Chameleon

Developing an Interactive Façade System Using RFID

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Abstract. This paper proposes an interactive façade system capable of displaying the meaningful information extracted from this interaction using RFID. This façade system is a domain-specific, embedded system composed of three parts: an input device that employs RFID, a physical façade model that includes an output device and a microcontroller, and an application that consists of a middleware for the connection between the input and the output. The array of meaningful information derived from the input device is displayed as aesthetically flexible patterns created by Cellular Automata algorithms through the middleware. We expect that this facade will contribute to enhancing the building's identity and to revitalizing desolate modern cities as an urban screen through the communication between people and buildings.

Keywords: Interactive façade; RFID; cellular automata; multi-color LED.

Introduction

Due to its recent advances, media technology is melting into architecture. Developments in display technology and building materials are contributing to the birth of new forms of architecture beyond current functions. Likewise, the building facade began to communicate in data flows beyond simply presenting its function and the architect’s spirit and ideology (Hall, 2006). According to these tendencies, different facades which use media technology have been appearing recently. Most of these new facades or walls simply present the aesthetic aspect of architects and designers with meaningless information; or they show intuitive images in advance through temperature changes; or they show advertisements in one-way feeds. However, it is more valuable for the facades to interact closely with the building itself and to display semantic information—and not be treated as independent, uncoupled isles (Rausch and Breinbauer, 2007). This can produce nomadic spatial communication and will result in making more public spaces. Accordingly, the new media facade system presented in this research supports the interaction between the building and its occupants, as well as the displaying of the semantic
information extracted from this interaction.

Basically, because building types such as department stores, cineplexes, wedding chapels, and galleries do not demand a relationship between the interior and the exterior, the exterior allows for more specialized attention towards each building type (Schmidt et al., 2005). However, the advancement of media technologies today has the potential to even consider a relationship between the interior and the exterior over the specialized building types. Accordingly, in looking forward to this possibility, I propose a prototype small-scale facade system for an office building. This system is a domain-specific, embedded system. This facade system is composed of three parts: an input device that employs RFID, a physical facade model that includes an output device and a microcontroller, and an application that consists of a middleware for the connection between the input and the output. The facade model was designed as a latticed grid with 92 multi-color LED’s, and a wiring I/O board was used as a microcontroller.

In developing this system, developing the middleware part which connects the flow of seamless data between the input device and the physical model is most pivotal. The array of meaningful information derived from the input device is displayed as aesthetically flexible patterns created by Cellular Automata algorithms through the middleware. We expect that this facade will contribute to enhancing the building’s identity and to revitalizing desolate modern cities as an urban screen through the communication between people and buildings. Moreover, considering today’s nomadic culture, this research will make contributions to the research and the practice of new media surfaces.

**New media surface**

Marshall McLuhan and Nicholas Negroponte highlighted the value of digital data in presenting communication technology (Mcluhan, 1962; Negroponte, 1996). Today, the development of media technology enhances the content of communication as well as the method. In the realm of architecture, new architectural facades which use new media technologies are emerging through the exploration of new materials. From starting the first ‘zipper’ sign in Times Square, New York, in 1928, an illuminated bulletin board which transmitted the day’s headlines on a building facade, the facades of today present various patterns or images through such display devices. Accordingly, contemporary architectural surfaces are becoming aesthetic, emotional surfaces through the representational means of digital media, as based on Information Technology (IT) (Perralla, 1998). Also, these surfaces are becoming interfaces by which the public can interact with the surface.

For instance, the Tower of Wind in Yokohama, Japan (1987), designed by Toyo Ito, represents various patterns through immaterializing light. The 1280 LED lamps respond to the sound patterns from the city and artificially maximize their effect. In terms of immaterialization, the sound coming in from traffic, or any other movement in the city, is transmuted into aesthetic lighting patterns on the facade. This surface just focuses on the abstract visual language by translating the changing physical phenomena but lacks the component of interaction. Today, this tendency emphasizing the abstract visual language in a media facade is the most common trend. This tendency might lead to the weakening of the nature of the architecture.

