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***The Curious Timekeeper: Creative Thesis in Interactive Sculpture***  
Dartmouth College Computer Science Technical Report TR2010-670

Kate I. Schnippering  
Advisor: Fabio Pellacini

May 23, 2010

# *The Curious Timekeeper*: Creative Thesis in Interactive Sculpture

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Figure 1: Sculpture Closeup

## **Abstract**

When we interact with computers, we have set expectations about our interactive experience, operating a mouse and keyboard to elicit predictable responses on a screen. Intersecting the world of Computing with Fine Art gains us potential to innovate outside these bounds by restricting the expected performance of a computer – setting it to a particular purpose rather than allowing it to run anyone’s software. To challenge standard human-computer interaction, this work set out to create an interesting and unusual interactive experience, fully integrated into a sculpture. The approach was to design a system to form a small environment, having many components rather than risking everything on any one feature. To push the bounds of Fine Art interactions, the work addresses time-control using video in a manner that painting or static sculpture cannot achieve. The result is *The Curious Timekeeper*, a large sculpture of a whimsical bird that hopes to bewilder viewers, to encourage them to consider the role of computing in their lives and in art.

# 1 Introduction

## 1.1 Motivation

As everyday computer users, we have set expectations about our interactive experience with our machine: we provide input from a mouse and keyboard and we expect output on screen. Our input decisions are selections from a clear set of options: left-click, right-click, and the keys on the keyboard. The computer's response is predictable as an 'a' appears when the key labeled 'a' is pressed. This may seem mundane and common sense, but this experience has been carefully designed as such in order to handle a broad spectrum of uses and to give micro-controls to the user. But to view computer interaction as necessarily constituting a keyboard, mouse and screen not only limits what we ask of the computing we use, but limits our freethinking and innovation.

By removing two constricting parameters we usually associate with computer use – that the user should have great control and understand what happens with every keystroke or mouseclick input – a lot of creative potential opens up.

Fine Art would, by most, be considered a distant discipline from Computer Science, and yet artists must address the question of user experience all the time. The difference is that artwork is meant to manipulate the viewer, meant to incite an emotional response or reaction. Using computing as a medium and tool in art, we can take this to a new level of possibility, wherein the art can interpret the viewer, can surprise or engage the viewer in ways a static painting or sculpture cannot. Here, the reactions are not only between the viewer and the art, but also influenced by the viewer's perception of and comfort with technology. By breaking down doors of expected computing we can explore other methods of interaction, whether more suited to implementing our ideas or an experiment in our psychological relationship with computers and expectations of them.

## 1.2 Sculptural Investigation

In this project and paper we will address two forms of interaction: *presence/location/image* and *physical manipulation* [1]. The first is constructed around, simply, the presence or absence of a viewer, and then engages the viewer by asking him to consider his presence and physical image. The second is constructed around interface with a device.

*The Curious Timekeeper* is a whimsical sculpture composed around an interaction. Encasing the hardware, the surrounding sculpture is a futuristic prehistoric peacock split by time to perch in one

instance on a high branch and the other on a low branch of a tree-like mast. The sculpture is made of wire, wood, electrical tape, and translucent paper dried taut with a glue solution. While the technology creates the illusion of intelligence, the sculpture creates the illusion of a present being. The two work together on this level, and also toward a deeper artistic concept and narrative.

The Timekeeper sits fairly passively, turning its head slightly from time-to-time. The video back-projected onto its tailfeathers shows the bird's "memories" overlaid with its present view from a webcam in the eye. When the bird recognizes a human face, it begins to capture video. The passerby viewer can interact with the bird by reaching up and squeezing its extended hand – a limited mode of input, but it causes the bird to look suddenly directly at the viewer and simultaneously controls the video projection. While the hand is squeezed the video rewinds rapidly through recordings of other viewers, and when the hand is released, the video plays forward at a normal pace. The viewer, in a sense, controls time through an apparatus on a fantastical time-machine.

The sculpture is displayed from May 11, 2010 through June 20, 2010 in the Jaffe-Friede Gallery in the Hopkins Center at Dartmouth College.

