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ACTIVE BUILDINGS

What can we do about buildings that simply stand still?

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Abstract. This paper presents background of our research and result of our pilot study to find methods for convincing building users to become active building participants. We speculate this is possible by allowing and motivating users to customise and manage their own built environments. The ultimate aim of this research is to develop open, flexible and adaptive systems that bring awareness to building users to the extent they recognise spaces are for them to change rather than accept spaces are fixed and they are the ones to adapt. We argue this is possible if the architectural hardware is designed to adapt to begin with and more importantly if there are appropriate user interfaces that are designed to work with the hardware. A series of simple prototypes were made to study possibilities through making, installing and experiencing them. Ideas discussed during making and experiencing of prototypes were evaluated to generate further ideas. This method was very useful to speculate unexplored and unknown issues with respect to developing user interfaces for active buildings.

Keywords. Interaction; interface; Building Information; Participatory; Adaptive.

1. Introduction

A building typically is a result of one-off project. Many buildings are designed from scratch and are never to be repeated. Most buildings are version-one unlike consumer products such as mobile phones and cars, which continue to evolve and be reintroduced with improvements with advantages clearly stated. Most building proposals do not even envisage how users can upgrade or customise their spaces. Conventional project proposals simply do not assume buildings evolve with their users. While some architectural projects invite future users to participate in the design process, the resulting buildings often are frozen entities that simply stand still and do not adapt well to changing user needs. Our research began by asking how people can continue to fully and actively utilise their buildings.

Building Information Modelling (BIM) provides interesting possibilities for designing and managing buildings through effective visualisation and management of various building information. The current focus of BIM, however, is intended for architectural and construction industries. There are exceptions with which BIM is used for facility managements (CRC for Construction Innovation, 2007) but it is rare. Beside them, there is no evidence that a formal study was conducted to make BIM available for users. When manufacturing technologies make it possible for virtually anyone to design and produce one-off components, the limitation is imposed by buildings that are not designed to provide a framework to allow users to do it. If building information is used effectively in conjunction with open, flexible and adaptable building hardware and software, buildings will begin to offer different scenarios to how we utilise them to live and work.

We hypothesise that the missing link between the building information model and adaptive building systems is a set of interfaces for users to access, understand and utilise building information effectively and another set to customise their spaces easily. This paper aims to demonstrate how users can take participatory roles as agents of change through digitally enhanced tangible interfaces. We argue architects can take a new role to provide built environments for users to effectively instigate changes. Our future scope is to propose a strategy to design building systems that inform, encourage and motivate people to change their environments and improve the operation of not only one building but also a city as a whole through their participation. The purpose of this paper is to report how we began to do this.

2. Background

Technological solutions that deal with such as climate, hygiene and lighting have made significant advancement. It is surprising, however, that introduction of devices such as smart phones and laptops instigated significant changes to our lifestyles in the last fifteen years while our perception of what buildings do to support our lifestyles hardly changed since the industrial revolution. Kaspori extends this argument by stating that architecture is reduced to mere scenery for a world on the move (2005). To consider alternative scenarios for architectural possibilities, the aim of this research is to study how people can actively use and interact with their buildings. Our main question is to ask what happens to buildings when the benefit of digital technologies to our lifestyle is pursued for designing buildings.

Since Sterling called networked object a Spime (2005), people began to recognise the importance of the Internet of things by experiencing more products, other than mobile phones and computers that exist within and influenced by the flow of information. The flow however is yet to influence much of the way buildings exist and how they are used today. As observed by some architects and critics (Kieran et al., 2004; Pawley, 1990) building users have hardly benefited from decades of technological advancements we have been experiencing through other products in our everyday lives. With respect to how a building serves its users, the expectation of what buildings do to support their users has not evolved much for centuries. As of today in the 21^{st} century, our buildings still stand still.

This is not to say they all do. This research is influenced by Habraken's approach to design support structures and infill components to provide flexible building (Habraken, 1972). The method and scenario he proposed was feasible and practicality of his idea was clearly demonstrated with NEXT21, a residential building constructed in Osaka, Japan in 1993 (Figure 1). The building is composed of support structure and infill components, and spaces are rearranged periodically when demand of users changes. Its success however was mainly due to full-time researchers conducting workshop and consultations for its residents. Their contribution is significant to maintain the building and it is difficult to believe the building will continue to function successfully and as intended if the operation and maintenance were left solely to residents. This hints that hardware such as support structure and infill components is not enough to keep a building alive. Support systems and user interfaces are vital to keep adaptive buildings to be fully utilised.

