Customer Behavior Analysis Using Service Field Simulator

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Abstract

A virtual environment system for human behavior analysis, called a service field simulator, and its application to marketing investigation are described. The practicability and advantages of applying this service field simulator to marketing investigation are demonstrated through two case studies involving actual business scenarios. The first case study highlights the similarities and differences that occur when in-store marketing investigation is carried out in a real store versus a virtual store. The results of the second case study, an actual in-virtual-store marketing investigation, verify the feasibility of the proposed service field simulator.

Keywords

human behavior sensing; virtual reality; in-store marketing

1 INTRODUCTION

To build an economically sustainable society even as the aging progress, it is necessary to study and design comfortable living spaces, service field, and working environments for various consumers in a wide range of ages. Because we defined services as human activities for value co-creation, based on functions expressed by human interaction, served goods, and well-designed environment, we believe it is important that designing space and service process based on the scientific analysis using human behavior measurement of the actual activities in these environments. The ability of the physical environment, referred as Servicescapes, to influence customers’ and employees’ behaviors in service business has been investigated long time and regarded as very important in the field of service management and service marketing (Bitner 1992). For example, Edvardsson et. Al suggested a notion of “hyperreality,” the simulated reality of a service experience and “experience room,” the place where the simulated experience takes place, in order to evaluate pre-service experience using six design dimensions (Edvardsson 2005). However, it is extremely difficult to strictly control the experimental conditions on the real field, and there are often restrictions on the equipment that can be used for measurement. One possible solution for the problem is Virtual Human-Sensing, which we defined as a human behavior sensing method using Virtual Reality technologies. Virtual reality technologies have been attracting renewed attention from businesses because of recently developed consumer gaming devices such as Oculus Rift. As virtual reality technologies become increasingly common, the number of areas in which they are being applied is increasing. From the beginning of virtual reality research, simulators for skill training are promising applications. They basically support provider’s service activities. Another promising application field is marketing because these technologies make it possible to reduce some risks and costs through “virtual” in-store marketing. For example, Kimberly-Clark’s Innovation Design Studio was highlighted by the Wall Street Journal as a new tool for marketing research and business development. The In-Store Marketing Institute reports that several cutting-edge companies, such as Kimberly-Clark and P&G, use virtual store simulations to investigate the purchasing behavior of customers and insists that a virtual store is a strong tool for enhancing existing in-store marketing practices (Breen 2009).

We also have developed a virtual reality environment called the service field simulator to evaluate and design service fields and processes (Hyun et. Al. 2011) (Hyun et. Al. 2010) (Okuma et. Al. 2016). The key design concept of the service field simulator is that users must use their own body motion during the virtual environment experience to keep their senses and behavior in line with the real environment as much as possible. For example, the service field simulator adopts an omnidirectional display system to show the virtual environment and to maintain a sense of the direction because it allows users to see all directions in the environment without rotating the virtual environment. The users have to change their own direction to see different directions in the virtual environment, as in a real environment. They have to also perform a “walk-in-place” motion to move around the virtual environment in order to maintain a sense of distance. However, in order to effectively use virtual environment for human activity analysis, it is very important to know similarity and difference between human behaviors in real and virtual environment. The white paper by the In-Store Marketing Institute also states that, “It is clear that additional validation work is necessary to assess the ability of virtual simulations to predict true in-store shopping behavior.”

Therefore, our research goal is to clarify the similarity and difference between human behaviors in real environment and those in the virtual environment. We previously compared the behavior of users in the simulator with that in the real
environment using some experimental evaluation tasks (Hyun et. Al. 2011) (Hyun et. Al. 2010). Consequently, we confirmed that users can maintain their sense of direction in the simulator as well as they do in the real environment. In this paper, we discuss the results of empirical studies conducted in an actual business scenario. Further, we use the results to evaluate the feasibility of in-store marketing and the capacity of the improved version of the service field simulator to accurately reproduce customer behavior.

