining discount usability techniques

In "Usability Engineering," Jakob Nielsen maintains the need to apply usability methods in developing interactive systems. Nielsen recommends employing "discount usability techniques," a set of usability methods which "is based on the use of the following four techniques: User and task observation; Scenarios; Simplified thinking aloud; Heuristic evaluations" (Nielsen, 1993, p.17) and "[its] main rules are simply to observe users, keep quiet, and let the users work as they normally would without interference" (Nielsen, 1990, p.18). "Discount usability techniques" helps to develop iterations of products through low fidelity techniques: paper prototyping, cognitive walkthroughs, heuristic evaluations, and the Wizard of Oz techniques.

There are three types of prototyping and testing, (1) *horizontal prototyping* that "reduce[s] the level of functionality and results in a user interface layer"; (2) *vertical prototyping* that "reduce[s] the number of features and implement[s] the full functionality of those chosen (i.e., we get a part of the system to play with)"; and (3) *scenarios*, "the ultimate reduction of both the level of functionality and of the number of features" (Nielsen, 1993, p.18). In this study, *horizontal prototyping* will be used for designing and evaluating Monumental-IT, and *scenarios prototyping* will be used to design and evaluate the WikiMonument.

5.2 WikiMonument and cognitive walkthroughs
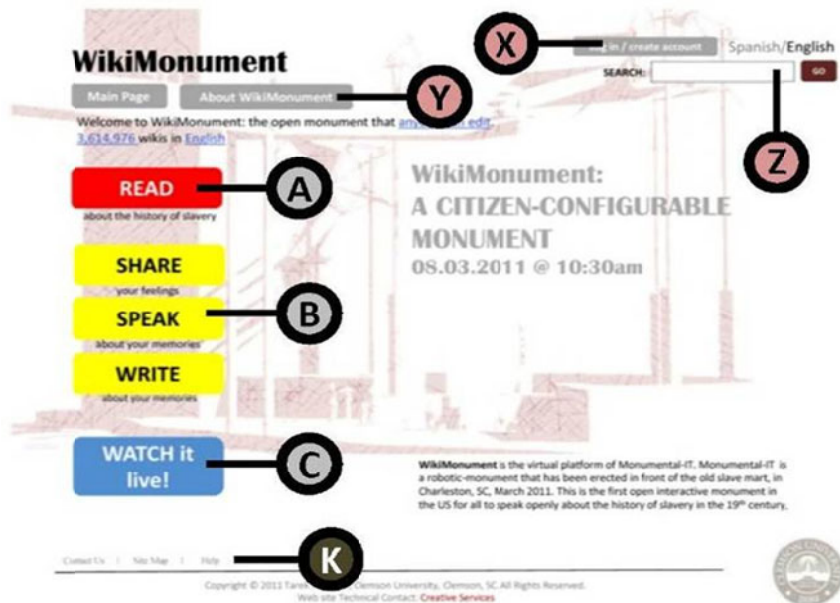
Figure 5.1 WikiMonument is comprised of three parts, top part: X- log in/create account, Y- main page and about WikiMonument, and Z- search; middle part: A-read, B- interaction by sharing, speaking, and writing, and C- watch it live; and the bottom part: K- contact us, site map, and help

"WikiMonument" is the internet interactive mode of the Monumental-IT "robotic-wiki" monument. In practical terms, WikiMonument is a website consisting of ten different web pages, hyper-linked to facilitate user interaction (see Homepage, Figure 5.1). The webpage is designed using a conventional form of a wiki webpage with three differently colored interactive icons to make it easy for users to recognize and understand their respective functions. There are three ways for users to interface with WikiMonument through the three color system: read (red icon), interact (yellow icons), and watch (blue icon). At the top of the webpage is: (1) an icon <login/create an account> that allows users' to create their secure personal sentiments concerning slavery for retrieval at a later date; (2) icons that direct users to the <main page> or to learn more

118

<about WikiMonument>; and (3) a <search> field to search and locate specific content. At the bottom of the webpage, the icons <contact us>, <site map>, and <help> are provided to aid users seeking website or technical support, (Figure 5.1).

To evaluate the human interaction with the WikiMonument website, scenarios were implemented using paper prototyping and PowerPoint hyperlinked pages. Both the paper prototyping and PowerPoint hyperlinked pages have been employed in the cognitive walkthrough evaluations of the wiki aspect of Monumental-IT with users. A cognitive walkthrough "evaluates the steps required to perform a task and attempts to uncover mismatches between how the users think about a task and how the UI [User Interface] designer thinks" by "'walking' your users through your view of their tasks" (Stone et al., 2005, p.71). The cognitive walkthrough evaluations were focused on the human-interaction components of the WikiMonument's interface (i.e., share, speak, and write,) but this interface was not connected to Monumental-IT's physical platform. This evaluation technique allows for the observation of users' interactions at each task step, so as to evaluate and develop the interface (Stone et al., 2005, p.71).

5.2.1 Design

WikiMonument's evaluation is a "formative evaluation" which "is done to help improve the interface as part of an iterative design process. The main goal of formative evaluation is thus to learn which detailed aspects of the interface are good and bad, and how the design can be improved" (Nielsen, 1993, p.170).

A "one-by-one" pilot study was conducted, whereby users were introduced, one-by-one, to the WikiMonument's concept, and its connection to Monumental-IT, as well

as to the similarities between WikiMonument, Wikipedia, and YouTube as a means of interfacing between open source interactions and communications. This study manipulated the task steps needed for interaction with the WikiMonument to evaluate users' understanding, the feedback they received, and appropriateness of the interface components and design.

The task steps of the cognitive walkthrough and the development of task sequencing and steps were designed after initially been tested by three users (Appendix I). The cognitive walkthrough is comprised of two tasks: Task One, to "know about WikiMonument and create an account"; and Task Two, to "interact with WikiMonument in order to share, speak, and write" about the history of slavery.
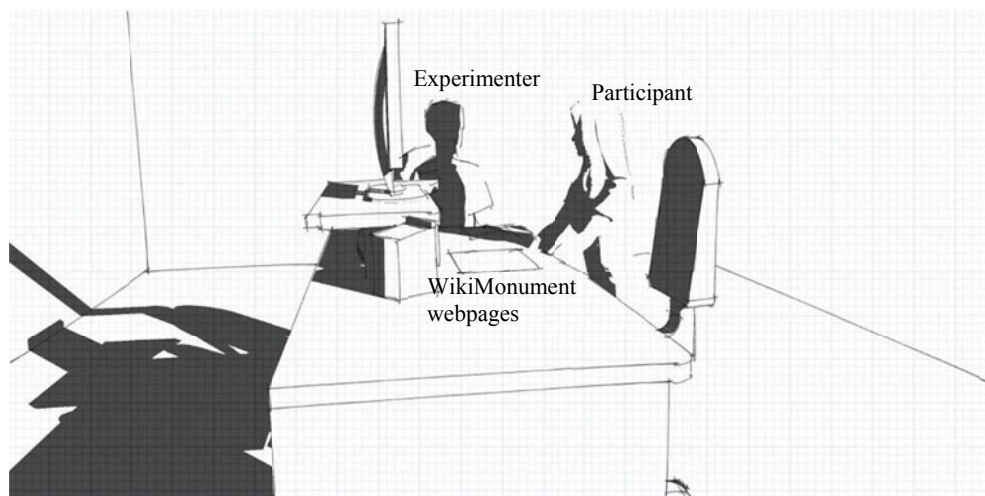
Figure 5.2 The cognitive walkthrough survey in a library setting

Task One consists of four task steps:

1.1 click on "about WikiMonument;"

1.2 read about "WikiMonument;"

1.3 click on "log in/create an account;" and

1.4 close log in window.

Task Two consists of seventeen task steps:

2.1 click on "share;"

2.2 click on one of the "faces;"

2.3 click on "click to watch how your response affects Monumental-IT;"

2.4 watch "Monumental-IT live;"

2.5 click on "speak;"

2.6 click on "record;"

2.7 click on listen;"

2.8 click on "save and accept;"

2.9 click on "list of your previous record;"

2.10 click on "listen;"

2.11 click on "click to watch how your input affects Monumental-IT;"

2.12 click on "write;"

2.13 start writing in the box;"

2.14 click on "accept;"

2.15 click on ignore;"

2.16 click on list of your "previous records;" and

2.17 click on "click to watch how your input affects Monumental-IT."

In the cognitive walkthroughs, the participants performed the two tasks introduced above in 15 minutes, one person at a time. The experimenter sat at the side of the participant at a desk, observing the user's interaction through each task step of the

WikiMonument's webpages (Figure 5.2). The tasks and their steps were represented in a written table format to be completed by the experimenter while observing the participant interaction with the paper prototype or the PowerPoint interface (see Appendix I).

5.2.2 Procedure

The cognitive walkthrough was conducted in a library setting. The experimenter introduced the WikiMonument concept and the two tasks of the cognitive walkthroughs. An explanation was provided of the importance of *natural behavior*: that the user should interact with the interface as if she or he is interacting with the website on the internet; that there are no wrong answers; that the user is allowed to return to a previous page to approach previously completed tasks in a different manner.

These participants completing the cognitive walkthroughs using *the paper prototype* were asked to click on the icons on the paper using a pen instead of a mouse click; these participants completing the cognitive walkthroughs using th*e PowerPoint prototype* were asked to use the mouse and the keyboard provided them on the desk.

After introducing the survey, the experimenter accessed and provided the first web page of the WikiMonument to the participant, asking her/him to click on step-one, task one, as described previously (i.e., to click "about WikiMonument"). With the pen or mouse click, the participants accordingly selected "about WikiMonument" icon. The experimenter meanwhile observed the user-interaction with WikiMonument and completes a form that includes four questions (the description of this form follows). After each participant completed the survey, participants were asked two subjective questions

about the understandability of the interface, and suggestions to offer that would improve the website.

5.2.3 Measurement

The goal of the cognitive walkthrough was to discover users' performance concerning human-computer interaction (HCI). The HCI was measured by the experimenter based on answers to four questions associated with observations of user interaction with each task-step. The four questions are: Will the user be trying to produce the effect that the task has?; Will the user be able to notice that the correct action is available?; Will the user know which is the right icon for the effect they are trying to produce?; and, Will users understand the feedback they get?

The two tasks, as described previously, are: Task One, understand WikiMonument, and create an account; and, Task Two, interact with WikiMonument, which is divided into three sub-tasks: A) "share" which is created from the task steps 2.1 through 2.4; B) "speak" which is created from the task steps 2.5 through 2.11; and C) "write", which is created from the task steps 2.12 through 2.17.

Two constructs were developed for this study to help in evaluating the interface design of WikiMonument: understandability and appropriateness for user-interface interaction. The first construct for this study, *user's understandability*, was created using the following variables: Will the user be trying to produce the effect that the task has?; and, Will the users know that it is the right one for the effect they are trying to produce? The second construct, *appropriateness of the interface to the user-computer interaction*,

was created using the following variables: Do you think that the whole website is easy to understand?; and, Will users be able to notice that the correct action is available?

The first outcome of this study is the effectiveness of the interface design, i.e., whether the understandability of the interface-design is excellent, very good, good, or poor. The second outcome of this study is the appropriateness of the interface according to the feedback users receive when interacting with the WikiMonument, i.e., whether the interface design is appropriate, slightly appropriate, slightly inappropriate, or inappropriate.

5.2.4 Participation

The demographics of the CW's participants								
	Used Method		Gender		Technology		Employment	
	Paper-prototyping	PowerPoint Prototype	Male	Female	User of Technology	Not User of Technology	Students	Employees
Number of Participants	6	6	5	7	12	0	8	4
	(50%)	(50%)	(41.7%)	(58.3%)	(100%)	(0%)	(66.7%)	(33.3%)

Table 5.1 The demographics of the CW's participants

Twelve (12) participants participated in this study: six (6) participants participated in the study using the paper prototype; six (6) participants participated in the study using the PowerPoint prototype. The participants are five (5) males (41.7%) and seven (7) females (58.3%). The age of the participants' ranged from 18 to 65 years. All participants

are users of technology at Clemson University (100%): eight (8) participants (66.7%) are

students; four (4) participants (33.3%) are employees.

5.2.5 Results
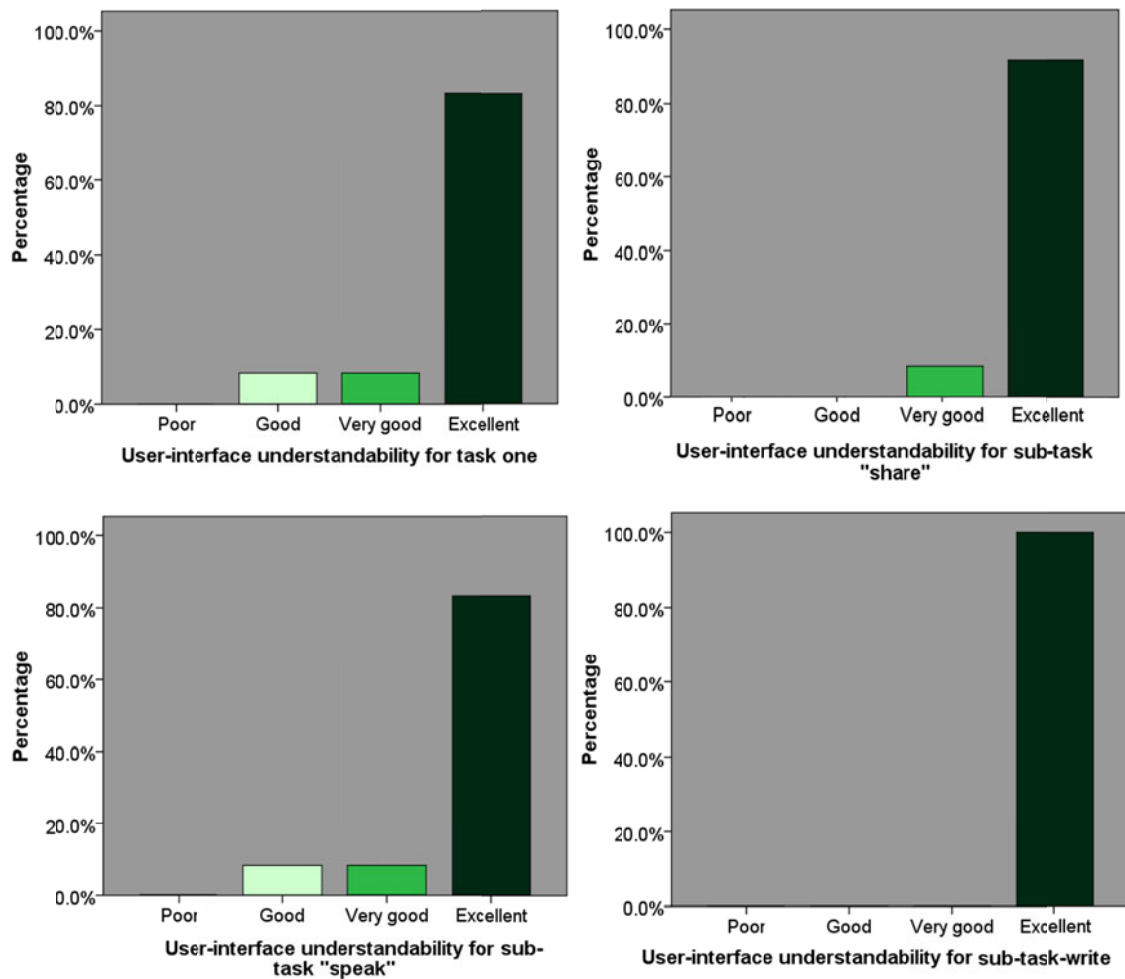
Figure 5.3 Results on user-interface understandability for task one (top-left), for sub-task two "share" (top-right), for sub-task "speak" (bottom-left), and for sub-task "write" (bottom-right)

After analyzing the data from the twelve participants, the results confirmed that

the user-interface understandability for task one is significant, with a mean value

(M)=3.79 on a scale of 4 and standard deviation (SD)=0.4981: 8.3% of the participants

reported that the design of the interface is good, 8.3% of the participants reported that the design is very good, while 83.3% of the participants reported that the design is excellent (Figure 5.3, top-left). The results on the sub-task "share" confirm that the user-interface understandability is significant M=3.92 and SD=0.29: 8.3% of the participants reported that the design of the interface is very good, and 91.7% of the participants reported that the design of the interface is excellent (Figure 5.3, top-right).

The results on the sub-task "speak," confirm that the user-interface understandability is significant M=3.835 and SD=0.45: 8.3% of the participants reported that the design of the interface is good, 8.3% of the participants reported that the design is very good, and 83.3% of the participants have shown that the design is excellent (Figure 5.3, bottom-left). The results on the sub-task "write," confirm that the user-interface understandability is significant M=4 and SD=0: 100% of the participants have shown that the design of the interface is excellent (Figure 5.3,bottom-right).

The results confirm that the appropriateness of the interface-design for task one is significant, with M=3.67 and SD=0.65: 8.3% of the participants have shown that the design of the interface is slightly inappropriate, 16.7% of the participants have shown that the design is slightly appropriate, 75% of the participants have shown that the design is appropriate (Figure 5.4, top-left). The results on the sub-tasks "share," "speak," and "write" confirm that the appropriateness of the interface-designs are significant, M=3.92 and SD=0.29: 8.3% of the participants have shown that the design of the interfaces are slightly appropriate, 91.7% of the participants have shown that the design of the interfaces are appropriate (Figure 5.3, top-right, bottom-left, and bottom-right

126

respectively). The standard deviations on all of the previous results, ranging from 0 to 0.65, suggest that there are very low variations from the expected mean, which support the significance of the results. Further, participants' responses received from the walkthrough-debriefing questions reported that they found the interface is easy to understand.
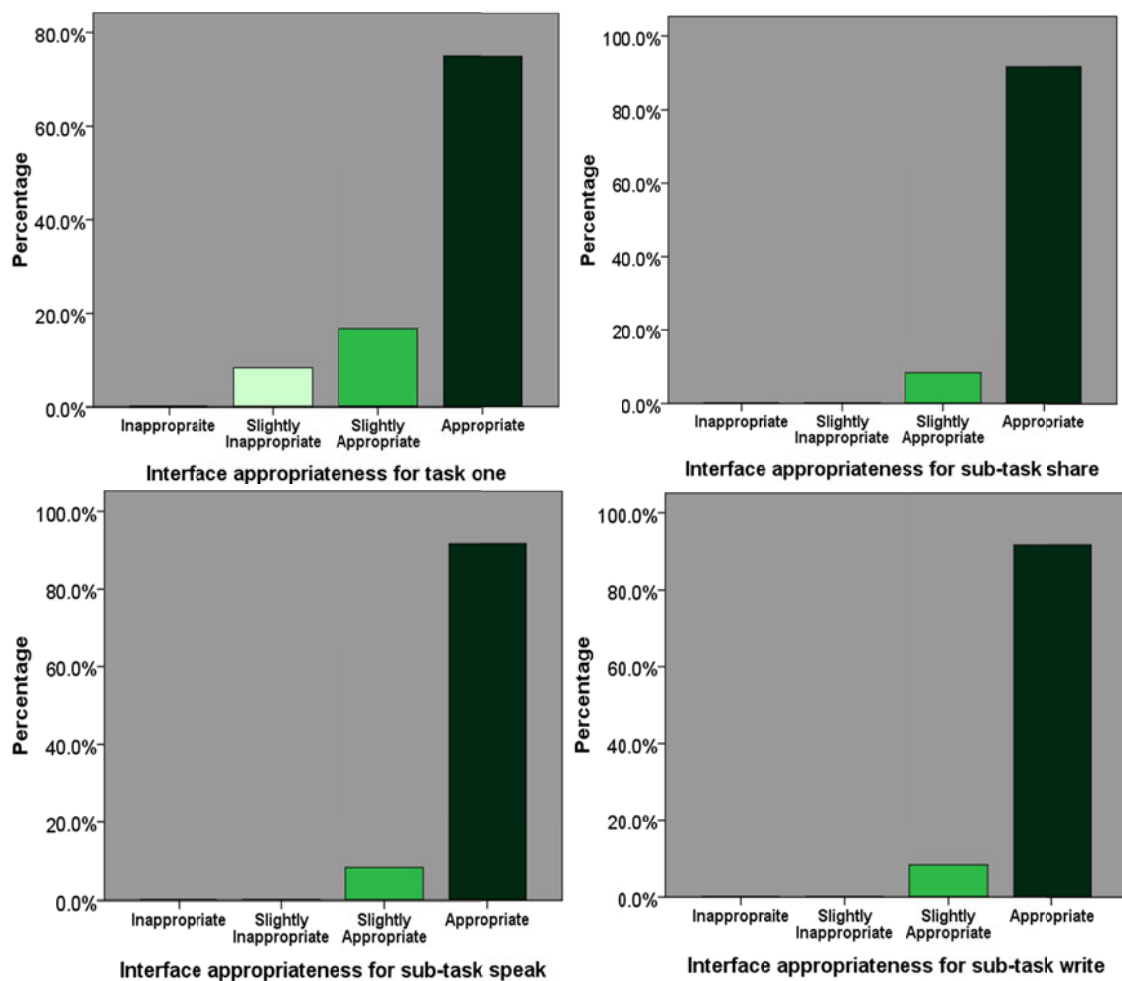
Figure 5.4 Results on user-interface appropriateness for task one (top-left), for sub-task "share" (top-right), for sub-task "speak" (bottom-left), and for sub-task "write" (bottom-right)

Reported results on the understandability and appropriateness of WikiMonument's interface design demonstrate significant support for the suggested

design. Further research is recommended to study the integration and implementation of the virtual interface to the physical monument with a larger sample population representing the intended end-users. It is anticipated that findings from additional research evaluating the usability and appropriateness of WikiMonument will support the significance of the aforementioned results.

5.3 Monumental-IT and heuristic evaluations

Monumental-IT is the robotic, physical interactional mode of the "robotic-wiki" monument. As with the "WikiMonument" prototyping, Monumental-IT has been evaluated using scenarios prototyping employing the Wizard-of-Oz technique. The scaled prototype includes all physical and multi-sensorial features: color, material, texture, sound, and motion. All the linkages of Monumental-IT were activated. Microphones envisioned for the design were replaced with pushbuttons as noted in Chapter Four earlier. The scaled prototype was evaluated using heuristic evaluations with usability experts, and with users surveyed in a lab setting, (described in the next chapter).

The "heuristic evaluation" method is "a set of techniques that involve inspectors [experts] examining the user interface to check whether it complies with a set of design principles known as heuristics" (Stone et al., 2005, p.525). The heuristic evaluation has been used before for concept evaluation in this study, and also for improving the usability of user-robotic interaction with its interface as part of the iterative design process. For this study, the experts' evaluations of the system were largely implemented in this prototype to *improve the usability of the interface design for better user-robotic interaction* prior to conducting user evaluations, (to be considered here in Chapter Six).

5.3.1 Design

Monumental-IT's heuristic evaluation is a formative evaluation, similar in character to the WikiMonument's cognitive walkthrough evaluations. A one-by-one study was likewise conducted, in which experts are introduced to the human-robotic interaction with Monumental-IT and its openness to change from one mode or configuration to another one due to user inputs (i.e. speech-recognition of users' emotions concerning slavery). The study manipulated the task-steps needed for interaction with Monumental-IT to help the experts focus on the human-robotic interaction of the interface, and to control the threats of unfocused participation that may occur due to distractions from the physical interface details or substructure.

There are two ways to interact with Monumental-IT: through the use of microphones on street level (Chalmers Street); and through the use of microphones from the bridge after visiting the Old Slave Mart museum, (Figure 5.5). For this study, the experts were introduced to these two ways of interaction on the scaled physical prototype.

Stone's model (Stone et al., 2005, pp.525-537) was employed in the preparation steps for conducting heuristic evaluation: (1) for creating the evaluation plan for heuristic inspection which is comprised of: [a-] choosing the set of heuristics, described later in the measurement section, and [b-] selecting the inspectors; and (2) for conducting the heuristic inspection which is comprised of: [a-] task descriptions, [b-] the location of the evaluation session, and [c-] collecting evaluation data; (3) for analyzing the heuristic inspection data (severity ratings, as described by Nielsen); and (4) for interpreting the heuristic inspection data.

Five experts ("inspectors") were selected, each of whom exhibited varying degrees of expertise related to evaluating Monumental-IT: two "double experts" in the domain fields of usability evaluations and architectural-robotics, two "single experts" in the domain field of architectural robotics, and one "novice" user with more than 15 years of experience in "digital interfaces" but not in the domain of architectural robotics.
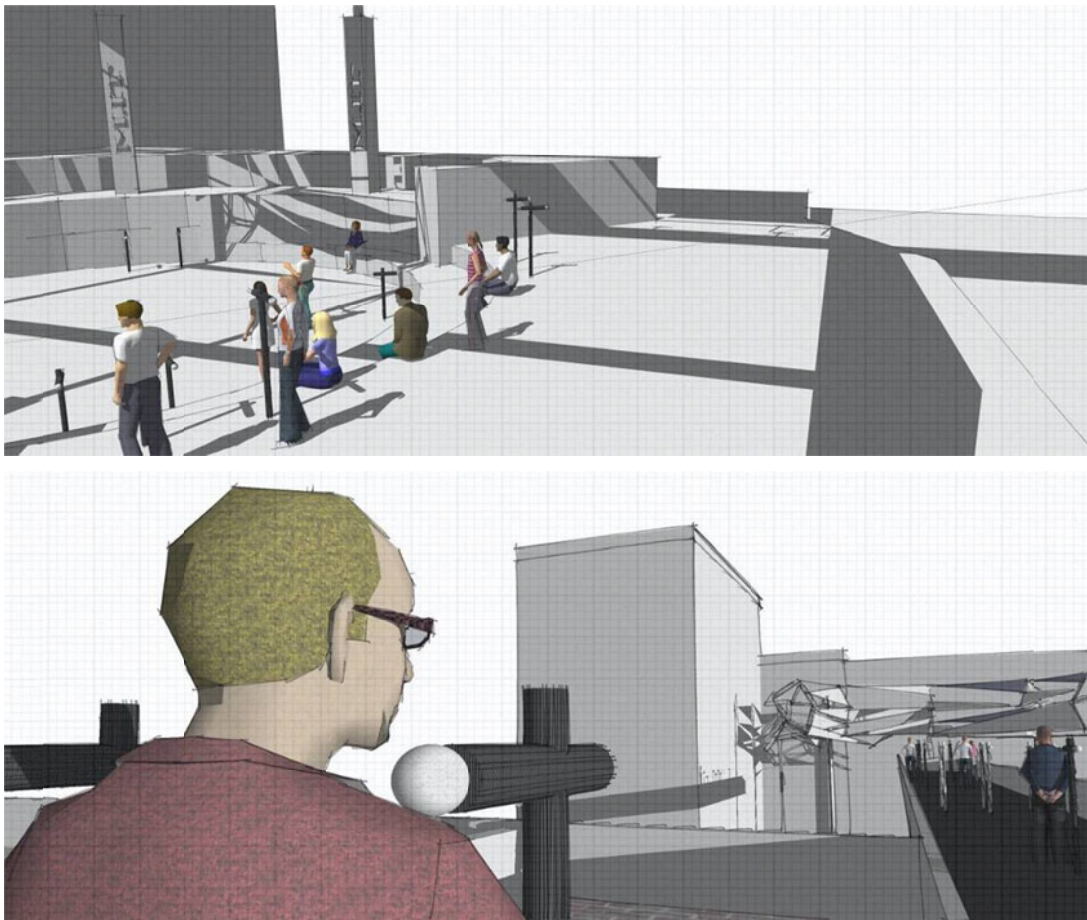
Figure 5.5 Interacting with Monumental-IT through the use of microphones from the street level (top), or using the microphones on the roof of the Old Slave Mart museum and the bridge (bottom)

For the task descriptions, three surveys were completed by the experts to specify the best task steps for interacting with Monumental-IT in recalling ones' memories about

the history of slavery in the US in the 19th century. A task analysis sheet was created, comprised of nine task-steps (Appendix K).

The heuristic evaluation for Monumental-IT's prototype does not include three of the previous task-steps that were later excluded in response to the pilot study recommendations. These are: 1) to listen to Monumental-IT's introductory speech, 2) to push the footstep to start Monumental-IT's interactive response, and 3) to sound a beep which indicates that Monumental-IT has begun its representation of formal cues. All the excluded questions violated the "aesthetic and minimalist design" of the interface. The task-step "smell sprinklers start" was also excluded based upon experts recommendations who noted some users may be allergic/sensitive to the proposed odors or chemicals.
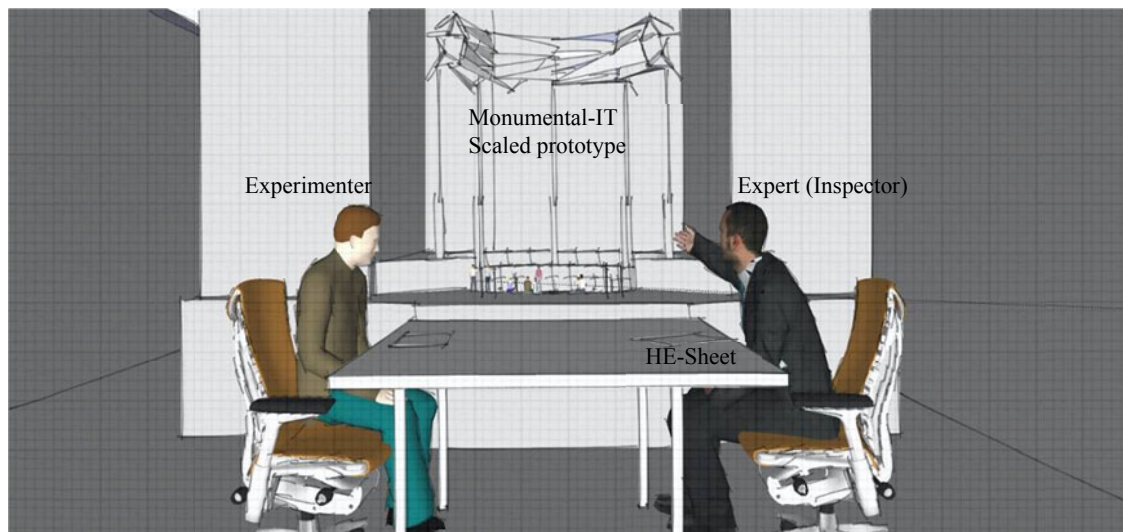
Figure 5.6 Monumental-IT in the lab setting, where the heuristic evaluations (HE) had been conducted

The nine task-steps are:

(1) walk to start interacting with Monumental-IT;

(2) read Monumental-IT's plaque;

(3) start recalling memories;

(4) speak to the microphone to express emotions about the history of slavery;

(5) the LED turns on;

(6) the skin starts morphing;

(7) the audio starts;

(8) people start to associate past memories about the history of slavery with the space of Monumental-IT, and use the space as a contextual cue for later retrieval; and

(9) users depart the site, reassessing their memories or emotions or interpretations of the human historical event.

Each expert inspected Monumental-IT in one hour, one inspector at a time, followed by a 15-minute debriefing. Monumental-IT was installed in a lab setting, with the scaled physical prototype accessible to the experts, (Figure 5.6). The lab was equipped with a table and two chairs. One chair was used by the expert who was free to stand and inspect the physical model at will, while the experimenter sat on the other chair to facilitate the evaluation session and provide the expert with the task-steps and respond to any questions about the interface. The horizontal distance between the expert and the physical prototype was 2.5 meters.

