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Master's Thesis

Academic Year 2015

Design and Implementation of Interactive Visual Contents Using Automatic Door

Graduate School of Media Design,
Keio University

LI WEIJUN

A Master's Thesis
submitted to Graduate School of Media Design, Keio University
in partial fulfillment of the requirements for the degree of
MASTER of Media Design

LI WEIJUN

Thesis Committee:

Associate Professor Kazunori Sugiura	(Supervisor)
Professor Naohisa Ohta	(Co-Supervisor)
Professor Masa Inakage	(Co-Supervisor)

Abstract of Master's Thesis of Academic Year 2015

Design and Implementation of Interactive Visual Contents Using Automatic Door

Category: Design

Summary

This research is focused on using automatic door as the medium for visualization strategies and interactive contents design, which makes interactive experience accessible to the greater public with an everyday encounter by naturally combining the physical environment with the virtual illusion through the automatic door.Three prototypes are presented in this research.While first and second prototype is focused on different interaction modality; the second and third prototype are designed to compare the effectiveness of augmented interactive virtual scenes. Each of them has its own characteristics and can contribute this research either as a single factor or a combination. The research also conducts experiments by using quantitative as well as qualitative methods. The results of three experiments show that this research is succeed to enhance user immersion through the interactive experience, by using automatic door as the medium to merge the physical environment and visual contents in routine environment.

Keywords:

Visual Content, Interactive Display, Natural Interaction, Immersion, Automatic Door

Graduate School of Media Design, Keio University

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Contents

List of Figures

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Chapter 1

Introduction

This section is divided into three parts as follows. The background and motivation are introduced to help understand the starting point of this research. The first part is followed by aim and goal, which are shaped out from the motivation of the research. Also the structureis presented to explain the overview of this paper in the third part.

1.1. Background and Motivation

We live in a time of rapidly evolving digital systems and the way we creatively express ourselves has strongly been influenced by the media systems we use on a daily basis [1]. In the current decade, interactivity is no longer an experiment in the media lab or an experience in a media art exhibition, but part of everyday life in digital culture [2]. At the same time, innovation has changed fundamentally that innovation is mainly substituted by its quality. Projects are not acknowledge in the media, curated, or awarded prices only because of their innovative and fascinating interface technologies, the content conveyed by them is raised up as the core for evaluation, which hint us that the new medium has matured. Interactive applications, installation and environments are judged be-

cause of the quality of their concept and design, the quality of experiences they evoke, the information mediated by them, and their utility [9].

Since then interaction design has become full-fledged research area and a recent stream of publications just underlines how important this topic is for designers and creators. Under the trend, providing experience which could enhance user immersion becomes one of a major thread in interaction design. As technology-mediated interactions form a greater part of our lives, previously programmed spaces and artifacts may be occupied in new ways. Compared with using regarding interaction as digital ornamentation, designers and creators may integrate the virtual and physical to a new level beyond the use of computer displays. This is an exciting prospect for the designers, who may start to operate increasingly within the virtual sphere, the practice shifting into new and unexplored territories [11].

Getting the opportunity to join the S.I.M.S project at the beginning in KMD, provided a precious experience to me of how to enhancing viewer immersion in interactive cinema. Instead of presenting predetermined scenes, this experience bring the world of narrative into the real spatial environment that viewer inhabit. S.I.M.S makes it possible for viewer to be totally submerged into an imaginative virtual world of the film by taking advantages of the real space and using natural interaction.

These inspirations could be seen as an effective direction of enhancing the quality of interactive experience by merging real space and virtual scenes. But this approach is unavailable to the general public because it is limited to specially appointed space and is also require an environment sensor which could be used by individual user taking parting in the interaction experience. Thus examining a new modality of interaction that is designed to optimize the experience for a group of users, rather than a single participant, becomes one of possible potential that could be extended in coming trail.

1.2. Aim and Goal

The goal of this research is to offer approaches of interactive visual content design for automatic door in routine environment by means of visual content and natural interaction. This research makes interactivity accessible to the greater public with an everyday encounter, by naturally combining the real object and the virtual illusion in a collocated interaction and visualization space.

Aim of the research is to provide the possibility to couple augmented virtual contents with natural interaction through assigning automatic door by means of projector-based spatial augmented reality. The hypothesis of this research is that using automatic door as the medium of interactive visual contents would enhance user immersion with the surrounded space in daily event.

Given a goal, the research has wide variety of design choices to select from. However, in the context of thesis, this research will only consider, using projector-based spatial augmented reality as the approach of the implementation. The door is assigned as an medium refers to a physical environment spatially and naturally registered with virtual objects. Here the automatic door is understood as a mark of connecting people with one another and people with space. Besides, using automatic door is accessible to the greater public with an everyday gesture, by naturally combining the inspection of the real object and virtual object in a collocated interaction and visualization space.

The approach of this research is to link interaction to the superimposed visuals on automatic door in a way that feels natural. Being natural means that the virtual illusion are perceived to mix in with the physical environment seamlessly and merge with each other. Tight spatial registration means virtual objects situated in the right location and pose, and this would be one requirement for naturalness [5].

1.3. Thesis Overview

The remainder of this thesis is organized as follows.

- Chapter 1 starts with the background and motivation of this research, they are followed by the goal as well as an overview of the basic structure of this research.
- Chapter 2 presents some related works, which scrutinized from different perspectives: interactive public display, media facades, presence and immersion, trends of interaction and interface design as well as the summary of issues based on the literature review and related works.
- Chapter 3 focuses on the forming of concept. Then several challenges and design approaches are presented for the design progress according to the analysis based on the related works.
- Chapter 4 presents the design and implementation of three prototypes using automatic door, namely *AQUA*, *FRAGILE* and *MOKUMOKUREN*. Each of them has its own characteristics and can contribute to the implementation interactive contents for the automatic door either as a single contribution factor or a combination.
- Chapter 5 explains the design of the user test and presents the evaluation results for each prototype by using several evaluation methods.
- Chapter 6 brings the results all together and concludes with possible directions for future work.

Chapter 2

Literature Review and Related Works

This chapter reviewed the previous researches and related works. Also, the innovative point and significance of this research when compared with those related researches are summarized. This research builds on the following research areas. They are *interactive public display*, *media facades*, *presence and immersion*, as well as *trends of interaction and interface design*.

2.1. Interactive Public Display

The design of using automatic door for the interactive contents can be informed as a part of public display. Interactive public settings have unique characteristics and therefore impose unique challenges to designers. Public spaces attract diverse people who differ in ages, interests, and experience with technology and who will engage in spontaneous and often unpredictable activities, individually and in groups [28].

In this trend, a large body of research presents unique technical solutions for display installations, and designed for particular public settings and display

technologies. For instance, railway SNCF presented an interactive public installation called "Europe, It's Just Next Door"in 2013. This public installation consisted of several brightly colored doors with different names of city, placed in public areas around Paris. When people opened the door, the scene inside the door displayed real-time events happening in those cities. These interactive fun experiences not only created multicultural links among Europeans, but also enabled us all to realize that interactivity is not merely the ability to navigate the virtual scene.

The Media Ribbon is a gesture-based interface developed as a public display located at the University of Sydney. The display consists of two high-performance projectors positioned inside the glass wall of the building, facing the courtyard of an adjacent theater [16]. Tracking of participants is carried out with a single Microsoft Kinect camera. This system was developed to support people exploring the interaction with digitally augmented urban spaces and promote social encounters.

Karolina Sobrecka also presents an inspiring work. "It's You" is an interactive storefront-window projection that explores the mechanisms of public behaviors and the line between the real and constructed social actions. The installation, while being a literal display, simultaneously takes part in the pedestrians reality, the characters responding to the social space they help to create. At the same time it remains a metaphor that relies on the suspension of disbelief, and leads the viewers to examine their relationship to their social and physical environment.

However, in the area of interactive public display, interaction paradigms and techniques often dont generalize across different public settings [28]. In "Making Public Displays Interactive Everywhere", Sebastian Boring and Dominikus Baur address the challenge of designing interaction techniques that apply to a variety of settings and that maintain some independence from the particular characteristics of the public space, peoples activities, and the display technology.

2.2. Media Facades

Digital technologies are rapidly finding their way into urban spaces which is gradually emerging as a prominent arena for information systems design and presents a unique set of challenges and potentials for the design of interactive systems and installations. Media facades is one example, which offers great potential for interaction and for becoming the future trend of the public display domain [29]. Media facades comprise a category of urban computing concerned with the integration of displays into the built environment, including buildings and street furniture [22]. These uncannily innovative ways of combining modern design and architecture have proven to be a successful way for social entertainment, businesses looking to attract consumers, or to showcase a specific event. The challenges reflect the fact that the urban setting as a domain for interaction design is characterized by a number of circumstances and society practices that differ from those of other domains.

In order to exemplify the challenges and discuss how they may be addressed, we give an overview on the most relevant works from these categories and we discuss how they are related to the work presented in this paper [22].

One of the first design for interactive media facades was presented by dECOI Architects, named "The Aegis Hyposurface", which is developed for The Birmingham Hippodrome Theatre. The brief asked for a piece which could portray on the exterior that which was happening on the interior as a dynamic and interactive art work [19]. The piece is a metallic surface that has potential to deform physically in response to stimuli from the environment. The Aegis Hyposurface translates information into form, and creates an entirely new medium, digitally dynamic and materially tactile [19].

Bohmer et al. developed a dedicated virtual simulator tailored to the specific facade to embed their content into a 3D model for testing. Based on this test, Bohmer et al. confirmed that prototyping for media facades is a critical part in the design process and the lack of generalized tools makes it impossible to

reproduce installations in a controlled setting [25].

Fischer et al. presents Spread.gun, an urban media intervention tool allowing users to shoot text messages onto a projected media facade [21]. They report on how they misjudged visibility and the appearance of colors during testing in a controlled lab setting. Besides, they outline the discrepancies between testing in a controlled setting and deploying an application in the wild. Moreover, based on this project, they stated that the location of the facade, its scale and the technologies utilized have an impact on how the displayed content is experienced by a user. They further explored the spatial settings of media facades to provide a better understanding of the relationship between virtual and physical environment.

Boring et al. describe how they applied Touch Projector to allow multiple users to simultaneously interact with a media facade through live video on mobile devices. They point out that due to the lack of suitable testing and prototyping tools, their initial implementation performed poorly on the target facade in the real-world setting for variable viewing distances and changing lighting and weather conditions [25]. They needed to perform additional design revisions to solve those issues.

Aarhus by Light is an example of how media facades prompt new forms of interaction. People arriving to Musikhuset or merely passing by the facades on their way to some other location in general had no expectation that they had the opportunity to use an interactive installation [22]. Therefore they did not carry along with them any interaction devices, perhaps except for their mobile phone, and due to concerns for robustness it was not feasible to provide interaction devices for potential users to grab. For those reasons they decided to employ camera tracking which brought the users silhouettes onto the facades as avatars that could interact with other elements in the facades. Thus, there were no traditional input devices available to users, who instead used their bodies to control interaction.

The Dynamically Transparent Windows installation is another example of new form of media facades. The installation was developed specifically for a high street shop front. Despite successful pilot tests carried out in lab settings, this installation for the most part failed to attract extra attention of the pass-by users. One of the key findings from the analysis of the installation was that many users simply did not notice that the rather [22]. Passers-by instead expected the shop window to function as a regular window. In other words, the installation lacked affordances that would invite interaction. This highlights the importance of ongoing experiments with new types of media facades interfaces, and analyses of their use in practice in order to inform future interaction design processes.

Designing interaction for media facades has been extensively explored by researchers and designers, and providing valuable insights into the design and deployment process, as well as into problems occurring therein. One thing we need to stress is that, when introducing media facades in public spaces, there is the risk that people may become unwillingly involved in interaction, or be put in situations in which they appear in ways in which they did not intend to [22].

Here in this research, automatic door is a prime special case, as a part of the first-world impression of specific spaces and it is also noticed particularly when interrupt the flow of traffic rather than aiding it, which could overcome this problem in terms of avoiding unwilling or unnoticeable interaction. Automatic door is perched on the threshold of spectacle and background, as well as efficiency and disruption [12]. What determines acceptable design of interactive contents is very much a matter of balancing freedom of user action in public space, which depend on the culture and values of the facade of the architecture itself in where the automatic door located. The issues regarding content and new types of media in the urban setting are explored in more detail in the following chapters of this paper. We identified simulation and prototyping tools for digitally augmented environments as a further area related to this research.

2.3. Presence and Immersion

Over the last twenty years researchers have defined and explicated the concept of presence in a number of different ways. Notably, in their conceptualization of presence, Slater and Wilbur distinguish it from another related concept immersion. Slater and Wilbur suggest that presence in a virtual environments is inherently a quality of the users psychology, representing the extent to which an individual experiences the virtual setting as the one in which they are consciously present. On the other hand, immersion can be regarded as a quality of the system's technology, an objective measure of the extent to which the system presents a vivid virtual environment while shutting out physical reality [6]. By this account, the technological level of immersion afforded by the virtual environments system facilitates the level of psychological presence.

Witmer and Singer state that presence in a virtual environment, is dependent on immersion and involvement [7]. Whilst Slater and Wilbur also suggest that one of the key components of immersion is the extent to which a virtual environment surrounds the user. However, a virtual environment is constructed from objects, which permits the definition of presence to be re-written as "the subjective experience of being co-located with a set of objects, even when one is physically not in such a situation". If this definition is used, the implication that the user should be surrounded, inherent in the concept of environment, is replaced with the idea that a user should have a feeling of being 'with' an object [7].

Considering the components of immersion as suggested by Slater and Wilbur, the quality of a display, the range of sensory modalities and the correspondence between the users actions and displayed information are all aspects of how naturally a display supports a user [26]. These components are not unique requirements for immersive displays. Indeed the only factor unique to immersion apart from surrounding user, is the extent to which a user is removed from reality.

However, some tasks do not require the user to be surrounded or isolated.

It is assumed that the more natural the display feels, the greater its usefulness. This naturalness may better enable a user to utilize real-world skills in a virtual environment although it may also help to transfer learning from the virtual environment back into the real- world. The conventional definition of presence suggests that non-immersive displays are inadequate, even for tasks that do not require the user to be surrounded and isolated. Therefore, a new measure is needed to assess presence for non-immersive displays that will more closely consider task requirements and how naturally a display supports a user.

"It is here"is the idea that a display medium brings an object or person to the user. This idea has only been investigated for conventional television programmes, where it assesses the belief that the actual object being displayed exists within the television set. However, this concept can be extended to provide a measure for non-immersive displays where the object appears to be in the users physical environment, instead of inside the display.

Following the style used by Witmer and Singer, "the subjective experience that a particular object exists in a users environment, even when that object does not" will be termed 'Object-presence' [7]. This definition does not distinguish between real or virtual environments although in the context of immersive virtual reality, object-presence and presence would be interdependent. More interestingly though, is the subjective experience that an object exists in the real-world. This can be thought of as a special case of virtual reality, where the user is co-located with a virtual environment Presence and object-presence have a close relationship. Both have been conceptualised as types of transportation where the user is either transported to the virtual environment or the virtual environment is transported to the user [15]. This sense of object-presence is an important element for coincident haptic and visual displays that use a physical model as a three dimensional screen for projected visual information [7].

2.4. Trends of Interaction and Interface Design

It is interesting to see where early notions of interactivity came from, which is once used to be only of concern to a small group of artists, who in Duchamps tradition proclaimed active participation and later active interaction, has now commonly accepted and practiced by millions through artistic, intuitive, conceptual, social and critical projects in interaction and interface design, and show how digital processes are essential elements of the artistic creation process. Since last few decades, public domain has become popular sites for media art. People can observe and accompany such actions in public places, but also actively take part. In this way, the digital is situated, appreciated and discussed in the public domain [18].