2 SERVICE FIELD SIMULATOR

2.1 Concept

In many service fields, such as shopping malls, retail stores, restaurants, hotels and hospitals, service processes often comprise repetition of small activities such as walking, simple work, and the gaining of information. In other words, human activities involving movement and acquisition of information from the environment are comprised by various service processes. By providing a ‘Virtual Servicescape’ wherein such activities can be experienced, human reactions to possible service processes, the layouts of service environments, and the design of tools used in the service process can be sensed and recorded. We developed a service field simulator based on this hypothesis. A service field simulator can be defined as a virtual reality system that simulates actual service fields in order to sense and record customers and providers behaviors and biological information in the simulated service field, especially, during their activities involving movement and acquisition of information from the environment.

2.2 Hardware Configuration

Immersiveness is an important factor that has to be considered during the system hardware configuration of a simulated service field designed to observe natural behavior. To provide an immersive virtual environment, various immersive displays have been investigated. Head-mounted displays (HMDs) are one of the most popular devices for this purpose. Compared with other devices, HMDs are small and can easily provide immersion. However, they are limited by a narrow field of view, low resolution, eye fatigue, and discomfort when worn. Further, users complain of virtual motion sickness, owing to the delay between head motions and rendering of the appropriate computer graphics (CG) scene, while wearing HMDs. Theoretically, this time delay is impossible to eliminate from HMD settings.

Another important factor to consider in the design of the hardware configuration of a service field simulator is whether it is possible to combine it with human sensing equipment such as eye-tracking devices and electroencephalography (EEG) devices. HMDs sometimes interfere with the installation of these devices.

In addition, it is also important for a service field simulator to allow persons experiencing the virtual service fields to see real objects they may be holding, such as mobile information devices, because we assume that the service field simulator is being used for usability evaluation of real objects.

The cave automatic virtual environment (CAVE) (Cruz-Neira et. Al. 1993) immersive display room is not affected by the problems afflicting HMDs. However, it is very difficult for a user to maintain a sense of direction when they walk around a virtual environment with a partially omnidirectional setting, such as the original CAVE system, because the system must rotate the virtual environment to display all directions. It is important to maintain stability between the sense of absolute direction and that of the real
environment because we would like to sense and record human activities in the virtual environment that are as close as possible to those in the real environment. Full solid angle CAVE-type displays such as COSMOS (Yamada et. Al. 1993) and Garnet Vision (Iwata 1996) would be ideal for our purpose. However, they require a large room and very complex optical systems that must be calibrated very precisely. To minimize cost and space we therefore adopted a fully omnidirectional CAVE-type screen configuration in our system to maintain a sense of horizontal direction as a minimum requirement.

The first implementation of the service field simulator used four image projectors to construct the omnidirectional screen (Hyun et. Al. 2011) (Hyun et. Al. 2010). However, the resolving power of the first simulator was only approximately 0.190 pixels per minute—a limitation that resulted in low realism and high task load, especially in tasks that require participants to read text. To evaluate a service environment, text in the environment should at least be easy to read. Therefore, we replaced the four image projectors with 24 liquid crystal displays (LCDs) to improve the resolution of the virtual environment. Each LCD has full-HD resolution (1920 × 1080 pixels), and they are positioned to form an octagonal prism. Consequently, the horizontal angle resolution was improved to approximately 0.733 pixels per minute, which enables it to represent 20/30 vision. In addition, this configuration reduces the required floor space and height (approximately 2300 mm). Thus, this version of the service field simulator can be placed in many popular Japanese office buildings.

During prior investigations of the simulator, the lack of a vertical viewing angle field was a drawback, especially in an investigation conducted using a virtual drug store because we had to set the LCDs at a low position to show products on the lowest shelf. Consequently, we could not display direction boards hung from the ceiling, and could therefore not confirm whether this type of direction board is useful in helping customers find products. To rectify this issue, we have since increased the number of LCDs to 40, which has resulted in an increase in the vertical viewing angle (Figures 1 and 2). The upper vertical and lower vertical viewing angles of the new configuration are approximately 35° and 58.5°, respectively.