5.3.2 Procedure

As noted, the "heuristic evaluations" was conducted in a lab setting where the expert and the experimenter were in front of the scaled robotic model of Monumental-IT. The experimenter introduced Monumental-IT's concept, the context of the project, task description, and the testing guidelines. The experimenter explained to the expert that she

or he can ask, at any time, to repeat any task-step or ask any questions that are technical, or context-specific, but that are not "usability-specific," (to avoid usability biases if the experimenter explains how the end-users interact with Monumental-IT).

In the first phase of this segment of the study, the experimenter provided an overview of the project, and written testing guidelines to each expert, (Appendix L). Then, the experimenter handed out the task analysis sheet (Appendix K) which included the task of interacting with Monumental-IT, and explained that the goal of the expert evaluation is to complete all expected task-steps, and to evaluate each step against a set of heuristics that have been handed out in the testing guidelines, (Appendix L). The heuristics "*are general rules that seem to describe common properties of usable* [systems]. The inspector (expert) is also allowed to consider any additional usability principles or results that come to mind that may be relevant for any specific dialogue element" (Nielsen, 2005, p.1).

The second phase was to demonstrate Monumental-IT's robotic interface to each expert, with task-steps presented one-by-one. Experts were allowed six minutes to compose and write his or her observations on the usability of the interface in each task-step. Within those same six minutes, the expert was asked to "think aloud" to allow the experimenter to understand the expert's cognitive understandings of the system. In this phase, the expert completed the task-analysis sheet, and the experimenter was also writing notices from the "think aloud" talks of the expert.

Upon completion of the evaluation and task-analysis sheet, the expert executed all task-steps, the experimenter collected the sheet, and then asked each expert, in a 15

minute debriefing session, about his or her recommendations and overall impressions on the system.

5.3.3 Measurement

Heuristic evaluation "is [a] usability engineering method for finding the usability problems in a user interface design" (Nielsen's Website, 2005). The Monumental-IT interface has been evaluated against six heuristics in two main categories, (1) a *general category* heuristics defined following Nielsen's heuristics ("recognition rather than recall," "visibility of system status," "user control and freedom," and "aesthetic and minimalist design"); and, (2) a *category-specific* heuristics ("differentiate Monumental-IT's configurations," and "response rate to human-monument interaction"). For more details, see Appendix L.

Five usability experts evaluated the system and recorded the violated heuristics for each task step on the heuristic evaluation sheets provided. According to Nielsen, five experts should identify 75% of usability problems, (Nielsen, 1993, p.156). As the main idea has been to improve the usability of the interface for better user-robotic interaction, I have used the recommendations from the first three experts to enhance the usability of the interface; the last two experts then conducted heuristic evaluations on the developed prototype so as to identify violated heuristics (if any).

5.3.4 Participation

Five experts evaluated Monumental-IT: four males and one female. Three of these experts initially evaluated the system: the first and the second were "single-experts" in

the domain field of architectural-robotics, and the third was a "single-expert" in designing digital interfaces. The experts evaluated the prototype shown in Figure 5.7 - left, with a plaque/signage placed on the left side of the model as shown in Figure 5.7 - right.

Figure 5.7 Monumental-IT's prototype (left), and the plaque that have been left on the left side of the model-base (right)

Finally, the two remaining "double-experts" in the domain fields of architectural-robotics and usability evaluations evaluated Monumental-IT. They evaluated a different iteration of the interface (i.e., the physical prototype) in response to the former three experts' recommendations for Monumental-IT (Figure 5.9).

5.3.5 Results

The results are divided into two parts. In the first part, I describe the results of the heuristic evaluations of the first three experts on the system. In the second part, I describe the results of the heuristic evaluations of the latter two experts on Monumental-IT.

The first expert reported three violated heuristics on Monumental-IT's interface: (1) on task-step two, "reading Monumental-IT's plaque," he reported that this step

violates the "aesthetics and minimalist design" and "recognition rather than recall" heuristics. He suggested to change the place of the plaque and have it as a press concrete on the front of the monument; (2) on task-step three, "start recalling memories," he reported that it violates the "recognition rather than recall" heuristic. He explained that memories take more time to recall than to quickly recognize, which cannot be avoided; and (3) on task-step four, "speak on the microphone to express emotions about the history of slavery," he reported that it violates the "recognition rather than recall" heuristic. While the abstraction of the microphone's shape was appropriate, it was difficult to discern the importance of having the microphones in the site of Monumental-IT. The expert suggested using formed concrete signage at the base of the microphone, inscribed with "speak" to help users recognize that they need to speak to activate the monument.

The second expert reported different violated heuristics on Monumental-IT's interface: (1) on task-step one, "walk to start interacting with Monumental-IT," he noticed that this step violates the "visibility of system status" heuristic. He suggested using signage or a banner to encourage visitors to start interacting with Monumental-IT. This recommendation is also supporting the first expert's suggestion having a cue or a sign; (2) on task-step seven, "the audio starts," he reported that it violates the "response rate to human-monument interaction" heuristic. Yet, he was not able to judge whether the sound could be optimized or not because of the electronic noise that the hardware (microcontroller) produces; and (3) on task-step eight, "people start to connect past memories about the history of slavery within the space of Monumental.IT and use the space as a contextual cue for later retrieval" he reported that it violates the "aesthetic and

minimalist design" heuristic. He suggested using an overlay of images from the slavery period to be projected on the skin of Monumental-IT, to strengthen associations between the past and present.

The third expert reported one violated heuristics on Monumental-IT's interface: on task-step two and three, "reading Monumental-IT's plaque" and "start recalling memories," he noticed that it violates the "visibility of system status." He suggested using signage to explain what the user should be doing in order to interact with Monumental-IT.

Figure 5.8 Monumental-IT's developed prototype showing a signage on each microphone (left), and the design of the signage (right)

After this first part of the evaluations, I employed the three experts' recommendations of the design to the design of the monument, enhancing the prototype. I altered the plaque and placed signage on each microphone that communicates what the visitors can do to interact with Monumental-IT. The signage was comprised of three words: "Recall" (the history of slavery), "Speak" (about your memories and emotions), and "Experience" (the collective memory). The signage also includes a brief description

about the monument (Figure 5.8). Also following the suggestions of the experts, Monumental-IT's skin was "texturized" by projecting images from the "Documenting the American South" website on it (Figure 5.9), (Appendix G for the selected images).

Finally, the two "double-experts" evaluated the enhanced prototype. The fourth expert did not report any violated heuristics. She only asked about the definition of "M.IT," engraved on the Aluminum plates at the base of the posts, suggesting that the definition of "M.IT," which is Monumental-IT, be integrated into the design of the microphone's signage. She expressed an appreciation of the design and the usability of the monument. The fifth expert did not find any violated heuristics, and stated that the interface is easy to understand and easy to use.
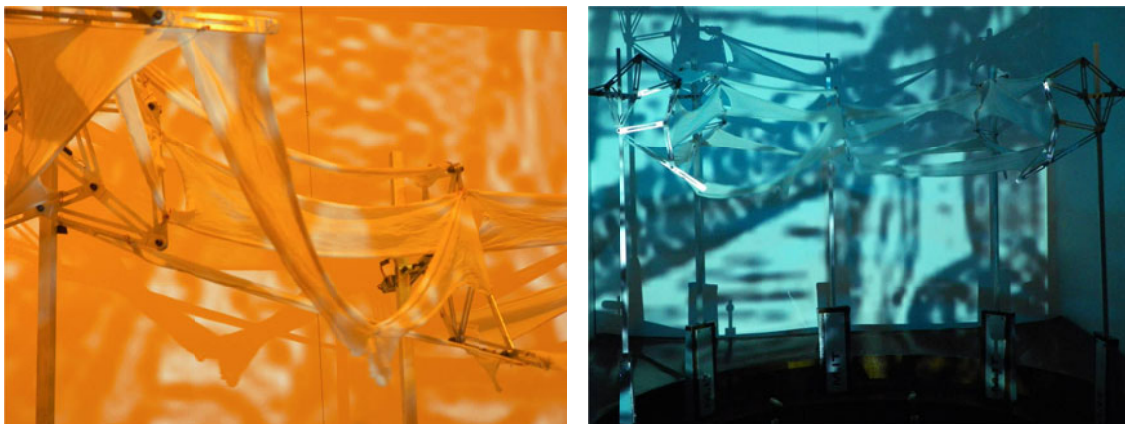
Figure 5.9 Two configurations for Monumental-IT after projecting images on its skin

The cognitive walkthroughs and heuristic evaluations of the "robotic-wiki" monument, calling it Monumental-IT, supported the design of the interface as a platform for visitors to easily interact and understand Monumental-IT. Ultimately, Monumental-IT is an easy and understandable platform for sharing memories. Monumental-IT should

also be evaluated by users, who will provide additional significance to the results described previously, as considered in the next section.

CHAPTER SIX

QUASI-EXPERIMENTAL DESIGN FOR MONUMENTAL-IT

Monumental-IT has been designed according to human-centered design approach and an iterative design process. Monumental-IT has been evaluated by users and experts against a set of usability and concept-specific requirements. The goal is to develop a design that meets users' requirements. In the following study, I employed surveys to evaluate the effectiveness of the multi-sensorial robotic features of Monumental-IT's prototype in enhancing the human-robotic interaction in public spaces.

For this project, I am using a quasi-experimental research design to evaluate the physical robotic components of Monumental-IT. This quasi-experimental research design is widely used for evaluation in the social and behavioral sciences (Campbell and Stanley, 1966/1963; Cook and Campbell, 1979; Singleton and Straits, 2005/1988).

6.1 Quasi-experimentation (Separate-Sample Pretest-Posttest design)

In evaluating the effectiveness, understandability, and usability of the human-robotic interaction in response to Monumental-IT's contextual and formal cues, I am using the "Separate-Sample Pretest-Posttest" design – a "quasi-experimentation" design. In this research design, two separate user groups participate in the experiment. To begin, the first test group takes the pretest-1 survey. This group encounters treatment X, consisting of Monumental-IT's multi-sensorial features. The same group then takes another survey, posttest-1, during the same session with less than 2 minutes elapsing between surveys. The two tests are named O_1 and O_2, respectively. The second test group

takes only a single posttest survey after having experienced treatment X. This single posttest survey is named posttest-2, or O_3.

"Quasi-experimentation" is a research design in which "experiments have treatments, outcome measures, and experimental units, but do not use random assignment to create the comparisons from which treatment-caused change is inferred" (Cook and Campbell, 1979, p.6) and "because full experimental control is lacking" (Campbell and Stanley, 1966/1963, p.34). I employed the "quasi-experimental design" instead of an "experimental design" for two reasons. First, although controls in a laboratory setting can be more straight forward than in a field setting, the full control of the experiment would still be lacking due to the complexity of surrounding social interactions with the prototype. Second, it is not possible to bring to a laboratory the relatively large population needed for an experimental design.

There are many variables to consider in describing the complex social interactions that occur *in a lab setting* when simulating a monument to be used in an open public space such as proposed for the site of this project (in front of the Old Slave Mart in Charleston). In a lab setting, we also must consider how to mitigate threats to the construct validity of the project.

The first consideration is that, when conducting a study on human-robotic interaction with the Monumental-IT prototype *in a lab setting*, there are no sounds that can simulate the changing outdoor environment of Charleston. The lack of "real life" urban sounds can change the effectiveness of user-interaction with Monumental-IT. Yet, if the surrounding urban sounds do have an effect on user-interaction with Monumental-

IT, the sound level and the position of the speakers in the real setting in Charleston can be tuned to be similar to what is used in the laboratory. For this study in the lab setting, the sound level of the audio that has been used from the two loud speakers was calibrated using a simple code within the MATLAB software. This code indicated that the sound level of Monumental-IT's audio source varied from 73 dB to 86 dB when the speakers where at a height of 45 cm, and 1.2 meters away from the table where users participated in the survey, (Figure 6.1).
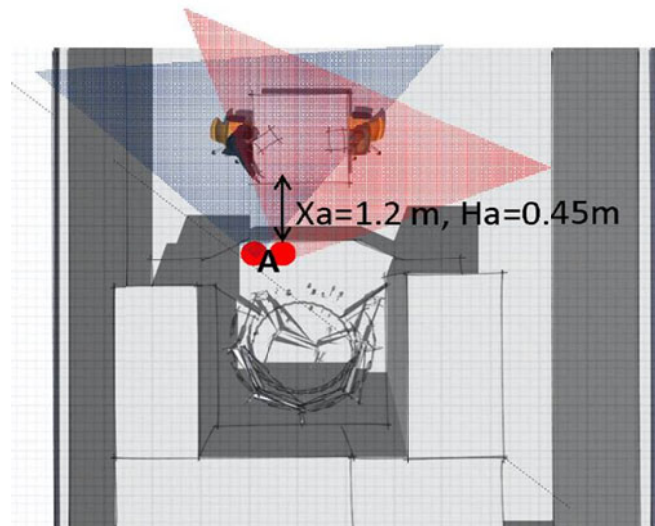
Figure 6.1 Plan view showing the position of the speakers at "A," where the audio for Monumental-IT's prototype takes place

As for the second consideration, the buildings surrounding the real Monumental-IT affect the way the participants understand the monument. This effect of not having the real surroundings has been reduced by using projected images of the surrounding buildings on the walls of the scaled structure, and showing the context to the participants before they proceed with the experiment. As for the third consideration, because the scaled prototype is not the full scale structure, there is the possibility that the users will

not have a sense of the true physical dimensions of the prototype. Thus, I have inserted a scaled model of a person at 1:6 to help participants better understand the anticipated scale in relation to the structure while they are watching the prototype (Figure 6.2). Finally, the perceived colors of the LEDs may vary from person to person, from daylight to night-light, and from one season to another. There is no control for this factor in the study, but the LED colors have been kept consistent throughout the experiment. Moreover, I have used the same materials for the scaled prototype as would be employed in the full-scale physical monument described in chapter four.
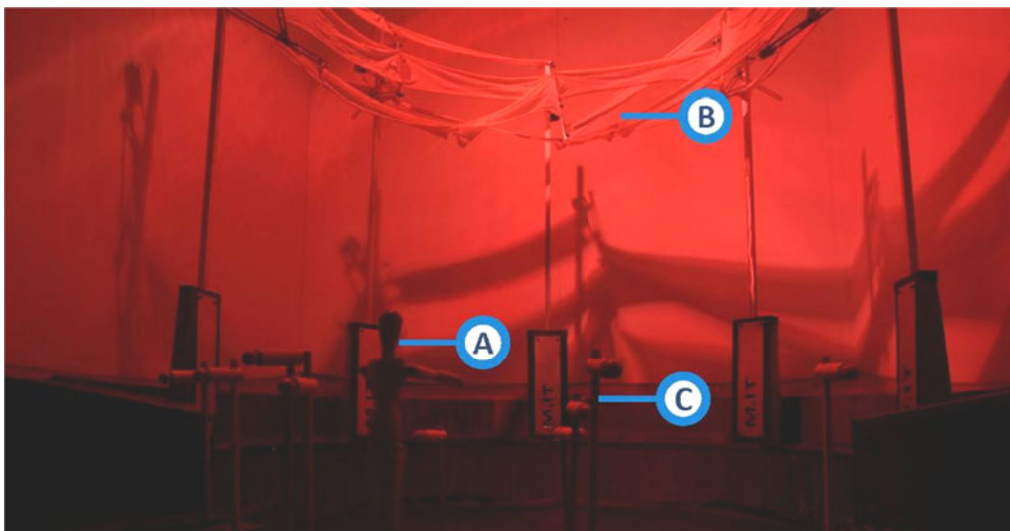
Figure 6.2 Monumental-IT's scaled prototype showing A- scaled model of a person, B- scaled microphones, and C- the scaled prototype

6.1.1 Controlling threats to internal validity

One of the main threats to internal validity[1] for this type of research design, as Campbell and Stanley described in their seminal work, *Experimental and Quasi-*

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[1] *Internal validity* as described by Campbell and Stanley, "refers to the approximate validity with which we infer that a relationship between two variables is causal or that the absence of the relationship implies the absence of cause" (Cook and Campbell, 1979, p.37).

experimental Designs for Research, is "failure to control for history" (Campbell and Stanley, 1963, p.53). On the other hand, Cook and Campbell maintain that we can control for such threats by "insulating respondents from outside influences [in laboratory research]" (Cook and Campbell, 1979, p.51). "History" as a threat to internal validity "consists of events in the subjects' environment, other than the manipulated independent variable, that occur during the course of the experiment and that may affect the outcome, [calling them extraneous variables]" (Singleton and Straits, 2005/1988, p.188).

Taking this into consideration, I rigorously and consistently applied procedures in the laboratory setting that allowed the elapse of just two minutes between the pretest-1 and the posttest-1 experiments for the first group, (see section 6.1.2 for a detailed explanation).

Following from Campbell and Stanley, the Separate-Sample Pretest-Posttest design successfully controlled for five factors relating to internal validity. These are: (1) *testing*[2] (controlled by subtracting the responses of the separate group posttest-2 $[O_3]$ from the responses of the first posttest-1$[O_2]$, $[O_2-O_3]$); (2) *instrumentation*[3] (keeping the participants unaware of the ongoing experiment, and selecting groups that are not familiar with each other so as to avoid what Cook and Campbell described as "interviewer expectations [that] may create differences"); (3) *statistical regression*[4] (not a

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[2] As described by Cook and Campbell, testing is "a threat when an effect might be due to the number of times particular responses are measured [when taking more than one test]…familiarity with the test sometimes enhance performance [thus should be avoided]" (Cook and Campbell, 1979, p.52).
[3] Instrumentation is "a threat when an effect might be due to change in the measuring instrument between pretest and posttest and not to the treatment's differential impact at each time interval" (Cook and Campbell, 1979, p.52).
[4] Regression is a threat "operating where groups have been selected on the basis of their extreme scores" (Campbell and Stanley, 1966/1963, p.5).

concern in this design, because the Separate-Sample Pretest-Posttest design has no control group); (4) *selection* (also not a concern since there is no selection due to likeness or previous scores); and (5) *mortality* (controlled by having pretests and posttests not separated in time).

According to Campbell and Stanley, the Separate-Sample Pretest-Posttest design has three weaknesses (i.e., threats): (1) *history* (addressed as described previously); (2) *maturation*[5] (not relevant in this study since the time interval between tests was not separated by long periods of time); and (3) *interaction of selection and maturation* (also not relevant in this study due to the lack of time-separation between pretest and posttests' treatments).

6.1.2 Controlling threats to external validity

Concerning threats to external validity[6], or "representativeness," the research design controlled for the different threats to external validity (i.e., aiming to produce an approximate generalization). Another reason for choosing to use the Separate-Sample Pretest-Posttest design is that it is considered an apt design for controlling threats to external validity, because it "puts so little demand upon the respondents for cooperation, for being at certain places at certain times, etc., that a representative sampling from populations specified in advance can be employed" (Campbell, 1966/1963, p.54).

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[5] Maturation is a threat when "the respondents' growing older, wiser, stronger, more experienced, and the like between pretest and posttest" (Cook and Campbell, 1979, p.52).
[6] *External validity* refers to "the approximate validity with which we can infer that the presumed causal relationship can be generalized to and across alternate measures of cause and effect and across different types of persons, settings, and times" (Cook and Campbell, 1979, p.37).

As for mitigating threats to external validity: (1) the threat of "interaction of testing and X [treatment]" in which "a pretest might increase or decrease the respondent's sensitivity or responsiveness to the experimental variable and thus make the results obtained for a pretested population unrepresentative of the [examined] effects" (Campbell, 1966/1963, p.6) was controlled, as described in mitigating the threat of testing in the previous section; (2) "interaction of selection and X [treatment]," also called "interaction effects of selection biases," was controlled by recruiting participants on a voluntarily basis and those having free time are likely to spend some time watching monument, and who are not being paid or receiving other types of inducements; and (3) the threat of "reactive arrangements" that affect "persons being exposed to [the treatment] in nonexperimental settings" was controlled by having participants take the test in a laboratory setting under rigorously applied procedures (Campbell and Stanley, 1966/1963, p.6).

6.2 Quasi-experimentation design

I designed two surveys for this study, a pretest-1 survey, which included open and closed questions on Monumental-IT's contextual and formal cues in the static mode (i.e., with no interaction with its robotic multi-sensorial features), (Appendix N); and a posttest survey which included open and closed questions on Monumental-IT's changing contextual and formal cues when the monument was interacting with its users, (Appendix O).

Both the pretest and posttest surveys included the following categories of information: demographic questions, user-monument background, specific questions on

slave narratives, design questions on narratives and Monumental-IT, "forms in motion" and emotions, colors and emotions, sounds and emotions, and general questions including open and closed questions on users' experiences with Monumental-IT. The two survey forms, the recruitment email form, and the two informational letters for conducting the experiment have been approved by the Informational Review Board (IRB) at Clemson University before conducting the experiments, (Appendix R).
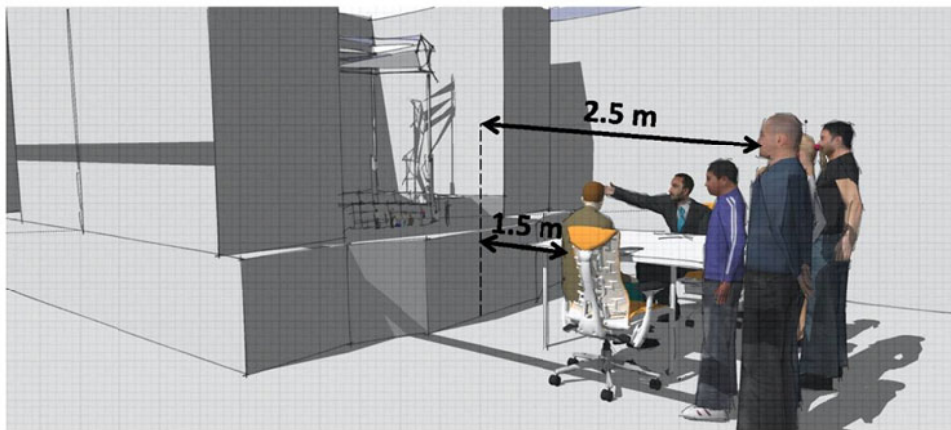
Figure 6.3 Participants conducting the quasi-experimentation for Monumental-IT in a lab setting

For this study, I used *convenience and purposive sampling*, a non-probability sampling. Participants were recruited on a voluntarily basis, using email invitations (Appendix M). The participants completed the survey in not more than 40 minutes for the first experiment (i.e., pretest-1 and posttest-1 surveys), one group at a time; and in 30 minutes for the second experiment (i.e., the posttest-2 surveys). Monumental-IT was set up in a room with the scaled physical prototype facing the participants (Figure 6.3). The horizontal distances between the participants and the physical prototype ranged from 1.5 meters to 2.5 meters.

The pretests and posttests were designed for a laboratory setting in which groups of participants ranging from 2 to 8 participants take surveys, one group per session. For the first group, those taking the pretest-1 and posttest-1 surveys, I established controls for the pretest study so that all participants have no knowledge of how the experiment will proceed (i.e. there is no explanation that the work is interactive). I only explain that the survey has a "part two" to be introduced to them after the participants finish the first part. Also there are no extraneous sounds that can adversely affect Monumental-IT's sounds. Likewise, the LEDs are not changed or replaced throughout the whole study. Monumental-IT's program was uploaded to the microcontroller, as described in the prototype section, insuring that all participants had the same treatment regarding the monument's motions, colors, sounds, and textures, (i.e., the independent variables). "Textures" are projected images on the skin of the prototype, uploaded as a GIF file to the digital projector and consistently projected every time the treatment started.

In the pretest experiment, Monumental-IT was presented as static with no motion or color or any of the hypothetical treatments. The participants were then asked to complete a survey (O_1). After that, the same participants were presented with the monument consisting of the monument interacting with them by means of pushbuttons, instead of the microphones, using all the hypothetical treatments of the reconfigurable sounds, motions, colors and textures, posttest-1 experiment. Participants were then asked to fill out another survey (O_2).

For the posttest-2 experiment, another group of participants were selected. This time users did not fill out a pretest survey; they only interacted with the monument

exhibiting all the hypothetical treatments described previously. Participants were then asked to fill out survey (O_3). The tests were conducted in the laboratory at various times of the day, but there was no access to daylight.

6.3 Quasi-experimentation procedure

The pretests and posttests quasi-experimentations were conducted in a closed room where the physical prototype was set up. The room does not permit any distractions or daylight. The participants were brought to the room in groups from 2 to 8 participants at a time, according to the participants' availability to conduct the experiment. Participants entered the room and were asked to sit at the table shown on Figure 6.3, where chairs are provided if needed.

There were two different informational letters, one for the pretest groups and the other for the posttest groups. I handed these out at the beginning of each group's session. They included the following sections: a description of the study and the participants' role in it, risks and discomforts, possible benefits, protection of privacy and confidentiality, choosing to be in this study or not, the option of stopping at any time, and contact information for the person if the participants have any questions or concerns about this study (Appendices P and Q). After I handed out and explained the content of the information letters, and obtained the agreement of the participants to conduct the experiment, I handed out the survey forms (Appendices N and O).

For the pretest-1 and posttest-1 experiment, participants were initially given pretest informational letters and survey forms. After they completed the pretest survey, I handed out the posttest informational letters and posttest survey forms. After they agreed

to participate in the second part, the posttest-1 experiment, I reduced the light of the room to have the full effect of the LED colors. I then explained to participants that I will be showing them four different configurations for Monumental-IT, assuming it has analyzed the sounds collected by its microphones to reflect the emotions of the participants on the history of slavery. The participants were free to ask, at any time, to repeat any of these configurations, defining them by colors (i.e., the blue configuration, red configuration, green configuration, and blue configuration). After the participants finished the surveys, I collected the surveys and thanked them for participating in the study. Also, I frankly asked them to keep what they had done as a secret for at least two weeks, to obtain the maximum effect from my quasi-experimentation method.

6.4 Measurements

The aim of the quasi-experimentation design for this study is to evaluate the effectiveness and understandability of the human-robotic interaction with Monumental-IT's contextual and formal cues. The quasi-experimentation study helps to:

(1) Determine the extent to which the probability of having an effective human-emotion interaction varies with the change of Monumental-IT's colors, motions, sounds, and textures.

(2) Measure the *effectiveness* of Monumental-IT's interactive multi-sensorial features (the treatment) on human-robotic interaction.

(3) The *significance* of Monumental-IT's *multi-sensorial configurations* on the human-emotion interaction with Monumental-IT.

(4) The age of those who would be interested in visiting Monumental-IT.

(5) Whether or not Monumental-IT can help people recall memories regarding the history of slavery.

The surveys have other components that help to evaluate the effectiveness of data-mining historical documents as a mean of presenting people's emotions. Additionally, the surveys begin to suggest if Monumental-IT's different configurations represent the same interpretations about historical documents for each person. This in turn can demonstrate the usefulness of Monumental-IT for revealing the many personal differences involved in the interpretation of history.

After the participants conducted the experiments, I collected the data, coded it, and analyzed it using multivariate statistical methods (i.e. Chi-square analysis, and analysis of variance – ANOVA). For measuring the effectiveness of Monumental-IT's interactive multi-sensorial features on human-robotic interaction, I use the Separate-Sample quasi-experimentation design as follows:

O_1 X O_2 (pretest-posttest)

X O_3 (posttest) >> Treatment effect= $(O_2 - O_1) – (O_2 - O_3)$

6.5 Participants

I used *purposive* (nonprobability) *sampling*[7], since Monumental-IT had been designed with two types of personas in mind: "Megan Fox" and "George Smith". Knowing the target group (end users) using a nonprobability sampling can be an acceptable alternative. In this study, the use of purposive sampling helped in recruiting

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[7] Purposive sampling is a nonprobability sampling, where "the investigator relies on his or her expert judgment to select units that are 'representative' or 'typical' of the population" (Singleton and Straits, 2005/1988, p.133).

probable visitors of monumental sites who would be, in turn, more relevant to the expected end users (visitors) of Monumental-IT. The variations on the selected nonprobability sampling for this study are evident as (Table 6.1): 17 (53.1%) males to 15 (46.9%) females, the ages range from 18 to 34 are 84.4% and the ages range from 35 to 65 are 15.6% (M=29.16, SD=19.2) representing the two personas described before, 43.7% are employed and 56.2% are non-employed, annual income ranges from less than $20,000 to more than $150,000 (M=6.22, SD=3.215) on a scale from 1 to 11 etc.

The demographics of the participants in the quasi-experimental design

	Age*		Gender		Employment	
	18 to 34	35 to 65	Male	Female	Employed	Non-employed
Number of Participants	27	5	17	15	14	18
	(84.4%)	(15.6%)	(53.1%)	(46.9%)	(43.7%)	(56.2%)

* On a scale from 18 to 65, M=29.16 and SD=19.2

Table 6.1 The demographics of the participants in the quasi-experimental design
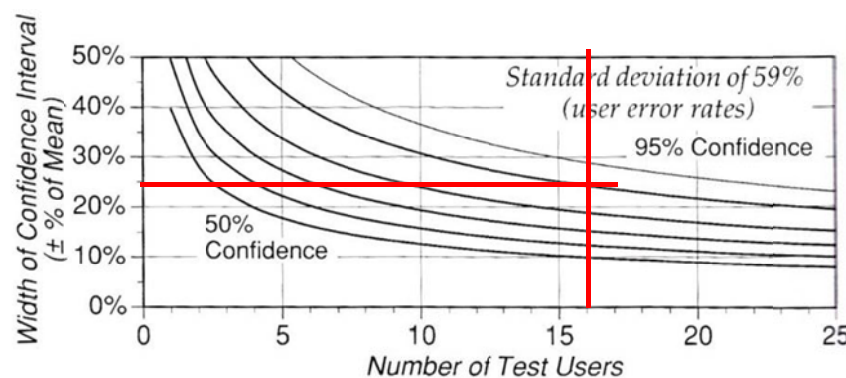
Figure 6.4 Confidence intervals for usability testing (source: Nielsen, 1993, p.168, emphasis added)

In order to measure the effectiveness and the understandability of Monumental-IT's formal and contextual cues at 90% confidence level that the true values are no more

than ± 24% different from the mean value, we need 16 users to test Monumental-IT. According to Nielsen, the "90% confidence interval would be ± 24%. This level of accuracy might be enough for many projects" (Nielsen, 1993; p. 169). Consequently, I chose a sample size of 16 participants for the pretest experiment and 16 participants for the posttest experiment, for a total of 32 users.

However, employing nonprobability sampling in this research limits its generalizability. The variations (heterogeneity) in the representative sample and the sample size provide us with a comprehensive practical understanding concerning the use of robotics in the built environment and some preliminary conclusion regarding the scale of public collective environments, Monumental-IT.

6.6 Results

The statistical analysis confirms the significance of using colors, motions, and sounds on the human-robotic interaction with Monumental-IT. The results of using Monumental-IT's different sounds on the human-robotic interaction are significant, as M=4.65, SD=0.608, and Variance=0.37, on a scale from 1 (does not affect) to 5 (highly affects). Among the 32 partipants, 68.8% rated the use of sound as "highly affective," 21.9% as "relatively affective," and 6.2% as "normally affective," while one respondent refused to answer (Figure 6.5, top-right).