Figure 1: NEXT21

Price's Fun Palace is one of the most flexible technologically mediated buildings ever designed. It is questionable, however, that it was capable of accurately processing amount of building information and user instructions, interpret user intentions and respond to user needs. Moreover, it is hard to believe that, in the age when the idea of human computer interaction hardly existed, it offered sufficient interfaces for users to be able to communicate their intentions effectively to control complex array of flexible building systems. We argue that this is the main reason why a building like the Fun Palace has never come to exist as of today. Wigley describes “architectural responsibility to house humanity became a responsibility to shape flows of information” (2007). We need user interfaces to manage and utilise flows of information in adaptive and participatory buildings.

3. Research Method and Approach

This research is an “interpretive” research. Swann (2002) describes that interpretive research is “a form of qualitative research which is better suited to the behavior and sensitivities of human beings, relying more often on insight for the interpretation of human actions”. We conducted our research by constructing a series of prototypes, observing how people, including ourselves, use them and by understanding advantages and disadvantages of prototypes and context they were in.

This method was chosen because it is difficult, if not impossible, to find an adaptive building with real users in which we can test our prototypes. A building for users to customise simply does not exist. In order to pursue the idea of designing Active Buildings, we chose to begin testing a wide range of interfaces in isolation within certain relevant contexts.

Practical benefits of prototypes in our chosen contexts were not very important for this research because our aim was not to resolve specific problems in contexts we tested our prototypes. Our focus instead was to construct and test interfaces as proof of concept to identify possibilities of how users can interact with buildings and benefits of abilities to interact, and identify certain scenarios for Active Buildings.

4. User Interface Prototypes

We developed prototypes to study how building users can speculate, manipulate and learn actively or passively to influence the way a building works or is used. Our initial aim was to identify types of interactions between a building and its users and how certain interfaces allow this to happen. We identified from this study that there are several means for users to communicate and respond with building systems, as shown in Table 1.

Table 1. User Participation Matrix

	Active	**Passive**

Speculation	Investigation	Awareness
Manipulation	Conscious Selection	Automatic Selection
Learning	Participation	Observation

4.1 ANSI GRID AND MODULES

Australian National Sustainability Initiative (ANSI) is developing architectural systems to construct a lightweight, demountable space frame structure that supports a ‘green space wall’ (ANSI, n.d.). The key issue for developing a flexible and demountable architectural system is to understand possibilities of what the system is capable of offering. We recognised we need a tool to understand a variation of different spaces a set of building modules is capable of producing. We laser-cut a simple set of modular pieces and baseboard with triangular grid so that we could arrange modular pieces to study possible design options (Figure 2). Although the model is simple, it provided enough versatility to quickly and interactively study and recognise benefits of different spatial options collaboratively. This helped us to visualise one variation of how our modular components can be arranged to provide a building as shown in Figure 3.



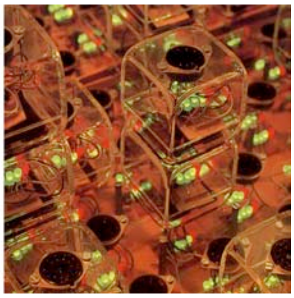


Figure 2. ANSI building kits; Figure 3. ANSI building proposal; Figure 4. Universal Constructor

This method involved extensive manual labour. It naturally led us to imagine how it can be streamlined with the aid of computer technology. For example, each piece can be augmented with sensors and actuators to inform users not only about arrangement of spaces but also about environmental, social and financial implications of combining and rearranging pieces. Each physical piece can be linked directly to a virtual component so that assembling modules create and alter information in BIM. The origin of this method can be traced back to Self-builder design kit developed by Frazer for Walter Segal for helping self-builders to design their own buildings (Frazer, 1995). Our idea is to take this further and allow building users to redevelop and modify their own building after its completion with every associating data collected as building information models. Although linking BIM to tangible user interfaces is the ultimate aid, our initial research aim is to develop a system that allows and encourages users to engage actively to manage their building to the extent post occupancy evaluations become redundant.