**Interactive Surface**

Interaction has become a key term for new media technologies. Rice defines the new media as communication technologies which enable or facilitate user-to-user interactivity as well as the interactivity between user and information (Rice, 1992). However, these interactions in new media architecture can also be defined with the concept of bi-directional communication, which occurs between two built components or between built components and people (Oosterhuis et al., 2007). This does not mean that these interactions are simply responsive or adaptive
to changing circumstances, but that these interactions involve three processes: input, process, and output. Thus, bi-directional interaction between two active parties is the main characteristic in an interactive surface. Another characteristic is also noticeable in aspects of the visual effects of the media surface. Through the interface of new media surfaces, the user’s sensory experience can be enhanced. These experiences between media surfaces and users are called interactions.

New media surfaces are not designed as simply images, but have aesthetic and cultural functions in addition to architectural functions by serving as the interface between city and building and between interior space and exterior space (Jang, 2007). Today, however, due to the focalization through the viewpoint of media, designers only concentrate on the visual language. For example, the facade of the Galleria department store which uses an LED facade, presents the aesthetic, abstract visual language via a one-directional interaction. However, if this could be upgraded to a bi-directional interaction and if this could present data more effectively on the facade, the media facade could become an interactive medium beyond simply the intuitive expression as ornaments or sculptures. As a result, a new media facade has to become an interactive facade in order to produce nomadic spatial communication in public spaces by means of a bi-directional interaction and not merely one-directional interaction.

Design

System overview
This interactive facade system can be defined as an embedded system whose special-purpose computer system is designed to do specific tasks rather than being a general-purpose computer for multiple tasks (Barr, 2007). This facade system is composed of three parts: an input device that employs RFID, a physical facade model that includes an output device and a microcontroller, and an application that consists of a middleware for the connection between the input and the output. The facade model was designed as a latticed grid with 92 multi-color LED’s and a wiring I/O board was used as a microcontroller.

For the flow of seamless data between the physical facade model and input device, a middleware was developed with Processing language based on Java. Figure 1 illustrates the system structure of this facade system.

Figure 1
System structure

System design
Two kinds of RFID readers were used for the input device of this system because these two readers have different recognition ranges: a Parallax RFID reader and an ID Innovations ID-12 reader. Through the connection with USB-to-TTL (Transistor-Transistor Logic) serial adaptor, a tag ID was sent to the middleware. Because the two readers can use the same tags, it is possible to work this system with only one tag.

Also we used 92 multi-color LED’s as the output device. Generally one multi-color LED (Light-emitting Diode) consists of four pins: Blue (pin 1), Green (pin 2), Anode (pin 3), and Red (pin 4). Blue, Green, and Red each need output pins, and an Anode pin is connected to the ground pin (GND). In order to use 92 multi-color LED’s, this facade system needs 276 outputs. For this, we need to extend the output pins with shift registers since the wiring board has only 48 I/O pins. As a shift register, 74HC595 which is an 8-bit serial-in, a serial or parallel-out shift register with a
storage register and 3-state outputs was used. As for using this shift register, we could control 8 outputs at a time with a few pins on a microcontroller. Moreover, for bridging multiple shift registers together, 279 outputs could be extended in this system.

**Facade design**

The goal of facade design is to satisfy both functions of being an architectural facade and a media surface, since this building type is an office building. The issue was to arrange multi-color LED's effectively. To make the dynamic pattern of a facade and to spread information, such as texts and visual representations, the facade model was designed as a latticed grid. 92 multi-color LED's and the windows were in turn arranged in this pattern.

**Information design**

The goal of visual representation in this facade system was to provide meaningful information with aesthetic and visual effect. Generally, when we design the facade of an office building, we have questions such as, “What represents the office building?” and “What kind of information do people want to obtain from an office building?”

We decided to represent the information of occupants (e.g. office workers) by the ratio of gender, the movement of occupants, and the organization of occupants because of our confidence in the occupants being able to represent the office building. In terms of the representation of the information, cellular automata are a suitable algorithm because office workers belong to a hierarchical organization of a company, and cellular automata also have such relationships between cells. So based on cellular automata, we developed a new pattern algorithm. Through this algorithm, the information of occupants in relation to an office building is efficiently presented on the facade.