Fleischmann and Strauss also point out the trend towards bringing interactive experiences and interventions into the public urban space with their work of Blinkelights in Berlin, where mobile phone users could send messages onto the houses facade which displayed the message content as the houses lighted up windows. Fleischmann and Strauss also elaborate on their own latest work Energie Passagen, where passer-by can see the most common keywords of texts feeds from mass-media newspaper floating on a large projection screen and then select those keywords through a touch-screen and voice input [3].

Sommerer and Mignonneau also develop interactive systems for public spaces. One of their projects is Wissensgewchs, which is a visually growing facade that would reflect the visitors attention and interest and entice them into the building. The concept of creating an interactive facade in a busy public space means not only engaging the media art experts in the creation of interactive content, it also allows the communication of interactive art to a large and diversified audience who would not normally engage in such art forms, which bring interactive art closer to the public and help eliminate borders between interactive art and life by directly involving the audience into an interactive work of art [13].

Now, an emerging paradigm based on physical objects and surroundings is

gradually connecting us to the urban environment, and providing a rich new framework in which to understand and inhabit space. It is the most recent technology of the emergent paradigm to pass into mainstream consciousness, and offers perhaps the greatest opportunity yet for coexisting digital work with routine physical environments.

A group of researchers in interaction design at Keio University whom directed by Masa Inakage, with their wide range of projects, fits well into the argument that interactivity has become absorbed into everyday experiences. They argues that ubiquitous content creation is an emerging genre that uses everyday and media as a platform for creative content to achieve emotional and entertaining experiences. Their research observes that the Industrial Society has developed to the Creative Society where personal and everywhere media will be not only important for art content creation but it also lets designers and artists embed ubiquitous media content and emotion in the artifacts and environment of our daily lives [17].

Following the trend, Lev Manovich coined the term of Augmented Space. While he recognizes differences between the physical and symbolic layering and augmented space, the establishment of a conceptual link makes it accessible to architects, and presents new possibilities as the reality and virtual together constitute the augmented routine surrounding space [14].

Meanwhile, Keiichi Matsuda, one of his latest experiemnts is Augmented City, in which he mentioned that the contemporary city is no longer simply about the physical space of buildings and landscape, more and more it is about the synthetic spaces created by the digital layout that we collect, consume and organise; an immersive interface may become as much part of the world we inhabit as the buildings around us. Beyond the physical exsistence we have built , the future will be as much about virtual and information [10].

2.5. Summary of Issues

To summarize, this chapter give us a glimpse into the trend of interaction design, which is no longer an abstract aesthetics or engineering point of view, but also from a social, conceptual, and even commercial angle as well and step by step get close into urban space. It considers where it has spread beyond the pure art context into wider fields through the creation of social experiences. These clearly expand beyond the art arena into areas such as entertainment, consumer products and other forms of socially shared media experiences. We consider the work of this research is dealing with interaction as another valuable form of creating social meaning obtained by interactive design and the creation of social experiences. And this research is highlight these cultural and societal aspects of interaction and interface design, as we are convinced that these issues will become ever more relevant in the future.

Specifically, it helps to draw an inspiration from the above brief review of related works. This parts has two main aims. The first aim is to capture some implicit theory of current related works that can be later applied in helping in the evaluation of the research. The second aim is to search for a conceptual approach that shows continuity with respect to the relationship between spatial immersion, virtual immersion and interactive immersion.

Immersion is a term used widely to describe the user experience, in particular in an entertainment context [26]. This paper identify three different types of immersion based on the related works: spatial, virtual and interaction, as shown in Figure 2.1. Spatial immersion refers to the sense of being in an environment and having close relationship with the circumstance. Virtual immersion is described as most powerful when a balance between the virtual illusion and the physical is ambiguous as seems to correspond to each other. Finally, interaction immersion happens when people are motivated and absorbed with their interactivity. A body of works also have formed around the boundary of different immersion type.

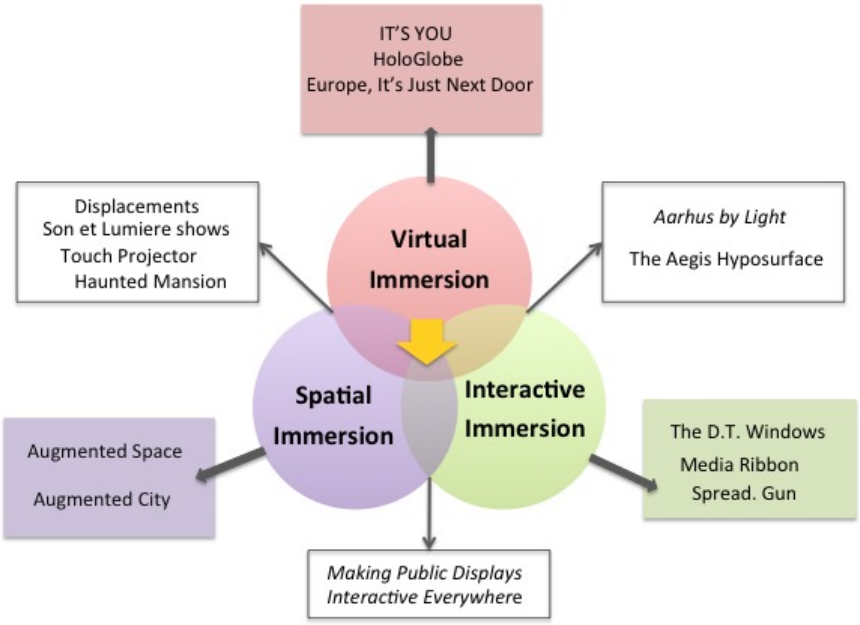


Figure 2.1: Relative scope of research to related works

As can be seen from above figure, existing works are mostly tailored to one specific type of immersion. They usually provide limited means to incorporate immersion interaction by a user. Due to the automatic doors visibility, technical capabilities and the connection with the surrounded environment, it offer great potential to use automatic door as the interactive contents medium for filling the blank area in immersion experience design. At this point, it is important to position the proposal research relative to existing research and clear the context, scope and focus on this research. Yet we speculate that using automatic door as the medium for interactive contents is capable of combing virtual, spatial and interaction immersion and offering the possibility of providing an extraordinary experience to users in daily urban environment.

Chapter 3

Concept and Design

This chapter presents the project concept of using automatic door as the medium for interactive contents design. The concept of this project is the interactive visual content using automatic doors by merging virtual scene with surrounded physical environment through natural interaction. Three core elements of this concept are explained in details following the concept, namely coexisting, merging and interaction. Further more, on the basis of analysis the related works, the research has addressed several prominent challenges that probably meet in the design progress. Furthermore, the research gives explanation of how the challenges may emerge in practice, and how these specific concerns can be addressed in design progress. To meet quality requirements in the design and implementation process for the prototype, various factors must be taken into consideration. These topics are addressed as a part of research progress. This section also shows some prepare work for the later prototype implementation. Also several design disciplines are explored in this section for overcoming challenges in the interactive contents design process.

3.1. Concept

The concept of this project is the interactive visual content using automatic doors as the medium, which could merge vi scene with surrounded physical environment through natural interaction. It offer approaches for augmented illusion design for the automatic door in routine environment, by means of spatial augmented reality technique and natural interaction. The result of the project is an unique automatic door which combines the interactions of natural human-to-human, human-to-physical world and human-to-virtual world(Figure3.1), and provides a special experience ranging from physical reality, augmented reality, to virtual reality in a routine event and daily space. There are three core elements in this concept as follows.

Coexisting is the first significant element of this project for contents design, which means that the visual contents should be coexist with the physical environment. Because these contents were mostly developed for public or semi-public spaces, instead of disembodied occupation of virtual worlds, the physical and virtual are seen together as a contiguous, layered and dynamic reality. In order to create an effective illusion of virtual objects coexisting with the physical automatic door, the augmented illusion should be integrated directly in users physical inhabit environment. The construct of the framework for contents design should be based on the original quality of daily objects.

Merging is also seen as one of the indispensable parts for user experience, which could merge their notion with the original definition of the automatic door and become a hybrid between creation, representation and unique interactive experience. Far from simply representing motion graphics, this augmented layer may define the parameters of the space itself to make the viewer build a relationship with virtual and real, and get an extraordinary experience in a routine physical space. Through the augmented door, virtual surfaces and objects combine to create new spatial ambiance. Here, virtual and physical spaces are no longer two separate dimensions, but just parts of a continuum. Through

passing and interacting with the automatic door, the physical and the digital environment have come to define each other. To the end, users could be inevitably affected by the augmented spacial experience.

Last but not least, *Interaction* is the core element to help understand the concept. Users action and behavior can get a real time reflect in the augmented contents on the automatic door. As described initially, the implementations dependent on the space and content they are designed for, where users can quickly seize the content or the designed experience. For this reason, the interaction principles are kept on a simple level. As mention before, because it is mostly developed for public or semi-public spaces, where users would have to understand them quickly and where they would often be used only once, the user interaction has to be intelligent and simple without giving a feeling of banality.

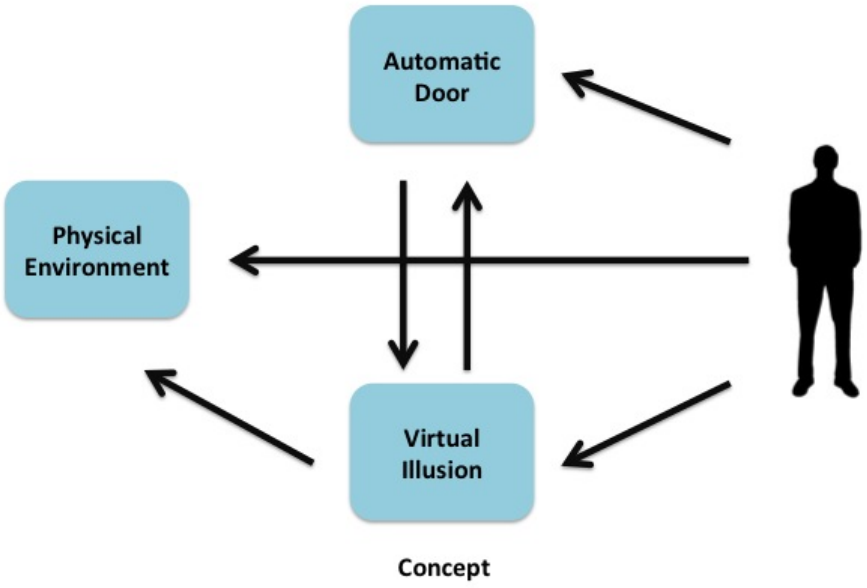


Figure 3.1: Design concept

3.2. Design Challenges

This section presents several challenges in the process of the interactive contents design for the automatic door. This set of challenges is based on concrete experiences with the several experimental tests, as well as a thorough review of related projects and academic publications. Each challenge has a specific focus, although in practice they are often intertwined. For each challenge, this paper emphasize what makes it particularly significant with regards to the future design.

- New interface
- Integration with physical structures
- Suitable contents
- Diversity of situations
- Emerging and unforeseen use of places

Challenge 1:New interfaces

The perhaps most salient challenge for design is that the automatic doors setting prompts a new form of interface. The displays used for automatic door differ from many traditional displays in terms of properties, which is the using the transparent glass as the display screen. Transparent screen has two main properties: they are transparent to a certain degree to allow the transmission of the image of the real environment, and they also emit the light of the rendered graphics. Users can see directly through the automatic door and through the image displayed on it to the real environment.

Challenge 2: Integration with physical structures

The design and the system must be integrated into existing physical structure of the original automatic door. This mainly includes the motion of the automatic door. Because of what mentioned above, it calls for a concern that not only the

illusion of the content for the automatic door but also the movement of the automatic door.

Challenge 3: Suitable Contents

A key challenge concerning content is striking a balance between supporting the intentions of the augmented visual illusion, and taking into account the format of the surrounded environment. The content has to fit the format of the display and the kinds of interaction intended to be supported. The actual scale of the automatic door making it very visible to many people, places and surrounded environment.

Challenge 4: Diversity of situations

A very wide variety of possible situations occur and overlap in the surrounded environment where the door may be located. Although the design for out prototypes primarily address one or few relatively stable situations; however, the surrounded setting for the automatic door is often characterized by a diversity of situations. The same physical space may be the setting of diverse and overlapping situations that may be perceived differently by different inhabitants. Thus, exploring the existing practices and preconceptions of the setting become a significant challenge during the design progress. Moreover, depending on the aim, it is also need to determine whether the interactive content should conform to the existing situations, extend or augment them. In conclusion, a thoughtful design for the door is based on an understanding of the setting situation.

Challenge 5: Emerging and unforeseen uses of places and systems

The interactive contents based on the automatic door will likely be used, perceived and appropriated in different ways. An almost inevitable aspect of designing for the automatic door, especially with regard to dynamic public environments, is that the door will be used and perceived in different ways than this research intended.

3.3. Design Approaches

3.3.1 Prototype Concept

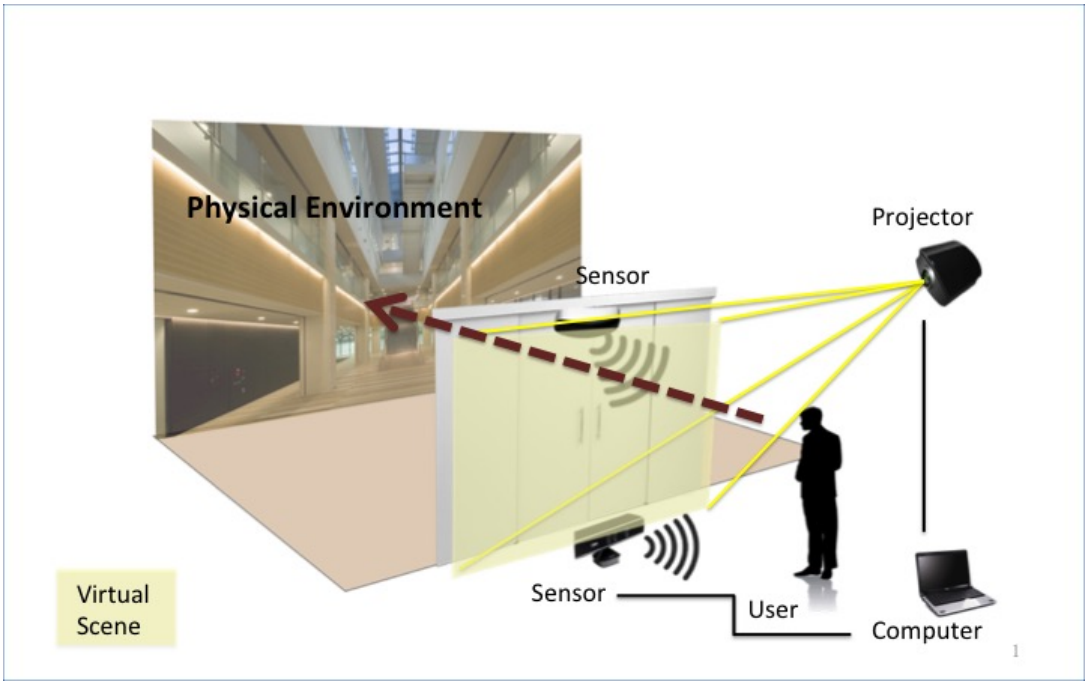


Figure 3.2: Concept of prototype design

This figure shows the concept of the prototype design(Figure3.2). The interaction is between users, automatic door, virtual scene, and as well as the physical environment. It is worth to mention that the physical environment is one of the main focus points. Since the material of the automatic door is made by transparent glass, the physical space in another side of the door can be also seen by users. so it indicated that, designing the virtual scene which could coexist with the physical environment become one the initial points pf the design
.