4.2 UNIVERSAL CONSTRUCTORS

To study interfaces that support active user participation, our first approach was to utilise Universal Constructor (UC) Cubes developed by Frazer and AA Diploma 11 students in 1990 (Figure 4). Although the output of each cube is limited to 8 LEDs, there are about 100 cubes in working order and they provided a starting point to study user interfaces for reconfigurable smart modular systems.

Because the original baseboard for UC was damaged, we produced a new means to control UC cubes and connect them to a computer. This was achieved by a combination of laser-cut bases each of which can carry a column of UC cubes and controlled by Arduino microcontroller board (www.arduino.cc). We produced two bases for two columns of UC cubes, but the number can be increased infinitely in theory in a very flexible manner; they can exist in a group in a grid-like order as they originally were designed for, loosely as a group of individual interfaces, or even remotely across the Internet.

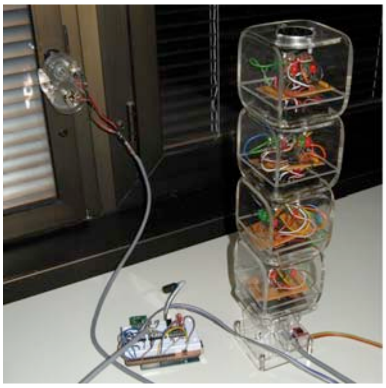
We found a set of scenarios can be developed to explain different use-case for interfaces such as UC cubes by going through all combinations of user participation modes in Table 1. For example, ANSI kit is an example of an active interface and can be used to speculate, manipulate and learn. The current form of ANSI kit, however, is too primitive to effectively provide information and feedback to building users because it relies too heavily on user experience and knowledge for the interpretation of consequences of changes. Further development of ANSI kit is to provide the rest of active participatory methods when it is augmented with digital technologies.

We envisage that users can also participate passively by not directly or consciously interacting with interfaces by making the systems to automatically and intelligently sense and interpret their behaviour. This has been researched heavily in building and home automation studies, for example, by Mozer (1999). Although it is a very important study for the successful deployment of active buildings, this paper will not discuss this because we are more interested in discussing user participation.

4.3 WINDOW SHADE CONTROLLER

To study and demonstrate basic principles of how active participation of building users can be encouraged and managed by tangible interfaces, we developed a range of simple means to actively and passively control venetian blinds in our office windows. The interface is consisted of UC cubes, motorised mechanism to turn the knob of venetian blind, light sensor, digital compass and accelerometer (Figure 5). Arduino is used to control all devices and communicate with a computer running a Processing application (www.processing.org) to upload data to Pachube (www.pacube.com) for sharing data with other networked devices.

Our experiment was to control the venetian blind by interacting directly with the interface, or control or monitor passively (automate) by detecting sunlight with or without a user interaction. The intention of this experiment was not to make a practical and useful set of interfaces but to study combinations of possible user-interface scenarios as mentioned earlier. It is more suitable to call this an artistic endeavour to identify possible architectural scenarios.



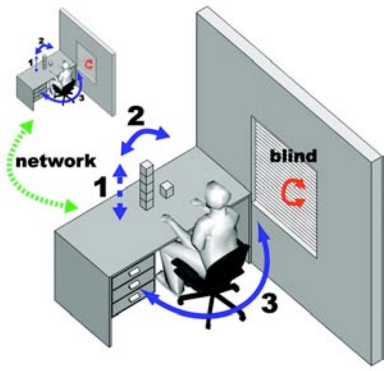


Figure 5. Shade Controller; Figure 6. Shade Controller Interfaces

All devices are connected and Arduino is programmed in such a way that there are three possible methods to control the venetian blind as shown in Figure 6. The method (1) is by stacking UC cubes, (2) is by tilting a UC cube column, and (3) is by swinging the chair. UC cubes visualises the intensity of light they receive by turning corresponding number of LEDs.