### 1.3 Paper Structure

In this paper we will discuss the context, design, and construction decisions for this project, primarily focusing on the embedded computing system and how it relates to the sculpture and aesthetic. Section 2 discusses some of the inspiration and reference works for the project, and initial decisions for hardware and software. Section 3 gives an overview of the system and its concealment. In Section 4, we will discuss the implementation, and in particular how it affects the sculpture. Section 5 is a further discussion of implementation decisions and some of the shortcomings and discrepancies from the original intent. Section 6 concludes with final reflection and a future direction for related efforts.

## 2 Related Work

### 2.1 Other Artists

Although interactive art has been gaining presence in recent years, it typically appears in digital games and 2D forms [1]. From our experience with viewers, it seems interactive sculptures or works that respond to the entire body and large gestures still seem alien. Several active artists working in the intersection of art and computing have proved to be of important reference for the development

and formulation of this project.

Camille Utterback works with the objective “to bridge the conceptual and the corporeal” [2]. While her systems create mostly abstract visuals – unlike *The Curious Timekeeper* – they toy with the viewer’s expectations by responding to gestures and physical location with rules the viewers do not know upfront, encouraging them to participate by testing the parameters with the movement of their bodies. Her *External Measures Series* is best exemplary of this.

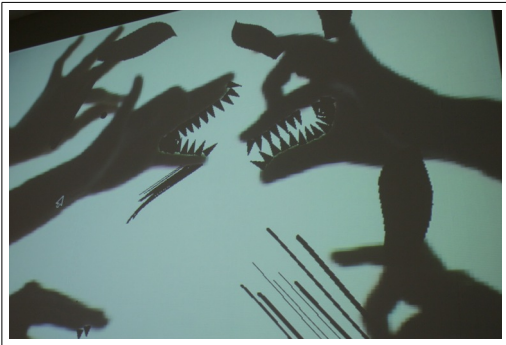


Figure 2: *Shadow Monsters*, P. Worthington [9]

Philip Worthington also confronts the viewer with randomness and a set of undisclosed rules. He brings to life hand-cast shadows to make shadow monsters, which change continually and randomly, especially as they respond to movement. He also addresses natural systems to translate into art through technology, such as leaf-cutter ants creating realistic patterns on a tabletop as they respond to the color and size of objects set down [3].

Daniel Rozin’s work responds more directly to the viewer’s image, rather than the viewer’s actions. He creates mechanical mirrors and software mirrors and exemplifies art that interprets the viewer, before the other way around [4].

## 2.2 Available Technology

Combining and extracting from the work of these artists and others led us to the interaction design for *The Curious Timekeeper*. The main ideas examined include providing limited information to the viewer for understanding the capacity of interaction, the power of randomness, and effective interaction between the viewer and an altered self-image. We also looked closely at the technology used in these systems, and found several promising options. On the hardware level, facilitating communication with a motor and pressure sensor is an Arduino Duemilanove – a basic Arduino USB microcontroller board. Arduino is an open-source electronics prototyping platform popular among the creative coding and interaction design community for its flexibility, reliability, and stand-alone ability [5].

On the processing level, most projects use either openFrameworks (C++) or Processing (Java). We selected openFrameworks [6], an open source C++ toolkit, for its performance benefits and greater flexibility from having a lower-level underlying language [1]. To the initial package, which includes extensions for OpenCV (Open Source Computer Vision) and Arduino using Firmata, we also imported a Haar Finder add-on [7]. The main challenge of openFrameworks proved to be little available documentation on bug patches.