3.3.2 Floor Plan

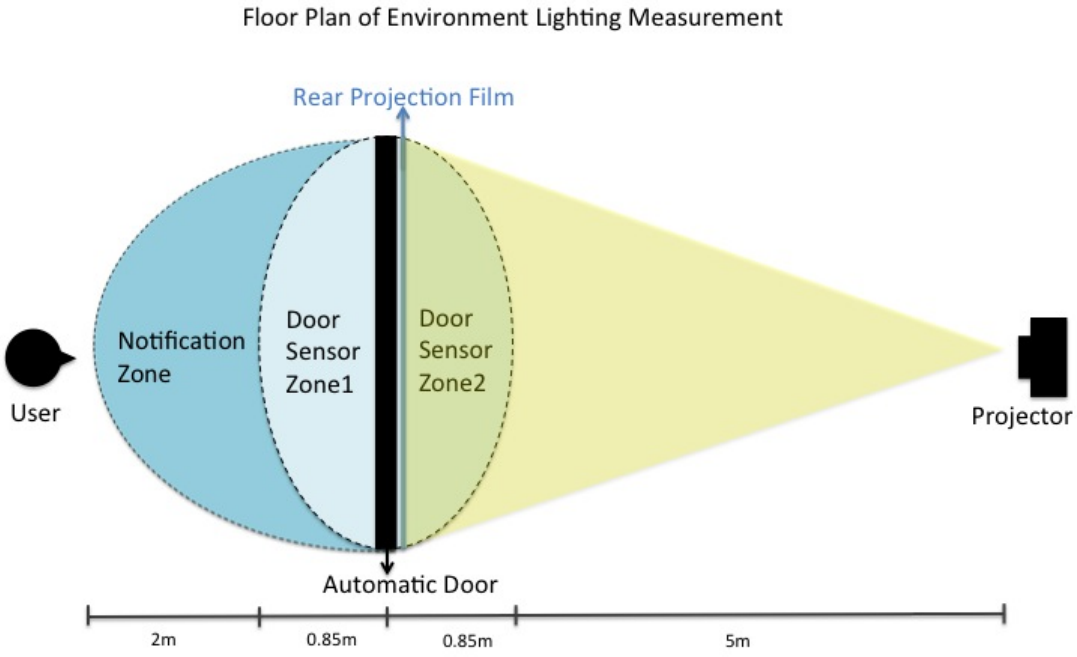


Figure 3.3: Division of test environment

Because of the space limitation of the test environment, three zones were divided firstly for the further prototype design (Figure3.3). The first zone is notification zone, where the users could see the projected image on automatic door in a close distance without activating the automatic door sensor. The sensor area is separated into two zones. Door sensor zone1 is the side where user could see the projected image clearly while the door sensor activated by the user. Door sensor zone2 is also the door sensor activating area, but this side is where the rear projection screen attached on, so the projected image on the door is not as clear as another side. Based on that, the further prototype test will be conducted mainly in notification zone and door sensor zone1.

Environment Lighting Test

		Projector On		Projector Off	
		Minimum	Maximum	Minimum	Maximum
Room Light On	Notification Zone	365	614	221	468
	Sensor Zone 1	365	435	221	242
	Sensor Zone 2	698	730	339	430
Room Light Off	Notification Zone	95	138	---------	---------
	Sensor Zone 1	138	175	---------	---------
	Sensor Zone 2	389	282	---------	---------

Figure 3.4: Test of lighting environment

Next, based on the division of the lab environment, a light meter (Light Meter HS- 1010) is used to measure the amount of the projection light in test environment for each zone. As can be seen from the result in Figure 3.4, the light condition of the projector in the notification zone and door sensor zone1 is not perfect to provide the ideal brightness of the illusion image on the automatic door. Based on this result, the further user experiment will be conducted in the dark environment to make sure the best visual effect of the prototype.

3.3.3 Automatic Door Test

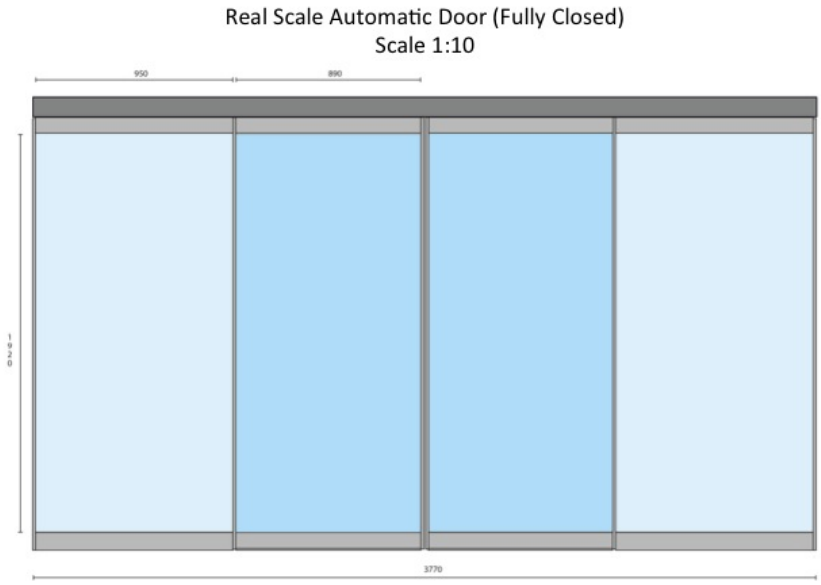


Figure 3.5: Real scale automatic door

As for the initial prepare work for the content design, we measured the automatic door in a fully closed state . Based on the results, the prototype content resolution is decided in 1920x3770 pixels to cover all the glass panels(Figure3.5).

Then we asked four volunteers to walk through the automatic door and recorded the video to get the time duration of each doors state and the users notification time . Additionally, the user passing time is measured from walking into notification zone to walk across the threshold of the automatic door.

Average of opening time: 5s12'

Average of opened state time: 2s16'

Average of closing time: 5s23'

Average of user passing time: 6s

Those results will be used in the video content design for the further prototype.

3.3.4 Design Disciplines

Beside those constraints of the automatic door and experiment environment, this paper also made some disciplines to suit for the constrains and overcome some of the challenges that mentioned above, the further prototypes should meet the following specifications.

1) Visual contents should be familiar to users. Because of this object recognition, users are better able to compensate for distortions in visual contents on the automatic door. Overall, using familiar objects will help connect a virtual object to the users sense of its physical presence in the physical environment.

2) When familiar objects cannot be used to satisfy the above discipline, then emphasize pictorial cues such as shading, color fading, and atmospheric effects. This can help compensate for the lack of familiarity, allowing for novel virtual objects.

3) The interaction system should not obstruct the users operation of the automatic door; in other words, the system should be functional while the automatic door is in operation.

4) The interaction should allow user interact in a natural and predictable manner.

5) Considering the fact that the automatic door is located in environments in which people naturally pass through, the interaction cannot rely on users to employ dedicated input devices, but have to employ other means of input. Thus the gesture-based interaction or embodied interaction could be the possible directions to start.

With these design approaches, the prototype is believed to be able to meet the goal of this research and offer a unique interactive experience to users through the automatic door.

Chapter 4

Implementation of Prototypes

This chapter will describe the solutions to implement the concept of the project. This paper proposed three prototypes using automatic door, namely *AQUA*, *FRAGILE* and *MOKUMOKUREN*. Each of them has its own characteristics and can contribute to the implementation interactive contents for the automatic door either as a single contribution factor or a combination. While *AQUA* and *FRAGILE* are mainly focused on the comparison of the effect of different interaction modality, the *FRAGILE* and *MOKUMOKUREN* are designed to compare the effectiveness of different virtual illusions. In each section, this paper will describe the implementation of the content and interaction design, and then explain the system configuration for each prototype.

4.1. First Prototype: *AQUA*

4.1.1 Implementation of Visual Content

The initial goal of the first prototype is to discover if using projection spatial augmented reality to design automatic door would make users get a more immersive and enjoyable experience. Although the interaction modality is also a significant factor to be taken into consideration. According to those above,

the first prototype is focused on the visual effect design for both pre-rendered scenes and the real-time reflect interaction output.

Based on the theoretical strategies which mentioned in chapter 3, the very first step for designing the first prototype is to make a suitable illusion content for the automatic door. According to its physical properties, especially the material of transparency glass, the aquarium is chosen as the theme of the first prototype design in order to achieve the purpose of merging physical and virtual boundaries. A scene consisting of light, water and marine organism is made while the real-time rendered shadow particles of the user body is mixed into the aquarium scene, by which the users could redefine the physical space in their subconscious. (Figure4.1).

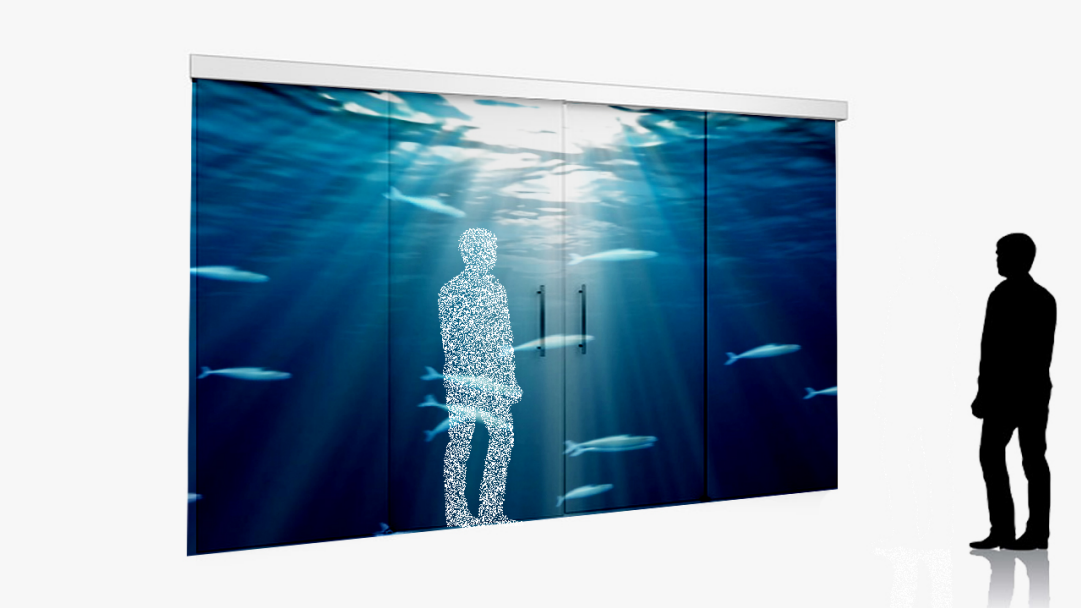


Figure 4.1: Design sketch of *AQUA*

4.1.2 Implementation of Interaction

In the first prototype, the silhouette tracking is chosen as mental modality, which could help users create a relationship with the virtual augmented space.

We developed an customized application using open Frameworks with Kinect device is developed to capture live human models of the users and render the user image into light particles onto the augmented interface. In addition to enhance the interaction, some basic functions are developed to change the visual effect of the particles, such as particle color changing(Figure 4.2), glowing effect, distance control. The users can perform gestures while recognizing the change of rendered scene in the automatic door. By using Kinect for rendering the real-time particles, we want to instigate users to notice their own sense of spatial perception and interaction.

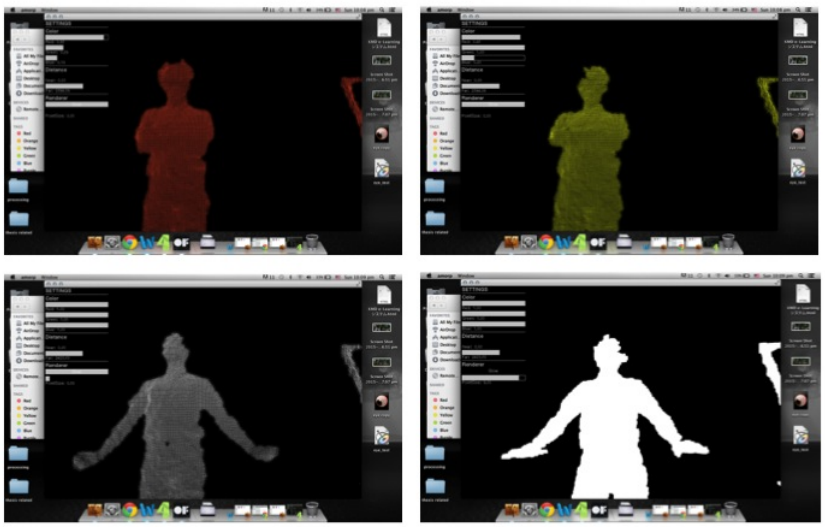


Figure 4.2: Custom built application for Kinect

The first prototype employs one HD video projector and a Kinect device.

This current implementation is primarily hosted on a single laptop, which drives all hardware, rendering the Kinect depth images and other image processing. The projector is mounted about 2.15 meters above the floor. This is oriented so that the image, which projected from the projector, could cover the whole automatic door. The Kinect sensor is equipped in the bottom of the automatic door, facing front of the users, to cover the area in front of the automatic door between 0-2 meters. This is to help the users act as in normal condition and they can perform in front of their screens conveniently(Figure 4.3).

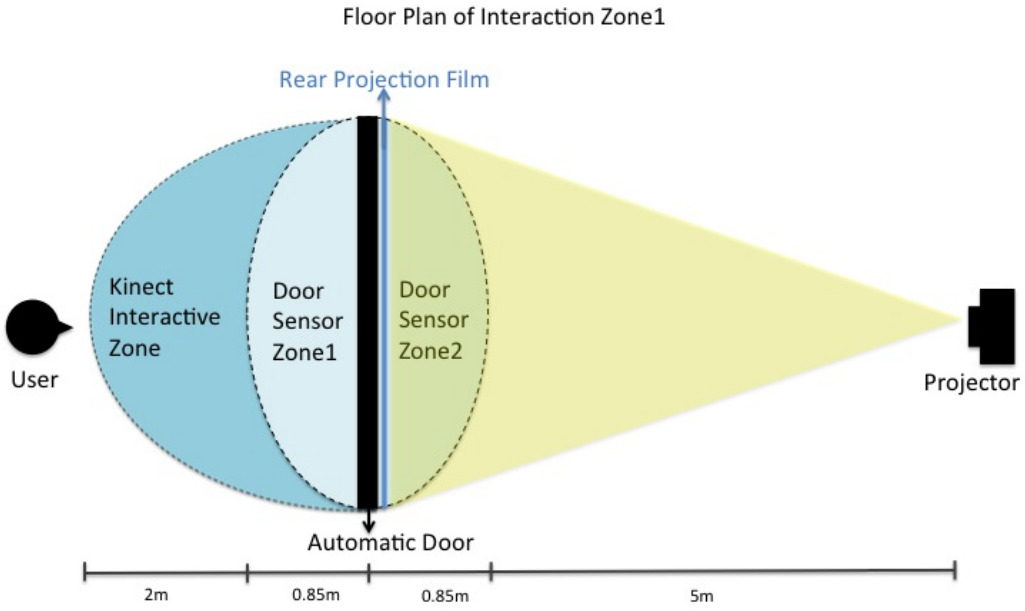


Figure 4.3: Floor plan of interaction zone for prototype *AQUA*

Roughly speaking, the users view is rendered by a projector above them. Meanwhile, body tracking of the user is supported by the opposite facing Kinect camera, which works well in this configuration. This symmetric arrangement of projectors and sensor follows the nature interaction.