The results of using Monumental-IT's different colors on the human-robotic interaction are also significant as M=3.87, SD=0.846, and Variance=0.716; 21.9% of the users rated the use of colors as "highly affective," 46.9% as "relatively affective," 21.9%

as "normally affective," and 6.2% as "relatively does not affect," while one user refused

to answer, (Figure 6.5 top-left).
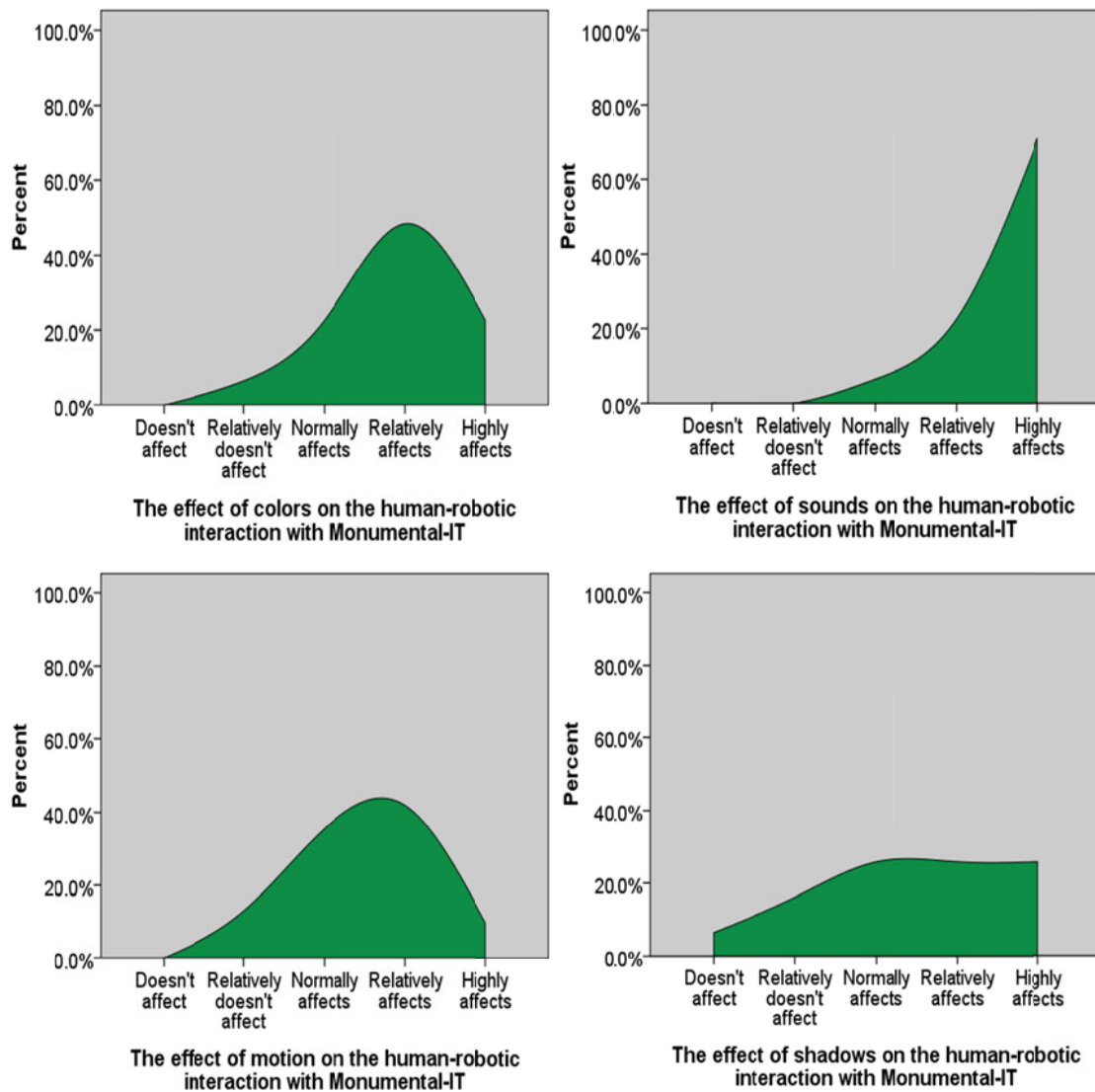
Figure 6.5 Results on using Monumental-IT's colors (top-left), sounds (top-right), motion (bottom-left), and shadows (bottom-right) on the human-robotic interaction with it

Also, the analysis of using Monumental-IT's different motions on the human-

robotic interaction are significant, as M=3.48, SD=0.851, and Variance= 0.725; 9.4% has

rated the use of motion or dynamic structures as "highly affective," 40.6% as "relatively

affective," 34.4% as "normally affective," and 12.5% as "relatively doesn't affect," while one user refused to answer, (Figure 6.5 bottom-left).

Finally, the results on the change of Monumental-IT's shades and shadows due to the structures' motions are significant, as M=3.48, SD=1.235, and Variance=1.525; 25% of the users rated their effectiveness as "highly affective," 25% as "relatively affective," 25% as "normally affective," 15.6% as "relatively does not affect," and 6.2% as "does not affects".

The results show significant support for using colors, sounds, and motions as multi-sensorial features for Monumental-IT. Yet, the effectiveness of these dimensions cannot be only confirmed by considering the responses on the effect of using them on participant's emotions. Nevertheless, the usefulness of the quasi-experimentation as an approximate design that can help in confirming such effectiveness, and to determine to what extent the treatments of using the robotic features improve the human-robotic interaction with Monumental-IT can be clearly seen.

The analysis concerning measuring the effectiveness of Monumental-IT's reconfigurable multi-sensorial features (the treatment) on the human-robotic interaction showed an overall improvement of 134.2%, which suggest that integrating these kinds of features in the design of monuments, and the use of robotic reconfigurable elements in monuments for public spaces are effective. The treatments have been evaluated by asking participants to rate to what extent the different phenomenological features of Monumental-IT affected their emotions. I then used their replies as a unit of analysis in

helping to determine the effectiveness of the human-robotic interaction with Monumental-IT.

Treatment effect on Monumental-IT					
		Effect of Sound	Effect of Colors	Effect of Motion	Effect of Texture
Mean Value	O_1 (Pretest-1)	2.50	2.75	1.00	3.94
	O_2 (Posttest-1)	4.93	4.13	3.60	3.13
	O_3 (Posttest-2)	4.38	3.62	3.38	2.56
Standard Deviation	O_1 (Pretest-1)	1.27	0.775	0.00	0.93
	O_2 (Posttest-1)	0.26	0.52	0.83	1.13
	O_3 (Posttest-2)	0.72	1.03	0.89	1.09
Variance	O_1 (Pretest-1)	1.60	1.20	0.00	0.86
	O_2 (Posttest-1)	0.07	0.27	0.69	1.27
	O_3 (Posttest-2)	0.52	1.05	0.78	1.20
Treatment Effect $(O_2-O_1)-(O_2-O_3)$		1.88	0.87	2.38	-1.38
Change due to treatment effect		0.376	0.175	0.476	-0.276
Treatment Effect in Percentage		137.60%	117.5%	147.60%	72.40%

Table 6.2 Results on Monumental-IT's quasi-experimentation design

As shown on Table 6.2, the "motion" treatment, with a treatment effect of 147.6%, showed the highest effect on the human-robotic interaction among Monumental-IT's multi-sensorial features. The treatment effect means that the use of the robotic programmable actuators in public spaces to change the structures' motion has a valuable effect on the human-robotic interaction with Monumental-IT, and improves the interaction with Monumental-IT by approximately 1.5 times the effect of interacting with a static monument. The use of different sounds likewise suggested a strong effect of

sound on the human-robotic interaction with Monumental-IT, with a treatment effect of 137.6%. This suggests that the reconfigurable sounds improved the interaction with Monumental-IT by approximately 1.4 times the effect of interacting with a static monument.

The analysis of the quasi-experimentation surveys with regard to the reconfigurable colors confirmed the significance of this dimension in interacting with Monumental-IT, with a treatment effect of 117.5%. This treatment effect means that the use of colors has improved the interaction with Monumental-IT by approximately 1.2 times the effect of interacting with a static monument.

The added "textures" to Monumental-IT showed no significant effect on the human-robotic interaction with Monumental-IT, with a treatment effect of 72.4%. We can conclude that the use of textures has not improved the interaction with Monumental-IT. Regarding the use of textures, the results point to the need for more studies to determine a more effective interaction with Monumental-IT, for example, by changing the textures from distorted images to more formal textures.

Additionally, the analyses showed a significant effect for the use of multi-sensorial configurations on the human-emotion interaction with Monumental-IT. For the "blue" configuration, the analysis showed that 100% of the participants found that the kinetic movement, the blue color, and Ji PyeongKeyon's soundtrack of "Over the Green Fields" reflect "sadness," (Figure 6.6 - left). For the "red" configuration, the analysis shows that 96.9% of the participants found that the kinetic movement and Pierre Henry's music "Psyche Rock" reflect "anger," while 3.1% found the kinetic movement reflects

157

"fear," while 3.1% were missing values in answering questions about the effect of the music on their emotions. All participants (100%) found that the red color reflects "anger," (Figure 6.6 - right).
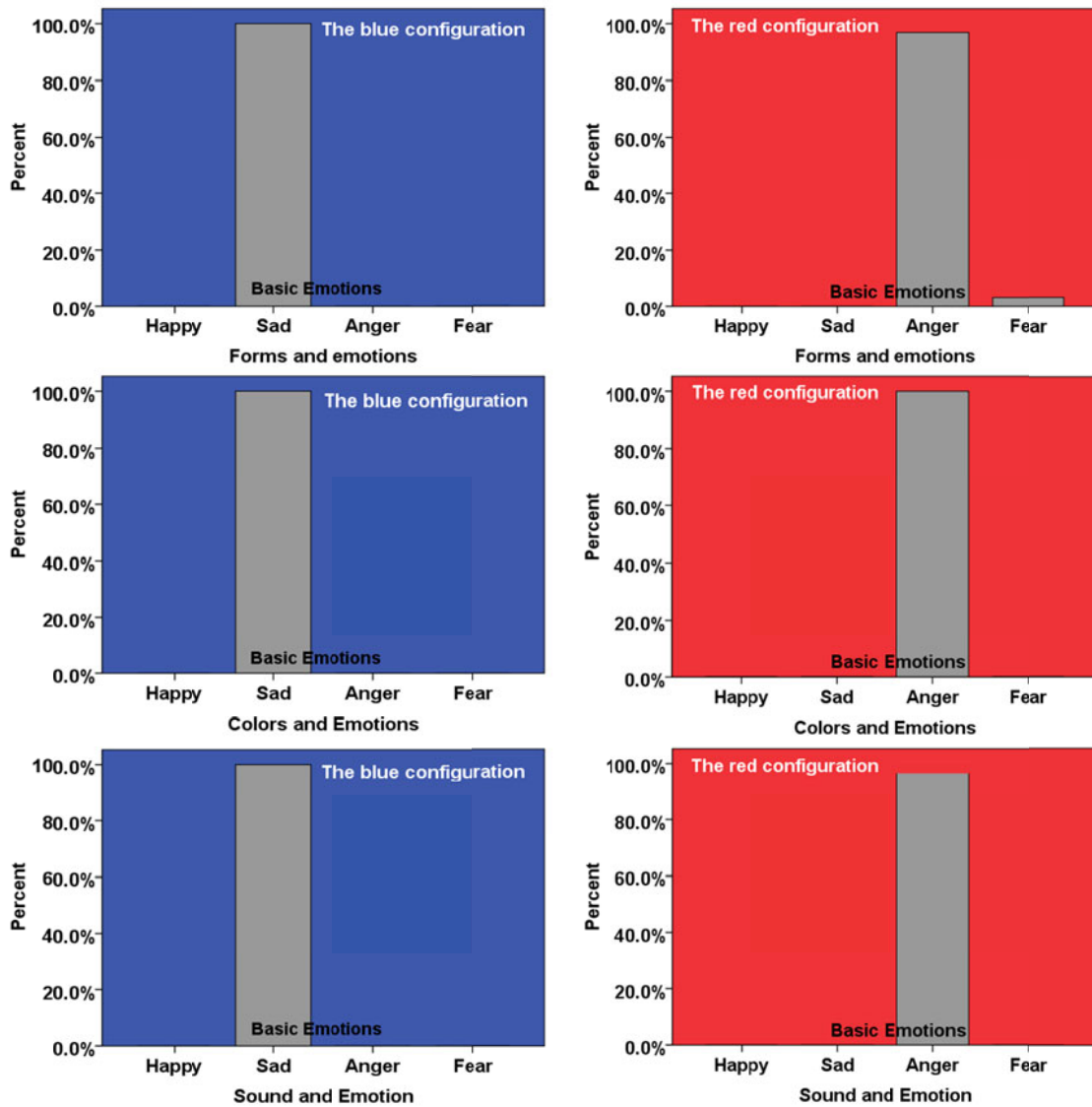
Figure 6.6 Results on the effect of Monumental-IT's forms, colors, and sounds for the blue configuration (left), and the red configuration (right)

For the "green" configuration, the analysis shows that 93.8% of the participants found that the kinetic movement reflects "fear;" 3.1% found it reflects "sadness," and

3.1% were missing values. For the effect of the "green" color on emotions, 81.2% found it reflects "fear," 3.1% found it reflects "sadness," while 12.5% were missing values. For the use of Kevin Macleod's soundtrack of "The House of Leaves," 93.8% found it reflects "fear," 3.1% found it reflects "sadness," and 3.1% found it reflects "anger," (Figure 6.7 - left).
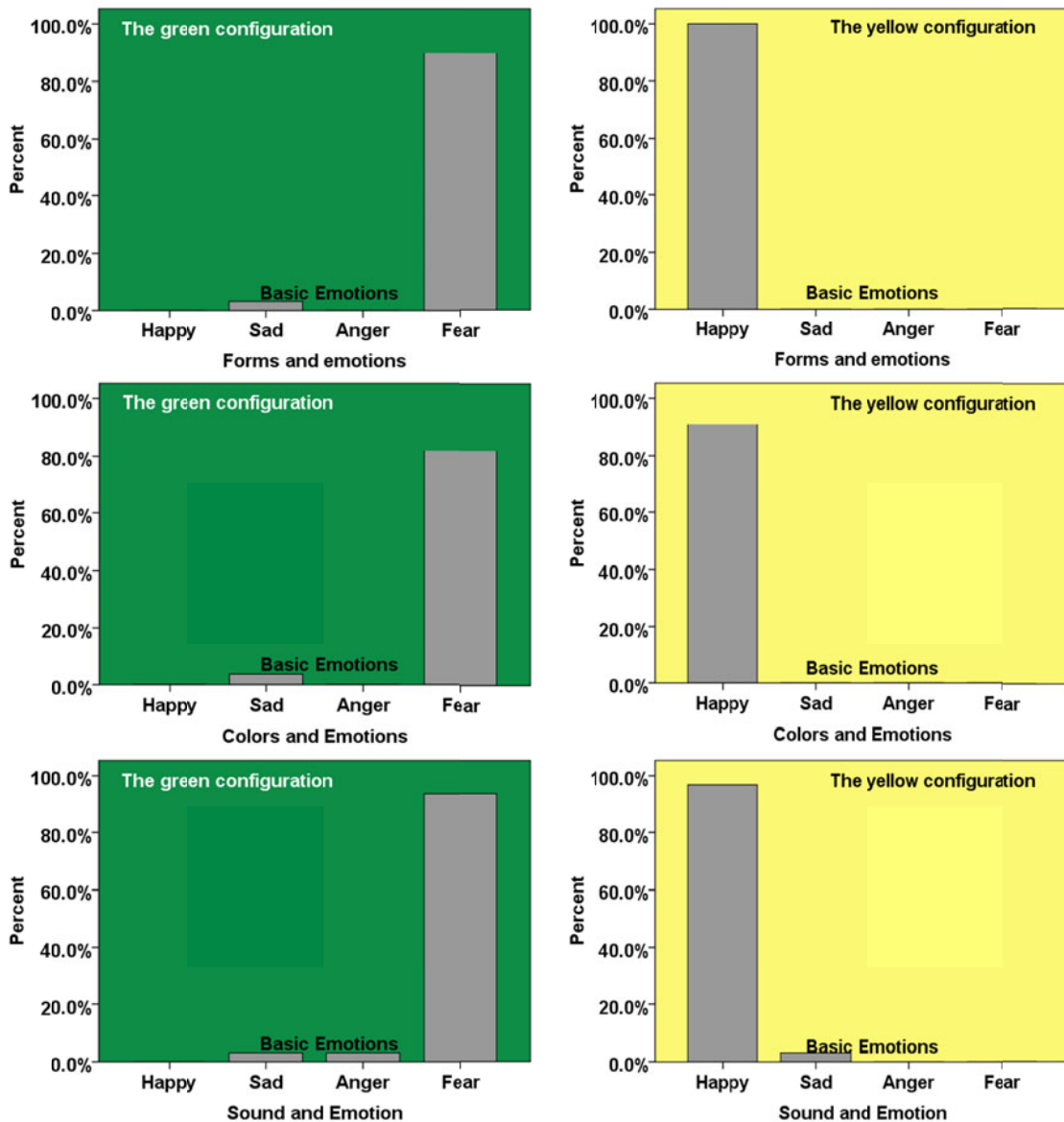
Figure 6.7 Results on the effect of Monumental-IT's forms, colors, and sounds for the green configuration (left), and the yellow configuration (right)

For the "yellow" configuration, the analysis shows that all participants found that the kinetic movement reflects "happiness;" 93.8% of the participants found that the yellow color reflects "happiness;" and 3.1% were missing values; and 96.9% found that Johann Strauss II's music "Perpetuum Mobile – A Musical Joke" reflects "happiness," while 3.1% of the participants found that it reflects "sadness," (Figure 6.7 - right).
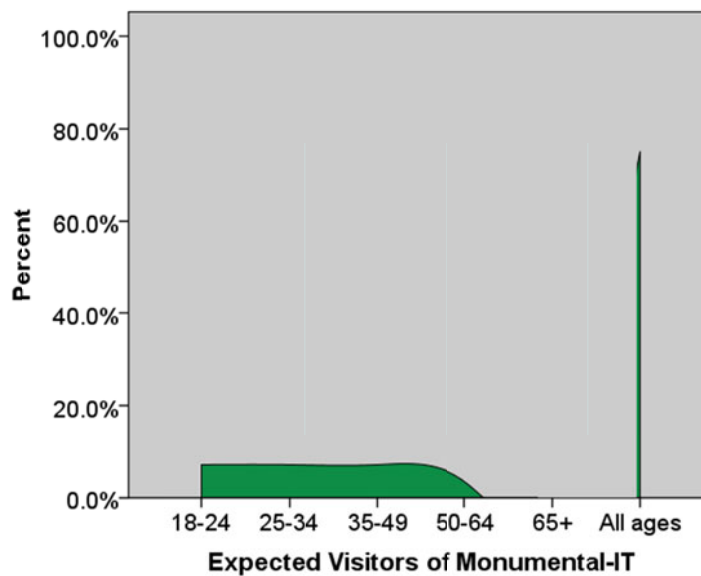
Figure 6.8 Results on the expected visitors of Monumental-IT

The analysis showed significant results for the expected visitors of Monumental-IT to be a monument for "all ages," as M=5.07 on a scale from 1 (for ages from 18-24) to 6 (for all ages), SD=1.72, and variance=2.958, (Figure 6.8). Most of the participants (75%) found that Monumental-IT's expected users will be of any age; while 3.6% found that it will be a monument for users between the ages of 50 and 64; 7.1% found that it will be a monument for users between the ages 35-49; 7.1% found that it will be a monument for users between the ages 25-34; and 7.1% found that it will be a monument for users between the ages 18 and 24.

The Chi-square analysis on whether or not Monumental-IT can help people to recall memories on the history of slavery does not show significant differences between males and females, $X^2=2.01$ at df=1 and p<0.05; yet 92% of the participants had found that Monumental-IT can help people in recalling memories, (Figure 6.9).
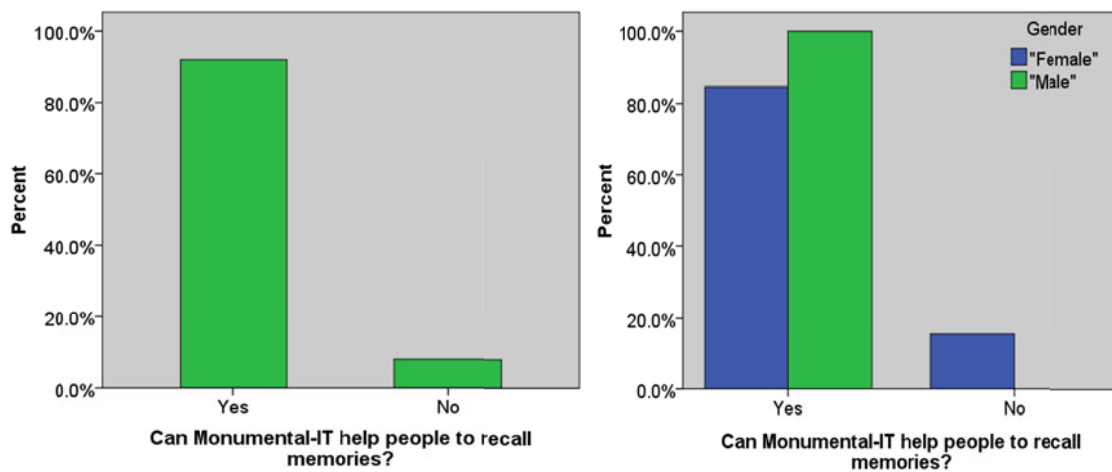
Figure 6.9 Results on whether or not Monumental-IT can help people to recall memories on the history of slavery

The analyses confirm the effectiveness of data-mining historical documents as a means to present people's emotions, as the responses of the participants were mostly similar when asked to read some quotes from the "Documents of the American South" website that constituted the reading part of the WikiMonument. Each quote was selected for its word(s) that reflect one of the four basic emotions, (Table 4.1). The results shown on the graphs of Figure 6.10 represent an approximate confirmation to the idea of using "data-mining" of historical documents to represent the four emotions in the form of the monument, which is also confirmed by analyzing the participants' responses when asked to select the configuration that reflects the emotions of the same quotes (but presented to them in a different order) (Figure 6.11).

161
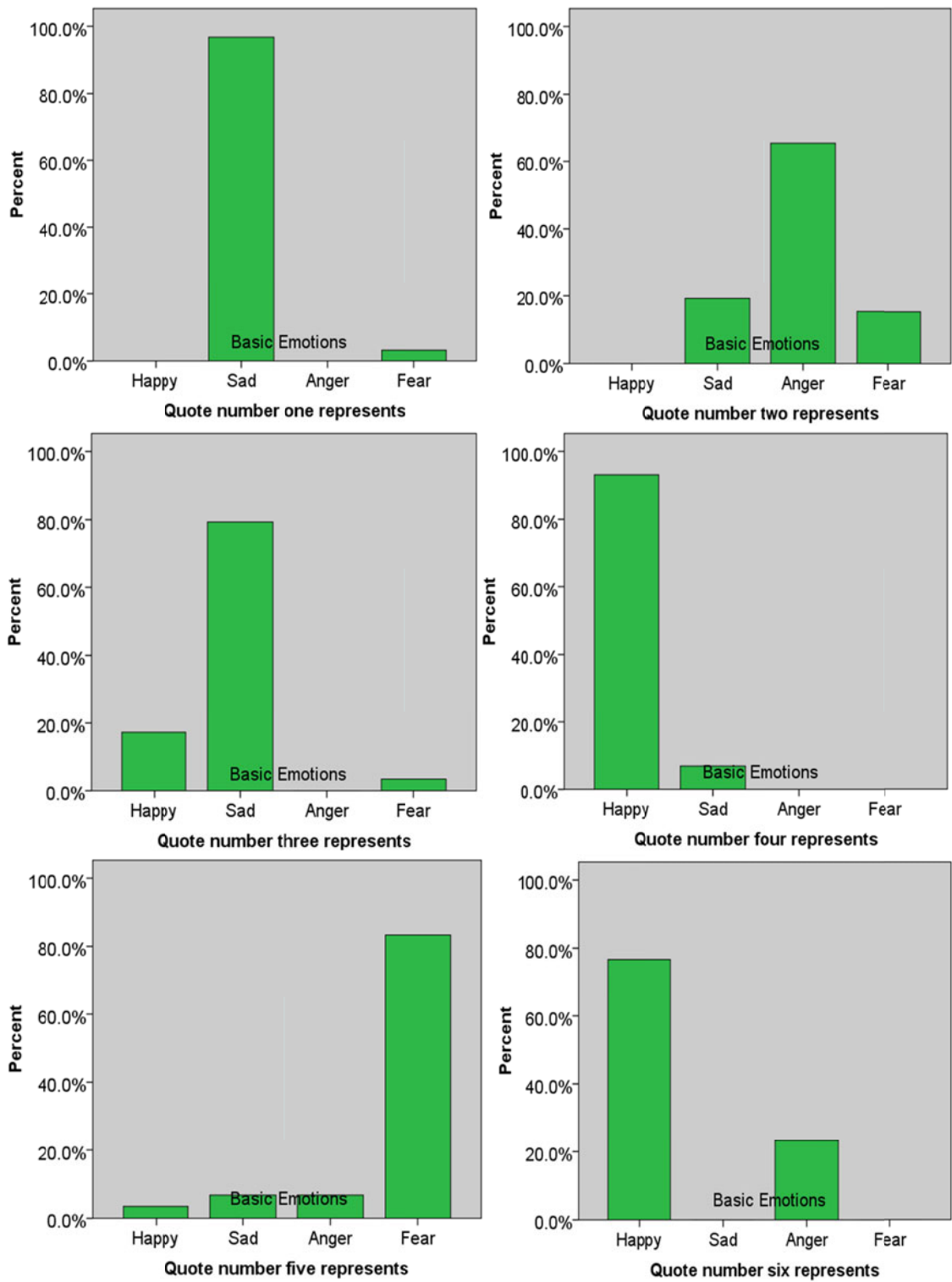
Figure 6.10 Participants' responses on matching the emotion they detect within the quotes (continue)
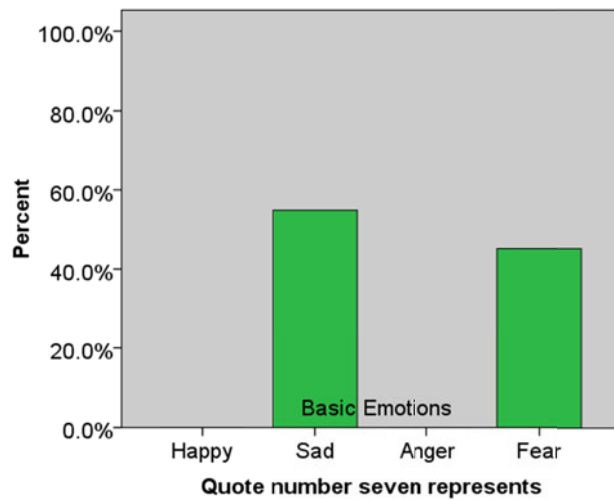
Figure 6.10 Participants' responses on matching the emotion they detect within the quotes

Quote one: "You see, I have such a **hurtin'** in my back en such a drawin' in my knees en seems like de sun does just help me along to bear de **pain**."
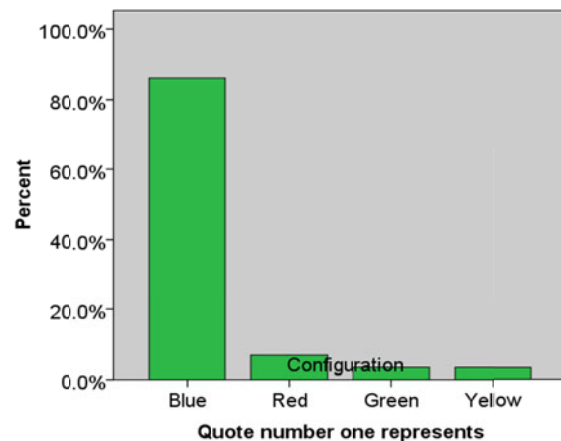
Quote two: "Then Lincoln was **raised up** for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."

Figure 6.11 Participants' responses on selecting the design that matches their interpretation of the quotes (continue)

163
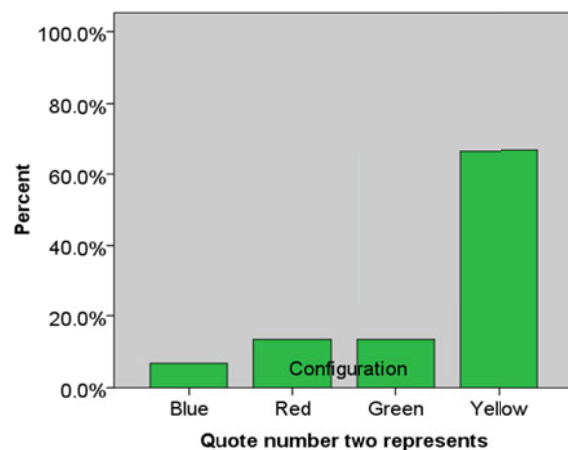
Quote three: "I does **worry** 'bout it so much sometimes."
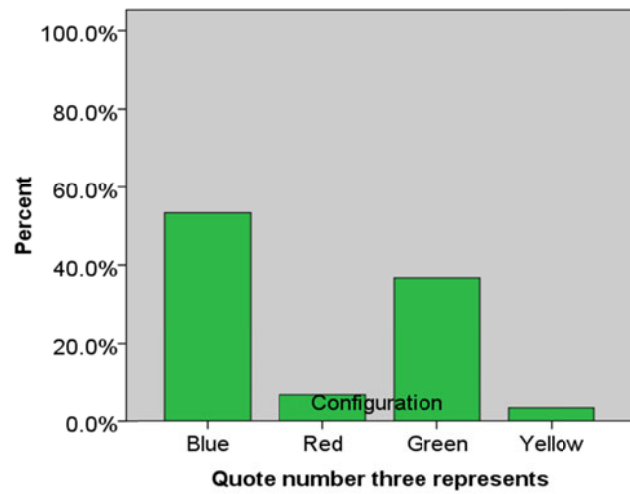
Quote four: "I can tell you 'bout my **poor** soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun **dead** en gone en God left me to live among **dese wild** varments here. I have **to cry** sometimes when I think how dey **die** en leave me in dis troublesome world."
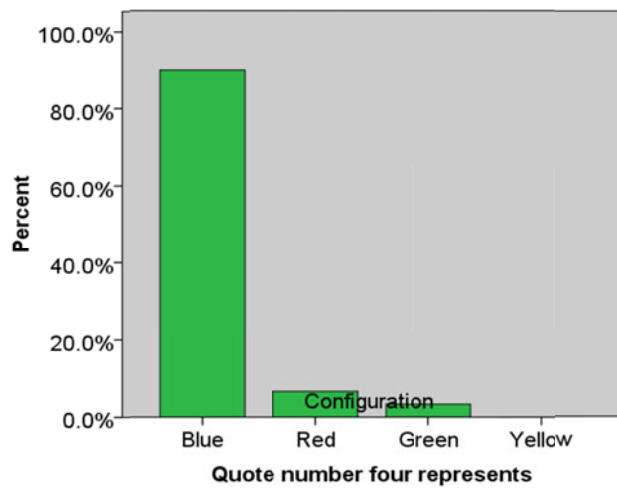
Quote five: "I think 'bout my old mammy heap of times now and how I's seen her **whipped**, wid de **blood** dripping off of her."