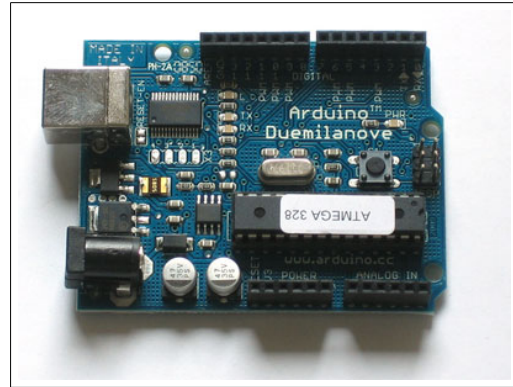


Figure 3: Arduino Duemilanove [10]

### 3 System Overview

The computing system of *The Curious Timekeeper* is fully embedded in the sculpture. The Arduino is located in a back compartment of the top bird segment, and connects to the computer, breadboard, and servo. The breadboard is fixed in the wrist under the detachable hand, and receives power and ground from the Arduino to distribute to both the pressure sensor and servo. The pressure sensor extends up from the breadboard, 1-2 inches above the wrist. The detachable hand contains tweezers that set around the pressure sensor, and when the viewer squeezes the hand by interlocking fingers with the talons, the sensor is squeezed in turn and transmits the signal to the Arduino.