First, the LED cell which is initially detected is arranged on each floor randomly according to the floor of a particular worker's office. Second, if a person of the same organization is detected, another LED cell becomes the neighbor of the first according to its position in the hierarchy. If a person is not of the same organization (perhaps in another country), the second LED cell is also arranged randomly because it has no relationship with the first cell. The shape of the patterns will appear as a tree structure. Figure 4.8 presents the rule for the distribution of cells.

**Interaction Scenario**

Scenarios for interactions were made considering two situations: when the RFID is detected (Detection Scenario) and when the RFID is not detected (General Scenario). The RFID reader is installed at the entrance of a building and on each floor. Each floor has an RFID zone. However, in our prototype system, an RFID reader was installed in the entrance and on the third floor.

In the general scenario, the facade represents visual information such as the gender ratio and the age ratio of occupants in a building which constantly fluctuates. When an RFID reader is detected, the detection scenario starts. First, if a worker enters a building, the RFID reader at the entrance detects this, and the facade system presents text messages, like greetings, along with animated visual representations. After that, according to his/her work floor, the LED cell on the floor turns on randomly with an appropriate color. For example, if a person works on
the third floor, the LED cell of the third floor turns on. After the animated patterns, the detection scenario is closed, and the general scenario is started. Second, if a worker on the floor enters its RFID zone, the detection scenario again starts with the representation of organizational structures. Figure 3 illustrates interaction scenarios.

**Implementation**

We created an interactive facade system through making a multi-color LED-based facade model with RFID readers, which constitutes an embedded system inserted into a microprocessor. Our final prototype consists of an interactive facade model and an application to connect the RFID readers and the model. Figure 4 shows our completed interactive facade system.

In order to prove the concept of our research, we tested our interactive facade system according to the two scenarios mentioned above: the general and detection scenarios.

**General Scenario**

In the general scenario, the facade system represents the animated visual information, such as the gender and age ratios of occupants in a building, which constantly fluctuate. Figure 5.10 shows the gender ratio of occupants. For this implementation, we set up a situation where 28 men and 22 women would be in a building. The blue and red colors signify men and women, respectively (Figure 5). Also, the facade system has random modes that only represent visual effects without messages.
Detection Scenario
In the detection scenario, if a worker from the second floor enters a building, the RFID reader at the entrance detects this, and the facade system presents text messages, like greetings, on the second floor, along with other animated visual representations. If, in another country, a worker from the third floor enters a building, the facade system presents text messages on the third floor (Figure 6). If a worker on the floor enters the floor’s RFID zone, the detection scenario again starts with the representation of organizational structures (Figure 7).

Conclusion and future work
The interactive facade system, as described in this research, is a domain-specific facade system for an office building which uses general information from occupants, avoiding the problem of privacy and displaying aesthetically flexible patterns as created by Cellular Automata algorithms. The main goal of this research was to investigate how individuals could effectively interact with a building itself.

Recently, media technology has become embedded into architecture, and buildings themselves are changing and becoming media infrastructure (Slaatta, 2006). Recently, a facade that can display intuitive images which reflect temperature change is appearing. However, beyond these ambient displays, the interaction between occupants and building is being explored further as a way of representing the identity of a building. Accordingly, we developed a new facade system supporting the interaction between the building and its occupants by displaying the semantic information extracted from that interaction. This facade system is composed of three parts: an input device for color detection, a physical facade model with 92 Multi-color LED’s as an output device, and a middleware for the connection between the...
input and the physical model. We expect that this facade will contribute to enhancing the identity of the building and to revitalizing desolate modern cities through the communication between people and buildings. Moreover, considering that today is a nomadic age, this research will make contributions to the field of both research and practice of new media surfaces.

Further research issues that have been identified include: extending beyond an office building to different building types and devising more effective interaction methods between people and buildings. Also, our system has a flexible software application that can change the data for a visual language. If we do further research about the effective information design in harmony with an urban context, this system will be upgraded.

References

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