Figure 6.11 Participants' responses on selecting the design that matches their interpretation of the quotes (continue)

164
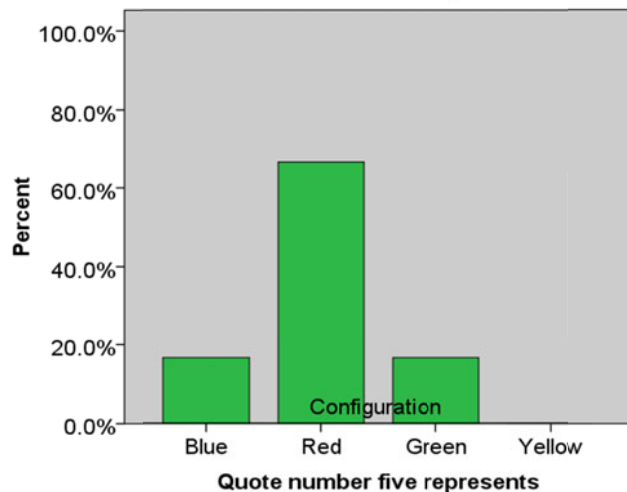
Quote six: "My Master was **kind** to his slaves an' his overseer was all Negroes."
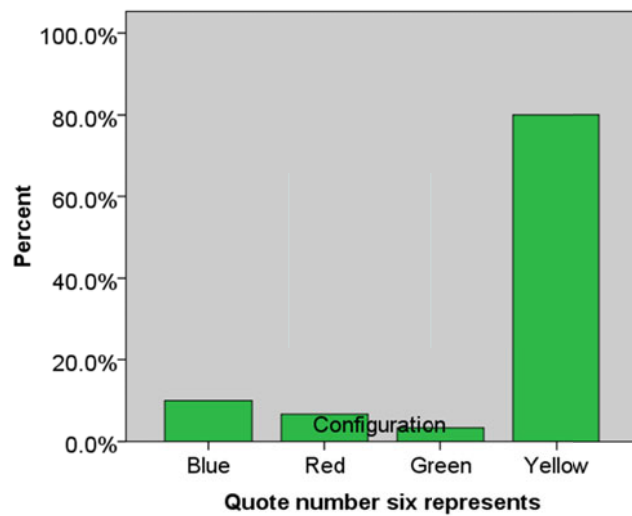
Quote seven: "sometimes niggers could see **ghosts** around dere at night, so dey say."
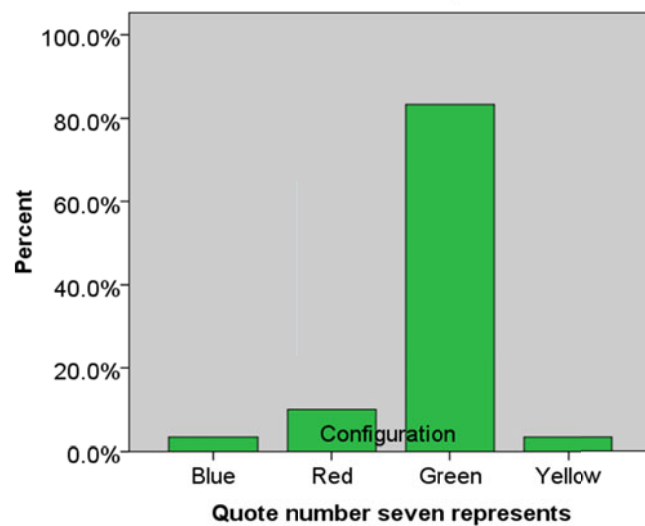
Figure 6.11 Participants' responses on selecting the design that matches their interpretation of the quotes

Participants were asked whether or not Monumental-IT will be a better choice than the existing typologies of monuments. The results show that 83.3% find it a better choice than existing typologies, 11.1% do not think it is better, and 5.6% refused to answer, (Figure 6.12).

Finally, the analysis of the participants' responses on how they describe Monumental-IT after engaging with its interactive multi-sensorial dimensions confirmed

the previous results on the effectiveness and understandability of Monumental-IT as a monument for an increasingly digital world. The findings suggest that the robotic monument has the capacity to convey peoples' emotions concerning a human event of historical significance –a novel human-space-interaction.
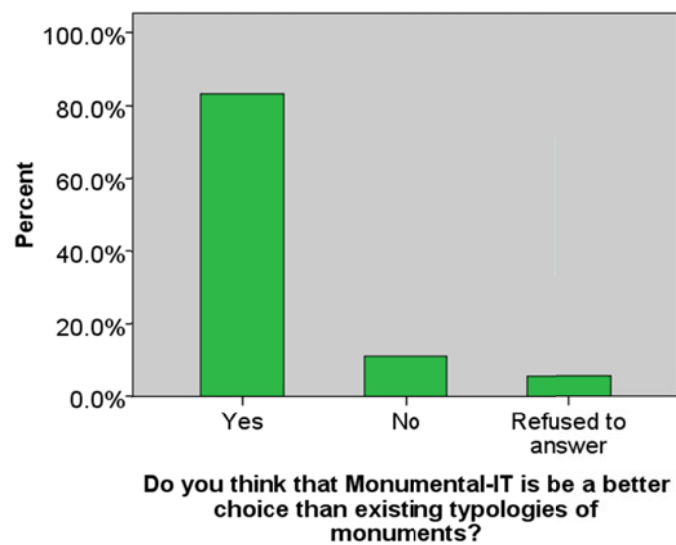
Figure 6.12 Participants' responses on whether or not Monumental-IT will be a better choice than the existing typologies of monuments

The responses showed positive support for Monumental-IT. Participants offered these words about Monumental-IT: "a sound conductor of emotions," "reflects humans' emotions," "soaring above the urban landscape, synonymous with hope and freedom," "adapts to people's emotions," "robotic contraption evokes emotions with texture," "an interactive, moving, horseshoe-shaped, cloth-based monument," "thought evoking and emotional evoking," "interactive with both emotions and feelings," "overpowering," "a monument designed to engage all senses to create memories," "emotionally stimulating," "it is a powerful, multi-sensory experience, through sound, motion and color," "the sensory approach is new, fresh,

and engaging," "a powerful way to represent a sad part of history that should be remembered," "good attempt," "interesting to see the same monument interpreted so many different ways," "it looks sort of like clothes hanging on a line to dry which reminds me of slavery," "very powerful and memorable," "interesting combination of senses to evoke emotions;" "very interesting concept regarding emotion and form," "Interesting and inventive," "an expression of slave-related emotions for the publics' awareness," and "motion, sound, and texture trying to cause emotion." One negative response was offered as "kind of scary looking," while two responses are interpreted as ambivalent: "feels torn and tattered and eerie, almost creepy," and "the monument seems just a touch obnoxious."

Ultimately, the results strongly suggest that the four distinct configurations of the robotic, multi-sensorial Monumental-IT evoke four distinct emotions in users. As well, users interacting with the Monumental-IT prototype evaluate the design as strongly aiding their recollection of human events (here, the history of slavery in the testbed, Charleston, South Carolina, USA). Finally, users overwhelmingly evaluated the Monumental-IT design to be more apt for our increasingly digital society than conventional monument design.

CHAPTER SEVEN

CRITICIAL DISCUSSIONS: EVOLUTION OR REVOLUTION?

"The work of art is concerned with the future and directs us along new paths, a building is concerned with the present…the building has nothing to do with art…Only a tiny part of architecture comes under art: the monuments."

-- Adolf Loos, Architecture

From a formal perspective, Monument-IT can be seen as an evolution in the typology of the monument. Monuments have evolved and changed from platonic to figurative, then from abstract to electronic, or from the "hero monument" to the "social monument," and to what I have called Monumental-IT, an open interactive monument. While the static and petrified forms of monuments satisfy the goal of preserving memories, architects and institutions commissioned to produce monuments have partially excluded people's "interpretations" from the design equation.

If "interpreting" history is open to the diversity and complexity of sharing opposing thoughts and opinions, the idea of having "all" people agree or disagree about a historical event or a person will not be always possible. In contemporary societies, people should have the right to represent and express themselves. Web2.0 has repositioned social power from those individuals or institutions who have had the power to dominate the media in its various forms to "all" people so that they can share and publish for free. For example, internet sources such as YouTube, Facebook, Twitter, and Wikipedia are open to all. Thus, the need for a revolution seems quaint per se. A revolution, that "draw[s] people out from their state of comfort" as Adolf Loos explained, will motivate society to realize monuments that not only preserve memories but also challenge, teach, and inspire

us. Adolf Loos, in the past century, asserted that monuments were the only architectural artifacts that combine both art and architecture, and that while "a work of art is revolutionary, a building is conservative:" "*A work of art is concerned with the future and directs us along new paths; a building is concerned with the present*" (Loss, 1996/1910, p.82, emphasis added).

The research on Monumental-IT supports Adolf Loos's vision. First, Monumental-IT is a *piece of architecture* because it preserves the past and is satisfying to many people. Nevertheless, it cannot satisfy everyone, as Loss foresaw, simply because we do not all share the same backgrounds. Second, Monumental-IT is *a piece of art* that opens and challenges people to look into the future, and open a space for interaction where all sort of emotions can emerge. Even if Monumental-IT as an example of art does not produce a unified form for positive social interaction regarding the history of slavery – we do not know if it will – yet, it can still help us to understand our "uncomfortable zones" and explain reality. Additionally, it can help us better understand patterns that change over time concerning what people like or dislike. It may also explain changing emotional attitudes of people over time. Quoting the Critical Art Ensemble's thesis on "Digital Resistance:"

> "if resistant culture has learned anything over the past 150 years, it's that 'the people united' is a falsehood; this concept only constructs new exclusionist platforms by creating bureaucratic monoliths and semiotic regimes that cannot represent or act on behalf of the diverse desires and needs of individuals within complex and hybridizing social segments" (CAE, 2001, P.15).

Monumental-IT as a work of art and architecture represents an evolution and a revolution in current monumental practices. Monumental-IT can also be seen as a

169

complex form of social-interactional space. It is not only presenting a placeholder for collective memories on the history of slavery, but it also recognizes the complexity of such a placeholder considering that the past cannot be repeated but only interpreted. Recalling the past that is distant from present consciousness can be as simple, or as complex as recalling a dream – a dream we had just had but cannot recall in all of its details, or a dream we cannot recall at all. Yet, recalling the past is more complex than recalling a dream, because it requires, in addition to the dream, reflection and judgment, and the complexity of the historical event itself, especially for sensitive memories as is slavery in the American history.

In this chapter on "Evolution and Revolution?" I discuss lessons learned from designing, prototyping, and evaluating Monumental-IT. My goal is to promote a critical understanding of the complexity of conducting research on complex systems which employ robotics and information technology in the built environment. Finally, I present research contributions for three fields of the research: architecture, robotics, and history.

7.1 Learned lessons from Monumental-IT

Monumental-IT was designed using a human-centered and iterative design process that helps in answering research questions and providing a more comprehensive understanding of a "robotic-wiki" system. Returning to the first research question, what is a monument for a world that is increasingly digital and "free"? In designing Monumental-IT, there were an innumerable number of concepts that might be asked about a free and open monument. This was clarified by identifying the main purposes of the monument, the intended users, and broadly speaking the technology that would be

applicable. These clarifications helped to provide a means to reach the project's goals. The relevant designs were compared and evaluated. Then, several pilot projects helped to identify the challenges as well as the opportunities, described previously in Chapter Three. A final prototype was selected for further iterations and evaluations (Chapters 4, 5, 6).

Figure 7.1 Art sketches created in the process of designing Monumental-IT

During this process, I have learned, first, that while the process of designing a monument should utilize both artistic and functional approaches, specifically, art and architecture, the approach to art is time consuming and nonlinear. The nonlinearity of the work of art can be explained in the use of what I may call the "osmosis effect". By that, I mean getting myself involved with the idea of designing "an open and free monument," and then reflecting that in paintings. These paintings provided an additional entry into various levels of abstraction and into the process of understanding "openness" as expressed in the form of the monument (Figure 7.1). The linearity may have an end, yet in art that seems impossible. Thus, the need for a system that can help in evaluating and

assessing these differences is important. In this system, not only should the objective value of the work be satisfactory, but also the subjective input from colleagues, friends, and family members. In addition, the opinions of lay people who visit monuments can be of great help in easing the challenge of creating an artistic composition. This has been explained in the concept-generation phase, concept description, concept screening matrix for Monumental-IT, and the use of heuristic evaluations and surveys to understand users' objective and subjective responses regarding the system (Monumental-IT), (Chapter 3 for a detailed explanation.)

I have learned, second, that the monument needs to fulfill the functional requirements of being a monument. For instance, the size should be contextually-related and also attractive and evocative. In order to create an attractive and evocative structure that represents people's different interpretations about the past, one source of inspiration was the architecture of complex systems, such as biological systems. Thus, "skin and structure" became a model for this research. This biological analogy helped in creating an organic form which is similar to the complexity and the diversity found in the natural, social, and historical worlds. This was clearly evident in the users' thoughtful responses to Monumental-IT; they describe it as "soaring above the urban landscape, synonymous with hope and freedom;" "it looks sort of like clothes hanging on a line to dry which reminds me of slavery;" and, "a sound conductor of emotions." Thus, the organic forms of Monumental-IT's configurations helped to represent different interpretation of history, as confirmed in users' responses evidenced by the various emotional states that the users reflect, and in the selecting of corresponding configurations. The results confirm that

Monumental-IT is capable of representing different interpretations regarding a complex historical event such as slavery.

Ultimately, in addition to the six characteristics of monuments that were defined based on William Gass's thesis on "Monumentality/Memory," a monument for an increasingly complex and digital society should:

(a) *Respect people's mental models about monuments and interactive systems*. The monument's size should be huge, yet contextually acceptable. Also, the monument's interface should be easy to learn and use. These have been confirmed from the heuristic evaluations concerning the six heuristics for Monumental-IT. The heuristic evaluation results supported the user-robotic interaction and understandability of Monumental-IT. Also, the results shown on Chapter Six (Figure 6.8) on the expected users of Monumental-IT support the acceptability of Monumental-IT among all ages.

(b) *Be reconfigurable*. In this research, I employed closed-loop chain kinematics that used mechanisms that change form by employing the use of effectors and actuators. The results confirmed the effectiveness of Monumental-IT's different motions, with a mean value M=3.48, SD=0.851, skewed toward the high effect rate (Figure 6.5).

(c) *Be responsive*. i.e., sensing people's different emotions and responds accordingly. This has been confirmed by using the quasi-experimentation design of Monumental-IT. The analyses showed a significant effect of an overall improvement of (134.2%) for the use of Monumental-IT's multi-sensorial

configurations on the human-robotic interaction. Also, the analyses showed a significant effect for the use of Monumental-IT's multi-sensorial configurations on the human-emotion interaction with Monumental-IT (Figures 6.6 and 6.7). For the blue configuration, all participants found Ji PyeongKeyon's soundtrack of "Over the Green Fields," the blue color, and the selected motion reflect "sad" emotions; for the red configuration, (96.9%) found Pierre Henry's music "Psyche Rock," and the selected motion reflect "anger" emotions. All participants found that the red color reflects "anger" emotions; for the green configuration, 93.8% found Kevin Macleod's soundtrack of "The House of Leaves," and the selected motion reflect "fear" emotions, and (81.2%) found the green color reflects "fear" emotions; and for the yellow configuration, (93.8%) found that the yellow color reflects "happy" emotions, (96.9%) found Johann Strauss II's music "Perpetuum Mobile – A Musical Joke" reflects "happy" emotions, and all participants found that the selected motion reflects "happy" emotions. These results confirm the responsiveness of Monumental-IT's multi-sensorial features on human's emotions.

(d) *Be usable from a usability perspective.* The user-interface interaction with the monument should be easy to understand, easy to remember, and acceptable. The results on the effectiveness of Monumental-IT's configurations on human-emotion interaction and the positive qualitative responses on Monumental-IT support the understandability of its interface. These results were shown in the previous section, in addition to the qualitative responses which showed that

174

88.4% of the participants were having a positive support for Monumental-IT. Also, the heuristic evaluations and the cognitive walkthroughs confirmed the same results. The results on whether or not Monumental-IT can help people recall memories regarding the history of slavery was significant, as 92% of the participants found that Monumental-IT can help in recalling memories. The results showed that 83.3% found that Monumental-IT is a better choice than the conventional monuments, and 75% found that all ages will be interested in visiting Monumental-IT. These results confirm users' acceptability of Monumental-IT.

(e) *Be open to different interpretations*. This was achieved by having a design that can be interpreted differently when it reconfigures according to users interaction with it. The results confirm that users interpreted the four configurations differently, showing that each configuration is capable of representing a different emotion (Figures 6.6 and 6.7). Although, the notion of a reconfigurable form seems simple, it needs more study and experimentations to discover and explore existing and new kinematic systems as in the thesis on Kinetic Architecture considered here (Zuk and Clark, 1970). For this research, I examined only one of these structures, the closed-loop chain kinematic linkages, through an iterative process (Figures 3.11 and 3.12).

(f) *Be socially evocative*. The monument requires an open space in which people can interact with it, where they can meditate and recall the past, and where they can stand, sit, and even lie down (Figure 7.2).

Figure 7.2 Monumental-IT's socially interactional space where people stand, sit, or lie down

(g) *Have a high bandwidth*. In sociological terms, the bandwidth is a measure of the degree of connectivity and coherence between any two social systems. In this research, the bandwidth was highlighted and intensified by employing robotics that sense and respond accordingly, and also by the hybridization of the virtual and the physical worlds using the "robotic-wiki" platform. The hybridization and responsiveness of Monumental-IT provide a cybernetic system that is capable of connecting people to the place by evoking people's emotions and getting people to talk to the monument and the monument to talk to them.

176

(h) *Be emotionally evocative.* The monument should use multi-sensorial phenomenological cues that aid in representing and affecting people's emotions. The results showing the effect of Monumental-IT's multi-sensorial features on the human-robotic interaction were significant (Figures 6.6 and 6.7).

To return to the research questions, the second research question, How can intelligent systems "creatively" reconcile current conceptualization of history with monument-making?. History has being preserved in different forms, for example in text, images, recordings, buildings, artifacts, et cetera. Yet, it is not possible for one person to read all of the historical documents about the history of slavery or all the documents on complex historical events in her or his life span. Franco Moretti suggests in his thesis on "Maps, Graphs, and Trees" that there is a need to move the study of history from the close reading model of historical documents to the "distant-reading" model. Moretti suggests employing the use of data-mining in order to overcome the temporal limitations on our ability to read and comprehend huge amounts of historical data.

Inspired by Franco Moretti's model, Pierre Bayard's "How to Talk About Books You Haven't Read," Umberto Eco's "Opera Aperta" (The Open Work,) and Michelangelo's incomplete or "non-finito" art work, Monumental-IT was designed to change our understanding of history from a fixed, closed model, to an open interactive model. Using robotics technology that provides an open cybernetic system capable of retuning and reconfiguring interpretations on history helps us overcome limitations inherent in our understanding of history (i.e., to move from a single fixed form of an interpreted past, to collective interpretations of that past).

The test results from the human-robotic interaction with Monumental-IT confirm such openness and configurability of Monumental-IT. Also, the results on the WikiMonument's interface confirmed a human understanding and acceptability of this advanced monument. The results of the users' responses on the effect of data-mining the text on their emotions were significant; the responses to the quotes about the history of slavery showed that participants had mostly agreed on the corresponding reflected emotions, (Figure 6.10). Also, participants' responses to selecting Monumental-IT's configuration that matches their interpretation of the quotes from the "Documents of the American South," support the effectiveness for the use of data-mining in representing historical documents in the form of the monument.

As to the research questions, the third research question, What role can intelligent systems and Human Centered Computing (HCC) play in creating significant, meaningful, physical, urban places for collective memories?. Monumental-IT is one example of the use of intelligent systems. Monumental-IT is comprised of a robotic, programmable system that senses and responds according to people's interaction with it. The system is programmed using "Wiring" language, which is based on C and C++ programming languages, (Appendix H). The use of a human-centered and an iterative design process showed significant results with respect to users understanding and acceptability when interacting with Monumental-IT. Results regarding the human-emotion interaction, the effectiveness of Monumental-IT's multi-sensorial features on the human-robotic interaction, and the positive qualitative responses on Monumental-IT also showed

significant support for the use of human-centered computer design with interactive monuments.

In addition, Monumental-IT's prototype showed significant results on all hypothesized treatments. Further research on the use of the "robotic-wiki" monuments in a real world setting will add significantly to the understanding of the use of interactive technologies in urban spaces. Also, the effects of the context and the surrounding environment of Charleston on the human-robotic interaction with Monumental-IT should be further evaluated. And cost-benefit analysis for such interactive environments can help in encouraging public and private institutions to invest in this field. Finally, there is a need to evaluate Monumental-IT's patterns over a long period of time in order to understand its effect on society and the broader culture.

7.2 Designing and evaluating complex systems

Monumental-IT is an interactive system that employs technology in helping people to recall memories in public spaces. The complexity of such system is clearly shown in the different methods that have been used in this research. I have employed different methods from a wide variety of disciplines.

For developing the hardware of this system, I used an *empirical approach* for testing the system in a lab setting. For designing the system, I used artistic and architectural approaches such as *brainstorming, sketching, and charrettes* for envisioning it, and *digital fabrication* technology for implementing it. For evaluating the designs, I used *production design* approach developed by Ulrich and Eppinger in the phases of concepts generation, screening, resolution, and selection. For programming the system, I

used the *computer science engineering languages "C" and "Wiring"*. For evaluations, I employed human factors psychological methods such as: *heuristic evaluations, cognitive walkthroughs, paper-prototyping, and the Wizard of Oz model*. From sociology, I used quantitative and qualitative methods – *a mixed method approach*. For quantitative analysis, I used *statistical methods* and a *quasi-experimental design* to evaluate the system with real users. For qualitative methods, I used *surveys*, in addition to the psychological methods described above which also use qualitative methods.

Moreover, the research on monuments cannot be separated from understanding the history of the event, in this case, the history of slavery. Research on the history of slavery helped me to understand the context for Monumental-IT, and in deciding where to implement the monument. Monumental-IT was designed to fit the context of one of the very buildings that was used for slave trading that still exists in Charleston, SC. By understanding the context, an architecture analysis was used to understand the best circulation for Monumental-IT, (see "4.2 Context" Section in Chapter Four.)

In this study, I developed a novel metrics approach, outlined below, for conducting research on the design and evaluation of complex systems that may provide a model for more studies in the field of architectural-robotics. This research, broadly, is an experimental research design. I divided the metrics into three main activities:

1. *Defining research content and structure:* In this step, I defined the type of research, i.e., exploratory research, which includes research questions and hypotheses. Also, I defined the research key concepts, dimensions, operational definitions, and operational measures.

2. *Research Design:* In this step, I developed *a mixed methods research design* that combines human-centered design and quasi-experimentation design. Quantitative and qualitative methods have been used interchangeably throughout the study. Human-centered design was used for designing and iteratively developing and understanding the prototypes. Quasi-experimental design was used for designing the evaluation procedures and the interpretations of collected data.

3. *Data collection and evaluations:* For evaluating the human-robotic interaction with Monumental-IT and the WikiMonument, I used a quasi-experimentation design and employed the use of surveys and the Wizard of Oz model with real users. For evaluating the WikiMonument, I used Cognitive Walkthroughs and employed the use of paper-prototyping and PowerPoint hyperlinked pages with real users. Also, I used heuristic evaluations and the Wizard of Oz model to evaluate the usability of the system with experts.

7.3 Broader impacts

This research impacts three major fields: architecture, robotics, and history. Monumental-IT provides initial scientific evidence for the appreciation of the need to move technological advancements from the one science to the trans-disciplinary sciences. For example, the architect instead of depending on a limited network of the built environment specialists (i.e., landscape architects, planners, real estate agents, entrepreneurs, and engineers) and clients, the architect in the IT age should open his network to human-factors psychologists, sociologists, roboticists, and computer scientists. Architecturally, Monumental-IT as an example of "architectural-robotics"

provides new evidence for the applicability and potentialities of such field to architectural practices. For Roboticists, Monumental-IT provides empirical evidence regarding the impact of moving desktop technology to the areas of ubiquitous computing which supports Weiser's vision of the importance of invisibility and ubiquity of technology in our lives. Additionally, historical studies benefit specifically from the use of intelligent systems and "architectural robotics" as a new platform and avenue for history to be encountered in new physical and empirical ways.

CHAPTER EIGHT

ROBOTIC MONUMENTS IN THE AGE OF ORGANIC SYSTEMS
AND CYBERNETIC ENVIRONMENTS

In the current of technological advancements in IT and robotics, there are many technical and design challenges. Some of these challenges are related to: artificial intelligence of interactive systems (AI), sensation and actuation (Robotics), Human-Robotic Interaction (HRI); others are related to the design of comprehensive systems that accomplish specific needs as described in Chapter Seven. In my research on Monumental-IT, I designed and evaluated a "robotic-wiki" monument for embodied interaction in the informational world. In this process, I developed a monument for an increasingly digital and "free" world. Monumental-IT was able to engage people in a novel platform for human-robotic interaction in a public space by employing the use of robotics. Yet, the challenges of artificial intelligence, related to sound recognition and data-mining historical texts, have not been solved in this study. This research on robotic monuments is only one step in understanding the impact of using "robotic-wiki" environments in the built environment.

In this chapter, I connect the research on Monumental-IT to the broader theory of cybernetics. Finally, I present some critical questions that need further study for designing monuments in the age of organic systems.

8.1 Convergences

In an increasingly complex world, simplicity may be what is needed. Yet, whenever a new system is designed, people ask for more capabilities and features that

fulfill a wide range of needs, or what amounts to a more complex system. These complex systems are inevitably organic in nature. They change from one day to the other, due to changes in the world's natural and cultural orientations, as well as changes in people's interests and preferences. As Donald Norman described in his book *Living with Complexity*, "the technologies we use must match the complexity of the world: technological complexity is unavoidable" (Norman, 2011, p.265).

Nevertheless, scholars in technological fields keep developing and discovering systems that are usable and acceptable for the users. These systems are organic in nature, which means that they cannot remain fixed. Cybernetics systems can help us learn from organic systems, especially biological systems, teaching us how to live with complexity, and leading us to the imitation of biological system properties (survive, adapt, stabilize, and communicate,) as previously described in Chapter One.

Monumental-IT is an example of a cybernetic system that is able to survive, adapt, stabilize, and communicate. First, Monumental-IT is not a flattened interface that exists in a luminous glass (2D interface) world. It is a physical platform embedded with phenomenological and technological components. These components are comprised of physical atoms and digital bits. The physical atoms are expressed in the materiality of the structure of the monument, employing the use of metals and fabrics for its structure, and in the physicality of its sensors, microcontroller, and actuators. The digital bits are expressed in the "WikiMonument" platform, and in the program that defines the configurations for Monumental-IT. The physical atoms and the digital bits are entities that drive the monument in physical space, which are in turn governed by laws of physics

and nature. Ultimately, Monumental-IT is *surviving* in a physical platform that defines its structure and performance.

Organic systems are adaptable, which means they "survive in changeful surroundings" (Pask, 1961, p.72). Monumental-IT uses robotics and IT to adapt to different interpretations on history. However, it is using the lowest type of *adaption* in that it alternates its behavior according to the state of its environment, i.e., it responds to inputs from its sensors, like the hedgehog example described in Chapter One.

Monumental-IT is designed with *internal equilibrium* software. This software is what drives the structure whenever needed. It retunes the structure to a different configuration once the system is provided with a different input. The Wiring program that drives it (Appendix H) is designed with logical statements that simplify the work as follows: "if you get this input, perform this action; if you do not get an input, do not perform an action." Similar to organic systems, Monumental-IT is a *communicative* environment. Based on the results described in this research, Monumental-IT has proven that it is capable of providing an effective human-robotic, interactional environment.

Ultimately, Monumental-IT is imitating biological systems by being able to survive, adapt, stabilize, and communicate. It has also proven its effectiveness in being a responsive environment for people to interact with it. From a cybernetics perspective, Monumental-IT is a conversational system. It is open for human-machine interaction.

But on what order of cybernetics is Monumental-IT? According to Hugh Dubberly in his article "Design in the Age of Biology: Shifting from a Mechanical-Object Ethos to an Organic-Systems" (Dubberly, 2008), the shift from mechanical to

organic systems in the 21st century is not only in participations' roles and services of information technologies, but occurs also in the human-machine interactions, or in cybernetics. He was referring to Heinz von Foerster's framing of two types of cybernetics to present such change, (Table 8.1). By using the same framework, Monumental-IT can be considered as a 2nd order cybernetics system, which is an organic type of cybernetics (Table 8.2).

CYBERNETICS MATURES	
1st-order cybernetics	*2nd-order cybernetics*
Single-loop	Double-loop
Control loops	Learning loops
Regulating in environment	Participating in conversation
Observed systems	Observing systems
Observer outside frame	Observer in frame
Observer describes goal	Participants co-create goals
Assumes objectivity	Recognizes subjectivity
	Adapted from Paul Pangaro [21]

Table 8.1 Heinz von Foerster's framework of 1st and 2nd order cybernetics (source: Dubberly, 2008, p.41)

Monumental-IT	
Has	**Has Not**
Single loop*	Double loop **
Control loops *	Learning loops **
Participating in conversation **	Regulating in environments *
Observing systems **	Observed system *
Observer in frame **	Observer outside frame *
Participants co-create goals **	Observers describe goals *
Recognize subjectivity **	Assumes objectivity *
Monumental-IT has 71.4 % of the 2nd order cybernetics properties	

* indicates a 1st order cybernetic properties

** indicates a 2nd order cybernetic properties

Table 8.2 Monumental-IT represents a 2nd order cybernetics system

Monumental-IT as a 2nd order cybernetic system can provide us with another "view of the world and our place in it" (Dubberly, 2008, p.35). This view of the world is a shift from being a technology-centered world into being a human-centered world. In the human-centered world, "human beings" can freely change and tune the materialistic world according to their will; "human beings" are able to take a leading position in organizing and shaping their lives. Human beings will be able to add a new layer to "democracy," which is "the freedom of shaping the world". Monumental-IT as well is providing an evidence for the developing "interactive design" practices, leading to "creat[e] new types of jobs…[which means that] both what we design and how we design are substantially different from a generation ago" (Dubberly, 2008, p.35).

8.2 Divergences

This research is based on the use of "collective minds" to produce many different representations of memories in the form of the monument. From a creativity perspective, does it produce a creative act? The answer is that the creative act involved in the Monumental-IT experience comes from the idea that we are partners who share memory and participate in its representation(s). If we track the accumulation of Monumental-IT's representations over two or three years, it might produce a single "collective pattern" or, alternatively, numerous patterns. The "collective pattern" is the collective change that Monumental-IT will represent in a selected time frame. While people will end by depending on the "collective pattern," as a form of representation, so as to understand the effect of their voices on memory which can be seen as a challenge in producing a creative

act; yet, that may not be fully true because individual voices will be shared and added to create the "collective" form.

Information technology in the post informational age, as Jaron Lanier foresaw, requires that we think about new approaches to avoid the trap of producing "the one book" (Lanier, 2011/2010). Lanier suggests that we "kill the hive," and leave individuals free to generate new social and creative acts away from the collective "hive". However, this suggestion may not be fully appropriate in the context of monuments, since the social and collective dimensions which are essential to Monumental-IT are substantially different than memos, relics, reminders, or the internet, the "hive", in that Monumental-IT is based on phenomenological and spatial experiences. The monument is not only collecting data from the internet, but it also provides people with spatial and embodied interaction, which the 2d interfaces cannot provide.

Monumental-IT as a space for collective memory assumes that we share only a part of the larger society. Nevertheless, our individual voices as well as our collective voices are significant. Future studies on how Monumental-IT can provide a collective space for such creative acts are needed. This is in a way similar to the democratic political practice in which the candidate of the winning party becomes the representative of the government. Although, this example is much different than how a monument might represent the past, it illustrates how complex it is to have a single act represents collective participation.

Monumental-IT can be also considered an example of what is called "cultures of participation." "Cultures of participation" as described by Gerhard Fischer, a computer

scientist, "are needed because cultures of participation are not dictated by technology; they are the result of changes in human behavior and social organization" (Fischer, 2011, p.42). Thus, Monumental-IT can be considered a physical production of these cultures similar to Youtube, Wikipedia, Facebook, Twitter, and others. Monumental-IT faces some of the same challenges that these environments are facing, namely, "to conceptualize, create, and evolve socio-technical environments that not only technically enable and support users' participation, but also successfully encourage it" (Fischer, 2011, p.45). Although I have described a process for conceptualizing and creating Monumental-IT, we still need to understand more about how it evolves and encourages participation.