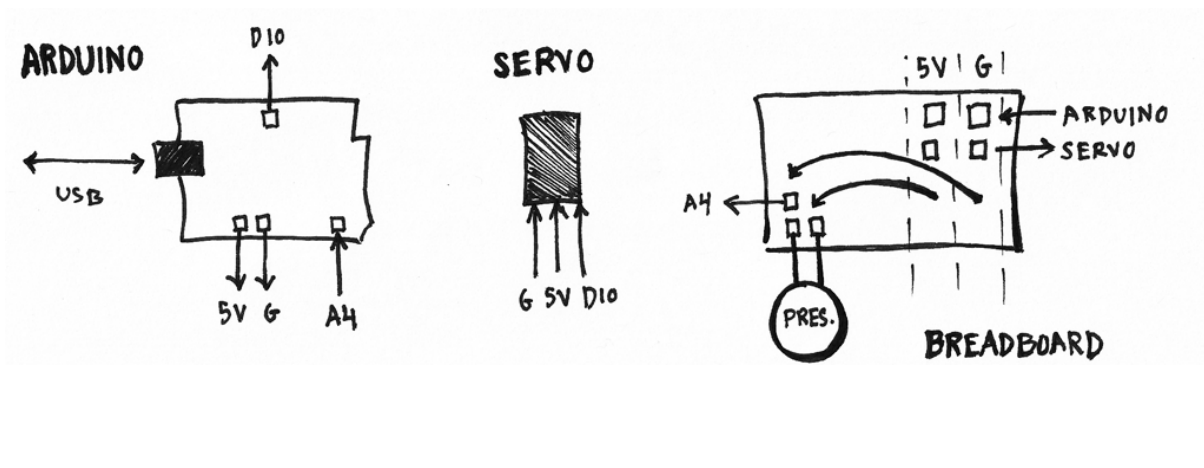


Figure 4: Arduino Communications

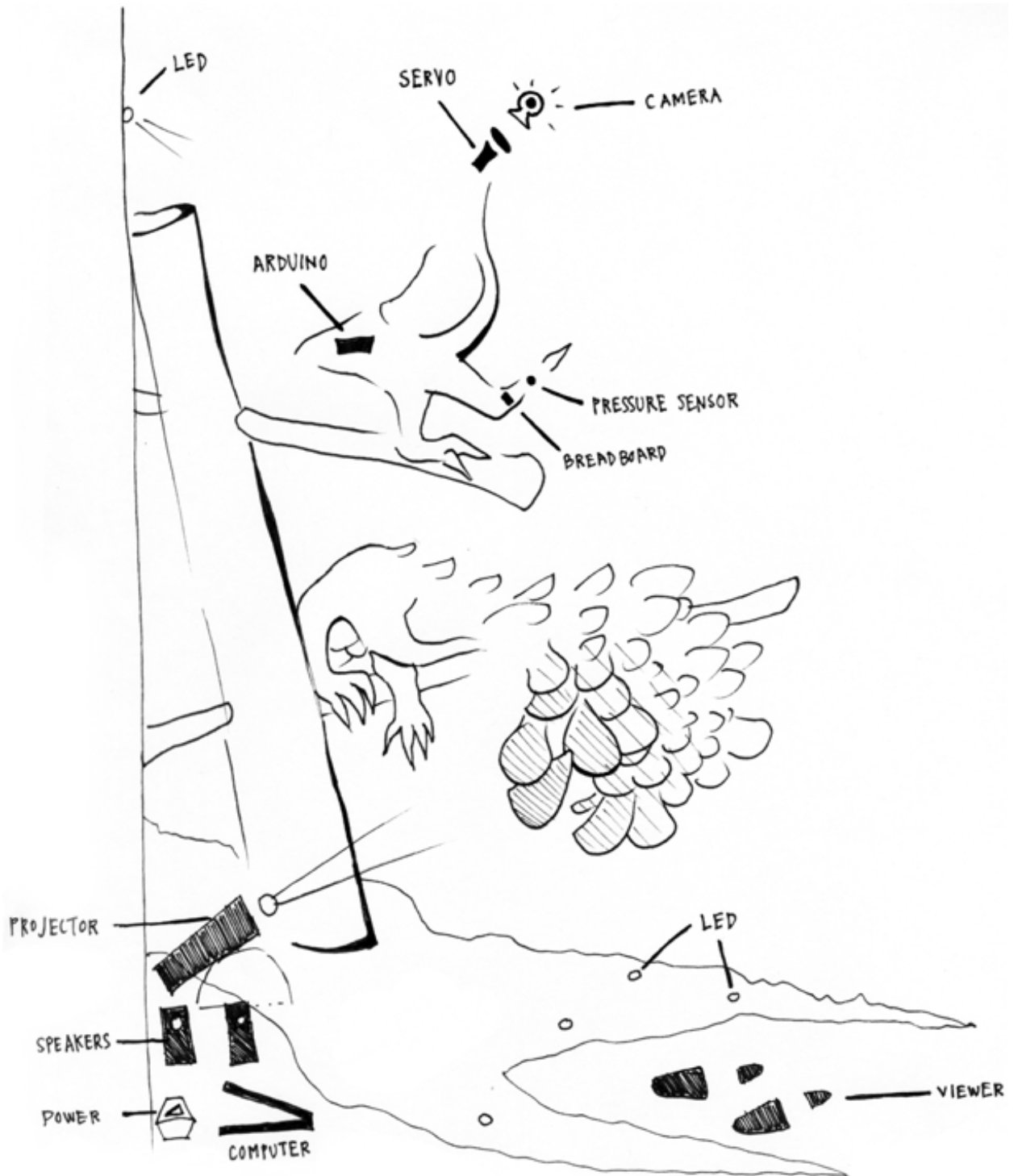


Figure 5: Embedded System



Embedded in the head of the bird and serving as its eye is an Xbox 360 Live Vision Camera [8], selected as one of few external webcams compatible with MacBook Pro. Velcro underneath the taped-in camera attaches the head to a small disk that sits on a Hextronix Standard Servo Motor held by wire in the neck. The servo can rotate 180 degrees, sufficient to support and turn the bird’s head in natural directions. To accommodate the camera’s USB cable that extends from the head through the neck and down the body, the neck area must provide significant clearance for the head to turn without the cable catching.

Jumper wires and most of the electronic parts are tightly bound and protected by electrical tape to avoid shifting and detachment or water-damage from the sculpture construction process. Most wires are concealed by the bird’s body, but the webcam and Arduino USB connections must run to the ground to connect to the computer. The cables leave through the standing foot of the bird, and join a net of decoy wires to disguise their purpose, wrapping around the mast and under the paper ground.

The computer outputs audio via speakers beneath the paper ground and video via a rear projection onto the lower bird’s tailfeathers. Motion-sensitive LED lights on the ground distract from the bright light emitted by the projector, and one LED on the wall illuminates a hidden silhouette through the bird’s chest. These are not controlled by the computing system, but serve as an important transition between the sculpture and technology components.

## 4 Implementation

### 4.1 Finite State Machine

In mapping out the implementation of *The Curious Timekeeper*, we determined our idea of “natural” behavior and then addressed issues of timing and synchronization accordingly. The code is entirely in openFrameworks/C++, able to communicate with the Arduino using a Firmata add-on, and essentially operates as a Finite State Machine, running on one main thread. Each state of the FSM is defined by three parameters: Human Present [**Y**es/**N**o]; Pressure [**Y**es/**N**o]; Video Playback [**H**alt/**F**orward/**B**ackward].