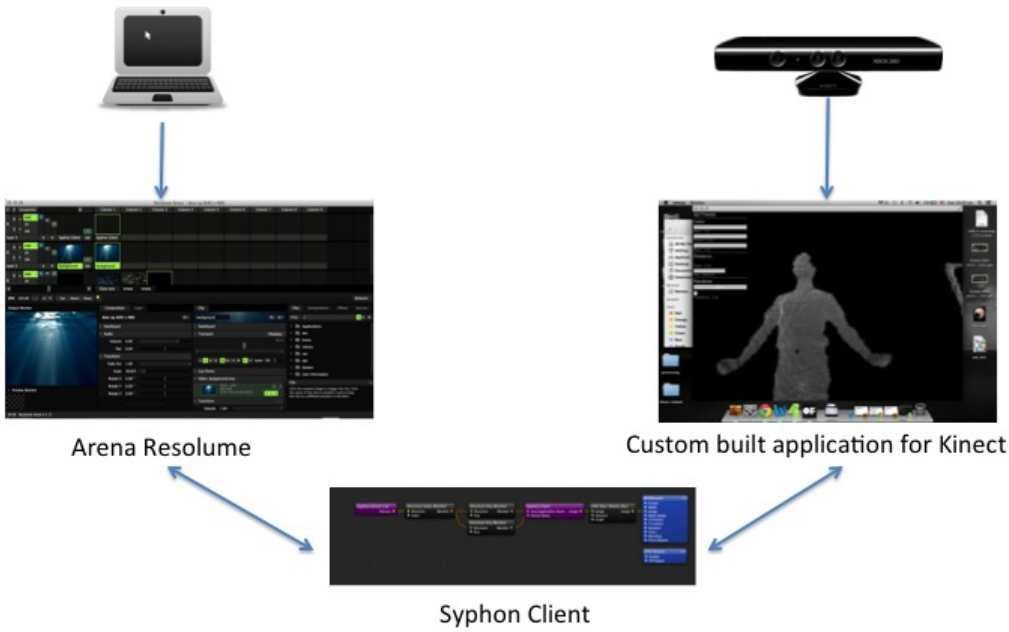


Figure 4.4: Interaction process of *AQUA*

The next step in the process is the construction of the virtual model using a commercial software package, which is Resolume Arena v4.1.11 . It provides a platform that could input the pre-rendered virtual contents and the real-time scene from the application, which is using for rendering the users image particles(Figure4.4).

Following this step, the function in Arena is used to adjust the scale and position of different clips to suit the automatic door and have match physical and virtual models. After all of them merging into a single scene in Resolume Arena and being projected out, the automatic door will be assigned as a virtual representation of an aquarium, and all the physical objects of the lab environment would also be seen by the users through the automatic door based on the property of the glass. This completes the initial setup of the virtual and physical design environment aspects.

4.1.3 System Configuration

The hardware configuration of prototype *AQUA* are shown in figure 4.5.

Hardware & Software specification1

Components	Specification1	Specification2	Number
Computer	MacBook Pro	Ver10.9.5	1
Projector	RICOH	IPSiO PJX618CRICOID	1
Automatic Door	NABCO	DS-75 Sliding Operating Unit with LOSCA Door (Slim Door)	1
Sensor	Kinect	v1	1
	NABCO Sensor	iS-N6000	2
Rear Projection Film	KIMOTO	T40Si	----
Software	Resolume Arena	Ver4.1.11	----
	Custom Built Application		----

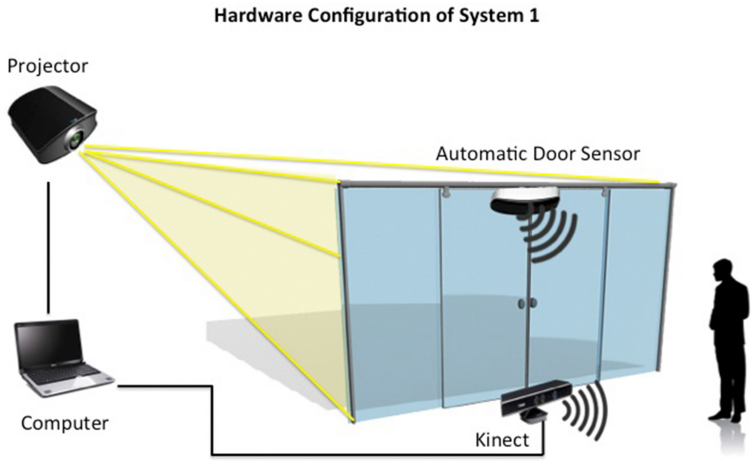


Figure 4.5: System configuration of Prototype *AQUA*

4.2. Second Prototype: *FRAGILE*

The purpose of second prototype is to explore possible improvement based on the feedback and expresses desires of the users who experienced the first prototype. This time, rather than targeting the visual effect of the augmented scenes, this prototype was designed to combine the automatic door as a significant part into interaction design.

4.2.1 Implementation of Visual Content

While the planning and design of the first prototype started from the interaction between users and the virtual scenes, the second prototype is mainly focusing on designing the interaction which includes the automatic door as one of the significant elements to be taking into considering, which means that the interactive visual contents need to have the connection with the motion of the automatic door.

As the main purpose of the second prototype is highlighting the automatic door into interaction parts, a suitable contents design for making the automatic door as a living thing is thought to be an origin point to start.

Typically, when virtual objects are introduced in the physical surroundings, the surfaces on which the virtual objects are projected have some resemblance to the physical surfaces in terms of shape or at least proximity. Realizing that, the stained glass is chosen as the content inspiration for the second prototype.

By creating the virtual illusion of the stained glass, the physical properties of the automatic door and the surrounded space could easily join together with the physical properties of the automatic door and the surrounded space. In this time, The second prototype aim to create this illusion of actually being the object that it depicts to provide a convincing perceptual impression.

4.2.2 Implementation of Interaction

As for the interaction, we use another custom built application using openFrameworks that splits videos into four section fitting into the side and dimension of the door panels, and move the illusion scene according to the doors motion position in real time. In that way , the illusion scene from the projector could move with the automatic door based on the tracking of the automatic door's motion. For the four states of closed, opening, opened and closing of the automatic door, four different videos for each state are rendered in order to make the interactive effect based on the motion of the automatic door, in other words, this interaction is based on the users position in the interactive zone(Figure 4.6).

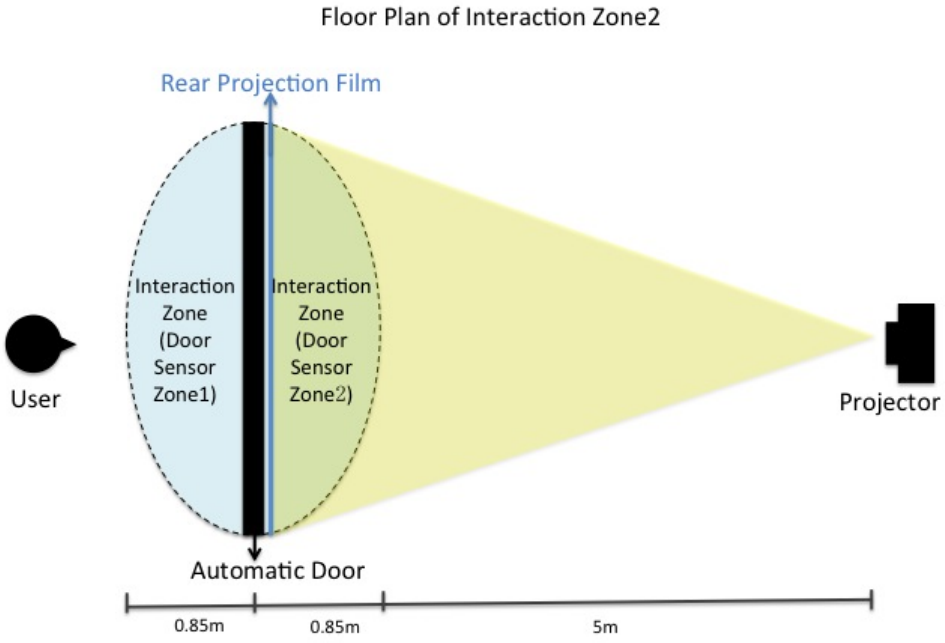


Figure 4.6: Floor plan of interaction zone for prototype *FRAGILE*

This prototype is focused on the tracked automatic door illumination. With this application, we can illuminate the automatic door so that the surface textures of the automatic door appear glued to the automatic door even as the

door is moving. The four glass panels of automatic door are illuminated by one projector in real time, following the motion of the automatic door, which is controlled by user. According to that, the initial step is to divide content into four clips, which could cooperate with the motion of the automatic door, while still focusing on the integrity of the content itself. The geometry changing of the stained glass is designed as the context for the four steps of the interaction(Figure 4.7).

- For the first stage of Closed, the stained glass effect texture overlays on the automatic door in stationary (No time limitation)
- For the second stage of Opening, the stained glass texture start rotate into a kaleidoscope-effect animated texture. The texture changing time is strictly controlled in 5 seconds, which is a little bit less than the time of the automatic doors motion speed in order to make sure the continuous of the interaction content.
- For the third stage of Opened, the illusion on the door continue showing as an entire kaleidoscope effect.
- For the fourth stage of Closing, the kaleidoscope effect will roll smoothly and reset back to the original stained glass texture.

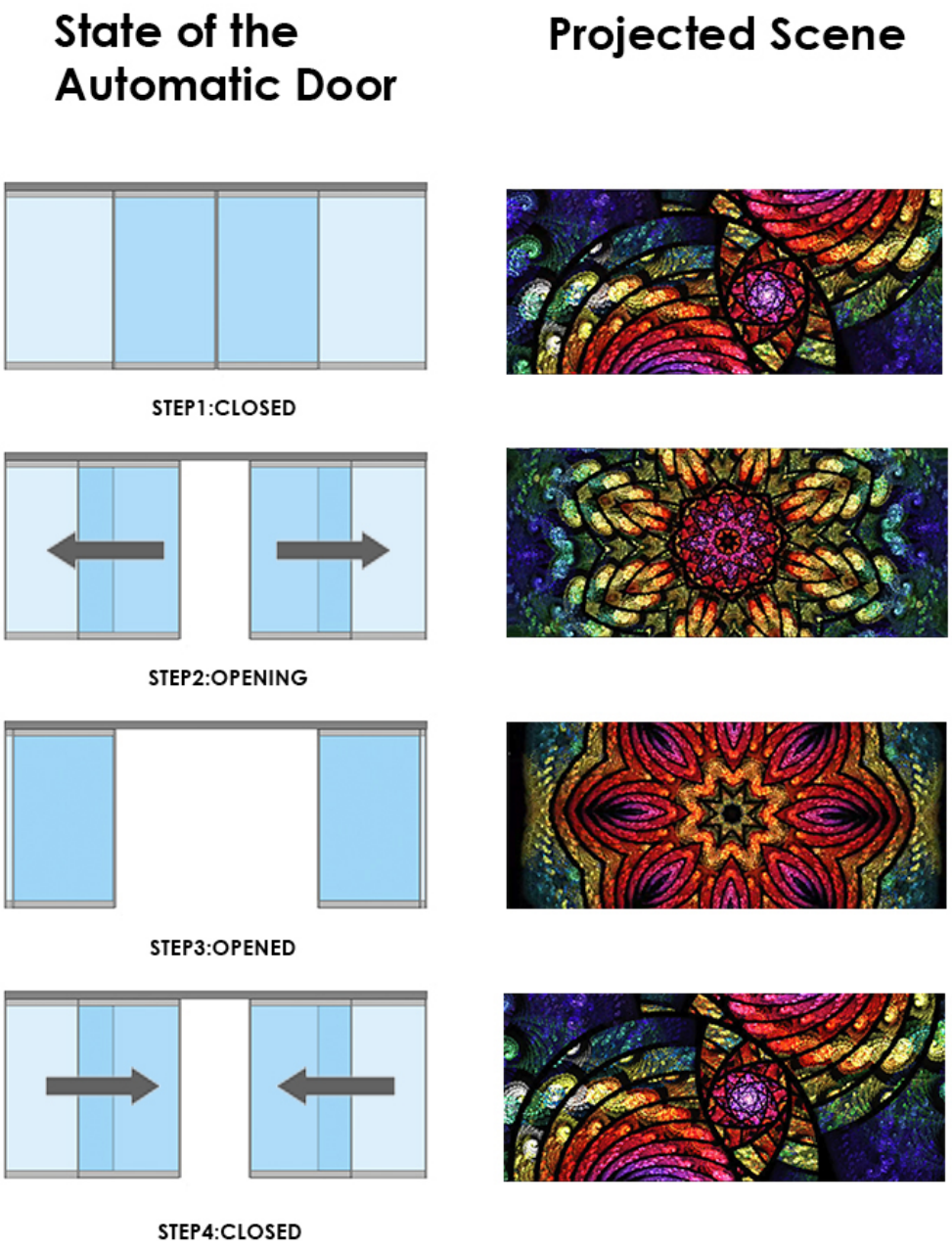


Figure 4.7: Interaction process of *FRAGILE*

4.2.3 System Configuration

The hardware configuration of prototype *FRAGILE* are shown in figure 4.8.

Hardware & Software specification2

Components	Specification1	Specification2	Number
Computer	MacBook Pro	Ver10.9.5	1
Projector	RICOH	IPSiO PJX618CRICOID	1
Automatic Door	NABCO	DS-75 Sliding Operating Unit with LOSCA Door (Slim Door)	1
Sensor	NABCO Sensor	iS-N6000	2
Rear Projection Film	KIMOTO	T40Si	----
Software	Custom Built Application		----

Hardware Configuration of System2

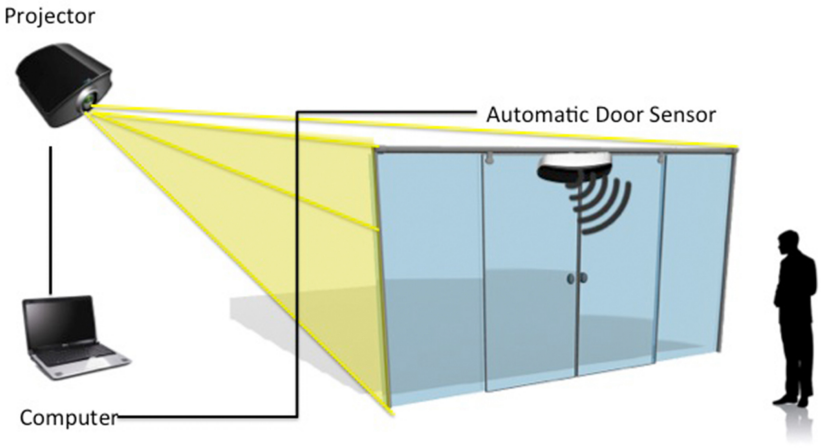


Figure 4.8: System configuration of prototype *FRAGILE*

4.3. Third Prototype: *MOKUMOKUREN*

The third prototype insight is the complexity of the relationship with inspirational augmented illusion sources, motion of automatic door and the spaciousness sense for the physical environment.

4.3.1 Implementation of Visual Content

While the planning and design of the augmented illusion content of first two prototypes are mainly focused on 2D imagery and covered all the surface of the automatic door, the third prototype is approached from the point of view of three-dimensional content toward immersion by creating a sense of depth that integrated the user into the pictorial space.