8.3 Future works

This thesis has provided a step towards expanding the typology the monument. Experience with the Monumental-IT prototype has provided evidence for the continuing development of design practices that will help change our lives for the better. It also provides evidence for the use of robotics in the built environment, and indirectly for history to be seen as an evolving practice rather than as a fixed state of affairs in the shape of static media such as books or static architectural environments. For better understanding and enhancing Monumental-IT, more research will be needed in two important respects. First, from the sociological and cultural perspectives, there is a need for ethnographic studies on how people will affect and be affected by such environments. Also, what will such monuments mean for different ethnic groups? How will it change

people's behavior in monumental spaces over long periods of time? How will it change the demographic characteristics of the participants who interact in monumental spaces?

Second, from a technological dimension, how can the use of the evolving technologies (i.e., robotics and IT,) affect the evolution of Monumental-IT? Moreover, there is a need for comparing the effects of embedding different kinematic structures and algorithms into the mechanism of the human-robotic interaction. Also, how can we provide maintenance and security for Monumental-IT? Finally, how can we use it for other contexts, cultures, and memories?

While further studies are needed regarding the sociological, cultural, and technological dimensions of Monumental-IT, there is also a need for understanding the long term costs of such an environment. What are the "costs and benefits" for implementing Monumental-IT? And, how can we design and develop sustainable versions of "robotic-wiki" monuments?

APPENDICES

Heuristic Evaluation Sheet (Concept Evaluation)

Heuristic Evaluation sheet for testing Monumental.IT's Concept*

Full name:

Date:

Age: Gender(optional):

Address:

State: Zip code:

email address:

Agree to conduct the test as described

Evaluator's Signature:

	The Task: Interacting with Monumental-IT to recall ones' memories about the history of slavery in the US in the 19th century	**Heuristic(s) Violated**	**Descriptions/ Recommenda tions**
1	Walk to start interacting with M.IT		
2	Hear M.IT's introductory speech		
3	Start recalling memories		
4	Speak on the Microphone to express emotions about the history of slavery		
5	Push the footstep to start M.IT's interactive response		
6	A Beep starts, indicating that M.IT has started to represent formal cues		
7	The LED is going on		
8	The Skin starts morphing		
9	The audio starts		
10	The smell sprinklers start		
11	People start to connect past memories about the history of slavery with the space of Monumental.IT, and use the space as a contextual cue for later retrieval		
12	Leave the place or want to retune your memories/emotions/interpretations		

* Heuristic sheet will be handed out separately, then, it will be collected after the evaluator finishes his testing.

Survey Evaluation Sheet (Concept Evaluation)

In this survey, I am looking for users' feedback about design concepts, people's understandings of colors, forms, and more important how the different contextual cues will be tasked (task analysis.)

Population: Lay citizens who are interested in the history of slavery; the method that will be used is "random sampling."

Demographic Questions

1. Contact information (We will keep your personal information secure.)

Name:

Company:

City/Town:

State/Province:

ZIP/Postal Code:

Country:

Email Address:

Phone Number:

2. Which of the following categories includes your age?
   o Under 18
   o 18-24
   o 25-34
   o 35-49
   o 50-64
   o 65+
   o Rather not say

3. What is your gender?

   o Female
   o Male
   o Rather not to say

4. Select the educational level you have reached.
   o Grade school
   o Some high school
   o High school graduate

- o Vocational/technical
- o Associate degree
- o University undergraduate graduate
- o Masters degree
- o Professional degree (JD, MD, etc.)
- o Advanced degree (PhD, PsyD, etc.)
- o Other

5. Which of the following categories includes your household's annual income?

- o Less than $20,000
- o $20,001-$29,999
- o $30,000-$39,999
- o $40,000-$49,999
- o $50,000-$59,999
- o $60,000-$69,999
- o $70,000-$79,999
- o $80,000-$99,999
- o $100,000-$119,999
- o $120,000-$149,999
- o $150,000+

6. What is your current employment status?

- o Employed full-time
- o Employed part-time
- o Not employed
- o Self-employed

7. What is your job title?

8. What is your racial background?
- o White
- o American Indian
- o Alaska Native
- o Asian
- o African American
- o Native Hawaiian
- o Other Pacific Islander
- o Of two or more races. Please indicate:

User-Monument Background
1- How many times have you visited monumental sites (sites of physical monuments)?

- o Never

- Less than 5 times
- 6 to 20 times
- 21 to 50 times
- More than 50 times

2- Describe the best monumental site experience you have had in your life.

3- Why did you select the previous monument as the best? (Select as many as apply)

A- Formal Aspects
- Scale of the monument
- Aesthetics (proportions-materials-colors-landscaping)
- Shape and craftsmanship
- Iconic quality and memorability

B- Conceptual aspects

The monument you select (select only one):
- Tells you a full story
- Tells you a partial story
- Evokes your thoughts about the past
- Uses contextual cues (reflections-colors-sounds-smell-form-texture) to recall the past

C- Preferential aspects
- Recommendation by others
- Design by a famous Architect
- Location of the monument
- Personal or family relevance to the memory

D- Historical aspects

D.1. How much does the history of the monument affects your selection?
- Not at all
- Very little
- A lot

D.2. How much does the memory represented in the monument affects your selection?
- Not at all
- Very little
- A lot

E- Emotional aspects

E.1. Does the monument represent the emotional aspect of the memory?
- Not at all
- Very little
- A lot

E.2. Do you think that emotions are the best representation of collective memories?

  o Not at all
  o Very little
  o A lot

E.3. Which of the following emotions represent the memory represented in your selected monument?

  o Happy
  o Sad
  o Angry
  o Fear

Specific Questions

" *Born in Slavery: Slave Narratives from the Federal Writers' Project, 1936-1938* contains more than 2,300 first-person accounts of slavery and 500 black-and-white photographs of former slaves. These narratives were collected in the 1930s as part of the Federal Writers' Project of the Works Progress Administration (WPA) and assembled and microfilmed in 1941 as the seventeen-volume *Slave Narratives: A Folk History of Slavery in the United States from Interviews with Former Slaves.*"

Please read the following quotes; then select the one that matches the emotion you detect within the quotes:

1- "I can tell you bout my poor soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun dead en gone en God left me to live among dese wild varments here. I have to cry sometimes when I think how dey die en leave me in dis troublesome world."

  o Happy
  o Sad
  o Anger
  o Fear

2- "I think 'bout my old mammy heap of times now and how I's seen her whipped, wid de blood dripping off of her."

  o Happy
  o Sad
  o Anger
  o Fear

3- "You see, I have such a hurtin in my back en such a drawin in my knees en seems like de sun does just help me along to bear de pain."

- o Happy
- o Sad
- o Anger
- o Fear

4- "My Master was kind to his slaves an' his overseer was all Negroes."

- o Happy
- o Sad
- o Anger
- o Fear

5- "Sometimes niggers could see ghosts around dere at night, so dey say."

- o Happy
- o Sad
- o Anger
- o Fear

6- Then Lincoln was raised up for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."

- o Happy
- o Sad
- o Anger
- o Fear

7- "I does worry bout it so much sometimes."
- o Happy
- o Sad
- o Anger
- o Fear

Design Questions

Monumental.IT's design is a dynamic art not a static one, thus, all the following questions depend on the video(s)/real user interaction with the physical model.

Please read the following quotes; then, select the design that matches your interpretation of the following quotes:

1- "You see, I have such a hurtin in my back en such a drawin in my knees en seems like de sun does just help me along to bear de pain."
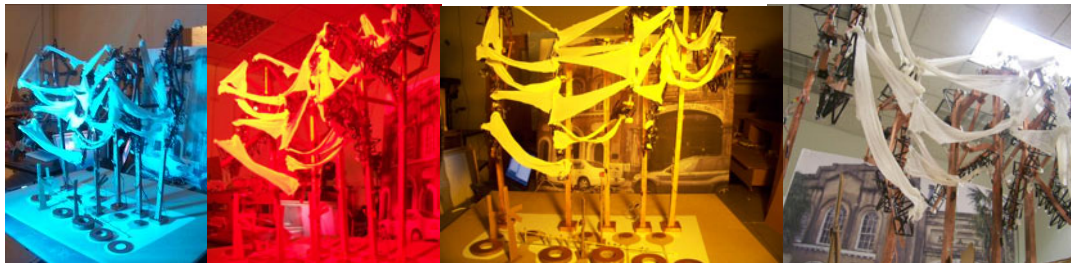
A (Blue) **B (Red)** **C (Multi-color)** **D (White)**

2- Then Lincoln was raised up for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."
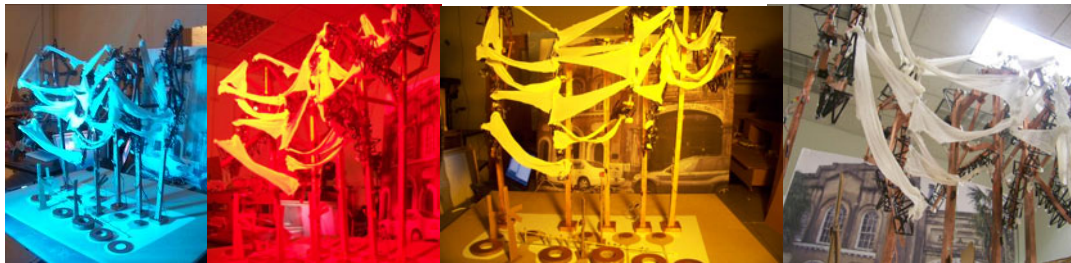
A (Blue) **B (Red)** **C (Multi-color)** **D (White)**

3- "I does worry bout it so much sometimes."
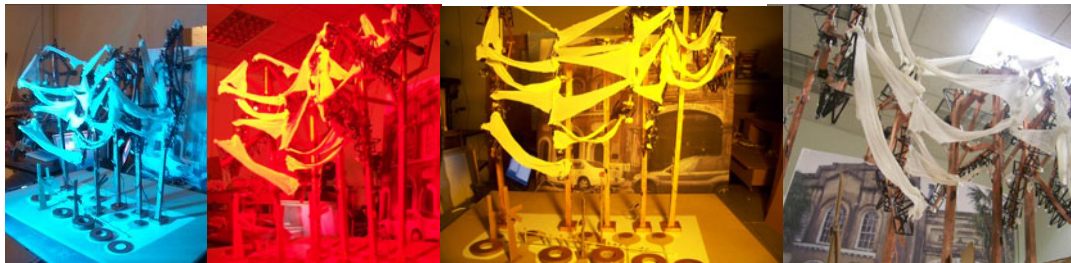
A (Blue) **B (Red)** **C (Multi-color)** **D (White)**

4- "I can tell you bout my poor soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun dead en gone en God left me to live among dese wild varments here. I have to cry sometimes when I think how dey die en leave me in dis troublesome world."
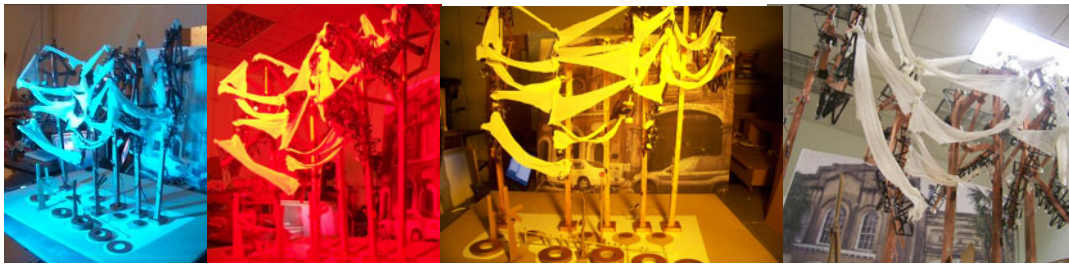
A (Blue)   **B (Red)**   **C (Multi-color)**   **D (White)**

5- "I think 'bout my old mammy heap of times now and how I's seen her whipped, wid de blood dripping off of her."
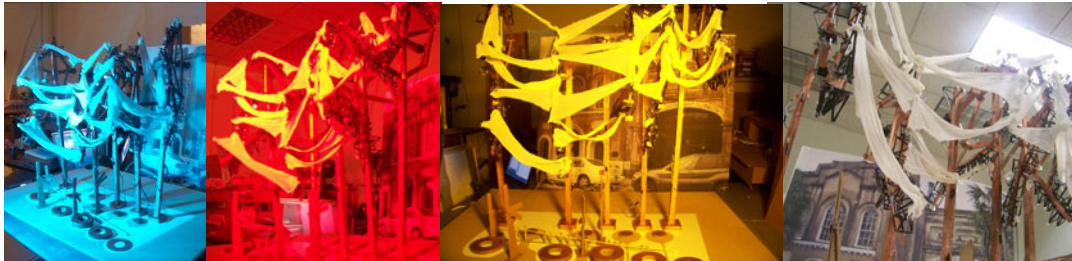
A (Blue)   **B (Red)**   **C (Multi-color)**   **D (White)**

6- "My Master was kind to his slaves an' his overseer was all Negroes."
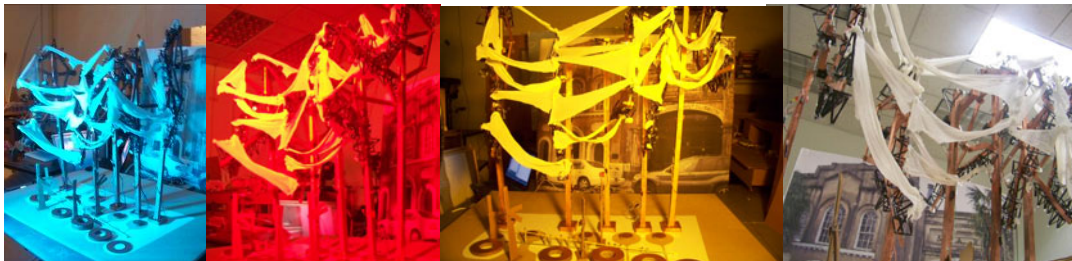
A (Blue)   **B (Red)**   **C (Multi-color)**   **D (White)**

7- "sometimes niggers could see ghosts around dere at night, so dey say."
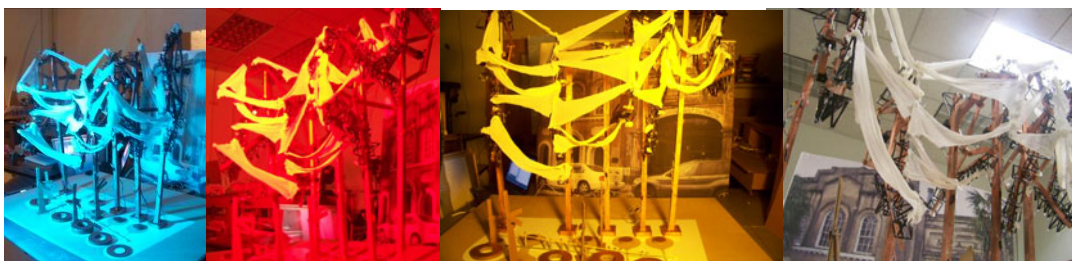
A (Blue)   **B (Red)**   **C (Multi-color)**   **D (White)**

Forms and emotions

Please select the emotion that matches your interpretation of the following forms:

1- (The Blue Configuration)

- o Happy
- o Sad
- o Anger
- o Fear

2- (The Red Configuration)

- o Happy
- o Sad
- o Anger
- o Fear

3- (The Multi Color Configuration)

- o Happy
- o Sad
- o Anger
- o Fear

4- (The White Configuration)

- o Happy
- o Sad
- o Anger
- o Fear

Colors and Emotions

Please select the emotion that matches your interpretation of the color represented in the following designs:

1- (The Blue Configuration)
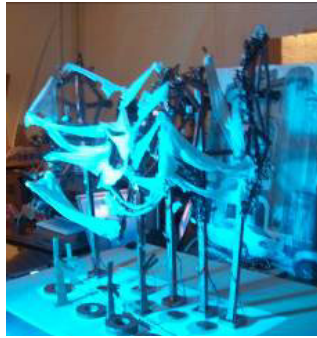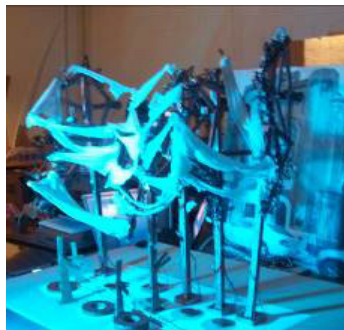
- o Happy

- Sad
- Anger
- Fear

2-(The Red Configuration)

- Happy
- Sad
- Anger
- Fear

3- (The Multi Color Configuration)
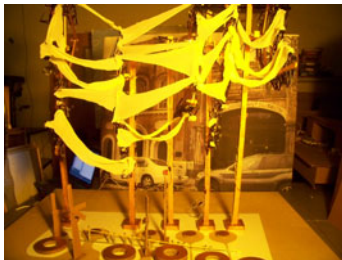
- Happy
- Sad
- Anger
- Fear

4- (The White Configuration)

- Happy

o Sad
o Anger
o Fear

Task Analysis Questions

After briefly explaining M.IT's concept, and showing preliminary design.

1- Please sort the following tasks in an order that you think will help you understand Monumental.IT

      o The color changes
      o A Warning (sound-color) will be given
      o Another warning sound starts
      o A (spicy/soft) smell will spread in space
      o The form of M.IT changes
      o Push the pressure footstep
      o Speak over the microphone
      o A sound represent the name of the slave
      o The automatic configuration starts

2- What are other important tasks that could help you understand M.IT? (Don't use the previous tasks)

3- What is the best way to attract your attention to a new change in M.IT reconfiguration?

4- How long do you think each configuration needs to stand still before a new configuration starts?
      o Less than a minute
      o 1 minute- 3 minutes
      o 4 minutes- 10 minutes
      o 11 minutes – 30 minutes
      o 30 minutes - one hour
      o More than an hour

General Questions (Optional)

1- Describe Monumental.IT in one sentence.

2- Thinking about implementing Monumental.IT at any site, do you think that it will be beneficial to peoples' participation for recalling memories in public spaces?

- Yes
- No
- Don't know
- Refused

3- When talking about monuments, do you think that Monumental.IT will be a better choice than the existing typologies of monuments?

- Yes
- No
- Don't know
- Refused

4- Talking about who would be interested to visit the real Monumental.IT, people of age:
- Under 18
- 18-24
- 25-34
- 35-49
- 50-64
- 65+
- All ages

Monumental-IT Linkages Type A
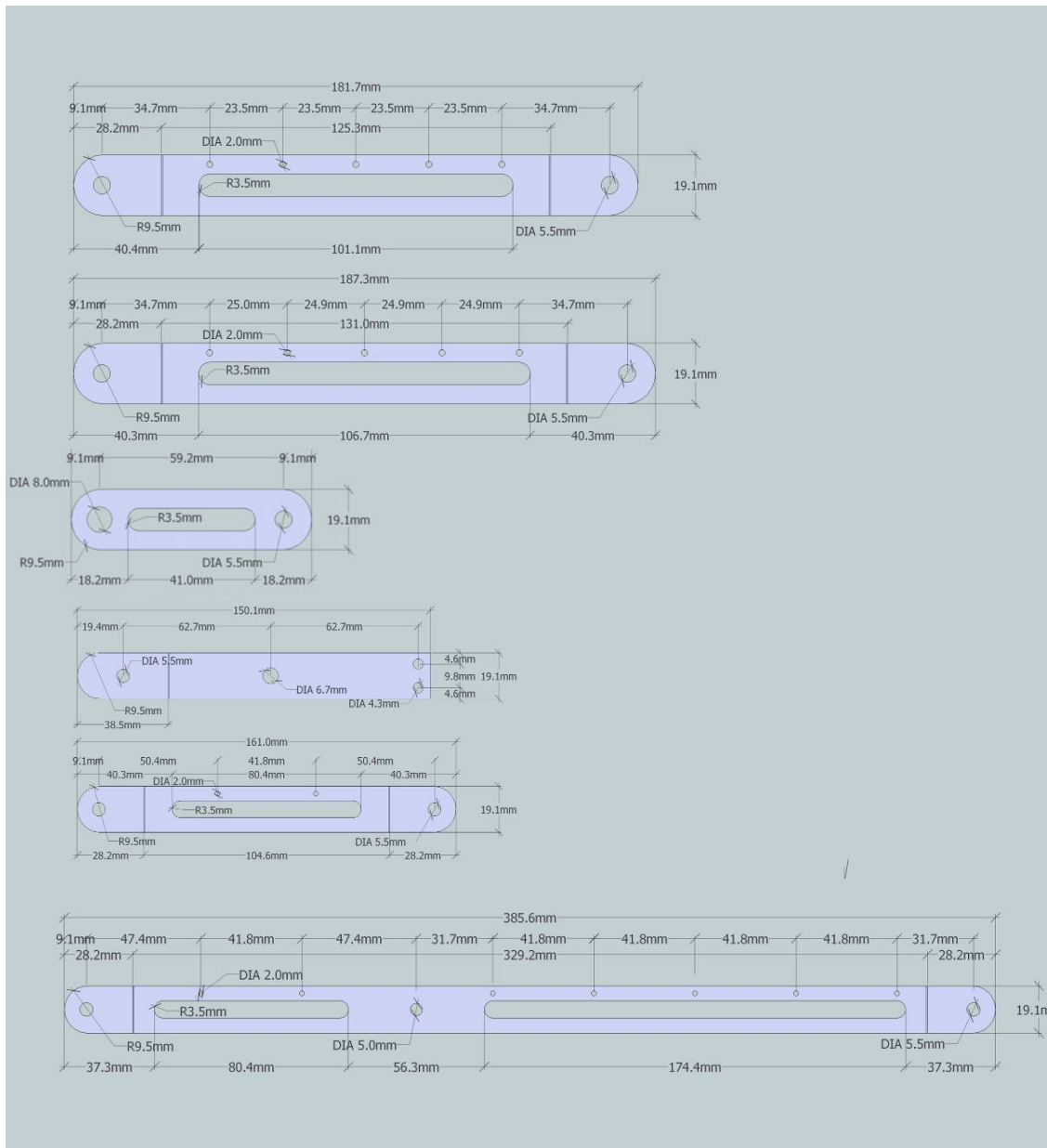
Monumental-IT Linkages Type B
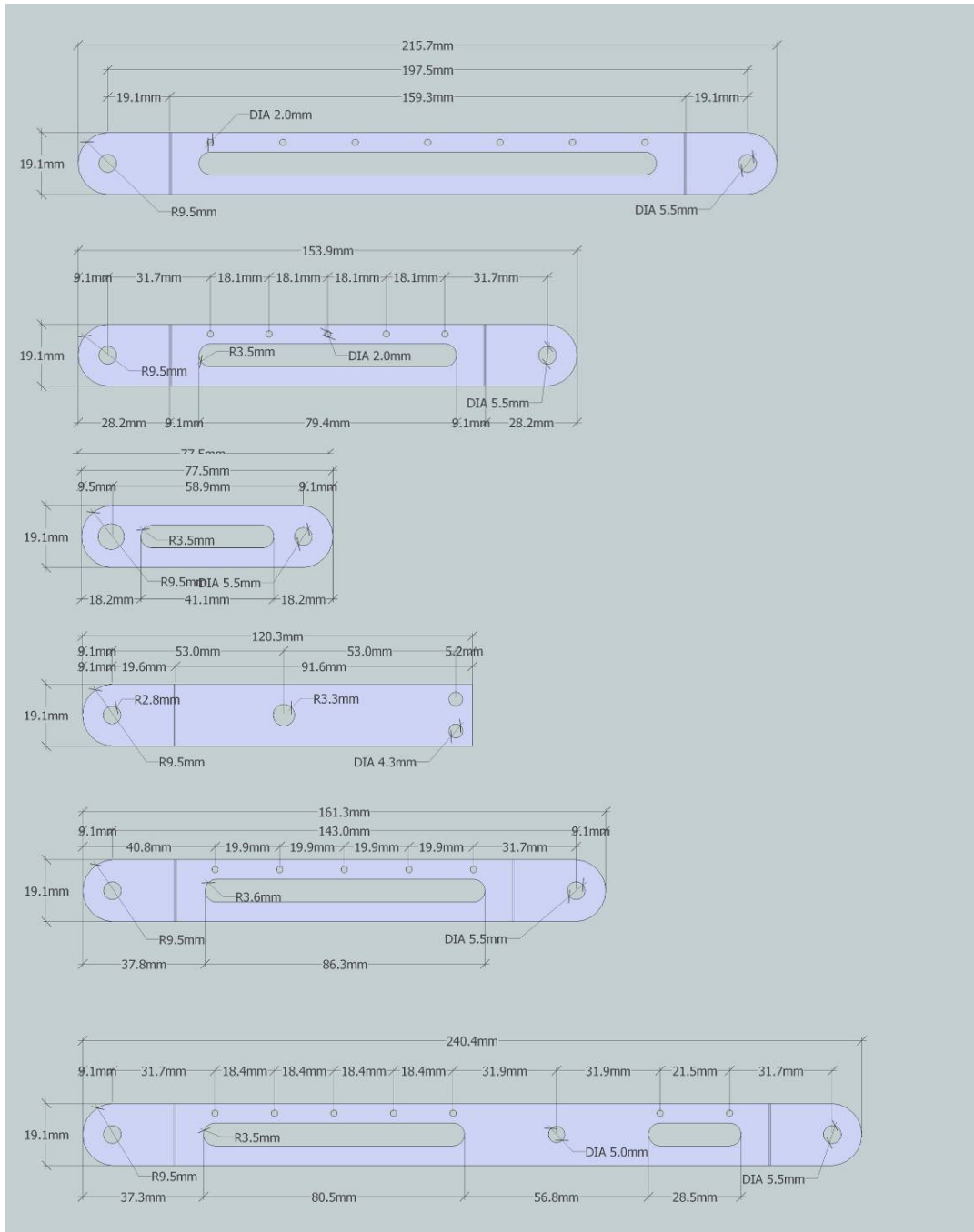
Monumental-IT 36"x36"x.08" Multipurpose Aluminum (Alloy 6061) Sheet
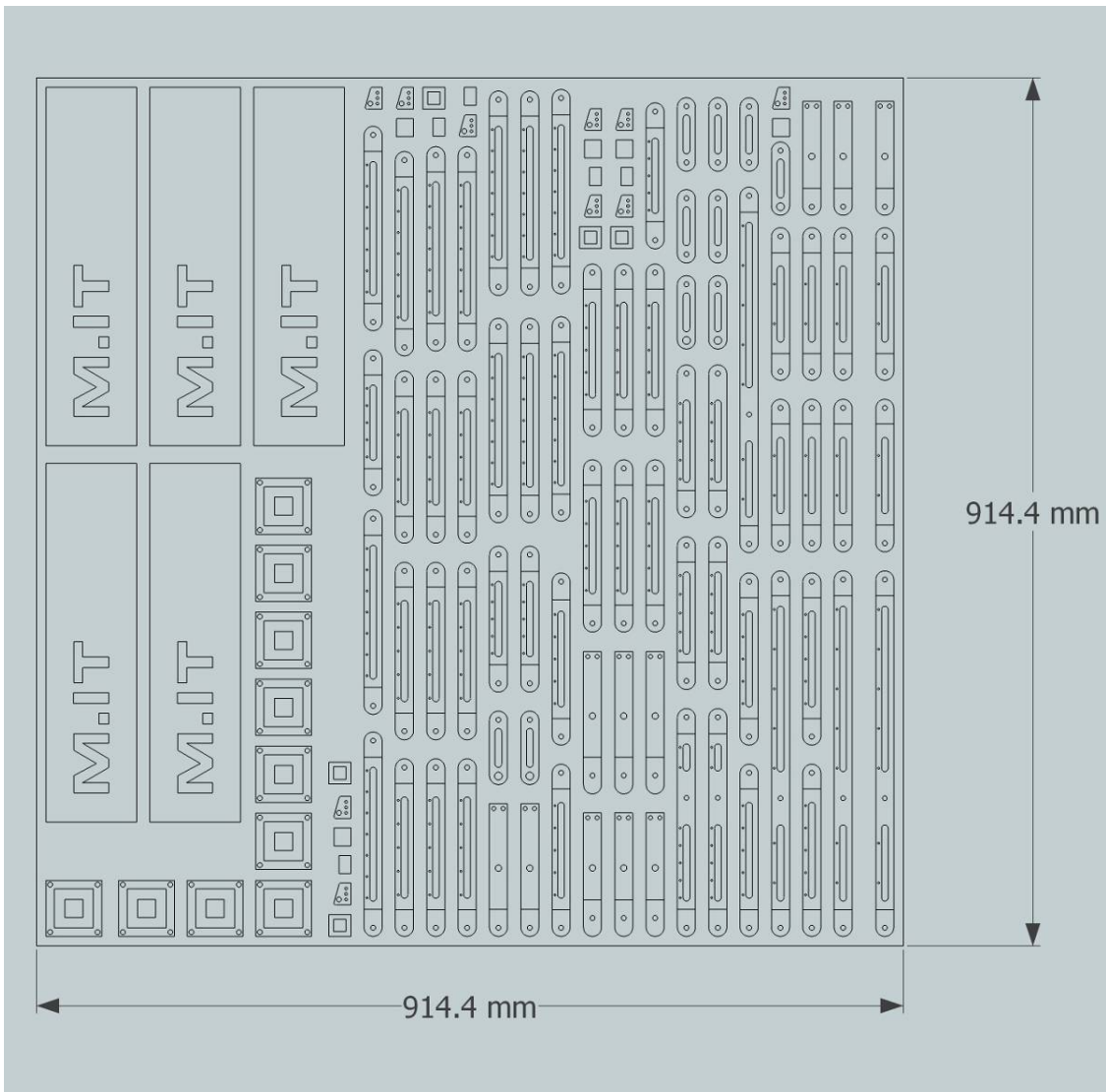
Appendix F

Documenting the American South Copyright Usage Permission

CLEMSON UNIVERSITY   Tarek Mokhtar <tmokhta@g.clemson.edu>

FW: By EMAIL? Fwd: [docsouth] Copyright Usage Request:

Smith, Natalia N <nsmith@email.unc.edu>   Fri, Dec 10, 2010 at 12:33 PM
To: "tmokhta@g.clemson.edu" <tmokhta@g.clemson.edu>

Dear Tarek:

I have to admit that I was **so** excited to receive your request and to hear about your plans to work with our collection

(I assume you talk about http://docsouth.unc.edu/neh/, but it's possible that you have in mind other DocSouth collections as well.

First, yes, you have our permission to use the data for your research.

Second, I would love to hear more about your plans, what tools would use and whom do you work with?

Finally, I would like also to talk to you about eventually using your findings on our site.

DocSouth is one of the oldest online collections and is very much used by users around the world!

So, yes, go ahead and let's talk!

Have a fabulous weekend and my very best wishes, ns

Natalia (Natasha) Smith

Head, Digital Publishing Group and *Documenting the American South*

Carolina Digital Library and Archives

Wilson Library CB#3990

UNC-Chapel Hill

tel. (919) 962-9590

http://cdla.unc.edu/

http://docsouth.unc.edu/

Copyright Usage Request from the Head of the University Library at The University of

North Carolina at Chapel Hill for using images on Appendix G

Appendix G

Projected Images (Source: http://docsouth.unc.edu/index.html)

GAMBLING FOR A SLAVE.

ANCIENT SLAVERY.

CHLOE AND HER PLAYMATES TAKEN CAPTIVE BY THE SLAVE-DEALERS.

EMANCIPATION.

EMANCIPATION.

THE SUCCESSFUL MAN HUNT. Page 231.