The system’s default and passive state is **NNH**. The projection cycles through the bird’s “memories” – prerecorded videos of outdoor nature scenes, played at variable speed. The servo receives signals randomly to turn the head slightly, alerting the viewer to the bird’s seeming awareness.

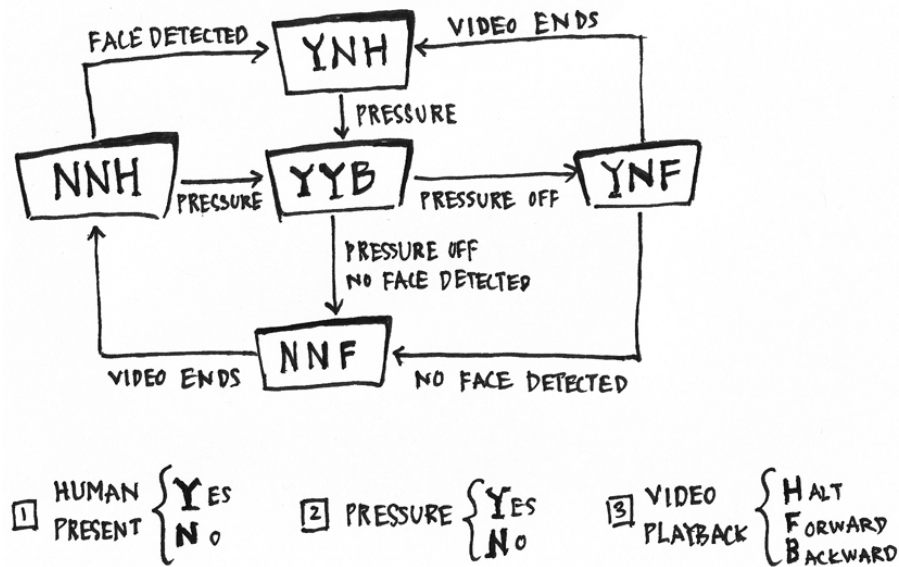
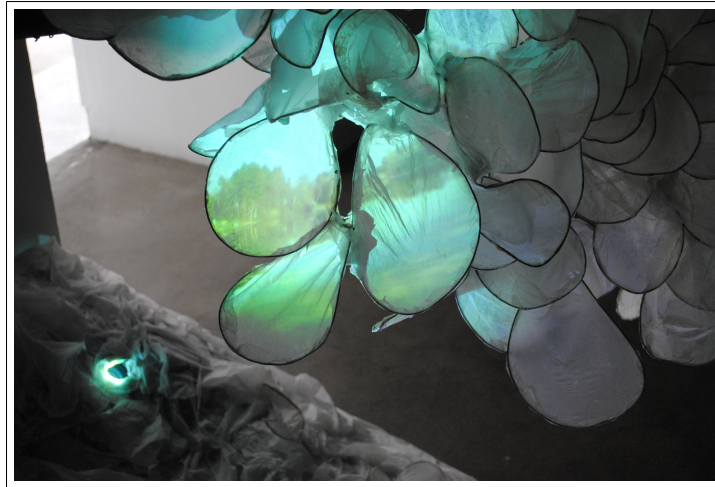


Figure 6: Finite State Machine

Every image received from the camera in real-time is, for speed, resized to 50% and then analyzed for Haar-like features, using a Haar Finder and OpenCV. Having Haar-like features strongly indicates the presence of a face, and in a controlled bare environment face detection is highly accurate. However in a more complex or moving environment, the analysis will yield many false positives. One way to make the check robust would be to follow the facelike-blobs detected and eliminate the least consistent. In the gallery context where the sculpture resides, this solution would not have made much difference, but we may have implemented it for a different setting.

On recognition of a face, the state changes to **YNH**, and as long as a face is detected or recently detected camera images are recorded and saved as a frame-by-frame video. This state can be recognized by the loud “*kha*” noise played when it begins. There are 10 slots for video clips, each typically about 30 seconds, and sometimes several slots for one viewer depending on amount of movement. New video records over the oldest slot, updating the new length.