2.3 Virtual Viewpoint Control Method

To imitate motion in service fields, we provide a function that controls the virtual viewpoint using a walking motion. This function allows persons experiencing the virtual service field to use their hands freely so that we can test the service process with real tools used in the field. Another important point is the physical load required to move around the virtual environment. Therefore, the function is suitable for evaluating the service process and layout settings.

There are two possible implementation options to realize this moving around function in the simulator. One option uses an omnidirectional treadmill, while the other uses methods to detect walk-in-place motion and body direction. Walking on an omnidirectional treadmill is very similar to its counterpart activity in the real environment. However, considering cost limitations, we have currently only adopted a method to
detect walk-in-place motion and body direction in the system because it is more practical to be used for the actual business.

3 COMPARISON OF CUSTOMER BEHAVIOR BETWEEN REAL AND VIRTUAL STORES

In order to evaluate the potential that the service field simulator has, we conducted feasibility studies. As the first step, we have selected the retail field because buying process mainly consists of activities involving movement and acquisition of information from the environment. Although we started from customer behavior analysis with the simulator, targets of investigation using the service field simulator are not limited to the customer behavior.

3.1 Feasibility Study

To figure out the similarities and differences that occur when in-store marketing investigation is carried out in a real store and a virtual store, we compared the behaviors of customers in a real drug store with those in a reconstructed virtual drug store. This feasibility study was conducted in conjunction with an actual in-store marketing investigation. In the comparison of the actual investigation results with the virtual investigation results, there were a few trade-offs. The main trade-offs were related to do the order of the investigations and the layout of the products. During reconstruction of the drug store in the virtual environment, the layout of the products in the real store was rearranged for a promotion. Consequently, in order to carry out the comparisons under the same layout conditions, we captured photos immediately after the investigation in the real drug store. The store was then reconstructed in the virtual environment using our previously proposed modeling method (Ishikawa et. Al. 2014), and then the investigation in the virtual drug store was conducted.

Eleven participants participated in this experiment. We asked the participants to find and identify some products (the number was not limited) that they wanted to buy from a single product category in the real drug store. During the task, participant trajectories were recorded manually. Eye-tracking data were also recorded. The participants subsequently performed the same task in the virtual store. Participant trajectories and eye-tracking data were also recorded. The present study was approved by the National Institute of Advanced Industrial Science and Technology (AIST) Safety and Ethics committee and conducted only after each of the participants had given their written informed consent.

3.2 Comparison Results and Discussion

The participants were not told that the virtual store and the real store were the same. However, approximately 80% of participants reported that they recognized that the virtual store was the same store. Some participants relied on their memory of the real store to find products in the virtual store. This indicates two things. First, the rendering quality of the virtual store was sufficient for participants to recognize that both stores were the same. Second, we are not able to eliminate learning effects to the drug store because of the order of the investigation. We have to consider the quantitative analysis results could include the learning effect.

We compared eight valid participants’ data via quantitative analysis. The time spent shopping in the real store was significantly shorter than that in the virtual store (Figure 3; paired t test, p = 0.04073 < 0.05). However, no significant difference was observed for walking distance between the real and virtual stores (Figure 4; paired t test, p = 0.6688). These results indicate that participants spent more time in front of some shelves in the virtual store than in the real store even they have experienced shopping in the real store first. Through interviews with the participants, we determined that they spent time adjusting the position control to observe the products.

To compare shopping behavior in detail, we generated a heat-map visualization of the stay time for each 50-cm grid in the real and virtual stores, as shown in Figure 5. In the figure, the red area indicates that participants spent more time in certain areas. Because the position data in the real store was recorded manually, we only had the discrete position and timestamp data. Therefore, we could not compare those data precisely; however, we could make sure that they spent more time in front of shelves on which target products were placed using the visualized results. This result is consistent with the report from the participants.