Slaves being sold at Public Auction.

Monumental-IT's Wiring language Code

```
#include <Servo.h>
#include <NewSoftSerial.h>
#include <RogueMP3.h>
#include <RogueSD.h>

int soundPin = 0;
int val=0;
int value1=0;
unsigned char relayPin[4] = {4,5,6,7};
#define HAPPY "/happy.mp3"
#define SAD "/sad.mp3"
#define ANGRY "/angry.mp3"
#define FEAR "/fear.mp3"

NewSoftSerial rmp3_serial(2, 3);
RogueMP3 rmp3(rmp3_serial);

Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;
Servo servo5;

int pushb1=1;//analog pin number 1
int pushb2=2;//analog pin number 2
int pushb3=3;//analog pin number 3
int pb1=0;
int pb2=0;
int pb3=0;
int pb4=0;

void setup() {
 Serial.begin(9600);
  rmp3_serial.begin(9600);
  rmp3.sync();
  rmp3.stop();
  int i;
  for(i = 0; i < 4; i++)
  {
   pinMode(relayPin[i],OUTPUT);  } }
```

```
void loop() {
 int val1=0;
 int val2=0;
 int val3=0;
 int val4=0;

 while(1){
    val1=analogRead(soundPin);
    val2=analogRead(pushb1);
    val3=analogRead(pushb2);
    val4=analogRead(pushb3);

    if(val1==0){
       pb1=1;
       break; }
    if(val2==0){
       pb2=1;
       break;}
    if(val3==0){
       pb3=1;
       break; }
    if(val4==0){
       pb4=1;
       break; }
         }

  if (pb1==1){
     digitalWrite(relayPin[3],HIGH);
     Serial.println("VERY High value:");
     Serial.println(val1, DEC);
     rmp3.sync();
     rmp3.playfile(ANGRY);
     rmp3_serial.println(value1, DEC);

     while(1){
         for (int i=1600; i <= 1800; i=i+30){
            servo1.attach(12);
            servo1.writeMicroseconds(i);
            servo3.attach(10);
            servo3.writeMicroseconds(i);
            Serial.print("Running motor at: ");
            Serial.println(i, DEC);
            delay(1000);}
          servo1.detach();
```

```
 servo3.detach();

        for (int i=1500; i >= 1400; i=i-10){
            servo2.attach(11);
            servo2.writeMicroseconds(i);
            servo4.attach(9);
            servo4.writeMicroseconds(i);
            delay(1000);}
            servo4.detach();
            servo2.detach();

        for (int i=1600; i <= 2000; i=i+20){
            servo1.attach(12);
            servo1.writeMicroseconds(i);
            servo3.attach(10);
            servo3.writeMicroseconds(i);
            servo5.attach(8);
            servo5.writeMicroseconds(i);
            delay(1000);}
            servo1.detach();
            servo3.detach();
            servo5.detach();

        for (int i=1500; i >= 1400; i=i-10){
            servo2.attach(11);
            servo2.writeMicroseconds(i);
            servo4.attach(9);
            servo4.writeMicroseconds(i);
            delay(1000);}
            servo4.detach();
            servo2.detach();
            Serial.print("Stop!");

        delay(66000);
        rmp3.stop ();
        digitalWrite(relayPin[3],LOW);}
        delay(300);
        pb1=0;
        }

if (pb2==1){
    digitalWrite(relayPin[2], HIGH);
    Serial.println("LOW value:");
    Serial.println(val2, DEC);
```

```
int var=0;
int x=1;
rmp3.sync();
rmp3.playfile(FEAR);
rmp3_serial.println(value1, DEC);

while(1){
    servo1.attach(12);
    int i=1560;
    int b=1000;
    servo1.writeMicroseconds(i);
    Serial.print("Running first motor at: ");
    Serial.println(i, DEC);
    var++;
    x++;
    Serial.print("x: ");
    Serial.println(x, DEC);
    if (x==30){break;}
        }
    servo1.detach();
    delay(5000);

while(1){
    servo3.attach(10);
    int i=1560;
    servo3.writeMicroseconds(i);
    Serial.print("Running 2nd motor at: ");
    Serial.println(i, DEC);
    var++;
    x++;
    Serial.print("x2: ");
    Serial.println(x, DEC);
    if (x==60){break;}
        }
    servo3.detach();
    delay(5000);

  while(1){
    servo1.attach(12);
    int i=1560;
    int b=1000;
    servo1.writeMicroseconds(i);
    Serial.print("Running first motor at: ");
    Serial.println(i, DEC);
```

```
       var++;
       x++;
       Serial.print("x: ");
       Serial.println(x, DEC);
       if (x==90){break;}
             }
       servo1.detach();
       delay(5000);

  while(1){
       servo2.attach(11);
       int i=1560;
       int b=1000;
       servo2.writeMicroseconds(i);
       Serial.print("Running second motor at: ");
       Serial.println(i, DEC);
       var++;
       x++;
       Serial.print("x: ");
       Serial.println(x, DEC);
       if (x==120){
          break;}
             }
       servo2.detach();
       delay(5000);

  while(1){
       servo1.attach(12);
       int i=1560;
       int b=1000;
       servo1.writeMicroseconds(i);
       Serial.print("Running first motor at: ");
       Serial.println(i, DEC);
       var++;
       x++;
       Serial.print("x: ");
       Serial.println(x, DEC);
       if (x==150){ break;}
             }
       servo1.detach();
       delay(5000);

   while(1){
        servo3.attach(10);
```

```
    int i=1560;
    servo3.writeMicroseconds(i);
    Serial.print("Running 2nd motor at: ");
    Serial.println(i, DEC);
    var++;
    x++;
    Serial.print("x2: ");
    Serial.println(x, DEC);
    if (x==180){break;}
            }
    servo3.detach();
    delay(5000);

while(1){
    servo1.attach(12);
    servo2.attach(11);
    servo3.attach(10);
    servo4.attach(9);
    servo5.attach(8);
    int i=1560;
    int b=1000;
    servo1.writeMicroseconds(i);
    Serial.print("Running first motor at: ");
    Serial.println(i, DEC);
    var++;
    x++;
    Serial.print("x: ");
    Serial.println(x, DEC);
    if (x==210){break;}
            }
    servo1.detach();
    servo2.detach();
    servo3.detach();
    servo4.detach();
    servo5.detach();
    delay(5000);


while(1){
    servo2.attach(11);
    int i=1560;
    int b=1000;
    servo2.writeMicroseconds(i);
    Serial.print("Running first motor at: ");
```

```
        Serial.println(i, DEC);
        var++;
        x++;
        Serial.print("x: ");
        Serial.println(x, DEC);
        if (x==240){ break;}
                }
        servo2.detach();
        delay(5000);

while(1){
        servo1.attach(12);
        int i=1560;
        int b=1000;
        servo1.writeMicroseconds(i);
        Serial.print("Running first motor at: ");
        Serial.println(i, DEC);
        var++;
        x++;
        Serial.print("x: ");
        Serial.println(x, DEC);
        if (x==270){ break;}
                }
        servo1.detach();
        delay(5000);

 while(1){
        servo3.attach(10);
        int i=1560;
        servo3.writeMicroseconds(i);
        Serial.print("Running 3rd motor at: ");
        Serial.println(i, DEC);
        var++;
        x++;
        Serial.print("x2: ");
        Serial.println(x, DEC);
        if (x==300){break;}
                }
        servo3.detach();
        delay(5000);

 while(1){
        servo1.attach(12);
        int i=1560;
```

```
    int b=1000;
    servo1.writeMicroseconds(i);
    Serial.print("Running first motor at: ");
    Serial.println(i, DEC);
    var++;
    x++;
    Serial.print("x: ");
    Serial.println(x, DEC);
    if (x==330){break;}
            }
   servo1.detach();
   delay(5000);

  while(1){
    servo2.attach(11);
    int i=1560;
    int b=1000;
    servo2.writeMicroseconds(i);
    Serial.print("Running second motor at: ");
    Serial.println(i, DEC);
    var++;
    x++;
    Serial.print("x: ");
    Serial.println(x, DEC);
    if (x==360){break;}
            }
    servo1.writeMicroseconds(1800);
    Serial.print("Stop!");
    servo1.detach();
    delay(66000);
    rmp3.stop ();
    digitalWrite(relayPin[2],LOW);
    delay(100);
    pb2=0;  // just to reset the button
  }

if (pb3==1){
    Serial.println("Medium value:");
    Serial.println(val3, DEC);
    digitalWrite(relayPin[0],HIGH);
    rmp3.sync();
    rmp3.playfile(HAPPY);
    rmp3_serial.println(value1, DEC);
```

```
        servo1.attach(12);
        servo2.attach(11);
        servo3.attach(10);
        servo4.attach(9);
        servo5.attach(8);

while(1){
   for (int i=1500; i <= 1850; i=i+25){
        servo1.writeMicroseconds(i);
        Serial.print("Running motor at: ");
        Serial.println(i, DEC);
        delay(1200);}
        servo1.detach();

   for (int i=1500; i <= 1850; i=i+24){
        servo2.writeMicroseconds(i);
        Serial.print("Running motor at: ");
        Serial.println(i, DEC);
        delay(1200);}
        servo2.detach();

   for (int i=1500; i <= 1850; i=i+25){
        servo3.writeMicroseconds(i);
        Serial.print("Running motor at: ");
        Serial.println(i, DEC);
        delay(1200);}
        servo3.detach();

   for (int i=1500; i <= 1850; i=i+25){
        servo4.writeMicroseconds(i);
        Serial.print("Running motor at: ");
        Serial.println(i, DEC);
        delay(1200);}
        servo4.detach();

   for (int i=1500; i <= 1850; i=i+20){
        servo5.writeMicroseconds(i);
        Serial.print("Running motor at: ");
        Serial.println(i, DEC);
        delay(1200);}

        servo5.detach();
        Serial.print("Stop!");
        delay(66000);
```

```
        rmp3.stop ();
        digitalWrite(relayPin[0],LOW);}
        delay(100);
        pb3=0;
      }

if (pb4==1){
        Serial.println("LOW value:");
        Serial.println(val4, DEC);
        digitalWrite(relayPin[1],HIGH);
        rmp3.sync();
        rmp3.playfile(SAD);
        rmp3_serial.println(value1, DEC);
        int var=0;
        int x=1;

     while(1){
       int i=1800;
       int b=1000;
       servo1.attach(12);
       servo1.writeMicroseconds(i);
       Serial.print("Running first motor at: ");
       Serial.println(i, DEC);
       var++;
       x++;
       Serial.print("x: ");
       Serial.println(x, DEC);
       if (x==10){break;}
             }
       servo1.detach();
       delay(1000);

     while(1){
       int i=1600;
       servo3.attach(10);
       servo3.writeMicroseconds(i);
       Serial.print("Running 2nd motor at: ");
       Serial.println(i, DEC);
       var++;
       x++;
       Serial.print("x2: ");
       Serial.println(x, DEC);
       if (x==30){ break;}
             }
```

```
for (int i=1500; i >= 0; --i) {
     servo1.attach(12);
     servo1.writeMicroseconds(i);
     Serial.print("Running motor at: ");
     Serial.println(i, DEC);
     delay(5000);}

for (int i=1500; i >= 1300; i=i-20) {
     servo1.attach(12);
     servo1.writeMicroseconds(i);
     Serial.print("Running motor at: ");
     Serial.println(i, DEC);
     delay(5000); }

for (int i=1500; i >= 1300; i=i-20) {
     servo5.attach(8);
     servo5.writeMicroseconds(i);
     Serial.print("Running motor at: ");
     Serial.println(i, DEC);
     var++;
     x++;
     Serial.print("x2: ");
     Serial.println(x, DEC);
     if (x==40){
        break;}
         }

  for (int i=1300; i <= 1500; i=i+50)
    {
       servo1.attach(12);
       servo1.writeMicroseconds(i);
       Serial.print("Running motor at: ");
       Serial.println(i, DEC);
       delay(5000);}

  delay(5000);
    for (int i=1500; i <= 1700; i=i+20){
       servo1.attach(12);
       servo1.writeMicroseconds(i);
       Serial.print("Running motor at: ");
       Serial.println(i, DEC);
       delay(5000);}
```

```
                servo1.writeMicroseconds(1800);
                Serial.print("Stop!");
                servo1.detach();
                servo3.detach();
                servo5.detach();
                digitalWrite(relayPin[1],LOW);
                pb4=0;
            }
        }
```

/*
  Servo.h - Interrupt driven Servo library for Arduino using 16 bit timers- Version 2
  Copyright (c) 2009 Michael Margolis. All right reserved.

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  modify it under the terms of the GNU Lesser General Public
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  License along with this library; if not, write to the Free Software
  Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA
*/

/*

  A servo is activated by creating an instance of the Servo class passing the desired pin to
the attach() method.
  The servos are pulsed in the background using the value most recently written using the
write() method

  Note that analogWrite of PWM on pins associated with the timer are disabled when the
first servo is attached.
  Timers are seized as needed in groups of 12 servos - 24 servos use two timers, 48 servos
will use four.
  The sequence used to sieze timers is defined in timers.h

  The methods are:

221

Servo - Class for manipulating servo motors connected to Arduino pins.

    attach(pin) - Attaches a servo motor to an i/o pin.
    attach(pin, min, max) - Attaches to a pin setting min and max values in microseconds
    default min is 544, max is 2400

    write()   - Sets the servo angle in degrees. (invalid angle that is valid as pulse in
microseconds is treated as microseconds)
    writeMicroseconds() - Sets the servo pulse width in microseconds
    read()   - Gets the last written servo pulse width as an angle between 0 and 180.
    readMicroseconds()   - Gets the last written servo pulse width in microseconds. (was
read_us() in first release)
    attached() - Returns true if there is a servo attached.
    detach()   - Stops an attached servos from pulsing its i/o pin.
 */

#ifndef Servo_h
#define Servo_h

#include <inttypes.h>

/*
 * Defines for 16 bit timers used with Servo library
 *
 * If _useTimerX is defined then TimerX is a 16 bit timer on the curent board
 * timer16_Sequence_t enumerates the sequence that the timers should be allocated
 * _Nbr_16timers indicates how many 16 bit timers are available.
 *
 */

// Say which 16 bit timers can be used and in what order
#if defined(__AVR_ATmega1280__)
#define _useTimer5
#define _useTimer1
#define _useTimer3
#define _useTimer4
typedef enum { _timer5, _timer1, _timer3, _timer4, _Nbr_16timers }
timer16_Sequence_t ;

#elif defined(__AVR_ATmega32U4__)
#define _useTimer3
#define _useTimer1
typedef enum { _timer3, _timer1, _Nbr_16timers } timer16_Sequence_t ;

```c
#elif defined(__AVR_AT90USB646__) || defined(__AVR_AT90USB1286__)
#define _useTimer3
#define _useTimer1
typedef enum { _timer3, _timer1, _Nbr_16timers } timer16_Sequence_t ;

#elif defined(__AVR_ATmega128__)
||defined(__AVR_ATmega1281__)||defined(__AVR_ATmega2561__)
#define _useTimer3
#define _useTimer1
typedef enum { _timer3, _timer1, _Nbr_16timers } timer16_Sequence_t ;

#else  // everything else
#define _useTimer1
typedef enum { _timer1, _Nbr_16timers } timer16_Sequence_t ;
#endif

#define Servo_VERSION          2      // software version of this library

#define MIN_PULSE_WIDTH       544     // the shortest pulse sent to a servo
#define MAX_PULSE_WIDTH      2400     // the longest pulse sent to a servo
#define DEFAULT_PULSE_WIDTH  1500     // default pulse width when servo is
attached
#define REFRESH_INTERVAL    20000     // minumim time to refresh servos in
microseconds

#define SERVOS_PER_TIMER       12     // the maximum number of servos controlled
by one timer
#define MAX_SERVOS   (_Nbr_16timers  * SERVOS_PER_TIMER)

#define INVALID_SERVO         255     // flag indicating an invalid servo index

typedef struct  {
  uint8_t nbr        :6 ;           // a pin number from 0 to 63
  uint8_t isActive   :1 ;           // true if this channel is enabled, pin not pulsed if false
} ServoPin_t  ;

typedef struct {
  ServoPin_t Pin;
  unsigned int ticks;
} servo_t;

class Servo
{
```

```cpp
public:
  Servo();
  uint8_t attach(int pin);          // attach the given pin to the next free channel, sets
pinMode, returns channel number or 0 if failure
  uint8_t attach(int pin, int min, int max); // as above but also sets min and max values for
writes.
  void detach();
  void write(int value);            // if value is < 200 its treated as an angle, otherwise as
pulse width in microseconds
  void writeMicroseconds(int value); // Write pulse width in microseconds
  int read();                       // returns current pulse width as an angle between 0 and 180
degrees
  int readMicroseconds();           // returns current pulse width in microseconds for this
servo (was read_us() in first release)
  bool attached();                  // return true if this servo is attached, otherwise false
private:
  uint8_t servoIndex;               // index into the channel data for this servo
  int8_t min;                       // minimum is this value times 4 added to
MIN_PULSE_WIDTH
  int8_t max;                       // maximum is this value times 4 added to
MAX_PULSE_WIDTH
};

#endif
```

```
#ifndef SoftwareSerial_h
#define SoftwareSerial_h

#include <inttypes.h>

class SoftwareSerial
{
  private:
    uint8_t _receivePin;
    uint8_t _transmitPin;
    long _baudRate;
    int _bitPeriod;
    void printNumber(unsigned long, uint8_t);
  public:
    SoftwareSerial(uint8_t, uint8_t);
    void begin(long);
    int read();
    void print(char);
    void print(const char[]);
    void print(uint8_t);
    void print(int);
    void print(unsigned int);
    void print(long);
    void print(unsigned long);
    void print(long, int);
    void println(void);
    void println(char);
    void println(const char[]);
    void println(uint8_t);
    void println(int);
    void println(long);
    void println(unsigned long);
    void println(long, int);
};

#endif

/* $Id: RogueMP3.h 125 2010-10-18 03:04:22Z bhagman@roguerobotics.com $

  Rogue Robotics MP3 Library
  File System interface for:
   - uMP3
   - rMP3
```

A library to communicate with the Rogue Robotics
MP3 Playback modules. (uMP3, rMP3)
Rogue Robotics (http://www.roguerobotics.com/).
Requires
uMP3 firmware > 111.01

See http://www.roguerobotics.com/faq/update_firmware for updating firmware.

Written by Brett Hagman
http://www.roguerobotics.com/
bhagman@roguerobotics.com

***/

```
#ifndef _RogueMP3_h
#define _RogueMP3_h

#include <avr/pgmspace.h>
#include <stdint.h>
#include <Stream.h>
// The Stream class is derived from the Print class

/**********************************************
* Public Constants
***********************************************/

#ifndef _RogueSD_h

#define DEFAULT_PROMPT              0x3E

#define ERROR_BUFFER_OVERRUN            0x02
```

```c
#define ERROR_NO_FREE_FILES             0x03
#define ERROR_UNRECOGNIZED_COMMAND      0x04
#define ERROR_CARD_INITIALIZATION_ERROR 0x05
#define ERROR_FORMATTING_ERROR          0x06
#define ERROR_EOF                       0x07
#define ERROR_CARD_NOT_INSERTED         0x08
#define ERROR_MMC_RESET_FAIL            0x09
#define ERROR_CARD_WRITE_PROTECTED      0x0a
#define ERROR_INVALID_HANDLE            0xf6
#define ERROR_OPEN_PATH_INVALID         0xf5
#define ERROR_FILE_ALREADY_EXISTS       0xf4
#define ERROR_DE_CREATION_FAILURE       0xf3
#define ERROR_FILE_DOES_NOT_EXIST       0xf2
#define ERROR_OPEN_HANDLE_IN_USE        0xf1
#define ERROR_OPEN_NO_FREE_HANDLES      0xf0
#define ERROR_FAT_FAILURE               0xef
#define ERROR_SEEK_NOT_OPEN             0xee
#define ERROR_OPEN_MODE_INVALID         0xed
#define ERROR_READ_IMPROPER_MODE        0xec
#define ERROR_FILE_NOT_OPEN             0xeb
#define ERROR_NO_FREE_SPACE             0xea
#define ERROR_WRITE_IMPROPER_MODE       0xe9
#define ERROR_WRITE_FAILURE             0xe8
#define ERROR_NOT_A_FILE                0xe7
#define ERROR_OPEN_READONLY_FILE        0xe6
#define ERROR_NOT_A_DIR                 0xe5

#define ERROR_NOT_SUPPORTED             0xff

#endif

/*************************************************
* Typedefs, structs, etc
*************************************************/

struct playbackinfo {
        uint16_t position;
        uint8_t samplerate;
        uint16_t bitrate;
        char channels;
      };

#ifndef _RogueSD_h
enum moduletype {uMMC = 1, uMP3, rMP3};
```

```
#endif

/**********************************************
* Class
*********************************************/

class RogueMP3 : public Print
{
  public:
    // properties
    uint8_t LastErrorCode;

    // constructor
//    RogueMP3(int8_t (*_af)(void), int16_t (*_pf)(void), int16_t (*_rf)(void), void
(*_wf)(uint8_t));
    RogueMP3(Stream &comms);


    // methods
    int8_t sync(void);

    moduletype getmoduletype(void) { return _moduletype; }

    // Play Command ("PC") methods
    int8_t playfile_P(const char *path);
    int8_t playfile(const char *path, const char *filename = NULL, uint8_t pgmspc = 0);
    void setloop(uint8_t loopcount);
    void jump(uint16_t newtime);
    void setboost(uint8_t bass_amp, uint8_t bass_freq, int8_t treble_amp, uint8_t
treble_freq);
    void setboost(uint16_t newboost);

    uint16_t getvolume(void);

    void setvolume(uint8_t newvolume);
    void setvolume(uint8_t new_vleft, uint8_t new_vright);

    void fade(uint8_t newvolume);
    void fade(uint8_t newvolume, uint16_t fadems);
    void fade_lr(uint8_t new_vleft, uint8_t new_vright);
    void fade_lr(uint8_t new_vleft, uint8_t new_vright, uint16_t fadems);

    void playpause(void);
    void stop(void);
```

```cpp
    playbackinfo getplaybackinfo(void);
    char getplaybackstatus(void);
    uint8_t getspectrumanalyzer(uint8_t values[], uint8_t peaks=0);
    void setspectrumanalyzer(uint16_t bands[], uint8_t count);

    // Information Commands ("IC" - MP3 information)
    int16_t gettracklength(const char *path, const char *filename = NULL, uint8_t pgmspc
= 0);

    // Settings ("ST") methods
    int8_t changesetting(char setting, const char *value);
    int8_t changesetting(char setting, uint8_t value);
    int16_t getsetting(char setting);
    // ************************

    inline int16_t version(void) { return _fwversion; }

    void write(uint8_t);  // needed for Print

    void print_P(const prog_char *str);

  private:

    // Polymorphism used to interact with serial class
    // SerialBase is an abstract base class which defines a base set
    // of functionality for serial classes.
    Stream *_comms;

    uint8_t _promptchar;
    int16_t _fwversion;
    moduletype _moduletype;

    // methods
    int16_t _get_version(void);
    int8_t _get_response(void);
    void _flush(void);

    int8_t _read_blocked(void);
    int32_t _getnumber(uint8_t base);

    uint8_t _comm_available(void);
    int _comm_peek(void);
    int _comm_read(void);
```

```
    void _comm_write(uint8_t);
    void _comm_flush(void);
};

#endif

/* $Id: RogueSD.h 126 2010-10-18 03:06:09Z bhagman@roguerobotics.com $

  Rogue Robotics SD Library
  File System interface for:
   - uMMC
   - uMP3
   - rMP3

  A library to communicate with the Rogue Robotics
  SD Card modules. (uMMC, uMP3, rMP3)
  Rogue Robotics (http://www.roguerobotics.com/).
  Requires
  uMMC firmware > 102.01
  uMP3 firmware > 111.01

  See http://www.roguerobotics.com/faq/update_firmware for updating firmware.

  Written by Brett Hagman
  http://www.roguerobotics.com/
  bhagman@roguerobotics.com

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  along with this program.  If not, see <http://www.gnu.org/licenses/>.

***********************************************/

#ifndef _RogueSD_h
#define _RogueSD_h
```

```
#include <avr/pgmspace.h>
#include <stdint.h>
#include <Stream.h>
// The Stream class is derived from the Print class

/***********************************************
* Public Constants
*********************************************/

#ifndef _RogueMP3_h

#define DEFAULT_PROMPT                 0x3E

#define ERROR_BUFFER_OVERRUN             0x02
#define ERROR_NO_FREE_FILES            0x03
#define ERROR_UNRECOGNIZED_COMMAND         0x04
#define ERROR_CARD_INITIALIZATION_ERROR      0x05
#define ERROR_FORMATTING_ERROR           0x06
#define ERROR_EOF                  0x07
#define ERROR_CARD_NOT_INSERTED          0x08
#define ERROR_MMC_RESET_FAIL           0x09
#define ERROR_CARD_WRITE_PROTECTED         0x0a
#define ERROR_INVALID_HANDLE           0xf6
#define ERROR_OPEN_PATH_INVALID         0xf5
#define ERROR_FILE_ALREADY_EXISTS        0xf4
#define ERROR_DE_CREATION_FAILURE         0xf3
#define ERROR_FILE_DOES_NOT_EXIST        0xf2
#define ERROR_OPEN_HANDLE_IN_USE         0xf1
#define ERROR_OPEN_NO_FREE_HANDLES        0xf0
#define ERROR_FAT_FAILURE            0xef
#define ERROR_SEEK_NOT_OPEN            0xee
#define ERROR_OPEN_MODE_INVALID          0xed
#define ERROR_READ_IMPROPER_MODE          0xec
#define ERROR_FILE_NOT_OPEN           0xeb
#define ERROR_NO_FREE_SPACE           0xea
#define ERROR_WRITE_IMPROPER_MODE         0xe9
#define ERROR_WRITE_FAILURE           0xe8
#define ERROR_NOT_A_FILE             0xe7
#define ERROR_OPEN_READONLY_FILE          0xe6
#define ERROR_NOT_A_DIR             0xe5

#define ERROR_NOT_SUPPORTED            0xff
```

```
#endif

/**********************************************
* Typedefs, structs, etc
**********************************************/

struct fileinfo {uint32_t position; uint32_t size;};
enum open_mode {OPEN_READ = 1, OPEN_WRITE = 2, OPEN_RW = 3,
OPEN_APPEND = 4};

#ifndef _RogueMP3_h
enum moduletype {uMMC = 1, uMP3, rMP3};
#endif

/**********************************************
* Class
**********************************************/

class RogueSD : public Print
{
 public:
   // properties
   uint8_t LastErrorCode;

   // methods

   // constructor
//   RogueSD(int8_t (*_af)(void), int16_t (*_pf)(void), int16_t (*_rf)(void), void
(*_wf)(uint8_t));
   RogueSD(Stream &comms);

   int8_t sync(void);

   moduletype getmoduletype(void) { return _moduletype; }

//   int8_t status(void);
   int8_t status(int8_t handle = 0);

   int8_t getfreehandle(void);
   int8_t open(const char *filename);
   int8_t open(const char *filename, open_mode mode);
   int8_t open(int8_t handle, const char *filename);
   int8_t open(int8_t handle, const char *filename, open_mode mode);
   int8_t open_P(const prog_char *filename);
```

```
int8_t open_P(const prog_char *filename, open_mode mode);
int8_t open_P(int8_t handle, const prog_char *filename);
int8_t open_P(int8_t handle, const prog_char *filename, open_mode mode);

int8_t opendir(const char *dirname);
int32_t filecount(const char *filemask);
int8_t readdir(char *filename, const char *filemask);

int8_t entrytofilename(char *filename, uint8_t count, const char *filemask, uint16_t
entrynum);

// delete/remove a file/directory (directory must be empty)
int8_t remove(const char *filename);

// rename a file/directory
//   int8_t rename(const char *oldname, const char *newname);

// read single byte (-1 if no data)
int16_t readbyte(int8_t handle);

// read exactly count bytes into buffer
int16_t read(int8_t handle, uint16_t count, char *buffer);

// read up to maxlength characters into tostr
int16_t readln(int8_t handle, uint16_t maxlength, char *tostr);

//   int16_t readprep(int8_t handle, uint16_t bytestoread);

// we will need to set up the write time-out to make this work properly (done in sync())
// then you can use the Print functions to print to the file
int8_t writeln(int8_t handle, const char *data);
void writeln_prep(int8_t handle);
int8_t writeln_finish(void);

// write exactly count bytes to file
int8_t write(int8_t handle, uint16_t count, const char *data);

// write a single byte to the file
int8_t writebyte(int8_t handle, char data);

fileinfo getfileinfo(int8_t handle);
int32_t getfilesize(const char *filename); // get using "L filename"

int8_t seek(int8_t handle, uint32_t newposition);
```

233

```cpp
    int8_t seektoend(int8_t handle);

    void gettime(int *rtc);

    void settime(int rtc[]);

//    void settime(uint32_t date, uint32_t time);
//    void settime(uint16_t year, uint8_t month, uint8_t day, uint8_t hour, uint8_t minute,
uint8_t second);

    void close(int8_t handle);
    void closeall(void);
    int8_t changesetting(char setting, uint8_t value);
    int16_t getsetting(char setting);

    inline int16_t version(void) { return _fwversion; }

    void write(uint8_t);  // needed for Print

    void print_P(const prog_char *str);

  private:

    // Polymorphism used to interact with serial class
    // SerialBase is an abstract base class which defines a base set
    // of functionality for serial classes.
    Stream *_comms;

    uint8_t _promptchar;
    int16_t _fwversion;
    moduletype _moduletype;

    // methods
    int8_t _open(int8_t handle, const char *filename, open_mode mode, int8_t pgmspc);
    uint32_t _get_filestats(int8_t handle, uint8_t valuetoget);
    int16_t _get_version(void);
    int8_t _get_response(void);
    void _flush(void);

    int8_t _read_blocked(void);
    int32_t _getnumber(uint8_t base);

    uint8_t _comm_available(void);
    int _comm_peek(void);
```

```
    int _comm_read(void);
    void _comm_write(uint8_t);
    void _comm_flush(void);
};

#endif
```

Cognitive Walkthrough Survey Sheets

		Will the user be trying to produce the effect that the task has?		Will users be able to notice that the correct action is available?		Will users know that it is the right one for the effect they are trying to produce?		Will users understand the feedback they get?		Description
Task step	Task Description	Yes	No	Yes	No	Yes	No	Yes	No	
	Task (1): Know about WikiMonument and create an account									
1.1	Click on "About WikiMonument"									
1.2	Read About "WikiMonument"									
1.3	Click on "Log in / create an account"									
1.4	Close Log in window									
	Task (2): Interact with WikiMonument: Share, Speak, and Write									
2.1	Click on "Share"									
2.2	Click on one of the faces									
2.3	Click on "Click to Watch how your response affects Monumental-IT"									
2.4	Watch Monuemntal-IT Live									
2.5	Click on "Speak"									
2.6	Click on Record									
2.7	Click on Listen									
2.8	Click on Save and Accept									
2.9	Click on List of your previous records									
2.10	Click on Listen									
2.11	Click on "Click to watch how your input affects Monumental-IT"									
2.12	Click on "Write"									
2.13	Start writing in the box									
2.14	Click on Accept									
2.15	Click on Ignore									
2.16	Click on List of your previous records									
2.17	Click on "Click to watch how your input affects Monumental-IT"									

Do you think that the whole website is easy to understand?
If No, what are your uggestions to improve the understandability of this website?