When the hand is squeezed and pressure is detected – as a safeguard, regardless of whether a face had already been detected – the state changes to **YYB**. The servo jumps suddenly to a calculated position to cause the camera to stare directly at (and perhaps startle) the viewer. Recording continues, but the video projection changes from the nature memories to rewind through the saved recordings of past visitors until the hand is released or the video has rewound all the way. To rewind, the video



(a) Pre-recorded “memories”



(b) Recent capture playback

Figure 7: Projections

plays frame-by-frame at 20 frames per second (fps) in reverse. It is overlaid with the present view.

The present is never depicted in the perfect clarity of the images received from the camera – instead, a ghosting effect is applied, by weighting the past image value and adding the new image pixels at reduced opacity.

When the viewer releases the hand and pressure is no longer received, the system state changes to **YNF** or **NNF**, and the video will play frame-by-frame forward at 10 fps, still overlaid with the present camera view. Playback eventually reaches the present, and returns to **NNH** or **YNH** until the next interruption. The viewer can squeeze the hand again during or after the playback, and so operates the time- machine.



Figure 8: Ghosting and present-past overlay

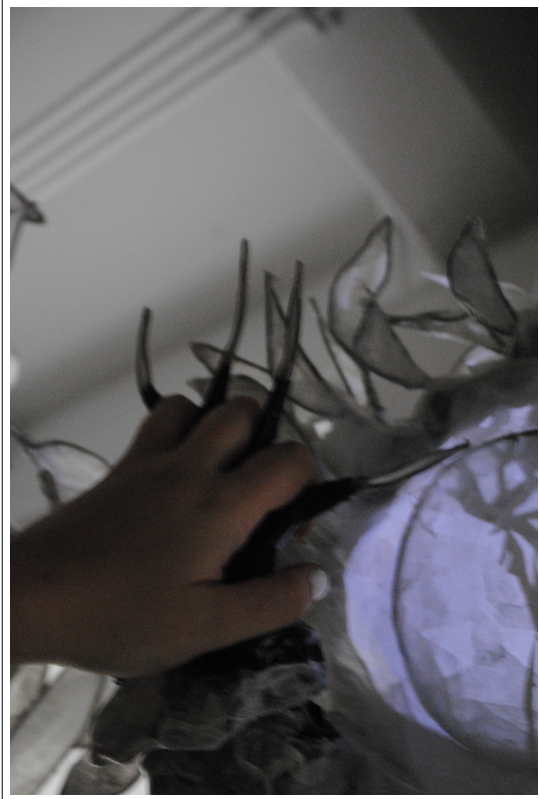
## 4.2 Realization as Sculpture

With the objective of achieving interaction through *presence/location/image* and through *physical manipulation*, *The Curious Timekeeper* was successful in its execution and realization. We found it wiser to construct a system with many small moments of interest rather than set high or complex expectations for any one aspect – such as computer vision – that could fall short of expectations after the sculpture’s move from studio to gallery.

Face-detection is highly accurate when the viewer faces the camera directly and unobstructed, and the positioning of components enables this. The viewer becomes acutely aware of his or her location when the bird’s head turns to look directly on squeezing the hand. The hand squeeze, as an instance of physical manipulation, breaks an established rule of no touching in a Fine Art context, especially bold when one must apply significant pressure to a fragile-looking, but fortunately sturdy, structure.

From here the viewer must maintain position to continue to control the projection with the hand, and so engages in a struggle between looking at the camera/hand or looking at the projection on the tailfeathers. The image of the viewer is immersed into the past visions of the recent recordings, and on staying long enough the recording mechanism will catch up for the viewer to be overlaid with himself.