We also compared the time spent gazing at target products using eye-tracking data. These products were placed in three areas with different sales purposes in the store. Regular products were placed in the first area (area A); promotional
products were placed in the second area (area B); and affordable products were placed in the third area (area C). The product gazing time in area A in the virtual environment is greater than that in the real environment (paired t-test, $p = 0.03861 < 0.05$, $n = 8$). No significant difference was observed in the gazing times for areas B and C ($p = 0.1838$, $0.5694 > 0.05$ for each) (Figure. 6). Conversely, some participants reported that the price tags and packages of some products appeared blurred when they stood in front of the products; thus, they spent more time observing the products. This indicates that the rendering quality of the virtual store was insufficient for reading small text information owing to the quality of the virtual content.

From these results and discussion, we figured out that service field simulator could give sufficient rendering quality to observe how the participants find shelves of the target product. However, it is difficult to reproduce participants’ behavior in front of the shelves. Therefore, service field simulator is useful for comparing behaviors moving between shelves and finding target product category with different shelving layout.

4 COMPARISON OF CUSTOMER BEHAVIOR WITH DIFFERENT SHELVING LAYOUTS

4.1 Feasibility Study

As the next step, we conducted an actual in-virtual store marketing investigation with the real drug store to demonstrate the feasibility of the method. Through an interview, we gained some awareness of issues that a sales representative may experience. The sales representative would like to have the area for their brand products in a store extended. The drug store lays out shelves to promote its private brand because they are highly profitable. Therefore, some shelves are unified by product category rather than brand. Thus, we set the experimental variables of the feasibility study on shelf layouts. It is known that the mere presence of categories, irrespective of their content, positively influences the satisfaction of customers who are unfamiliar with the choice domain. This is so-called “mere categorization effect” (Mogilner 2008). It is also known that brand familiarity results in a net positive effect for brand equality on purchase likelihood (Desai 2003). Therefore, in this feasibility study, we compared brand-based layout and product category-based layout (Figures 7 and 8). Following construction of the virtual drug store, some shelf models were edited for the experiment.

The participants were tasked with finding and deciding upon a single product to buy from a single product category. They performed the task in virtual stores with different shelf layouts (order was counter-balanced). During the task, each participant’s position in the virtual store and eye-tracking data were recorded.

Figure 7: Product layout based on brand

Figure 8: Product layout based on category

Figure 9: Comparison of shopping time for different layout conditions

Figure 10: Comparison of walking distance for different layout conditions
4.2 Quantitative Analysis
We did not observe a significant difference between the time spent deciding for each condition (Figure 9; N = 33, Welch’s t test, p = 0.2963 > 0.05). We also did not observe a significant difference between the walking distances during the task (Figure 10; N = 33, Welch’s t test, p = 0.06162 > 0.05). However, we did observe a tendency for each participant to walk a shorter distance with the category-based shelf layout.

This indicates that the time taken by the participants to stop and view the shelves was relatively longer in the category-based layout because the walking velocity was constant. Therefore, the participants spent more time observing each product or compared a larger number of products in the category-based layout. Thus, the category-based layout is more suitable for customers who want to compare products.

4.3 Qualitative Analysis
We conducted qualitative analysis using the recorded eye-tracking images. We observed that participants’ gaze points often move quickly over a large area in the brand-based layout condition. There were some products that should be considered in ‘skipped’ area. In the brand-based layout, we also observed the participants required more time to compare the same category of products because they have to move.

Under the category-based layout condition, we observed participants first looked at signs that displayed the category, determined where they wanted to go, and then compared products. In contrast to the brand-based layout, gaze points moved continuously.

4.4 Discussion and result
Because this feasibility study has conducted as a part of actual marketing investigation, we could get opinions from professional investigator who works in in-store marketing using eye-tracker technology. According to him, participants seemed to abandon their attempt to compare all candidate products under the brand-based layout condition. Brand-based layouts can be convenient for customers who have decided to buy a particular product based on brand image and may prevent customers switching to different product brands. In contrast to that, category-based layouts are more appropriate for products that have obvious competitive power.