Here Mokumokuren is chosen as the inspiration for the third prototype. Mokumokuren are spirits from Japanese mythology that literally means continuous eyes and usually live in shoji, which is a traditional Japanese sliding door. There are two reasons for choosing Mokumokuren as the third prototype content. The first reason is that Mokumokuren are widely known as those parasitic phantoms living in door as we mentioned before, also since taking considering that we want to design the automatic door as something with their own life, so it can be properly fit the content design for the automatic door with its own background. As for the 3d model creating perspective, the movement of the eyeball-looking animation is pretty effective to show the interaction effect, and it could also cooperate smoothly with application for the third prototype system, which will be introduced in the following subsection.

Briefly speaking, we want to use Mokumokuren to create an environment where the users can feel the ubiquitous gaze through the floating eyes in the automatic door. Rather than creating an ambient interactive experience in our fist two prototypes of *AQUA* and *FRAGILE*, the users will feel more exciting through ubiquitous floating eyes and the their intense gaze.

4.3.2 Implementation of Interaction

The third prototype also use the same custom built application which is also used in prototype *FRAGILE*, to undertake the interaction parts. The four steps of interaction is divided as follows(Figure 4.9).

- For the first stage of Closed, when there is no users or the users is far away from the door, the eyes will look ahead directly as they are keeping close watch on anyone who have attempt to pass through the automatic door.
- For the second stage of Opening, when the users get close and walk in front of the door within the area of 0.85 metres, which is the starting-up radius for the automatic door sensor, the eye will turn rapidly and focus in the middle central of the opening-state door, which is also the passing route of the users, as they are staring closely of the users.
- For the third stage of Opened, The gazing-status will last until the user passing through the door
- For the fourth stage of Closing, after the users walking through the door, the eyes will turn back to the original state.

The system configuration of this prototype is as same as prototype *FRAGILE* showing in figure 4.8.

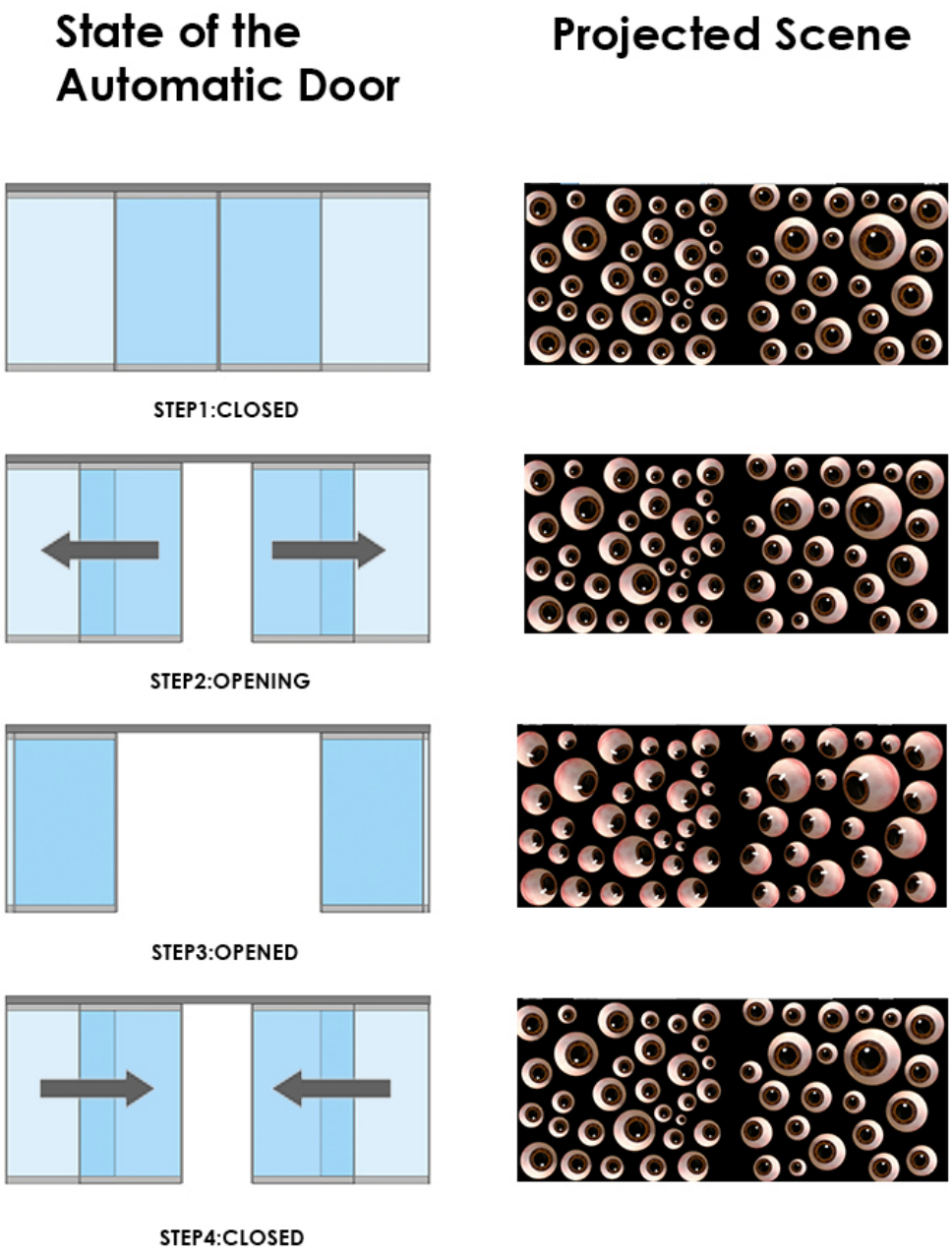


Figure 4.9: Interaction process of *MOKUMOKUREN*

Chapter 5

Evaluation of Prototypes

To test the feasibility of the prototypes, three tests for each prototypes are conducted with a small group of participants in the lab environment. This chapter explains the design of the user tests and presents the evaluation results for each prototype by using several evaluation methods.

5.1. Purpose of Evaluation

The main purpose of the evaluation is to test the user experience of how they feel about each interactive contents and whether they could merge the projected contents with the surrounded environment during the natural process of passing through the automatic door. Specifically, which kind of interaction modality is suitable for this experience, and what kind of visual contents is more attractive to users, are the directions that are mainly concentrated with during the tests.

The first prototype *AQUA* and the second prototype *FRAGILE* are focus on the comparison of using different interaction modality of body posture and body position, while the second prototype *FRAGILE* and the third prototype *MOKUMOKUREN* are the contrast of using different types of visual content for the automatic door(Figure 5.1).

	Interaction Modality	Virtual Scene
First Prototype AQUA	Body Posture	Ambient Motion Scene
Second Prototype FRAGILE	Body Position	2D Motion Scene
Third Prototype MOKUMOKUREN	Body Position	3D Motion Elements

Figure 5.1: Overview of three prototypes

5.2. Evaluation of *AQUA*

5.2.1 Experiment

To evaluate the effectiveness and user experience of first prototype, we conducted a user test that focus on the most relevant aspects of this system: first, can user correctly perceive virtual object presence in the automatic door; second, can users understand their presence interactions with the virtual objects in the scene.

In particular we examine whether the participants can perceive projected virtual objects as part of the spatial existence rather than spearing only at the projected surface (the automatic door panels), and what factors affect their perceptions. We also observe how well the participants work with the interaction function in the scene without giving them any clues or guidance about the interaction function.

A group of 12 participants (5 female, mean age 28 years, R=18), have been asked to use the system with no more information than the brief introduction of the purpose for this test. It was of interest to see, how each participant would start to use the system, if they would notice the interaction by themselves, and how they would interact with this system.(Figure5.2)

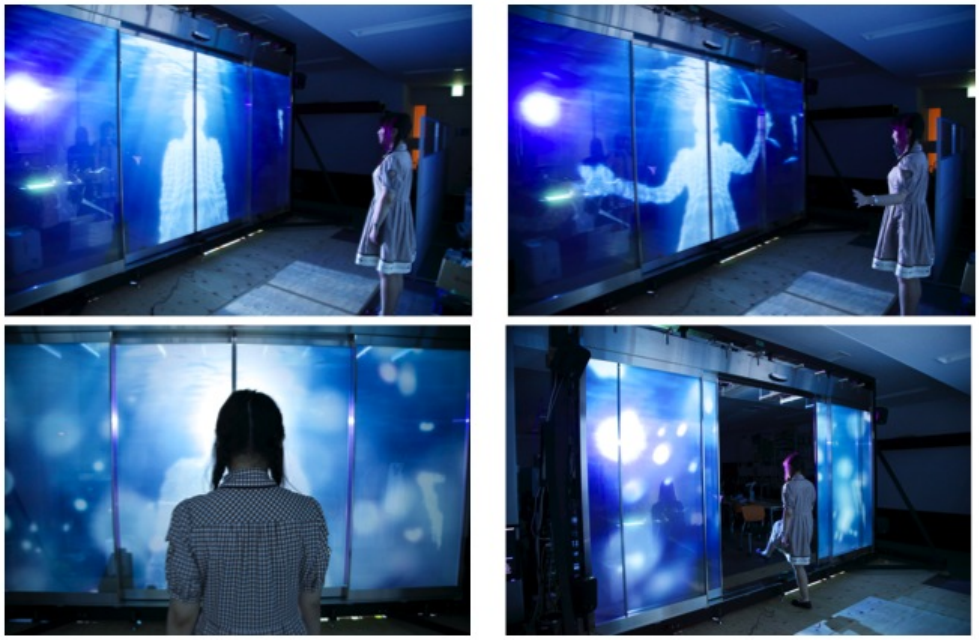


Figure 5.2: User test of *AQUA*

Participants were separated into two groups. The first group of participants was asked to stand facing the automatic door. In this way the Kinect sensor will catch their image and their movement, and meanwhile their own particles image will be rendered by the application and projected onto the automatic door in real-time. The participants were initially stood and waved their arms to interact with the particle shadow, which are projected on the door with the pre-rendered scene. For the second group, participants were explicitly told that they could move around or walk through the automatic door random as they used to do in the same routine situation. The purpose of the first group is to test the sense of presence of the augmented scene. The purpose of the second group is to simulate a routine environment and observe their action to this automatic door design and whether they feel natural of this interaction.

5.2.2 Results and Evaluation

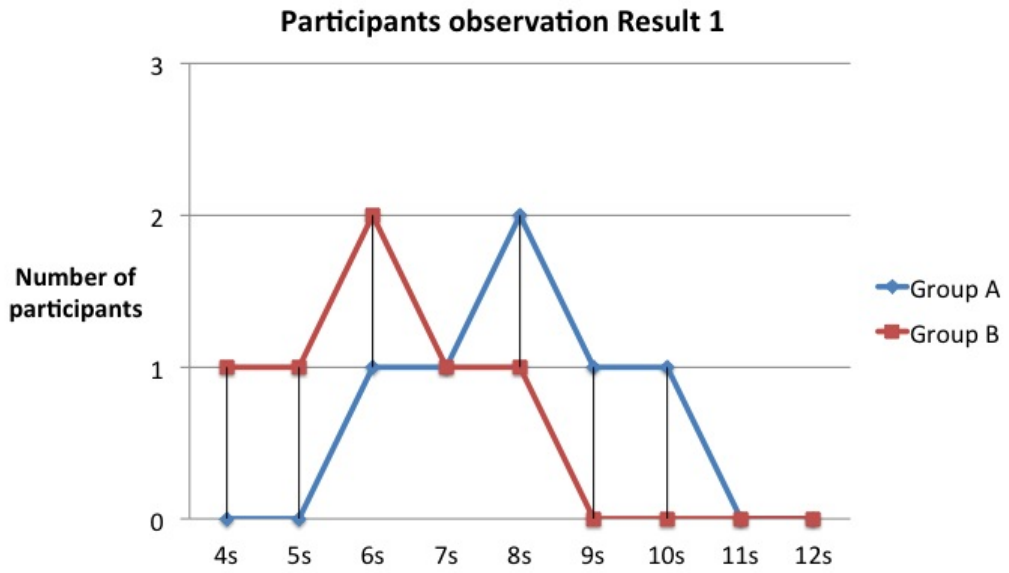


Figure 5.3: Duration of passing time of *AQUA*(From entering the Kinect Interactive Zone to Door Sensor Zone2 showing in figure 4.3)

By observing instant viewer's reactions during the test and conducting an oral interview, we gathered feedback of details which shows as follows.

- User A: I could feel the water floating in another side of the room. But I don't like the interaction function, which is disharmony with the aquarium.
- User B: When I walk close to the door, it makes me feel like the room is steeping into the sea.
- User C: I dont know what is the meaning of the white shadow on the door although it looks good.

- User D: It would be much more interesting if I could use my shadow catching fish in the scene.
- User E: I thought the fish will swim away when the door opening.
- User F: I like the interaction. But if the door were placed in a real environment, I would not interact with my shadow in front of many people. It's too embarrassing.
- User G: I thought the water will float with the door when I walk through it, but it didnt
- User H: Fantastic! It looks like an aquarium!
- User I: It's too dark here. Can you turn on the light? I want to see what is the effect on the door in a brighter environment.
- User J: I can feel the water, so what?
- User K: I like the aquarium scene! It makes me feel calm.
- User L: I like the aquarium scene too and also the awesome mirror effect. If there is such kind of automatic door in real place, maybe I would stand in front of the door if there is no body around me and I dont want to pass the door because it looks amazing.

To start with, the biggest finding was, that all participants in general liked the idea of combining the virtual scene with the physical automatic door together. And they could have the intuitive feel as there is the real water fully existing in the glass and make it looks like the environment of an aquarium. It is a significant effective way to enhance users' immersion by merging the virtual augmented illusion with the existence of the physical objects and environment.

The projection automatic door can provide a realistic natural stimulus to a user even though it has a limited field of view. This is more applicable to

non-immersive displays and should provide an interesting measure for use with projection-augmented objects. The idea of object-presence is suggested to measure the extent to which visual contents presented with a non-immersive display seems natural to a user.

As for the group A, they understood the principles without any guidance. Almost all participants tried to catch presented elements in order to activate content in the scene. In fact, the majority of them expected a movement-coupled interaction; such as they could using their particle shadow catch or touch the fish in the scene, which seems to be a key appeal of augmented reality, since it is the motion that reveals that virtual annotations stick to reality.

As for the group B, we found that effect of the real-time rendered shadow interaction is generally inconspicuous. Although we assumed that the participants would make a clear understand of this gesture-based interaction with the Kinect, it turned out that they found it rather confusing without knowing what the moving shadow it is when they passing through the automatic door within average of 6 seconds.(Figure 5.3) Without having enough time to stand still in front of the automatic door, people didn't understand exactly, why or how the system reacted in the interaction parts. That kind of feedback, which frankly worked as an indicator, shows us that the shadow-based interaction is not pretty suitable for the automatic door design, especially considering putting is in the real situation in public environment, where people usually passing the automatic door in hasty.

Over all, the feedback gathered offered good insight of the content creation and the lack of the interaction parts, which is still worth improving in our further prototype. This could also imply our design considerations for the next implementation.