236

Appendix J

WikiMonument Webpages

WikiMonument

Log in / create account   Spanish/**English**

SEARCH: [   ] GO

Main Page   About WikiMonument

Welcome to WikiMonument: the open monument that anyone can edit.
3,614,976 wikis in English

READ
about the history of slavery

SHARE
your feelings

SPEAK
about your memories

WRITE
about your memories

WATCH it live!

WikiMonument is an open website for citizens to share their memories about the history of slavery in the US in the 19th Century. The physical Monumental-IT in Charleston, SC, in front of the Old Slave Mart in Chalmers Street, is a robotic monument which is open for citizens to shape and reconfigure by using local microphones on-site. While WikiMonument is the virtual/internet platform of Monumental-IT.

How it Works?
1- You can interact with the physical Monumental-IT in Charleston, SC.
2- Or you can virtually **interact by using any feature** of this Wiki website: **SHARE**, **SPEAK**, or **WRITE**.
If you need to keep your response for later retrieval, please create an account
3- Once you interact with the physical robotic monument or in this website, the structure of **the monument will reconfigure itself** using its intelligent program that understands your inputs and responds accordingly.
4- You can also **watch Monumental-IT live**, as all inputs from this wiki, i.e. attached readings from READ menu, and from visitors of Charleston's monument, and your inputs to this wiki are encoded and collectively change Monumental-IT.

Click to start interacting with Monumental-IT.

Contact Us | Site Map | Help

WikiMonument

Log in / create account   Spanish/**English**

SEARCH: [   ] GO

Main Page   About WikiMonument

Welcome to WikiMonument: the open monument that anyone can edit.
3,614,976 wikis in English

READ
about the history of slavery

SHARE
your feelings

SPEAK
about your memories

WRITE
about your memories

WATCH it live!

NORTH AMERICAN SLAVE NARRATIVES

This section contains only a link to "Documenting the American South" Website, which "collects books and articles that document the individual and collective story of African Americans struggling for freedom and human rights in the eighteenth, nineteenth, and early twentieth centuries." Also, "this section of the bibliography lists biographies published in English before 1940 that were written by or about slaves or former slaves. Much less well known than autobiographical slave narratives, the biographies of slaves or former slaves constitute an abundant resource for the study of the nineteenth-century slave narrative tradition. In addition to book-length biographies, the following listing comprises biographical pamphlets, books of biographical sketches, historical volumes that contain a significant proportion of biographical narratives, and substantial biographical introductions to editions of authors' works. Generally more sermonic than narrative, eulogies are not listed here. Also excluded from this bibliography are various other non-narrative biographical forms, for example, the commemorative speech, the newspaper, magazine, or journal article, and the obituary, even though they were sometimes used for biographical purposes."

Click to visit Documenting the American South Website:
http://docsouth.unc.edu/neh/chronbio.html.

Contact Us | Site Map | Help

WikiMonument

Log in / create account   Spanish/**English**

SEARCH: [   ] GO

Welcome to WikiMonument: the open monument that anyone can edit.
3,614,976 wikis in English

READ
about the history of slavery

SHARE
your feelings

SPEAK
about your memories

WRITE
about your memories

WATCH it
live!

Please share your feelings about the history of slavery in the 19th Century in the US by clicking on one of the following faces

ANGER   FEAR   HAPPY   SAD

Click to **watch** how your response affects Monumental-IT

WikiMonument is the virtual platform of Monumental-IT. Monumental-IT is a robotic-monument that has been erected in front of the old slave mart, in Charleston, SC, March 2011. This is the first open interactive monument in the US for all to speak openly about the history of slavery in the 19th century.

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Web site Technical Contact: **Creative Services**

WikiMonument

Log in / create account   Spanish/**English**

SEARCH: [   ] GO

Welcome to WikiMonument: the open monument that anyone can edit.
3,614,976 wikis in English

READ
about the history of slavery

SHARE
your feelings

SPEAK
about your memories

WRITE
about your memories

WATCH it
live!

WikiMonument:
A CITIZEN-CONFIGURABLE
MONUMENT
2011 @ 10:30am

Please **SPEAK** to the microphone concerning your feelings about the history of slavery in the 19th Century in the US by clicking on one of the following faces

Record
Listen
Delete
Save and Accept

List of your previous records

Click to **watch** how your input affects Monumental-IT

...ument is the virtual platform of Monumental-IT. ...tal-IT is a robotic-monument that has been erected in front ...old slave mart, in Charleston, SC, March 2011. This is the first open interactive monument in the US for all to speak openly about the history of slavery in the 19th century.

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Web site Technical Contact: **Creative Services**

239

Heuristic Evaluation Task Analysis Sheet

Heuristic Evaluation Task Analysis Sheet

	Full name:		
	Date:		
	Age:	Gender(optional):	
	Address:		
	State:	Zip code:	
	email address:		
	Agree to conduct the test as described		
	Evaluator's Signature:		
	The Task: Interacting with Monumental-IT to recall ones' memories about the history of slavery in the US in the 19th century	**Heuristic(s) Violated**	**Descriptions/ Recommenda tions**
1	Walk to start interacting with Monumental-IT		
2	Read Monumental-IT's plaque		
3	Start recalling memories		
4	Speak on the microphone to express emotions about the history of slavery		
5	The LED is going on		
6	The skin starts morphing		
7	The audio starts		
8	People start to connect past memories about the history of slavery with the space of Monumental.IT, and use the space as a contextual cue for later retrieval		
9	Leave the place or want to retune your memories or emotions or interpretations		

* Heuristic sheet will be handed out separately, then, it will be collected after the evaluator finishes his/her inspection of the interface.

Appendix L

Heuristic Evaluation Guidelines

Testing guidelines to conduct the HE testing on Monumental.IT:

1. Each evaluator will judge the monument (the system) against set of heuristics. Make notes on flaws (with heuristics in mind.)

2. "These heuristics are *general rules that seem to describe common properties of usable [systems.]* The evaluator obviously is also allowed to consider any additional usability principles or results that come to mind that may be relevant for any specific dialogue element." (Nielsen, 2005)

   The heuristics as defined by Nielsen (with minor changes) are:

   "Recognition rather than recall
   Minimize the user's memory load by making objects and actions visible. The user should not have to remember information from one part of the [monument space] to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

   Visibility of system status
   The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

   User control and freedom
   Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

   Aesthetic and minimalist design
   [Monument design] should not contain information which is irrelevant or rarely needed. Every extra unit of information in [the monument design] competes with the relevant units of information and diminishes their relative visibility." (Nielsen, 1994)

   Category-specific heuristics

   Differentiate Monumental.IT's configurations
   Monumental-IT should provide different recognized and understandable configurations for the different ways its visitors will emotionally reflect on the history of slavery.

   Response rate to human monument interaction
   Monumental.IT should provide a good time pace for visitors to understand its reflection on users' inputs.

3. The evaluator will be given a task analysis sheet for what the actual users are going to use in order to be as representative as possible of the eventual use of the system.

4. "During the evaluation session, the evaluator goes through the system several times and inspects the various elements and compares them with a list of recognized usability principles (the heuristics)." (Nielsen, 1994)

Appendix M

Recruitment Email Form

Dear Colleagues,

I am seeking participants (40 minutes of your time) to evaluate a scaled monument that I designed as part of my PhD in PDBE: Planning, Design, and the Built Environment program at Clemson University. This involves visiting our lab, 259 Fluor Daniel (across from Lee Hall), and filling out a survey to report your sense of my project. It's fun, and I need your help!

My PhD advisory committee are: Dr. Keith Green (ARCH/ECE), Dr. Ian Walker (ECE) and Dr. Mickey Lauria (PLANNING).

I am in the process of evaluating and collecting peoples' opinions and suggestion to develop it. I am inviting you to share your thoughts with me in our "robotics and mechatronics" lab, 259 at Flour Daniel Room 259.

To schedule a meeting, please send me an email to: tmokhta@g.clemson.edu.

Hope to see you,

Fellow students at Clemson are welcome to participate - spread the word.

Thanks,

Tarek

Pretest Survey Form

In this survey, I am looking for users' feedback about design concepts, people's understandings of colors, forms, sound, and motion of the physical scaled prototype of Monumental-IT.
Population: Lay citizens who are generally interested in visiting monumental sites and particularly the history of slavery; the method that will be used is "purposive sampling."

Demographic Questions

1. Which of the following categories includes your age?
   o   18-24
   o   25-34
   o   35-49
   o   50-64
   o   65+
   o   Rather not to say

2. What is your gender?

   o   Female
   o   Male
   o   Rather not to say

3. Select the educational level you have reached.
   o   Grade school
   o   Some high school
   o   High school graduate
   o   Vocational/technical
   o   Associate degree
   o   University undergraduate graduate
   o   Masters degree
   o   Professional degree (JD, MD, etc.)
   o   Advanced degree (PhD, PsyD, etc.)
   o   Other

4. Which of the following categories includes your household's annual income?

   o   Less than $20,000
   o $20,001-$29,999
   o $30,000-$39,999
   o $40,000-$49,999
   o $50,000-$59,999
   o $60,000-$69,999
   o $70,000-$79,999

- o $80,000-$99,999
- o $100,000-$119,999
- o $120,000-$149,999
- o $150,000+

5. What is your current employment status?

- o Employed full-time
- o Employed part-time
- o Not employed
- o Self-employed

6. What is your job title?

7. What is your racial background?
- o White
- o American Indian
- o Alaska Native
- o Asian
- o African American
- o Native Hawaiian
- o Other Pacific Islander
- o Of two or more races. Please indicate:

User-Monument Background
For all of the following, the term "monumental sites" refer to: obelisks, statues, temples, monumental sculptures, memorials and national memorials; NOT including significant/iconic buildings or grave stones or tombs or mausoleums.

1- How many times have you visited monumental sites?

- o Never
- o Less than 5 times
- o 5 to 10 times
- o 11 to 15 times
- o More than 15 times

2- Describe the best monumental site experience you have had in your life?

3- Why did you select the previous monument as the best? (Select as many as apply)

   A- Formal Aspects
   - o Scale of the monument
   - o Aesthetics (proportions-materials-colors-landscaping)

- Shape and craftsmanship
- Iconic quality and memorability

B- Conceptual aspects

The monument you select (select only one):
- Tells you a full story
- Tells you a partial story
- Evokes your thoughts about the past
- Uses contextual cues (reflections-colors-sounds-smell-form-texture) to recall the past

C- Preferential aspects

- Recommendation by others
- Design by a famous Architect
- Location of the monument
- Personal or family relevance to the memory

D- Historical aspects

D.1. How much does the history of the monument affects your selection?
- Not at all
- Very little
- A lot

D.2. How much does the memory represented in the monument affects your selection?
- Not at all
- Very little
- A lot

E- Emotional aspects

E.1. Does the monument represent the emotional aspect of the memory?
- Not at all
- Very little
- A lot

E.2. Do you think that emotions are the best representation of collective memories?
- Not at all
- Very little
- A lot

E.3. Which of the following emotions represent the memory embodied in your selected monument?
- Happy
- Sad
- Anger
- Fear
- None

Specific Questions

" *Born in Slavery: Slave Narratives from the Federal Writers' Project, 1936-1938* contains more than 2,300 first-person accounts of slavery and 500 black-and-white photographs of former slaves. These narratives were collected in the 1930s as part of the Federal Writers' Project of the Works Progress Administration (WPA) and assembled and microfilmed in 1941 as the seventeen-volume *Slave Narratives: A Folk History of Slavery in the United States from Interviews with Former Slaves.*"

Please read the following quotes; then select the one that matches the emotion you detect within the quotes:

1- "I can tell you bout my poor soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun dead en gone en God left me to live among dese wild varments here. I have to cry sometimes when I think how dey die en leave me in dis troublesome world."
- o Happy
- o Sad
- o Anger
- o Fear

2- "I think 'bout my old mammy heap of times now and how I's seen her whipped, wid de blood dripping off of her."
- o Happy
- o Sad
- o Anger
- o Fear

3- "You see, I have such a hurtin in my back en such a drawin in my knees en seems like de sun does just help me along to bear de pain."

- o Happy
- o Sad
- o Anger
- o Fear

4- "My Master was kind to his slaves an' his overseer was all Negroes."

- o Happy
- o Sad
- o Anger
- o Fear

5- "Sometimes niggers could see ghosts around dere at night, so dey say."

- o Happy
- o Sad
- o Anger
- o Fear

6- Then Lincoln was raised up for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."

- o Happy
- o Sad
- o Anger
- o Fear

7- "I does worry bout it so much sometimes."
- o Happy
- o Sad
- o Anger
- o Fear

Design Questions

Please select the quote/quotes that match your interpretation of the following design:

- o "You see, I have such a hurtin in my back en such a drawin in my knees en seems like de sun does just help me along to bear de pain."
- o Then Lincoln was raised up for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."
- o "I does worry bout it so much sometimes."
- o "I can tell you bout my poor soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun dead en gone en God left me

to live among dese wild varments here. I have to cry sometimes when I think how dey die en leave me in dis troublesome world.”
- o “I think 'bout my old mammy heap of times now and how I's seen her whipped, wid de blood dripping off of her.”
- o “My Master was kind to his slaves an' his overseer was all Negroes.”
- o “sometimes niggers could see ghosts around dere at night, so dey say.”
- o All of the above
- o None

“Forms” and Emotions

Please select the emotion that matches your interpretation of the monument's form:
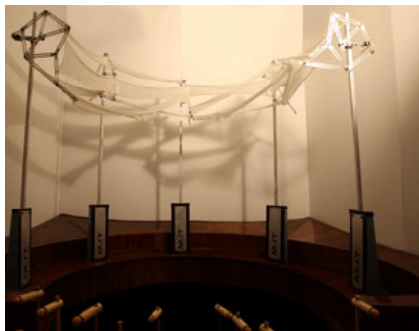
- o Happy
- o Sad
- o Anger
- o Fear
- o None

“Colors” and   emotions

Please select the emotion that matches your interpretation the monument's color:

- o Happy
- o Sad
- o Anger
- o Fear
- o None

“Sound” and Emotions

The sound of the monument is representing which of the following emotions?

- o Happy

- o Sad

- o Anger

- o Fear

- o None

General Questions

1. To what extent the following Monumental-IT's contextual cues (i.e., sound, color, texture, shades and shadows) affect your emotions.

A. The effect of Monumental.IT's sound on my emotions is:
  1 = Doesn't affect; 5 = Highly affects.
  - o 1
  - o 2
  - o 3
  - o 4
  - o 5

B. The effect of Monumental.IT's color on my emotions is:
  1 = Doesn't affect; 5 = Highly affects.
  - o 1
  - o 2
  - o 3
  - o 4
  - o 5

C. The effect of Monumental.IT's texture on my emotions is:
  1 = Doesn't affect; 5 = Highly affects.
  - o 1
  - o 2
  - o 3
  - o 4
  - o 5

D. The effects of Monumental.IT's shades and shadows on my emotions are:
  1 = Doesn't affect; 5 = Highly affects.
  - o 1

o 2
o 3
o 4
o 5

2- Describe Monumental.IT in one sentence:

……………………………………………………………………………………………………
………………………………………………………..

3- Thinking about implementing Monumental.IT on other sites, i.e., not in Charleston. Do you think that Monumental-IT will help people's participation for recalling memories in public spaces?

o Yes
o No
o Don't know
o Refuse to answer

3- When talking about monuments, do you think that Monumental-IT will be a better choice than the existing typologies of monuments?

o Yes
o No
o Don't know
o Refuse to answer

4- Who do you think would be interested to visit the real Monumental-IT? People's age in the range:

o 18-24
o 25-34
o 35-49
o 50-64
o 65+
o All ages
o None

5- To what extent Monumental-IT's contextual-cues (i.e., sound, color, texture, shades and shadows) affect your long-term memories? Thus, the memory of the event – "history of slavery" – can last longer. Please use numbers to arrange them from the highest affective cue on your long-term memory (number: 1) to the least affective cue on your long-term memory (number: 5):

o Sound
o Color
o Texture
o Shades and Shadows

Posttest Survey Form

In this survey, I am looking for users' feedback about design concepts, people's understandings of colors, forms, sound, and motion of the physical scaled prototype of Monumental-IT.

Population: Lay citizens who are generally interested in visiting monumental sites and particularly the history of slavery; the method that will be used is "purposive sampling."

Demographic Questions

1. Which of the following categories includes your age?
   o 18-24
   o 25-34
   o 35-49
   o 50-64
   o 65+
   o Rather not to say

2. What is your gender?

   o Female
   o Male
   o Rather not to say

3. Select the educational level you have reached.
   o Grade school
   o Some high school
   o High school graduate
   o Vocational/technical
   o Associate degree
   o University undergraduate graduate
   o Masters degree
   o Professional degree (JD, MD, etc.)
   o Advanced degree (PhD, PsyD, etc.)
   o Other

4. Which of the following categories includes your household's annual income?

   o Less than $20,000
   o $20,001-$29,999
   o $30,000-$39,999
   o $40,000-$49,999
   o $50,000-$59,999
   o $60,000-$69,999
   o $70,000-$79,999

- o $80,000-$99,999
- o $100,000-$119,999
- o $120,000-$149,999
- o $150,000+

5. What is your current employment status?

- o Employed full-time
- o Employed part-time
- o Not employed
- o Self-employed

6. What is your job title?

7. What is your racial background?
- o White
- o American Indian
- o Alaska Native
- o Asian
- o African American
- o Native Hawaiian
- o Other Pacific Islander
- o Of two or more races. Please indicate:

User-Monument Background

For all of the following, the term "monumental sites" refer to: obelisks, statues, temples, monumental sculptures, memorials and national memorials; NOT including significant/iconic buildings or grave stones or tombs or mausoleums.

1- How many times have you visited monumental sites?

- o Never
- o Less than 5 times
- o 5 to 10 times
- o 11 to 15 times
- o More than 15 times

2- Describe the best monumental site experience you have had in your life?

3- Why did you select the previous monument as the best? (Select as many as apply)

A- Formal Aspects
- o Scale of the monument
- o Aesthetics (proportions-materials-colors-landscaping)

- o Shape and craftsmanship
- o Iconic quality and memorability

B- Conceptual aspects

The monument you select (select only one):
- o Tells you a full story
- o Tells you a partial story
- o Evokes your thoughts about the past
- o Uses contextual cues (reflections-colors-sounds-smell-form-texture) to recall the past

C- Preferential aspects
- o Recommendation by others
- o Design by a famous Architect
- o Location of the monument
- o Personal or family relevance to the memory

D- Historical aspects

D.1. How much does the history of the monument affects your selection?
- o Not at all
- o Very little
- o A lot

D.2. How much does the memory represented in the monument affects your selection?
- o Not at all
- o Very little
- o A lot

E- Emotional aspects

E.1. Does the monument represent the emotional aspect of the memory?
- o Not at all
- o Very little
- o A lot

E.2. Do you think that emotions are the best representation of collective memories?
- o Not at all
- o Very little
- o A lot

E.3. Which of the following emotions represent the memory embodied in your selected monument?
- o Happy
- o Sad
- o Anger
- o Fear
- o None

Specific Questions

" *Born in Slavery: Slave Narratives from the Federal Writers' Project, 1936-1938* contains more than 2,300 first-person accounts of slavery and 500 black-and-white photographs of former slaves. These narratives were collected in the 1930s as part of the Federal Writers' Project of the Works Progress Administration (WPA) and assembled and microfilmed in 1941 as the seventeen-volume *Slave Narratives: A Folk History of Slavery in the United States from Interviews with Former Slaves*."

Please read the following quotes; then select the one that matches the emotion you detect within the quotes:

1- "I can tell you bout my poor soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun dead en gone en God left me to live among dese wild varments here. I have to cry sometimes when I think how dey die en leave me in dis troublesome world."
- o Happy
- o Sad
- o Anger
- o Fear

2- "I think 'bout my old mammy heap of times now and how I's seen her whipped, wid de blood dripping off of her."
- o Happy
- o Sad
- o Anger
- o Fear

3- "You see, I have such a hurtin in my back en such a drawin in my knees en seems like de sun does just help me along to bear de pain."

- o Happy
- o Sad
- o Anger
- o Fear

4- "My Master was kind to his slaves an' his overseer was all Negroes."

- o Happy
- o Sad
- o Anger
- o Fear

5- "Sometimes niggers could see ghosts around dere at night, so dey say."

- o Happy
- o Sad
- o Anger
- o Fear

6- Then Lincoln was raised up for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."

- o Happy
- o Sad
- o Anger
- o Fear

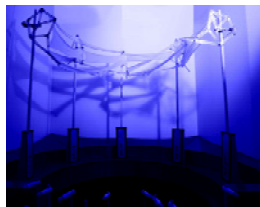7- "I does worry bout it so much sometimes."
- o Happy
- o Sad
- o Anger
- o Fear

Design Questions

Monumental.IT's design is a dynamic art not a static one, thus, all the following questions depend on the video(s)/real user interaction with the physical scaled model.
Please read the following quotes; then, select the design that matches your interpretation of the following quotes:

1- "You see, I have such a hurtin in my back en such a drawin in my knees en seems like de sun does just help me along to bear de pain."
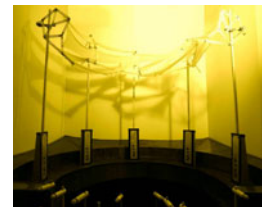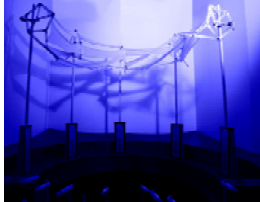

| A (Blue) | B (Red) | C (Green) | D (Yellow) |

2- Then Lincoln was raised up for a specific purpose, to end slavery, which was a menace to both whites and blacks, as I see it."

A (Blue) **B (Red)** **C (Green)** **D (Yellow)**

3- "I does worry bout it so much sometimes."
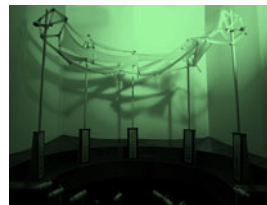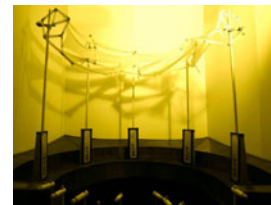
A (Blue) **B (Red)** **C (Green)** **D (Yellow)**

4- "I can tell you bout my poor soul. I think I know I'm bless to be here en raise three generation clear up dis world. All my chillun dead en gone en God left me to live among dese wild varments here. I have to cry sometimes when I think how dey die en leave me in dis troublesome world."
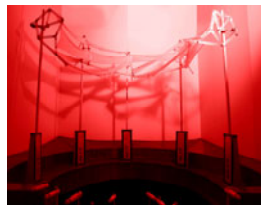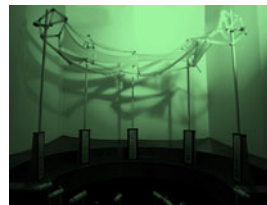
A (Blue) **B (Red)** **C (Green)** **D (Yellow)**

5- "I think 'bout my old mammy heap of times now and how I's seen her whipped, wid de blood dripping off of her."
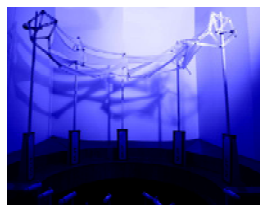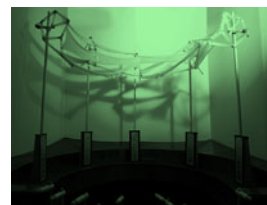
A (Blue) **B (Red)** **C (Green)** **D (Yellow)**

6- "My Master was kind to his slaves an' his overseer was all Negroes."
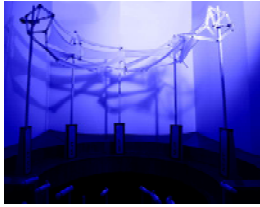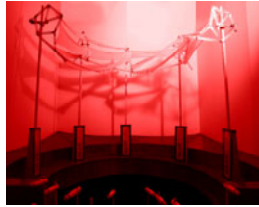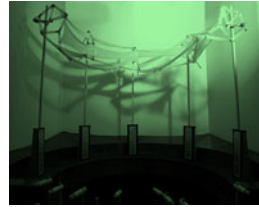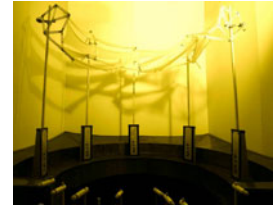
| **A (Blue)** | **B (Red)** | **C (Green)** | **D (Yellow)** |

7- "sometimes niggers could see ghosts around dere at night, so dey say."

| **A (Blue)** | **B (Red)** | **C (Green)** | **D (Yellow)** |

"Forms in motion" and emotions

Please select the emotion that matches your interpretation of the following forms:

1- (The Blue Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

2- (The Red   Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

257

3- (The Green Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

4- (The Yellow   Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

Colors and Emotions

Please select the emotion that matches your interpretation of the color represented in the following designs:

1- (The Blue Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

2- (The Red Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

258

3- (The Green Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

4- (The Yellow Configuration)

- o Happy
- o Sad
- o Anger
- o Fear
- o None

"Sound" and Emotions

1- The Blue Configuration sound is representing which of the following emotions?

- o Happy
- o Sad
- o Anger
- o Fear
- o None

2- The Red Configuration sound is representing which of the following emotions?

- o Happy
- o Sad

o   Anger

o   Fear

o   None

3- The Green Configuration sound is representing which of the following emotions?

o   Happy

o   Sad

o   Anger

o   Fear

o   None

4- The Yellow Configuration sound is representing which of the following emotions?

o   Happy

o   Sad

o   Anger

o   Fear

o   None

General Questions

1. To what extent the following Monumental-IT's contextual cues (i.e., sound, color, motion, texture, shades and shadows) affect your emotions.

E.   The effect of Monumental.IT's sound on my emotions is:
   1 = Doesn't affect; 5 = Highly affects.
   o   1
   o   2
   o   3
   o   4
   o   5

F. The effect of Monumental.IT's color on my emotions is:

1 = Doesn't affect; 5 = Highly affects.
- o 1
- o 2
- o 3
- o 4
- o 5

G. The effect of Monumental.IT's motion on my emotions is:

1 = Doesn't affect; 5 = Highly affects.
- o 1
- o 2
- o 3
- o 4
- o 5

H. The effect of Monumental.IT's texture on my emotions is:

1 = Doesn't affect; 5 = Highly affects.
- o 1
- o 2
- o 3
- o 4
- o 5

I. The effects of Monumental.IT's shades and shadows on my emotions are:

1 = Doesn't affect; 5 = Highly affects.
- o 1
- o 2
- o 3
- o 4
- o 5

2- Describe Monumental.IT in one sentence:

……………………………………………………………………………………………………
…………………………………………………………..

3- Thinking about implementing Monumental.IT on other sites, i.e., not in Charleston. Do you think that Monumental-IT will help people's participation for recalling memories in public spaces?
- o Yes

o   No
o   Don't know
o   Refuse to answer

3- When talking about monuments, do you think that Monumental-IT will be a better choice than the existing typologies of monuments?

o   Yes
o   No
o   Don't know
o   Refuse to answer

4- Who do you think would be interested to visit the real Monumental-IT? People's age in the range:
o   18-24
o   25-34
o   35-49
o   50-64
o   65+
o   All ages
o   None

5- To what extent Monumental-IT's contextual-cues (i.e., sound, color, motion, texture, shades and shadows) affect your long-term memories? Thus, the memory of the event – "history of slavery" – can last longer. Please use numbers to arrange them from the highest affective cue on your long-term memory (number: 1) to the least affective cue on your long-term memory (number: 5):
o   Sound
o   Color
o   Motion
o   Texture
o   Shades and Shadows

Pretest Informational Letter

Information about Being in a Research Study
Clemson University

Title: ***Monumental-IT: A "Robotic-Wiki" Monument for Embodied Interaction in the Informational World***

Description of the Study and Your Part in It

Dr. Keith Green and Mr. Tarek Mokhtar are inviting you to take part in a research study. Dr. Keith Green is a professor of Architecture at Clemson University. Mr. Tarek Mokhtar is a student at Clemson University, running this study with the help of Dr. Keith Green. Monumental-IT is a monument for an increasingly digital society, representing the history of slavery using the language of architecture. The purpose of this research is to study the usability, design, aesthetics, and functionality of the proposed monument.

Your participation will involve filling a questionnaire after watching the scaled monument in a lab setting.

It will take you 25mins to be in this study.

Risks and Discomforts

There are no known risks associated with this research. Your answers will be kept confidential and no one but the research team will know what you have said.

Possible Benefits

This research may help us improve the design of Monumental.IT.

Protection of Privacy and Confidentiality

We will do everything we can to protect your privacy and confidentiality. We will not tell anybody outside of the research team that you were in this study or what information we collected about you in particular. All information collected in the questionnaire is anonymous.

Choosing to Be in the Study

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study. For students: If you decide not to take part or to stop taking part in this study, it will not affect your grade in any way.

Contact information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Keith Green at Clemson University at 864-656-3887. If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-6460 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071.

A copy of this form will be given to you.

Information about Being in a Research Study
Clemson University

Title: *Monumental-IT: A "Robotic-Wiki" Monument for Embodied Interaction in the Informational World*

Description of the Study and Your Part in It

Dr. Keith Green and Mr. Tarek Mokhtar are inviting you to take part in a research study. Dr. Keith Green is a professor of Architecture at Clemson University. Mr. Tarek Mokhtar is a student at Clemson University, running this study with the help of Dr. Keith Green. Monumental-IT is a monument for an increasingly digital society, representing the history of slavery using the language of architecture, where lay-citizens have the ability to shape their monument experience by changing Monumental-IT's color, sound, and shape using microphones. The purpose of this research is to study the usability, design, aesthetics, and functionality of the proposed monument.

Your participation will involve filling a questionnaire after engaging with the interactive scaled monument using a microphone in a lab setting. No sound or voice recordings will be collected in this research.

It will take you 40mins to be in this study.

Risks and Discomforts

There are no known risks associated with this research. Your answers will be kept confidential and no one but the research team will know what you have said.

Possible Benefits

This research may help us improve the design of Monumental.IT.

Protection of Privacy and Confidentiality

We will do everything we can to protect your privacy and confidentiality. We will not tell anybody outside of the research team that you were in this study or what information we collected about you in particular. All information collected in the questionnaire is anonymous.

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A copy of this form will be given to you.

Appendix R

Informational Review Board (IRB) Validation Letter

Validation of IRB2011-108: Monumental IT...

Dear Dr. Green,

The chair of the Clemson University Institutional Review Board (IRB) validated the protocol identified above using exempt review procedures and a determination was made on **March 18, 2011**, that the proposed activities involving human participants qualify as **Exempt** from continuing review under Category **B2**, based on the Federal Regulations (45 CFR 46). You may begin this study.

 Please remember that the IRB will have to review all changes to this research protocol before initiation. You are obligated to report any unanticipated problems involving risks to subjects, complications, and/or any adverse events to the ORC immediately. All team members are required to review the Responsibilities of Principal Investigators and the Responsibilities of Research Team Members available at http://www.clemson.edu/research/compliance/irb/regulations.html.

 We also ask that you notify the ORC when your study is complete or if terminated. Please let us know if you have any questions and use the IRB number and title in all communications regarding this study. Good luck with your study.

 All the best,
Nalinee
Nalinee D. Patin
IRB Coordinator
Clemson University
Office of Research Compliance
Institutional Review Board (IRB)
Voice: (864) 656-0636
Fax: (864) 656-4475
E-mail: npatin@clemson.edu
Web site: http://www.clemson.edu/research/compliance/irb/
IRB E-mail: irb@clemson.edu

REFERENCES

1. A., A. 2009. Theo Jansen, Kinetic Sculptor. SpillSpace.com: Life Spills Over. http://spillspace.com/2009/theo-jansen-kinetic-sculptor/.