The important result for us is that we could compare participants behavior under the completely same condition except for the shelf layouts. Even though we could not remarkable knowledges as in-store marketing investigation results, we think we could show the potential investigation ability of the service field simulator.

5 DISCUSSION
It is important to note that we were able to quantitatively evaluate task completion time and virtual movement distance, qualitatively evaluate gaze points, and derive some knowledge about the experimental variables. These facts along with the in-store investigation show that we can perform “in-virtual-store” investigation using the service field simulator.

In addition, through the feasibility study and by consulting an actual person who conducts in-store marketing investigations using eye-tracker technology professionally, we confirmed that gaze point movement in the virtual environment is similar to that in a real store, especially from the entrance to the shelf where target products are displayed. These results are consistent with the conclusion of the first experiment.

In contrast, however, after participants stood in front of the shelf, the gaze point moved in a different manner compared with movement in a real store. Based on participant opinions, we concluded that fine adjustment of the standing point was difficult under the current implementation of the virtual viewpoint control function based on the walk-in-place motion detection, which we recognize as a current limitation. It might affect to shopping time in the feasibility studies, but we cannot say any certain things without additional investigation using perfect user interface for movement. However, we don’t think the conclusion changes, because still more cognitive load is required to compare two products placed apart such as in brand-based layout, even if they can control their position smoothly. This limitation of the current service field simulator is also consistent with the first experiment.

Through the two experimental feasibility studies, we could show that the service filed simulator has a potential to combine service management, service marketing and engineering research in terms of serviceology. Additionally, we believe it is promising that methodology for design and evaluation of service process using “Virtual Servicescapes”. The feasibility studies were able to be considered the first steps for building the methodology.

6 CONCLUSION AND FUTURE WORK
In this paper, we described our developed service field simulator—a virtual environment for human behavior analysis—and two feasibility studies to demonstrate the feasibility of the simulator. From the first study, with our current implementation of the service field simulator, 1) 80% of participants recognized the real drugstore and the reconstructed virtual store as the “same drugstore”, 2) time spent for shopping was shorter than that in the real environment because of insufficient implementation of position control method, 3) walking distance was not different with that in the real environment, 4) because of insufficient resolution of content (virtual price tag), gazing time also became longer than that in the real environment in some case. From these results, current implementation of the simulator is suitable for comparing behaviors moving between shelves and finding target product category with different shelving layout. Through another feasibility study, we concerned that we could compare participants behavior under the completely same condition except for the shelf layouts. Even though we could not remarkable knowledges as in-store marketing investigation results, we think we could show the potential investigation ability of the service field simulator.

The practicability and advantages of the service field simulator are still being confirmed through ongoing investigations. As we mentioned before, we just selected customer behavior analysis in retail field as the first step. In future work, we plan to verify the duplicability of human activities in the simulator by comparing such activities to those carried out in real environments not only for customer behavior but also service provider behavior. It is also very important to represent human communication in the
simulator in order to redesign and evaluate actual service processes. Although we did not discuss it in this paper, the original service field simulator concept actually includes a function for photo-realistic avatars (Hyun et. Al. 2011). We plan to verify the practicability of this function in future work.

We also aim to apply the service field simulator to “neuro-marketing” activities, i.e., marketing activities based on brain activity and neuroscience, which has been attracting much attention recently. Our institute has undertaken a feasibility study in a project called “neuro-aided-design” to examine service processes and product design. As part of the project, we conducted a feasibility study on an investigation method using an Electroencephalogram in the simulator to verify if we could acquire more detailed data with the simulator than in a real environment (Okuma et. Al. 2016). The experimental results obtained are described in a previously published report (Takeda et. Al. 2014). A method to measure the potential interest of customers using EEG data and the simulator to design more interesting service environments is also slated for future work.

7 REFERENCES