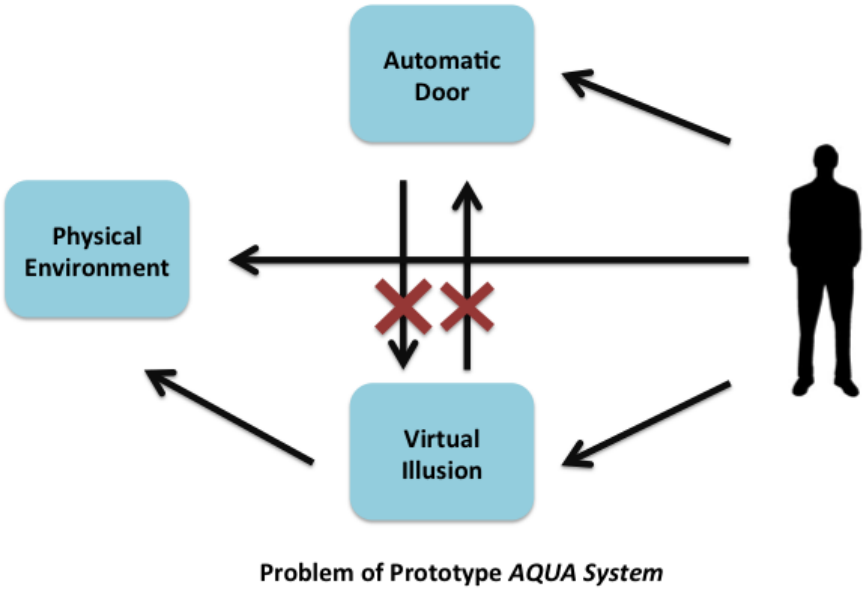


Figure 5.4: Problem of prototype $AQUA$

In summary, the biggest problem of the first prototype is that the design of the system didn't build the relation between the automatic door with the virtual illusion successfully(Figure 5.4). Based on the feedback from the test, the new implementation in next step would be:

- Make this interaction more clear and time saving in general.
- Considering using the automatic door in public place, it is better to change the interaction modality into a more natural way which control the range of the user movement as less as possible.
- Use visual hints additionally that tease the interaction effect in the spatial augmented scene.

5.3. Evaluation of *FRAGILE*

5.3.1 Experiment

Another brief test was conducted in order to understand the effectiveness of second prototype better. The same group of participants from the first test took part in this experiment(Figure 5.5). The evaluation is conducted with a quantitative method by gathering feedback form participants through a form of questionnaire. The paper questionnaire included closed-ended questions that queried participants with the following questions.

1. Is the augmented illusion natural?

1)Yes 2)No

2. Does the augmented illusion make you feel connection between the physical environment?

1)Yes 2)No

3. Is the interaction with the automatic door obvious?

1)Yes 2)No

4. Is the interaction with the automatic door natural?

1)Yes 2)No

5. Which interaction would you prefer compared with the first prototype *AQUA*?

1)*AQUA* (Using body gesture)

2)*FRAGILE*(Using body position)

After the experiment, we discussed about the different aspects of the prototypes, its weaknesses and strengths,etc.. Further more, we recorded their qualitative feedback and comments during and after the experiment.

Figure 5.5: User test of *FRAGILE*

5.3.2 Results and Evaluation

In second prototype test, we are not focusing on how well can the users understand the interaction between virtual scenes and user themselves, but rather how well can they understand the interaction between virtual illusions could cooperate with the automatic door when users passing through the automatic door. Here are some comments from the participants:

- User A: The scene looks amazing in the door. Especially I like the part that it changed with the door when I walk through.
- User B: The glass is too colorful that when I get close to it I will feel a little bit dizziness
- User C: I like the content. But it can be also projected on the wall or some other panels, right? there is no special meaning to use it on the automatic door.

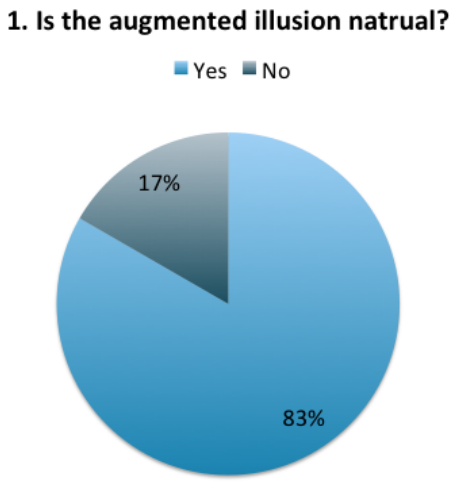


Figure 5.6: Result of questionnaire1

For the first question, the answer is very well clear that this stained glass texture content seems pretty natural to the automatic door(Figure 5.6). In the experiment, most the users regarded the virtual scene as parts of the real physical texture of the automatic door and invests an emotional interest in their mind. Five of participants gave us reason that why they feel it real is because they could physically touch the surface with their bare hands, which makes the effect of the stained glass more authentic to them. Alternatively, if people consider illusion to be essentially computer generated objects, then the act of being able to touch computer generated illusion may increase sense of spatial presence.

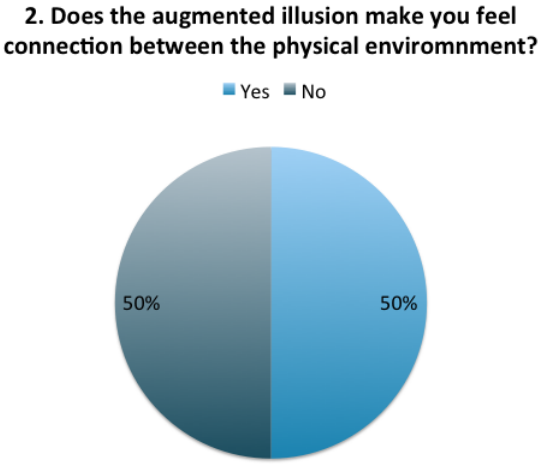


Figure 5.7: Result of questionnaire1

As shown in figure 5.7, "Does the augmented illusion make you feel connection between the physical environment?" question's result seems to be inconclusive. However, just by the results is hard to conclude the answer. According to the opinion of the participants towards this question, some of them gave us a very useful answer. Specifically, when they saw the illusion of stained glass texture on the automatic door, instead of being merged with the physical environment, the 2D imagery still exists as a virtual image that is attached to the physical surface of the automatic door. However, as the purpose of using interactive visual content to blend the virtual scene with physical environment through automatic door, we realized that what is most important in terms of results is creating sense of spaciousness. Therefore, increasing the different aspects of the illusion model may have a different effect on the strength of the illusion.

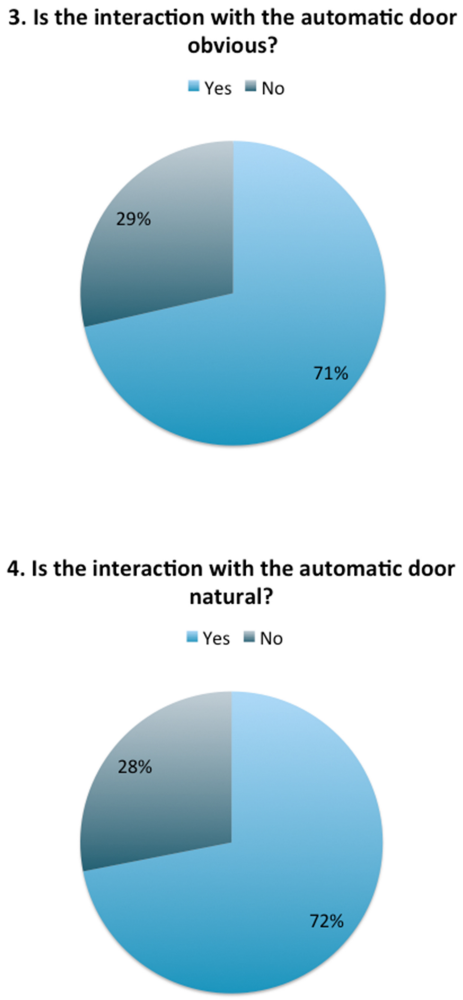


Figure 5.8: Result of questionnaire1

As for the third question and fourth question, most of the participants gave us a positive feedback, showing this embodies interaction based on the tracked automatic door motion is successful to create a natural interaction in this test(Figure 5.8).

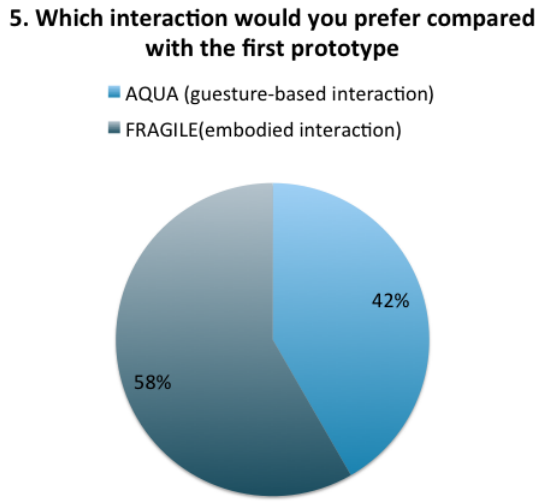


Figure 5.9: Result of questionnaire1

For last question of comparing the interaction of two prototypes, more than half participants choose the *FRAGILE* one, which shows that embodied interaction for the system design is more welcomed by the users(Figure 5.99).

Based on insights from the second prototype experiments, we specifically address that natural interaction is more appropriate for our design. Although this project is only at the prototype stage in the lab environment, the interaction models should allow a user to naturally get access to it.

Linked to the idea of a display of the automatic door supporting the user in a natural way, it is assumed that the more natural the illusion content feels, the greater its authentic. This naturalness may enhance a user ability to utilize real-world skills in a virtual environment, although it may also help to transfer learning from the virtual environment back into the real-world.

The result of the questionnaire greatly aided in clarifying further what kind of elements are attractive and effective for this kind of design and user experience

and what are redundant parts.(Figure 5.10) Based on all of the results, the improvement of the new implementation would be:

- Create a more impact augmented illusion, which could take advantage of the physical image showing through the transparent door glass.
- Focusing on merging complex 3D animations into the augmented virtual content design in order to modulate the surrounded space.
- Fine detail can be added into the visual content design, such as focus perspective and vertical feeling.

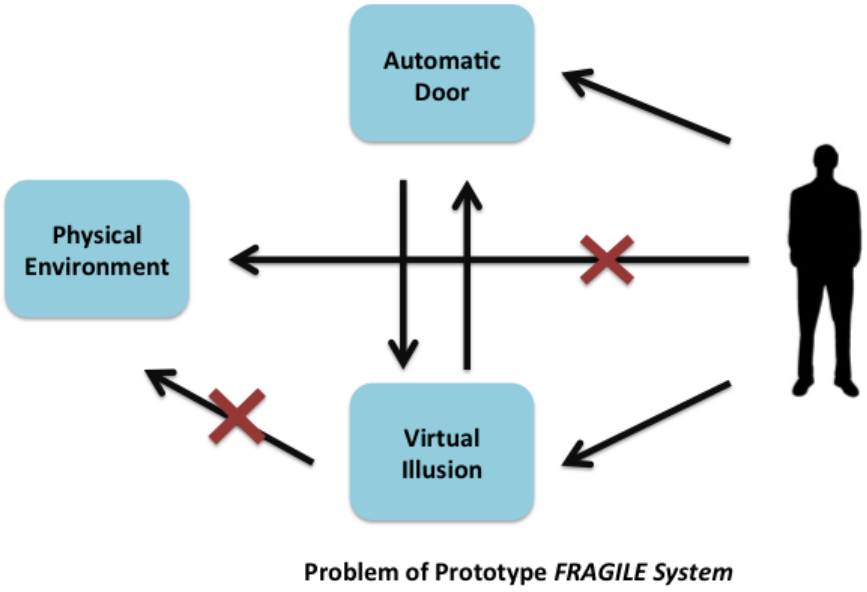


Figure 5.10: Problem of prototype *FRIGILE* system

5.4. Evaluation of *MOKUMOKUREN*

5.4.1 Experiment

In order to get an initial user feedback and to test the usability of the system, we recruited 17 (7 female) participants with mean age of 29(min 22, max 39) to test this prototype(Figure 5.11). There was no requirement for their action. At the start of the test, the participants were walk around in front of door, trying to figure out the relationship between their movement and the sight angle of the eyeballs. Then they started to get close and pass through the automatic door. After completing, participants also completed a post-experimental questionnaire.

(For Questionnaire see Figure 6.1 in Appendix)

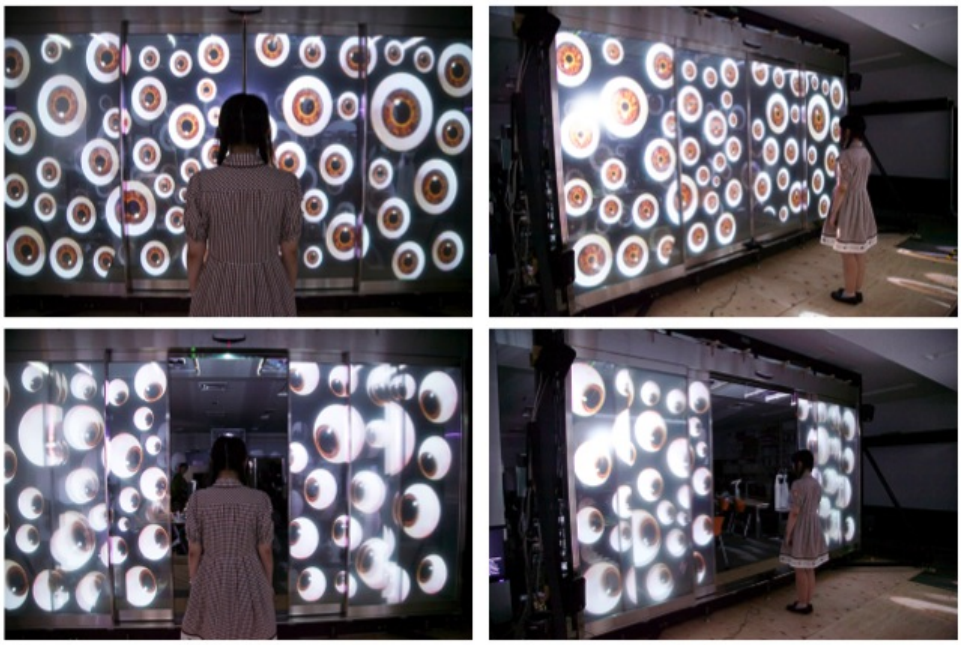
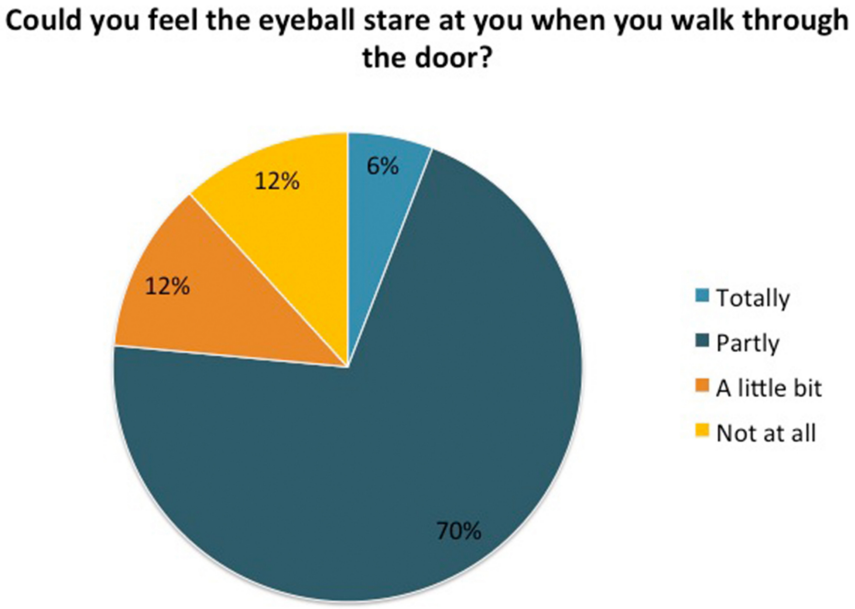


Figure 5.11: User test of *MOKUMOKUREN*

5.4.2 Results and Evaluation



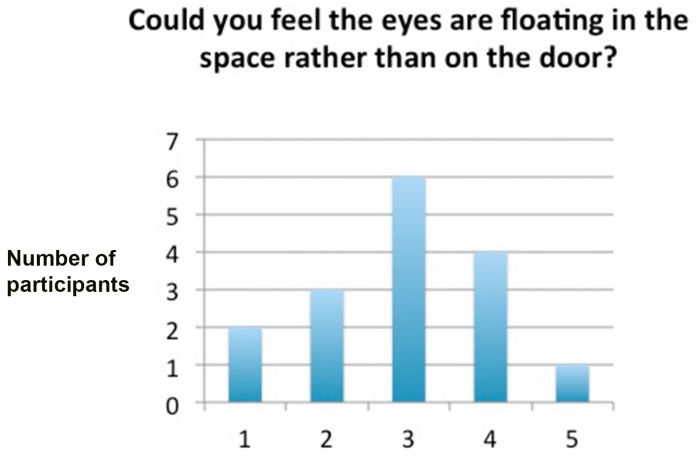


Figure 5.12: Result of questionnaire2

In general, the feed back from the participants indicate that the new implementation was successful as most of the participants showed their interest to this kind of automatic door design and greatly enjoyed the mixing of virtual scenes with the physical environment, also as well as the interaction with the virtual illusion brought them a lot of entertainment experience.