2. Anon. 2002. Monuments. Oxford University Press.

3. Anon. 2008. "Informing augmented memory system design through autobiographical memory theory." *Personal Ubiquitous Computing* 6 (12): 433-443.

4. Anon. Wiki. *Wikipedia Website*. http://en.wikipedia.org/wiki/Wiki.

5. Anon. Embodiment in data sculpture: a model of the physical visualization of information. In *Proceedings of the 3rd international conference on Digital Interactive Media in Entertainment and Arts (DIMEA '08)*, New York, NY, USA. New York, NY, USA: ACM.

6. Arras et al. 2002. Proceedings Workshop WS9 Robots in Exhibitions. *IROS 2002*.

7. Aussagen von Nutzern. RapidMiner. *rapid-I Report The Future*. http://rapid-i.com/component/option,com_frontpage/Itemid,1/lang,en/.

8. Ayers, Phoebe, Charles Mattews, and Ben Yates. 2008. *How Wikipedia Works And How You Can Be a Part of It*. USA: No Starch Press.

9. Bachelard, Gaston. 1994. *The Poetics of Space*. Beacon Press.

10. Bachimont, Bruno, and Jean-François Blanchette. 2006. Computer-Aided Hermeneutics : A Practical and Theoretical Approach to Digital Media Preservation. In *Computer-Human Interaction 2006 (CHI '06 - extended abstracts)*, 1727-1730. Montréal, Québec, Canada: ACM. http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Bachimont.pdf.

11. Barricelli, Jean-Pierre. 1993. "Michelangelo's Finito: In the Self, the Later Sonnets, and the Last Pietà." New Literary History 24 (3). Textual Interrelations: 597-616.

12. Barringer, Felicity. 2006. "A City of Memorials Finds Itself Filling Up." The New York Times, December 30, sec. U.S. http://select.nytimes.com/gst/abstract.html?res=F40C1EFC3D540C738FDDAB0994DE404482.

13. Bautier, Geneviève Bresc. 2005. The Slave – Michelangelo BUONARROTI, known as Michelangelo – Sculptures | Louvre Museum. Louvre's Official Website. http://www.louvre.fr/llv/oeuvres/detail_notice.jsp?CONTENT%3C%3Ecnt_id=10134198673237330&CURRENT_LLV_NOTICE%3C%3Ecnt_id=10134198673237330&FOLDER%3C%3Efolder_id=9852723696500824&baseIndex=72&bmLocale=en.

14. Bell, Gordon, and Jim Gemmell. 2009. Total Recall: How the E-memory Revolution will Change Everything. USA: Dutton.

15. Berman, Francine. 2008. "Got data?: a guide to data preservation in the information age." Communications, ACM 51 (12): 50-56.

16. Berzowska, Joanna, and Marcelo Coelho. 2006. Memory-rich clothing. In Computer-Human Interaction 2006 (CHI '06 - extended abstracts), 257-278. New York, NY, USA: ACM. http://doi.acm.org/10.1145/1125451.1125511.

17. Bratton, Benjamin. 2009. Notes on Habitat-scale Robotics and its Constraints. In Archibots Workshop at Ubicomp 2009. Orlando, FL, USA. http://workgroups.clemson.edu/AAH0503_ANIMATED_ARCH/archibots-3.htm.

18. Bratton, Benjamin H. 2008. "FEATURE: What do we mean by 'Program'?: the convergence of architecture and interface design." Interactions, May.

19. Breazeal, C., A. Takanishi, and T. Kobayashi. 2008. Social Robots that Interact with People, in Part G Human-Centered and Life-Like Robotics. In Springer Handbook of Robotics edited by Bruno Siciliano, Oussama Khatib, 1356. Springer-Verlag Berlin Heidelberg.

20. Brown, S. C., and F. I. M. Craik. 2000. Encoding and retrieval of information. In The Oxford handbook of memory edited by E. Tulving and F. I. M. Craik, 93-108. New York: Oxford University Press.

21. Brown, Tim. 2009. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation. Harper.

22. Calvino, Italo. 1997. Invisible Cities. Translated from Italian by William Weaver. Vintage Classics.

23. Campbell, Donald T., and Julian Stanley. 1966. Experimental and Quasi Experimental Designs for Research. USA: Houghton Mifflin Company.

24. Caponigro, Paul. 1986. Megaliths. New York Graphic Society Book, Library of Congress Cataloging.

25. Casaleggio, Davide. 2011. L'evoluzione di Internet of Things [Infographic]. Casaleggio Associati Website. http://www.casaleggio.it/2011/02/levoluzione_di_internet_of_thi.php.

26. Charleston's Historic Religious and Community Buildings. Old Slave Mart. The National Park Services. http://www.nps.gov/nr/travel/charleston/osm.htm.

27. Cohen, Simona. 1998. "Some Aspects of Michelangelo's Creative Process." Artibus et Historiae 19 (37): 43-63.

28. Cook, Thomas D., and Donald T. Campbell. 1979. Quasi-Experimentation: Design and Analysis Issues for Field Settings. USA: Houghton.

29. Crawford, David. 2009. Stop Motion Studies - Series 13. Stop Motion Studies (SMS) Website. http://www.stopmotionstudies.net/.

30. Crawford, John. 2005. Active space: embodied media in performance. In ACM SIGGRAPH 2005 Sketches (SIGGRAPH '05), Article 111. New York, NY, USA: ACM. http://doi.acm.org/10.1145/1187112.1187246.

31. Critical Art Ensemble. 1994. Electronic Disturbance. USA: Autonomedia.

32. Critical Art Ensemble. 1996. Electronic Civil Disobedience. USA: Autonomedia.

33. Critical Art Ensemble. 2001. Digital Resistance: Explorations in Tactical Media. USA: Autonomedia.

34. Crowe, Norman. 1998. The Death and Reseraction of embodied Memory. In Memory and Architecture Conference Proceedings. Washington University in St Louis: School of Architecture, Washington University.

35. Curtis, Nancy C. 1996. Black heritage sites: an African American odyssey and finder's guide. ALA Editions.

36. Dalsgaard, Peter. 2008. Designing for inquisitive use. In Proceedings of the 7th ACM conference on Designing interactive systems (DIS '08), 21-30. New York, NY, USA: ACM. http://doi.acm.org/10.1145/1394445.1394448.

37. Damazio, Vera, and Pablo Dias. 2003. www.a.site.for.things-that.bring.back.memories. In Proceedings of the 2003 international conference on Designing pleasurable products and interfaces (DPPI '03), 138-139. New York, NY, USA: ACM. http://doi.acm.org/10.1145/782896.782932.

38. Dimitropoulos, Harris. 1998. 1789 Redux: A Monument for the Bicentennial of the French Revolution. In Memory and Architecture conference proceedings. Washington University in St Louis, School of Architecture.

39. Donadio, Rachel, and Elisabetta Povoledo. 2009. "Italians Comb Through Rubble After Quake." The New York Times, April 7, sec. International / Europe. http://www.nytimes.com/2009/04/07/world/europe/07italy.html.

40. Dourish, Paul. 2004. Where the Action is: The Foundation of Embodied Interaction. MIT press.

41. Dubberly, Hugh. 2008. "On Modeling: Design in the age of biology: shifting from a mechanical-object ethos to an organic-systems ethos." Interactions.

42. Durrant, Abigail C. 2007. Designing domestic photographic experiences to support autobiographical memory. In The Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition (C&C '07), 281. New York, NY, USA: ACM. http://doi.acm.org/10.1145/1254960.1255017.

43. Eakin, Emily. 2004. "Studying Literature by the Numbers." The New York Times, January 10.

44. Eco, Umberto. 1989. The Open Work. Translated from "Opera aperta" by Anna Cancogni. Harvard University Press.

45. Eco, Umberto. 2009. The Infinity of Lists: An Illustrated Essay. Rizzoli, November 17.

46. Eich, E. 1995. "Mood as a mediator of place dependent memory." Journal of Experimental Psychology: General 124: 293-308.

47. Engeli, Maia. 2006. Digital Traces Conceptual Design Schemes for Collective Remembering. In Proceedings of Human-Computer Interaction CHI '06 (extended abstracts). Montréal, Québec, Canada: ACM. ttp://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Engeli.pdf.

48. Fischer, Gerhard. 2011. Understanding, Fostering, and Supporting Cultures of Participation. In Interactions, 42-53. June. http://doi.acm.org/10.1145/1962438.1962450.

49. Fisher, Thomas. 1998. The Architecture of Memory and Imagination. In Memory and Architecture Conference Proceedings. Washington University in St Louis, School of Architecture.

50. Fletcher, Sir Banister. 1987. Sir Banister Fletcher's A history of architecture. Butterworths.

51. Forster, Kurt W. 1982. "Monument/Memory and the Mortality of Architecture." Oppositions 25: n.d.

52. Fox, Michael. 2009. The End of Robotics in Architecture (As We Almost Got to Know It). In Archibots Workshop at Ubicomp2009. Orlando, FL, USA. http://workgroups.clemson.edu/AAH0503_ANIMATED_ARCH/archibots-3.htm.

53. Fox, Michael, and Miles Kemp. 2009. Interactive Architecture. USA: Princeton Press.

54. Frohlich, David, and Jacqueline Fennell. 2007. "Sound, paper and memorabilia: resources for a simpler digital photography." Personal and Ubiquitous Computing 11 (2): 107-116.

55. Frohlich, David, and Rachel Murphy. 2000. "The Memory Box." Personal Ubiquitous Computing 4 (4): 238-240.

56. Gass, William H. 1982. "Monumentality/Mentality." Oppositions 25.

57. Gemeinboeck, Petra, and Mary Agnes Krell. 2005. Art exhibition: impossible geographies 01. In Proceedings of the 13th annual ACM international conference on Multimedia (MULTIMEDIA '05), 1065-1066. New York, NY, USA: ACM. http://doi.acm.org/10.1145/1101149.1101379.

58. Gibilisco, S. 2003. Concise Encyclopedia of Robotics. New York, NY, USA: McGraw Hill Press.

59. Gilbert, Creighton E. 2003. "What Is Expressed in Michelangelo's 'Non-Finito'." Artibus et Historiae 24 (48): 57-64.

60. Goodwin, Kim. 1997. Perfecting Your Personas. User Interface Engineering (UIE) Website. http://www.uie.com/articles/perfecting_personas/.

61. Green, Keith E. 2008. Back to the Future: Three Educational Experiments in Interactive Environments Anticipated in 1960s Visionary Thinking. In Proceedings of the ACSA National Conference 2008, Seeking the City: Visionaries on the Margins edited by Dietmar Froehlich & Michaele Pride:839-845. Houston, TX, USA: ACSA. https://www.acsa-arch.org/resources/proceedings/indexsearch.aspx?txtKeyword1=14&ddField1=4.

62. Hawkins, Jeff, and Sandra Blakeslee. 2005. On Intelligence. USA: Owl Books.

63. Hoang, Mimi, and Eric Bunge. 2005. Party Wall. nArchitects. http://www.narchitects.com/frameset-party%20wall.htm.

64. Holl, Steven. 2000. Parallax. Princeton Architectural Press.

65. Hollier, Denis. 1989. Against Architecture: The Writings of Georges Bataille. The MIT Press.

66. Hoven, Elise van den, and Berry Eggen. 2006. Design Recommendations for Augmented Memory Systems. In The Proceedings of the Human-Computer Interaction CHI '06 (extended abstracts). Montréal, Québec, Canada: ACM. http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Hoven_Eggen.pdf.

67. Hoven, Jonathan. 2006. The Memory Library - a New Approach to Collective Recall. In The Proceedings of the Human-Computer Interaction CHI '06 (extended abstracts). Montréal, Québec, Canada: ACM. http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Livingston.pdf.

68. Hughes, C. J. 2009. "Gehry Chosen to Design Eisenhower Memorial in D.C." Architectural Record, April 16. http://archrecord.construction.com/news/daily/archives/090416gehry.asp.

69. Hugo, Victor. 2007. Notre-Dame de Paris - The Hunchback of Notre Dame. Book Jungle.

70. Husserl, Edmund. 2008. On the Phenomenology of the Consciousness of Internal Time (1893-1917), translated by John Barnett Brough. USA: Springer.

71. Iaspis et al. 2007. Emotional Cities. Emotional Cities Official Website.

72. Ihde, Don. 2009. PostPhenomenology and The Technoscience. USA: SUNY press.

73. International Standard: ISO 9241-210. 2010. Ergonomics of human–system interaction — Part 210: Human-centred design for interactive systems. Switzerland: ISO 2010.

74. Iranian Military History: The Achaemenid Dynasty. 1998. The Persian Wars, 2. The Scythian Campaign. The Circle of Ancient Iranian Studies (CAIS) Website. http://www.cais-soas.com/CAIS/Military/Persian_wars/persian_wars-scythian_campaign.htm.

75. Ishii, H., and B. Ullmer. 1997. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. In Proceedings of Human Computer Interaction (CHI 1997), 224-241. http://www.sigchi.org/chi97/proceedings/paper/hi.htm.

76. Kachun, Mitch. 2003. Festivals of Freedom: Memory and Meaning in African American Emancipation Celebrations, 1808-1915. Uncensored/ edition. USA: University of Massachusetts Press.

77. Kandel, Eric R. 2006. In search of Memories: the emergence of new science of Mind. W.W.Norton & Company.

78. Kaplan, Frederic. 2005. Everyday robotics: robots as everyday objects. In Proceedings of the 2005 Joint Conference on Smart Objects and Ambient intelligence: innovative Context-Aware Services: Usages and Technologies, 121:59-64. Grenoble, France: ACM. http://doi.acm.org /10.1145/1107548.1107570, 2005.

79. Karasic, Carmin, Rolf Van Gelder, and Rob Coshow. 2007. Hyper Handheld Histories as Hyper-Monuments. Turbulence: Commissioning and Supporting Net Art for 15 Years: 1996-2011 Website. http://turbulence.org/Works/HyperMonument/index_pc.php.

80. Karssenberg, Hans. 2008. For Your City's Daily Emotions: the D-Tower. Inspiring Cities Formerly known as erasmuspc. http://inspiringcities.org/index.php?id=395&page_type=Article&id_article=18824.

81. Katzeff, Cecilia, and Vanessa Ware. 2006. Video storytelling as mediation of organizational learning. In The Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles, 311-320. Oslo, Norway: ACM. http://doi.acm.org/10.1145/1182475.1182508.

82. Kemp, C., P. Fitzpatrick, H. Hirukawa, K. Yokoi, K. Harada, and Y. Matsumoto. 2008. Humanoids, in Part G Human-Centered and Life-Like Robotics. In Springer Handbook of Robotics edited by Bruno Siciliano, Oussama Khatib, 1329. Springer-Verlag Berlin Heidelberg.

83. Kessens, J., M. Neerincx, R. Looije, M. Kroes, and G. Bloothooft. 2009. Perception of Synthetic Emotion Expressions in Speech: Categorical and Dimensional Annotations. In The Proceedings of the 3rd International Conference on Affective Computing and Intelligent Interaction, 1-5. Amsterdam: IEEE. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5349594&isnumber=5349257.

84. Kientz, Julie, and Gregory Abowd. 2006. Collective Remembering in Evidence-Based Care. In Proceedings of Human-Computer Interaction CHI '06 (extended abstracts). Montréal, Québec, Canada: ACM. ttp://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Kientz.pdf.

85. Lang, P. 1995. "The Emotion Probe." the Journal of American Psychologists (May): 372-385.

86. Lanier, Jaron. 2011. You Are Not a Gadget: A Manifesto. Reprint. Vintage, February 8.

87. Larson, A.M., and L.C. Loschky. 2009. "The contributions of central versus peripheral vision to scene gist recognition." Journal of Vision 9 (6): 1-16.

88. Levine, Neil. 1982. The book and the building: Hugo's theory of architecture and Labrouste's Bibliotheque Ste-Genevieve. In The Beaux-Arts and nineteenth- century French architecture edited by Robin Middleton. Cambridge, Massachsetts: MIT press.

89. Levinson, Sanford. 1996. "Silencing the Past: Public Monuments and the Tutelary State." Report from the Institute for Philosophy and Public Policy 16 (3 and 4). http://www.puaf.umd.edu/IPPP/levinson.htm.

90. Lienhard, John. 2006. Victor Hugo and Architecture. In Engines of Our Ingenuity. http://uh.edu/engines/epi2293.htm.

91. Lih, Andrew. 2009. The Wikipedia Revolution. Hyperion Press.

92. Lima, Zeuler. 1998. Architecture and Memory: References in contemporary Culture. In Memory and Architecture Conference Proceedings. Washington University in St Louis, School of Architecture.

93. Lyndon, Donlyn, and Charles W. Moore. 1994. Chambers for a Memory Palace. MIT press.

94. Machine Learning Group. 2009. Weka 3: Data Mining Software in Java. WEKA The University of Waikato Website. http://www.cs.waikato.ac.nz/~ml/weka/.

95. Main, Carlyn. 2011. The Difference Between Male and Female Skeletons. Top Ten Reviews Website. http://human-skeleton-model-review.toptenreviews.com/the-difference-between-male-and-female-skeletons.html.

96. Manzano, Juan Francisco, and Richard Robert Madden. 1840. Juan Francisco Manzano, 1797-1854 and , 1798-1886 Poems by a Slave in the Island of Cuba, Recently Liberated; Translated from the Spanish, by R. R. Madden, M.D. With the History of the Early Life of the Negro Poet, Written by Himself; to Which Are Prefixed Two Pieces Descriptive of Cuban Slavery and the Slave-Traffic, by R. R. M. Documenting the American South. http://docsouth.unc.edu/neh/manzano/manzano.html.

97. Matlin, Margaret M. 2009. Cognition. Seventh Edition. USA: John Wiley and Sons.

98. McCullough, Malcolm. 2005. Digital Ground: Architecture, Pervasive Computing and Environmental Knowing. MIT press.

99. McGray, Douglas. 2009. "Hyper Texts: How one professor applies quantitative analysis to classic literature." Wired Magazine, December.

100. Messmore, Scott. 2002. Vietnam Veterans Memorial, Washington, DC. Vietnam Veterans Memorial Website. http://vietnam-veterans-memorial.visit-washington-dc.com/.

101. Minsky, Marvin. 1988. The Society of Mind. Simon & Schuster.

102. Mitchell, W. J. 2000. e-topia. Cambridge, Massachsetts: MIT press.

103. Mokhtar, Tarek H. 2008a. The Mnemotectonics of ZIA Paper Submitted to Dr.Mikey Lauria and Dr.Keith Green as part of EDP801: Advanced Theory, Clemson University.

104. Mokhtar, Tarek H. 2008b. Theaters as Memory Machines A Paper Submitted to Dr.Keith Green as part of EDP805: Readings in Architecture Course, Clemson University.

105. Mokhtar, Tarek H. 2010. An Introduction to Architectural Robotics Presentation for Roger Liska's course PDBE 810: Instructional Design Delivery, Clemson University.

106. Mokhtar, Tarek H., Keith E. Green, Ian D. Walker, T. Threat, V. Murali, A. Apte, and S. Mohan. 2010. Embedding Robotics in Civic Monuments for an Information World. In The Proceedings of the Computer Human Interaction Conference 2010 (CHI 2010: Work-in-Progres)s, 3859-3864. Atlanta, GA, USA: ACM.

107. Moretti, Franco. 2000. "Conjectures on World Literature." The New Left Review. http://www.newleftreview.org/A2094.

108. Moretti, Franco. 2005. Graphs, Maps, Trees: Abstract Models for a Literary History. Verso.

109. Mulholland, Matthew. 2007. "The Power of Remembrance: Memorials and the Holocaust." Kedma Journal: Penn's Journal on Jewish Thought, Jewish Culture, and Israel (4). http://www.hillel.upenn.edu/kedma/04/index.html.

110. Munari, B. 1977. Fantasia. Rome: Laterza.

111. Murnane, K., M.P. Phelps, and K. Malmberg. 1999. "Context-dependent recognition memory: The ICE theory." Journal of Experimental Psychology: General 4 (128): 403-415.

112. Murray, I., and J. Arnott. 1993. "Toward the Simulation of emotion in synthetic speech: A Review of the Literature on Human Vocal Emotion." Journal of Acoustic Society of America 2 (93): 1097-1108.

113. Nairne, J.S. 2005. The Functionalist Agenda in Memory. In Experimental cognitive psychology and its applications by A. F. Healy, 115-126. Washington DC: American Psycological Association.

114. Nass, C., and S. Brave. 2005. Wired For Speech: How Voice Activates and Advances the Human-Computer Relationship. USA: The MIT Press.

115. Negroponte, N. 1975. Soft Architecture Machines. Cambridge, MA: The MIT Press.

116. Negroponte, N. 1995. Being Digital. USA: Vintage Books.

117. Neufeldt, Victoria E., and David B. Guralnik. 1988. Monuments. Prentice Hall Trade.

118. Nielsen, Jakob. 1993. Usability Engineering. USA: Academic Press, Morgan Kaufmann Publishers.

119. Nielsen, Jakob. 2005. How to Conduct a Heuristic Evaluation. useit.com: Jakob Nielsen's Website. http://www.useit.com/papers/heuristic/heuristic_evaluation.html.

120. Nietzsche, Friedrich. 1980. On the Advantage and Disadvantage of History for Life. Translated by Peter Preuss. USA: Hackett Publishing Company.

121. Norman, Donald A. 1988. The Design of Everyday things. Basic Books.

122. Nox and Partners. 2003. d-toren. D-toren Official Website.

123. Oke, T.R. 1978. Boundary Layer Climates. London, New York: Methuen, Wiley.

124. Oklahoma City National Memorial & Museum – Official Website. A Place of Hope and Memories. http://www.oklahomacitynationalmemorial.org/secondary.php?section=5&catid=117.

125. Oosterhuis, K. 2003. Hyperbodies: Towards an E-motive Architecture. Basel: Birkhauser.

126. Oosterhuis, Kas, and Nimish Biloria. 2008. "Interactions with Proactive Architectural Spaces: The Muscle Projects." Communications 51 (6): 70-78.

127. Pachube.Community. Arduino + ethernet shields: connecting to Pachube. Pachube Website. http://community.pachube.com/arduino/ethernet.

128. Pallasmaa, Juhani. 2005. The Eyes of the Skin: Architecture and the senses. Wiley-Academy.

129. Pask, G. 1969. "The Architectural Relevance of Cybernetics." Architectural Design, September.

130. Pask, Gordon. 1961. An Approach to Cybernetics. New York, NY, USA: Harper and Brothers.

131. Patrick, Hagopian. 2009. The Vietnam War in American Memory: Veterans, Memorials, and the Politics of Healing. Univ. of Massachusetts Press.

132. Petrelli, Daniela, Elise van den Hoven, and Steve Whittaker. 2009. Making history: intentional capture of future memories. In , 1723-1732. Boston, MA, USA: ACM. http://portal.acm.org.proxy.lib.clemson.edu/citation.cfm?id=1518701.1518966&coll= GUIDE&dl=ACM&CFID=41873964&CFTOKEN=78521294.

133. Petrelli, Daniela, Steve Whittaker, and Jens Brockmeier. 2008. AutoTopography: what can physical mementos tell us about digital memories? In , 53-62. Florence, Italy: ACM. http://dis.shef.ac.uk/stevewhittaker/chi08_mementos.pdf.

134. Rice, Judy Cossel, Dan Lawyer, and Grant Skousen. 2006. Recapturing Memories and Reconnecting with the Past. In . http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Cossel.pdf.

135. Richter, Heather. 2006. Experiences in Indexing Meeting Content. In Special Interest Group pn Computer Human Interaction (SIGCHI'06). ACM. http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Richter.pdf.

136. Robertson, Toni, Tim Mansfield, and Lian Loke. 2006. Designing an immersive environment for public use. In , 1:31-40. Trento, Italy: ACM. http://portal.acm.org.proxy.lib.clemson.edu/citation.cfm?id=1147261.1147267&coll= GUIDE&dl=ACM&CFID=41873964&CFTOKEN=78521294.

137. Roediger, H. L., and M. J. Guynn. 1996. Retrieval processes. In Memory by E. L. Bjork and R. A. Bjork, 197-236. San Diego: Academic Press.

138. Rossi, Aldo. 1981. "A Scientific Autobiography." Oppositions.

139. Ruffaldi, Emanuele, Chiara Evangelista, Veronica Neri, Marcello Carrozzino, and Massimo Bergamasco. 2008. Design of information landscapes for cultural heritage content. In , 113-119. Athens, Greece: ACM. http://portal.acm.org.proxy.lib.clemson.edu/citation.cfm?id=1413634.1413659&coll= GUIDE&dl=ACM&CFID=41873964&CFTOKEN=78521294.

140. Rugoff, Ralph. 2005. Monuments for the USA. CCA Wattis Institute for Contemporary Arts.

141. Ruskin, John. 1989. The Seven Lamps of Architecture. N.Y.: Dover publications.

142. Rykwert, Joseph, Neil Leach, and Robert Tavernor. 1988. On the Art of Building. In Ten Books by Leon Battista Alberti. Cambridge, Massachusetts: The MIT Press.

143. Sampanes, AC, P Tseng, and B Bridgeman. 2008. "The role of gist in scene recognition." Vision Res. 21 (48) (September): 2275-83.

144. Sas, Corina, and Alan Dix. 2006. Designing for collective remembering. In , 1727-1730. Montréal, Québec, Canada: ACM. http://portal.acm.org.proxy.lib.clemson.edu/citation.cfm?id=1125451.1125773&coll=GUIDE&dl=GUIDE&CFID=41873964&CFTOKEN=78521294.

145. Sas, Corina, Alan Dix, Nigel Davies, and Adrian Friday. 2006. Capturing and Sharing War Memories. In Montréal, Québec, Canada: ACM. http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Sas.pdf.

146. Savage, Kirk. 2009. Monument Wars: Washington, D.C., the National Mall, and the Transformation of the Memorial Landscape. USA: University of California Press.

147. Scher, Steve. 2008. Architect Joshua Prince-Ramus: How to Design a Public Monument after 9/11. Weekday. A service of the University of Washingto. http://www.kuow.org/program.php?id=15789.

148. Schneider, M., A. Kroner, and R. Wasinger. 2006. Augmenting interaction in intelligent environments through open personal memories. In , 1:407 - 416. http://ieeexplore.ieee.org.proxy.lib.clemson.edu/stamp/stamp.jsp?tp=&arnumber=4197821&isnumber=4197733.

149. Shute, Tish. 2009. Pachube, Patching the Planet: Interview with Usman Haque. UgoTrade: Augmented Realities in "World 2.0." http://www.ugotrade.com/2009/01/28/pachube-patching-the-planet-interview-with-usman-haque/.

150. Singleton, Broyce A., and Bruce C. Straits. 2005. Approaches to Social Research. 4th ed. USA: Oxford.

151. Smith, S.M., and E. Vela. 2001. "Environmental context-dependent memory: A review and meta-analysis." Psychonomic Bulletin and Review 8 (2) (June): 203-220.

152. Stevens, Molly M., Gregory D. Abowd, Khai N. Truong, and Florian Vollmer. 2003. "Getting 'into' the Living Memory Box: Family archives & holistic design." Personal Ubiquitous Computing 7 (3-4): 210-216.

153. Stevens, Molly, Florian Vollmer, and Gregory D. Abowd. 2002. The living memory box: function, form and user centered design. In , 668-669. Minneapolis, Minnesota, USA: ACM. http://portal.acm.org.proxy.lib.clemson.edu/citation.cfm?id=506443.506537&coll=GUIDE&dl=ACM&CFID=41873964&CFTOKEN=78521294.

154. Stone, D., C. Jarrett, M. Woodroffe, and S. Minocha. 2005. User Interface Design and Evaluation. Morgan Kaufmann Series in Interactive Technologies. Morgan Kaufmann Publishers.

155. Sturken, Marita. 1997. Tangled Memories: The Vietnam War, the AIDS Epidemic, and the Politics of Remembering. U.C.B. Press.

156. Sullivan, Mary Ann. 2008. Benjamin Franklin "Ghost Structures," Franklin Court. Bluffton University Website: Philadelphia, Pennsylvania. http://www.bluffton.edu/~sullivanm/pennsylvania/philadelphia/venturighost/ghost.html.

157. Tao, Dominick. 2009. "Historic Monuments Spruced Up for Spring." The New York Times, June. http://cityroom.blogs.nytimes.com/2009/06/12/historic-monuments-aspruced-up-for-spring/.

158. Thagard, P. 2006. Hot Cognition: Mechanisms and Applications of Emotional Cognition. USA: MIT Press.

159. The 2011 Statistical Abstract: Arts, Recreation, & Travel. Arts, Recreation, & Travel Section in The US Census Bureau. http://www.census.gov/compendia/statab/cats/arts_recreation_travel.html.

160. The Circle of Ancient Iranian Studies. 1998. THE PERSIAN WARS: 2. The Scythian Campaign. The Circle of Ancient Iranian Studies (CAIS) Website. http://www.cais-soas.com/CAIS/Military/Persian_wars/persian_wars-scythian_campaign.htm.

161. Treib, Marc. 2009. Spatial Recall: Memory in Architecture and Landscape. Routledge.

162. Tulving, E, and S Rosenbaum. 2006. What do explanations of the distinctiveness effect need to explain? In Distinctiveness and Memory edited by R. R. Hunt and J. B. Worthen, 407-423. New York: Oxford University Press.

163. U.S. Census Bureau - Official Website. 2009. Arts, Recreation, & Travel. http://www.census.gov/compendia/statab/cats/arts_recreation_travel.html.

164. Ulrich, Karl T., and Steven D. Eppinger. 2000. Product Design and Development. second. McGraw-Hill.

165. Uriu, Daisuke, Shiratori Naruhiko, Satoru Hashimoto, Shuichi Ishibashi, and Naohito Okude. 2009. CaraClock: an interactive photo viewer designed for family memories. In , 3205-3210. Boston, MA, USA: ACM.

166. Vitruvius. 1960. The Ten Books on Architecture translated by Moris Morgan. New York, USA: Dower Publications.

167. Walker, Ian, and Keith Green. 2009. Architectural Robotics: Unpacking the Humanoid. In .
http://workgroups.clemson.edu/AAH0503_ANIMATED_ARCH/archibots-3.htm.

168. Walldius, Aake. 2006. Collecting, Storing, and Sharing Memorable Lessons about User Approved Software. In Montréal, Québec, Canada: ACM.
http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Walldius.pdf.

169. Weiser, Mark, and John Seely Brown. 1997. The coming age of calm technolgy. In Beyond calculation: the next fifty years, 75-85. Copernicus.

170. Wertsch, James. 2002. Voices of Collective Remembering. Cambridge University Press.

171. Whittaker, Steve. 2006. Design Considerations for Collective Remembering. In Montréal, Québec, Canada: ACM.
http://www.comp.lancs.ac.uk/~corina/CHI06Workshop/Papers/Whittaker.pdf.

172. Wilson, Margaret. 2002. "Six Views of Embodied Cognition." Psychonomic Bulletin & Review 9 (4) (December): 625-636.

173. Wilson, Stephen. 1994. Memory map: an interactive installation that maps memory space to physical space. In New York, NY, USA: ACM.
http://doi.acm.org/10.1145/192593.197436.

174. Yates, Frances A. 1966. The Art of Memory. the University of Chicago press.

175. Young, James E. 1993. The Texture of Memory. Yale University Press.

176. Zhao, Jack, and Andrew Vande Moere. 2008. Embodiment in data sculpture: a model of the physical visualization of information. In , 343-350. New York, NY, USA: ACM. http://doi.acm.org/10.1145/1413634.1413696.

177. Zumthor, Peter. 2005. Thinking Architecture. Birkhauser-Publishers for Architecture.

178. Zumthor, Peter. 2006. Atmospheres: Architectural Environments - Surrounding Objects. Birkhäuser Basel.