*The Curious Timekeeper* met success with the sculptural construction over the hardware, and with solutions to the significant engineering problems that developed for: the squeezable hand’s position and effectiveness, head-attachment mechanism, head-turning range, camera angle to viewer, one-foot perch position, focused and visible projection in lit room, concealment of electronics, and tall supportive structure that would not interfere with the interaction. Significantly, none of the hardware



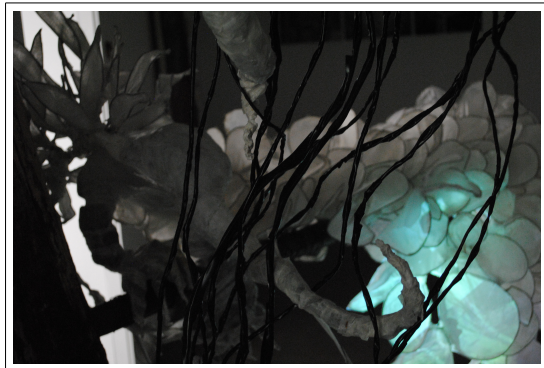
(a) Squeeze interaction



(b) Side view



(c) Pressure sensor exposed



(d) Camouflaged wires

Figure 9: Sculpture detail views

broke once fully embedded, and the system has been tested to run successfully for one hour.

In spite of the computational intensiveness of checking for Haar-like features on every frame captured from the camera, real-time video still plays at 7 fps, achieved through shrinking the image scanned for faces. On a full-size image scan, the video slows to 3 fps. Without face recognition real-time video will play at 11-14 fps, but this difference from 7 fps is surprisingly not very noticeable. From this, running the recorded video playback at 10 fps, the playback is always able to catch up to real-time, preventing an infinite loop of just-past recordings until the viewer's departure.



Figure 10: Front view



Figure 11: View behind projection

## 5 Discussion and Limitations

Our decision to develop the computing system for *The Curious Timekeeper* almost completely before construction of the sculpture proved to be a wise one, although somewhat limiting in the decisions it forced for the sculpture. These limits were in part a result of the nature of the devices, i.e., having wires required to reach the computer; the limitations of back-projection and of a projector's focus, distance, and lighting. The limits also resulted from conceptual decisions that asked the electronics to be integrated in a particular way, i.e., the turning head and angle; the hand at a reachable height and effective design for squeezing. The open chest of the bird is an artifact of an early idea that was

not executed. We originally intended the projection on the tailfeathers for the body of the bird, and replaced it with an LED-illuminated silhouette. The projection moved in order to avoid a bulging structure on the wall, poor focus at a too-near distance, and slight collapse of the circular space on the bird that would result in the top and bottom of the image awkwardly blocked.

Although *The Curious Timekeeper* was constructed in a separate studio, we had to ensure it was both portable and not much restricted by lighting or its exact environment in order to succeed in installation at the Jaffe-Friede Gallery in the Hopkins Center, one week before the opening of the exhibition. From a systems standpoint, this restricted options for the wires and the projector, which could not be situated until placed in the gallery, and until that point still planned on suspension from the wall. Furthermore, the paper ground could not be constructed until the projector moved to the ground, along with the computer and speakers, as a final solution to their exposure.

The gallery as a viewing context both was and was not sufficiently factored into the design process of the project. The idea of having infrequent viewers who would be singled out and recorded when they chose to interact, for the video-recording to span a significant amount of time, was an important part of the concept. However, due to the limited lifespan of the motor, possible risk of the head disconnecting without immediate repair, and fragility of the pressure sensor if over-exerted, the sculpture now runs fully only for short stretches of time. During its demonstrations – and keeping in mind its known limitations – the system has proved fairly robust. The supporting structure is sturdy to shaking and certainly to hand-squeezing, although skeptically constructed of narrow branches wedged into a tree trunk and held mostly by friction. The Arduino, motor, and pressure sensor are reliable, and the code handles variance in the sensor's readings after thorough testing for maximum false readings and for the effectiveness of the hand apparatus. While squeezing, the hand may occasionally move off of the pressure sensor and require resetting.

*The Curious Timekeeper's* main exposition happened during the gallery opening on May 11, 2010, where having so much movement in the gallery caused almost constant false-positives for the face-detection. Even without crowds, the other works in the gallery could sometimes be perceived as faces while the camera moves on the turning head. The ideal setting is a white, consistent background. This also enhances the power of the past recordings overlaid with the present self – a moving background can cause confusion over intrigue – and overall increases the clarity of the workings of the sculpture.