From the perspective of visual content design, the comments were mostly positive. Nearly all the viewers expresses they could merge the virtual scene with the physical environment through the automatic door to some extent(Figure 5.12),.

According to the feed back from the participants,they thought that the 3d virtual effect is the core reason for them to built the sense of spatial cognition when they see the scene and get the feeling of "presence" in this prototype. Another interesting finding is that, there are four participants figured out that there is a "double image" of the eyeballs in the scene(Figure 5.13), this is caused because of the blank space within the projected scene on the glass door. This double image accidentally create a sense of the depth of the space, which made them feel that there are t hounds of eyeballs floating in the room. And it would be a tech point that could be used for the future design.

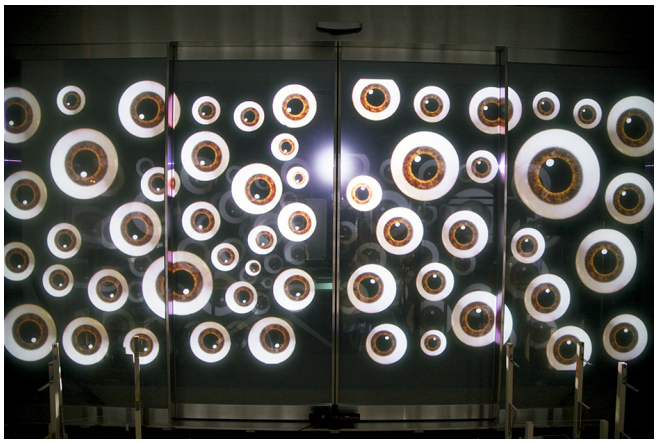
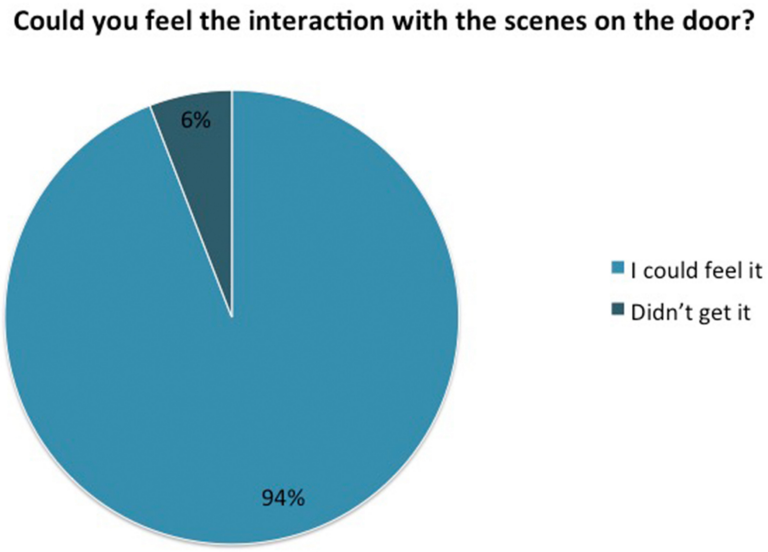


Figure 5.13: Detail of double image in the scene



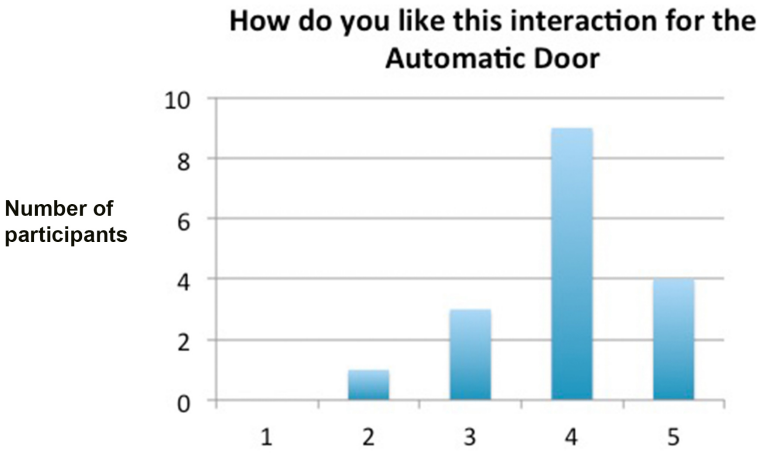
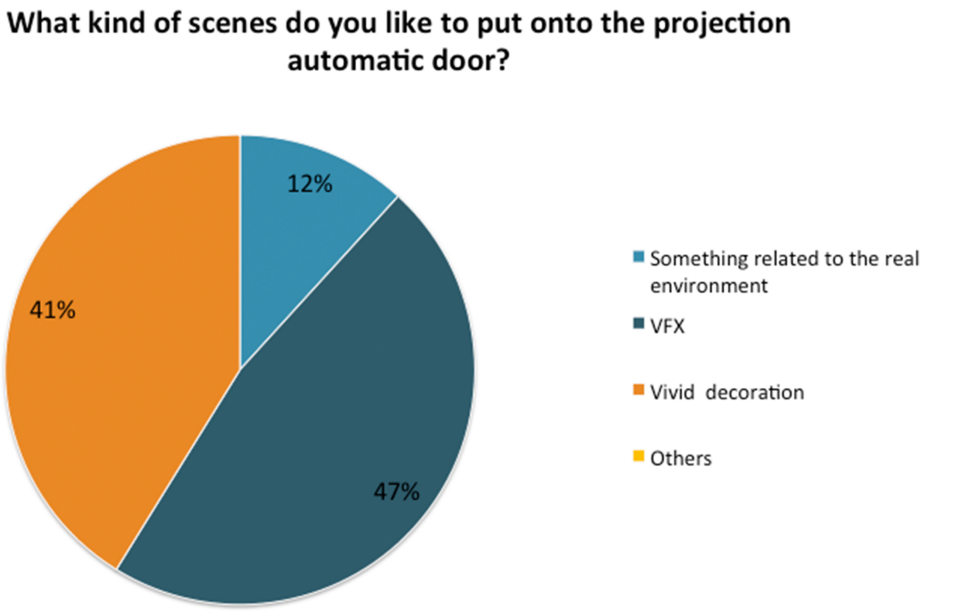


Figure 5.14: Result of questionnaire2

As for the interactive component, most participants could feel the interaction between virtual scenes and motion of automatic door(Figure 5.14), and they felt its much interesting because this kind of interaction makes the automatic door as natural as it was living.

Most of the participants said that they could feel the 3D eyeball illusion is keep staring at them when they stand and walk in front of the automatic door. And they could feel the instant focusing of the eyesight when the door opened. But there are still some defects in this interaction, which is the delay issue during the each scene's transition. Even this bug happened without a second, but it is still obvious to observed by users.

Participants also gave us several valuable advice after the experiment. Some of them mentioned that it will be much more interesting if the eyeballs in the automatic door could stare people wherever they stand and move. This advice is worth to be taken into consideration for our further trail which could be realized by using tracking sensor, such as Kinect and software of Unity to built this interaction. But there is still a limitation of this idea, which is that this kind of tracking interaction is best suit for individual user environment. Considering the automatic door's normal situation, maybe we will try some other method to fix it to support multiuser interaction.



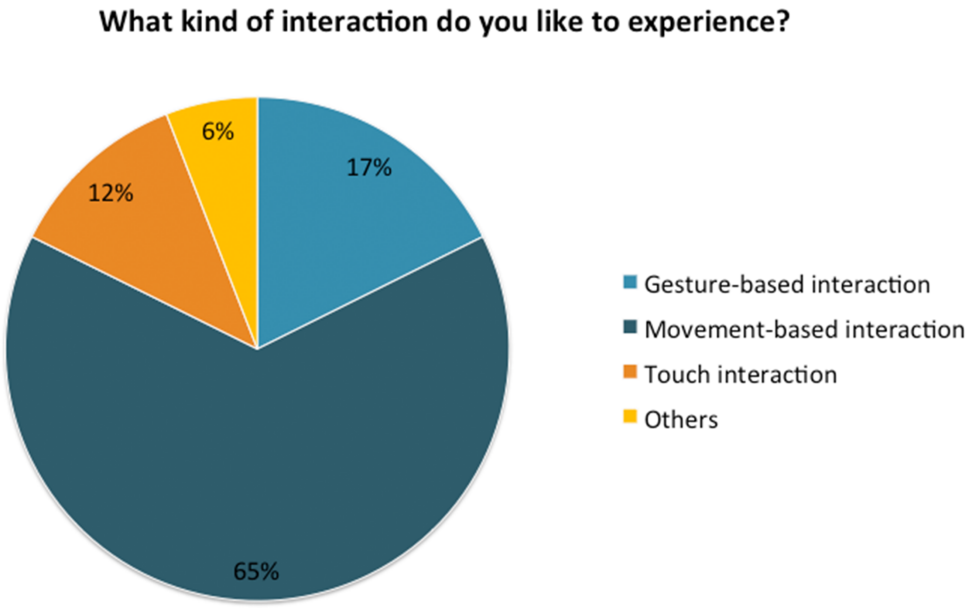


Figure 5.15: Result of questionnaire2

According to the question of "What kind of scenes do you like to put onto the projection automatic door", the result showed out the VFX content was chosen by most of participants(Figure 5.15).When asking them reason about that, some of the participants said that they would like to see something out of normal daily life experience. And the VFX could help them create an imaginary immersion. Compared with gesture-based interaction or some other interaction modality which need more activity, the embodied natural interaction is selected by most of the participants(Figure 5.16). And they gave us the reason that they could feel more comfortable with the implicit interaction in public environment,where the automatic door usually to be located in. The result gave us lots of inspirations for possible future design.

In regards to the comparison between the second prototype *FRAGILE* and the third prototype *MOKUMOKUREN* , two of the users who also participated in the second prototype's experiment,provided us some useful opinion on this point. While the second prototype demonstrates a full size scene covered all over the automatic door without any interval, the third prototypes virtual scene which leaves blank parts to show the real physical environment through the glass, turns out a better sense of the augmented virtual elements presence which provides a more real sensation of the space. In this prototype, taking advantages of the property of the glass to merge the virtual scene with the physical environment becomes an effective way for enhance the participant's immersion.

The success of the results shows that one of the most efficient strategy for promoting the participants' awareness of the interactive visual content is not to block access to the real physical existence world, but to engage the user in combining and merging the virtual and physical on their own initiative.

Chapter 6

Conclusion

The prototypes of *AQUA*, *FRAGILE* and *MOKUMOKUREN* are all providing much valuable insight on what users prefer in the different interactive contents for the automatic door. Through the feedback from the three prototypes, it is evident that this work has been able to reach the goal of this research, which is providing interactive experience with visual illusion and natural user interaction through assigning automatic door. The interactivity is made accessible to a group of users, by naturally combining the real object and the virtual illusion in a collocated interaction and visualization space in this paper. The participants in the experiments could compose very special experience of merging physical environment with the virtual scene together through the automatic door. However there are still some aspects of research that could be improved and investigated in order to make it a better design of the future work. This chapter will discuss about the specific findings and results based on the evaluation of three prototype experiments. Furthermore, the possible directions of future works are also discussed in this section.

6.1. Conclusion

This research has presented three prototypes, in order to contribute with experiences and examples of how to address a range of different challenges faced when using automatic door as the medium for designing interactive contents.

The general acceptance of this design by the users is very high. The interaction is designed in a way that it does not require any previous knowledge to participate. A simple approach and presence are enough to become part of the interaction with the illusion content. Designing an easy and intuitive access proved to be the right decision as the users usually have only a short attention span and needed to be attracted quickly to walk through the automatic door.

Generally, projector-based systems combines the best of both: simplicity of natural interface of the automatic door and power of visual impact of the content creation. The resulting visual images are highly compelling with the physical automatic door and the surrounded environment.

From a research perspective, although it is complicated to reconstruct the strands of inspiration in relation to the generated concepts and evaluate how each content addressed in particular, as well as the taking the whole real environment into consideration, this research has shown how different specific contents and interaction on the automatic door are salient in assuming conditions, as well as given examples of how designers can go about creating, iterating and capturing ideas for automatic door design as a significant part of facades design. And this research also shows that how different kinds of inspiration can be used to open up the design space and create new ideas for projection automatic door. Adding to this the research has consciously worked with several approaches. Furthermore, this research also underlines how different interaction modality can be used during the design process to overcome some of the challenges in the implementation of the prototypes.

6.2. Discussion

This section touches upon the limitation and possible design improvements of this research. This section do so for two reasons: one, they may support the specific development of better implementations of the interactive contents for the automatic door design in the future; two, these challenges apply to the larger context of introducing using daily objects as the medium for interactive contents in diverse public places, and thus relevant for a growing group of designers. This research has condensed those findings which guiding to outline two challenges, which the research identifies as the main causes for this discrepancy between expectations and outcome: visual issues and interaction issues. For each, this paper shall outline the main challenges followed by a discussion of potentials for future design.

One issue is the visual display quality. During the three tests, the most crucial problem with projector-based virtual illusion is significantly depends on the automatic door surface properties and the light condition of the surrounded environment. The quality of the rear projection screen attached onto the automatic door surface can have a significant influence of the contrast of the images. This limits the visual effect of the scene in controlled lighting environments with which light of the color in the content will be registered. On a more abstract level, the seemingly ideal fit between virtual scene on the automatic door and physical environment in lab situation maybe proved to be less than ideal when situated in a realistic environment. Besides, because the images are created in the physical environment rather than in individual users space, for front-projector-based design, shadows of the user can also create problems. This can be partially overcome using multiple projectors in the future implementation.