The method (1) allows users to set venetian blinds to a predetermined angle. Control device is programmed to rotate them to one extreme when five cubes are stacked on the base, another extreme when no cube is on the base, and other in-between positions are set when one to four cubes are stacked. The method (2) enables users to assign a specific angle to each number of stacked cubes. Venetian Blinds rotate in one direction when the cube column is tilted to one side by reading accelerometer value, and the direction is reversed when tilted to another side, and the angle is stored when it is in an upright position. The third method triggers the rotation when the chair is swang, allowing a human behaviour to override the predefined position. The device is programmed to open the blinds when the chair is swung towards the window. They move back to the original predefined position when the chair returns to the original angle. A digital compass is used to measures the orientation of the chair.

These interfaces allow users to interact with blinds in several ways. Stacking allows users to set blinds to let the light come through with predefined intensities. Blinds rotate to maintain a chosen intensity as the light condition changes outside. When users require to fine-tune, they can interactively choose the right intensity for each occasions and store them to each number of cubes. Lastly, to allow users to rotate venetian blinds spontaneously, swinging chairs towards a window allow users to open them. This is meant to introduce a response to an intuitive action users take to look at the window. Blinds open so that users can look through them.

5. Discussion

The venetian blind experiment was conducted to learn how buildings could be activated for their users and identify a level of control they have to change their environment. The task was to identify something we can augment (venetian blinds), build tangible interfaces (UC cubes) and utilise control and feedback systems (Arduino and Pachube), to identify limitations and possibilities of building systems and user interfaces. The act of making them, discussion that took place during installations, further discussions we had through interacting with the shade controller interfaces were valuable.

Components we can retrofit to convert most existing buildings into Active Buildings are very limited. For example, it is hard to imagine a shade controller to become a product to be retrofitted because this would only be possible if window shading systems in many buildings were standardised. If however we can assume that all future building components are modular and will have open building information available to users so that they can be rapidly manufactured or purchased, number of scenarios we can develop for Active Buildings increases exponentially. We, as academics, tend to complain that buildings designed by students with Revit all look similar and boring. This is largely because components available in Revit and ability for students to utilise them effectively is limited. Similarly, if a building is designed to be active but users hardly understand the range of available options, it is easy to imagine that the building will remain inactive and boring. We argue that BIM capable CAD packages are more than capable of managing required information, but means to access them for users is very limited.

When building users are informed and capable of making decisions, their building will no longer simply stand still. Building simulation interfaces like ANSI kit augmented with digital technologies can invite and encourage users to discuss current condition and future possibility of their building. Interactive interfaces not very dissimilar to Shade Controller can provide real-time feedback and collect user information for the collective benefit of building community. Users thus will activate buildings and their buildings will become active elements of their everyday lives.

This is very likely to change the way we operate as architects. What is at issue is participation as McCullough discussed (2004), and Active Building scenarios will demand architects to provide means for users to participate and allow them to become instigators of change. It will become an important role of architects to determine how building user community learns, which is an interesting response to criticism made by Brand about modern architectural practices (1997). It is also important to recognise that the design is not finite at the point of delivery (Kronenburg, 2007). This is very similar to how smart phones are purchased with basic configuration and users are expected to customise it to their liking. Backend supports to manage and utilise building and user generated data are being discussed (Fuller et al., 2008) and implemented (www.pachube.com). Infrastructure is already available and it is up to us to design the remaining missing links. Buildings can become co-adaptive (Santo et al., 2010) when it is designed and implemented.

It is also expected that architects, as the expert in the field, provide initial conditions that are set as a good starting point for all users. It is also expected that architects will continue to provide consultations to help users find good solutions during the entire lifespan of buildings.

6. Conclusion

We argue that the most crucial but overlooked issue architects are expected to understand for designing open, flexible and adaptive buildings is interfaces for building users. Through developments of simple user interfaces to design and use a chosen component of building systems, we identify it is important to introduce means for users to speculate, manipulate and learn, and ultimately participate, to allows users to activate adaptive buildings. Our research interests currently overlaps more with researches conducted in the field of Human Computer Interaction, which can be seen in the researches for example by Ishii (Ishii et al., 1997) and Dourish (2001). There is large volume of research conducted within architectural discipline to prepare architectural hardware to work for open, flexible and adaptive scenarios, but architectural software is hardly developed to utilise them appropriately. Although our research is still in its infancy, we recognise it is slowly advancing to fill this gap to activate buildings for their users.

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