Figure 12: Earlier version considers stilts and multiple segments

fundamental interaction and building out, rather than using the interaction as a way to solve a conceptual problem, could be more effective.

The question of the effectiveness of the interaction with the video may also be a question of feedback provided. Certainly the head-turning is important feedback with the hand-squeeze, but the audio feedback here is a little vague. Although particular whispers occur when a viewer squeezes the hand, the interaction might benefit from an increase in volume of a distinct sound, proportionate to increase or decrease in pressure. In the gallery setting where the video becomes more ambiguous, more feedback on the passage of time could also improve the interaction – perhaps the suggestion of a clock of some kind.

Working with technology and the limitations created by the computing system proved a useful way to impose constraints on an otherwise unbounded project, and we believe it led to the more creative solutions for the engineering problems, most notably the tree structure and the two-part bird with extra legs that help it attain the necessary height and imposing stature, and to distribute the weight of the perching bird, which could not have had the system and projection configured as planned with such a heavy tail. The technology was somewhat limiting in this project in the development of the

Discussing with viewers their reactions to *The Curious Timekeeper* and the interaction, most commented first on the head movement. The subtle, random movements that scan the environment until a hand squeeze were often caught by peripheral glances, and then on looking at the bird again it would seem to stay still until one looked away. This behavior was relatively simple to implement, in contrast with the complex video control system that not everyone fully engaged in, either because of their reluctance to touch an art piece, or perhaps because they were not able to make sense of it quickly enough. Although the objective was not necessarily to find a most intuitive means of integration – potentially sacrificing the concept – we suspect that starting from the intuitive and fun-

aesthetic, and also in testing. While simplified versions of the interaction and system existed or could be simulated throughout the process, it proved difficult to fully understand and test the interaction without building everything, and time did not allow for full construction, tear-down, and rebuilding.

## 6 Conclusions and Future Work

For a new viewer to fully understand the workings of the system or the exact behavior of the video when the hand is squeezed, *The Curious Timekeeper* demands patience and experimentation. It confuses on first approach because it confronts with size, physical movement, projected movement, audio; imposes a creature that the mind attempts to classify as quickly as possible as a bird, to some success but not complete satisfaction. While it may not teach the viewer anything directly about computing, or cause one to think about the hand-squeeze as taking the place of a mouseclick, or the back-projected image on the tailfeathers as taking the place of a monitor, the viewer encounters something from the world of computing that is mysterious in a way one is not accustomed to. Although viewers may not understand a computer's inner workings, they understand how to use one. Here, they understand that the creature is watching them, interpreting them somehow, and offering an interaction – but they don't know to what end, and this open engagement asks them to think more deeply about it, and their relationship to technology, and the capabilities of technology to integrate with the physical world.

While the large system assisted the overall success of *The Curious Timekeeper*, it ultimately created so many problems to solve in the physical building that the intricacy of the construction – more than finding the solutions – placed the greatest strain on the development and opportunity to try most ideas past a quick prototype. In future work exploring interactive art, we hope to isolate a few aspects from a system like this one to become their own pieces. Rather than try to combine movement, sensors, projection, and sculptural concept, to choose a subset of this and figure out a viewer's exact relationship. From there, to isolate the interesting interaction and then build up the piece. This approach is more experimental and human-oriented, and relies less on concept. In light of the interesting interaction created in this work, if we continue interactive art along the conceptual strain and hope to combine better with the experimental, great potential may lie in time passage as it relates to video and projection. Larger systems may be an important point of return with a re-visualization of the full creative capabilities of their smaller components.

## 7 Acknowledgements

Although of independent concept, design, and undertaking, this project would not have been possible and certainly not successful without the guidance and assistance of many. Special thanks to my advisors Fabio Pellacini (Computer Science), John Kemp Lee (Studio Art), and Soo Young Park (Studio Art) for their great insight and suggestions. Additional thanks to friends for their support over many months, for their advice and assistance in sculpture construction - holding, counting, carrying, testing, measuring.

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