Another issue is interaction. Based on insights from prototype tests, the research specifically addressed the effectiveness of embodied interaction based on the motion of the automatic door. In this way, the change from visual contents would be less in the periphery of their vision when entering the interaction

zone. This was done in order to create a fit with the movement of the users who would move within the specific area of the automatic door. When users present in the interaction zone, which is the automatic door opening function activated zone, the visual contents would start to switch over. This mode was designed to make clear to users that this specific display has special properties. However, setting up this embodied interaction mode led to another problem, namely delay issue when participants moving into the interaction zone. Since it only takes average 5-10 seconds to pass the automatic door, some people could not notice that they are in fact affected the visual contents changes. Even though the transition of the visual contents is very swift (typically taking less than a second), the observations and interviews during the experiments indicate that some users still perceived it as a flickering display in their peripheral vision rather than something that they could control themselves. Whereas this might not be noticed by the immediate users, the transition was to reveal to other potential users that they could interact with the automatic door. This again introduced another problem, considering the realistic environment for the automatic door during busy periods, the automatic door would continually be left open, which means the visual contents will stay in the loop state without any interaction function. On a concrete, there are a number of difficulties that led to these outcomes. However the research will have to carry out further studies to explore and substantiate these speculations.

Moreover, since these three prototypes tests are conducted in a lab environment, but the practical field environment for the automatic door continue to diversify. This research haven't done any field experiment for to test how people would respond to this automatic door in a natural setting, particularly how they would respond the first time they encountered such a door. In addition, this research also concerned about the effect that the natural variations around automatic door environment might have on peoples interpretations.

6.3. Future Perspective

This research presents several design approaches of using automatic door as the medium for the interactive visual contents design that combines projection mapping and embodied interaction to provide entertainment experience to users. This paper demonstrates the concept with three prototypes, which include *AQUA*, *FRAGILE* and *MOKUMOKUREN*. The research shows three initial spatial augmented reality contents and interactive experiences with the system, but clearly there is still existing potential to investigate that go beyond automatic door design. The research intends to continue the work in order to push forward in several directions.

One interesting possibility could be utilizing is combining more tracking technology for this design. This would greatly increase the adaptability of the concept, by making the augmented illusion more real in the physical environment. This could be used for the first prototype or third prototype, which the augmented elements in the scene could track with the user motion.

Besides, using haptic technique can be also taken into consideration into the design to enhance user immersion more effectively. By that way, the virtual illusion can also be touched to create a sense of what you see is what you feel. Supporting two or more sensory modality consistently is believed to create a stronger sense of palatability, or awareness that the object exists, and hence a strong sense of object-presence will be excited.

Furthermore, although this research is focused on automatic door design, the broader goal is to expand this concept into more areas concerned with the diversity daily artifacts in urban environment. It increasingly seems that an augmented future would place an emphasis on the inexpensive and dynamic augmented overlay, leaving the built environments infrastructure to be decorated for urban living and entertainment.

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Appendix

Questionnaire of MOKUMOKUREN Experiment

Age	
Gender	

1. **How do you like this design for the Automatic Door?**

   1 2 3 4 5

   Boring □ □ □ □ □ Interesting

2. **What is your favorite part of this design for the Automatic Door?**

   □The visual illusion mixed with the physical environment is fantastic
   □Adding interaction into automatic door is interesting
   □Engagement and involvement
   □Kind of entertainment
   □Others (Please write it):

3. **Could you feel the eyeballs stare at you when you walk through the door?**

   □Totally
   □Partly
   □A little bit
   □Not at all

4. **Does the eyeball illusion bring you immersion experience with the physical environment?**

   1 2 3 4 5

   Nope □ □ □ □ □ Totally

5. **Did you feel the interaction inside the door?**

   □I could feel it
   □Didn't get it

6. **How do you like the interaction for the SAR-based Automatic Door ?**

   1 2 3 4 5

   Boring □ □ □ □ □ Interesting

7. **What kind of scenes do you like to put onto the projection automatic door in future?**

   □Something related to the real environment
   □
   □Vivid decoration is fine
   □ VFX
   □Others

8. **What kind of interaction do you like to experience for future design?**

   □Gesture-based interaction
   □Movement-based interaction
   □Touch interaction
   □Others (Please write it):

9. **Any other related feedback or opinion about this design you would like to give?**

Figure 6.1: Questionnaire of MOKUMOKUREN

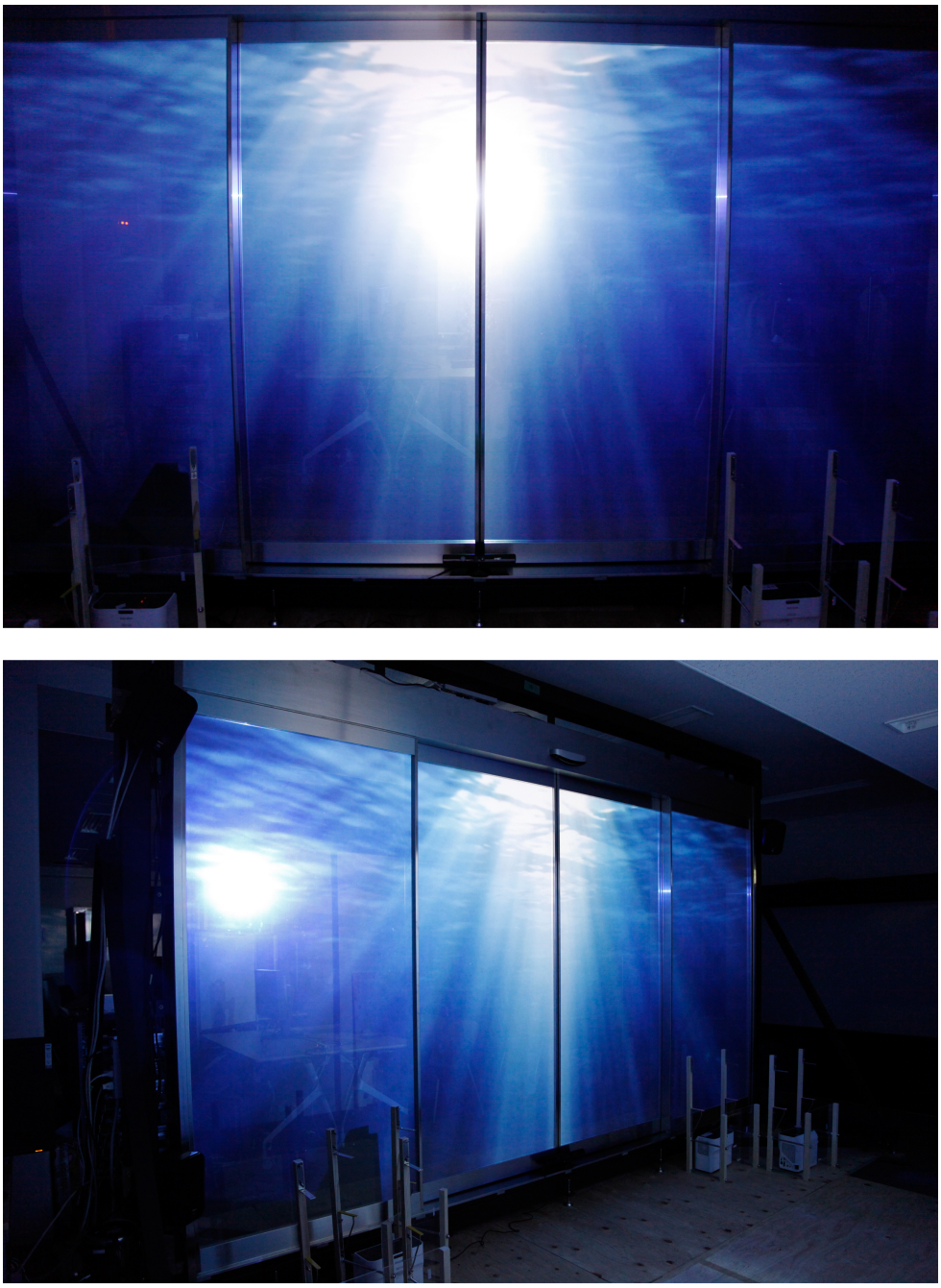

Figure 6.2: Photos of AQUA

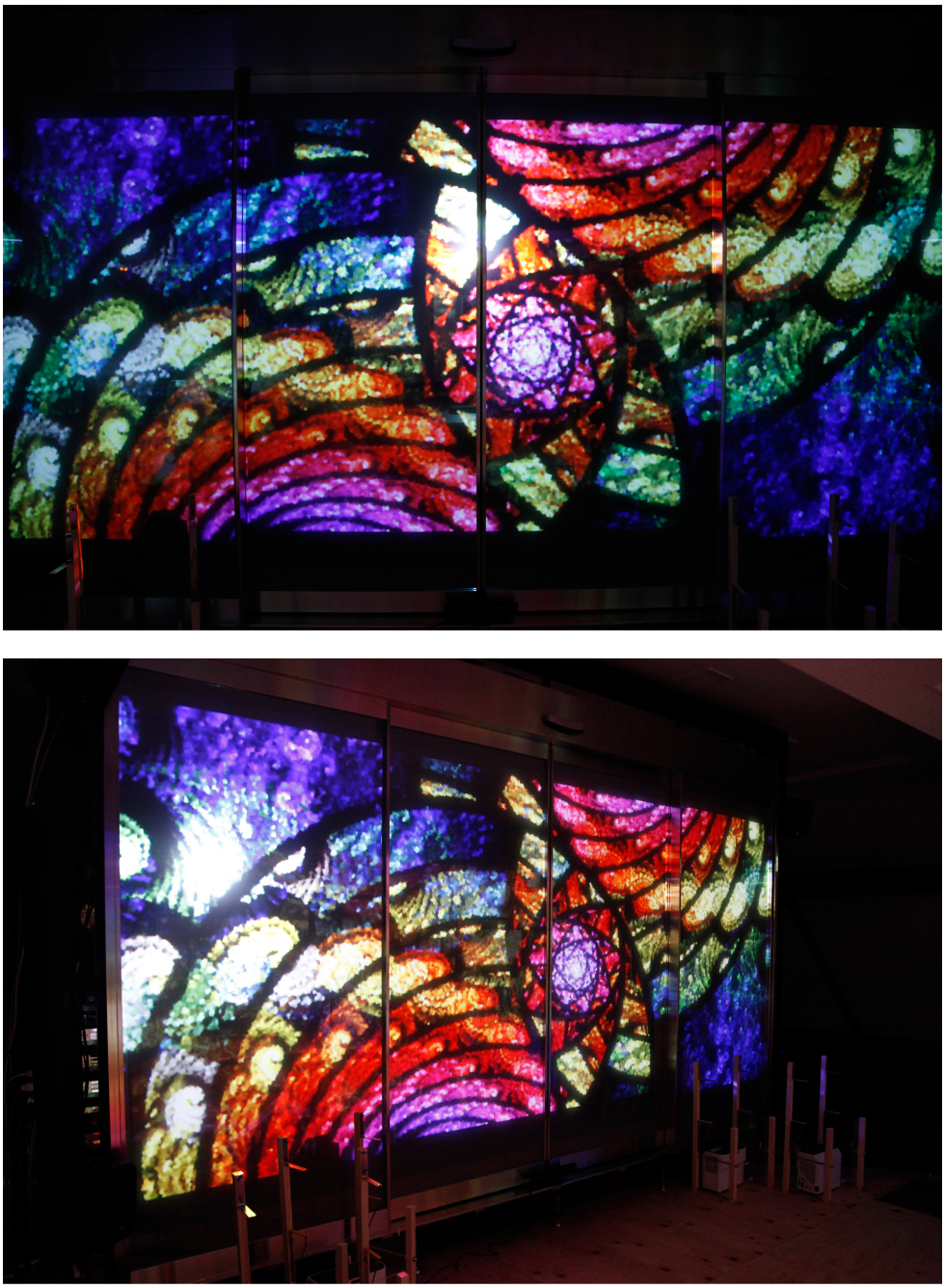

Figure 6.3: Photos of FRAGILE

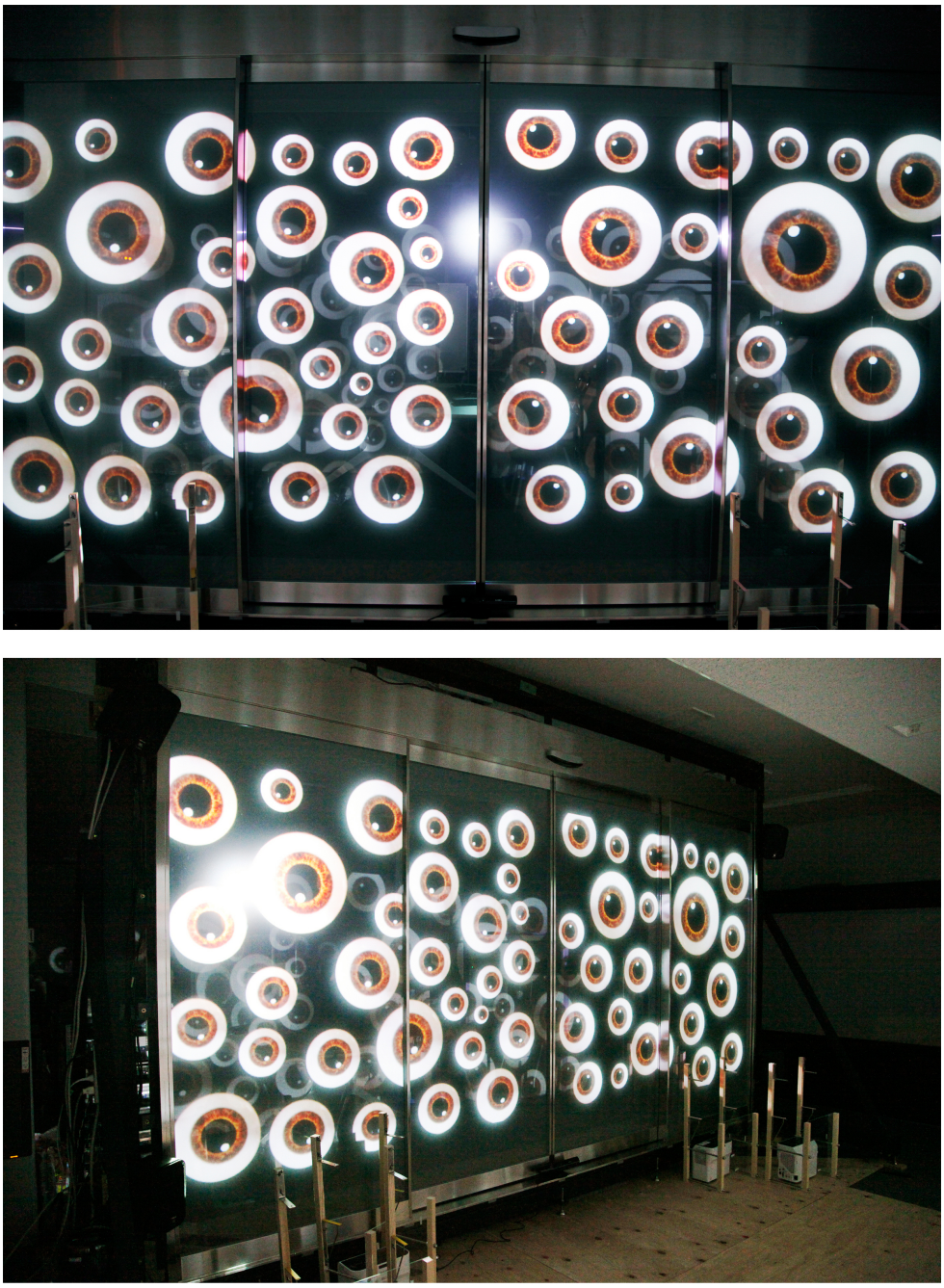

Figure 6.4: Photos of MOKUMOKUREN