International Conference on Artificial Reality and Telexistence
Eurographics Symposium on Virtual Environments (2018)
T. Huang, M. Otsuki, M. Servières, D. Michael-Grigoriou (Editors)

Study of Human Behavioral Characteristics:
Using Virtual Reality to Analyze Behavior of Following Moving Objects

Kazuya Yonezawa, Eigo Segawa and Ryuta Tanaka

Fujitsu Laboratories LTD., Japan

Abstract

It is crucial to model the physical world for simulation in which various phenomena are represented on a computer. In the case of simulation involving human actions, it is necessary to model not only physical phenomena but also human behaviors. However, there are still many unclear things about human behaviors. In this study, to clarify these behavioral characteristics, we verified two hypotheses using virtual reality. One was that "people follow moving objects similar to humans in shape," and the other was that "people follow the route with the majority of other objects." We tested these hypotheses by conducting two experiments allowing participants to select a route in a virtual maze in which objects were moving under certain rules. The results showed that people tend to follow moving objects regardless of their appearances, and also tend to follow the majority.

CCS Concepts

• ***Human-centered computing*** → *Virtual reality;*

1. Introduction

Today, simulation, in which physical phenomena are represented on a computer, is commonly used in various fields. In the case of simulation involving human actions, it is necessary to model not only physical phenomena but also human behaviors. For example, the simulation of an evacuation needs a model of how people escape from a building that is on fire. Similarly, the simulation of sales in a retail store requires a model of how customers reach store shelves. In such simulations, it is especially significant to know the routes people follow and why they select them. Therefore, it is necessary to comprehend human routing behaviors.

Hokugo [Hok84] has reported such behavioral characteristics as people tending to head toward well-lit and wide passages and to follow other people (hereinafter called the "following property"). Among these, the properties regarding the static environment, such as width and illuminance of passages, have been revealed to a certain degree [HMN97]. On the other hand, for the characteristics regarding dynamic environments, such as the following property, even the occurrence conditions have not been clarified. We assume the primary reason for this is the difficulty in controlling moving objects in the real world, such as people walking nearby. Therefore, we used virtual reality in which we can control the properties of objects easily. In this paper, to clarify the conditions in which the following property occurs, we proposed two models of the following property, and verified them by conducting two experiments.

2. Model of the Following Property

In the field of neuroscience and psychology, there has been some research related to the following property. Some studies have reported on mirror neurons in the brains of monkeys, which are activated both when one performs a particular action and when one observes another individual performing a similar action. Fadiga [FFPR95] indicated the existence of mirror neurons in human brains. We assume, then, that people tend to take actions similar to what they see under the influence of mirror neurons. Another study reported on conformity, stating that one's actions and opinions tend to adapt to those of the majority. Asch [AG51] showed one's own answer has a tendency to comply with the majority answer even if it is obviously wrong. Considering this research, we assume that people tend to follow the route in which the majority of other people follow. Based on the above, we established the following two hypotheses as the models of the following property.

Hypothesis 1 People follow moving objects similar to humans in shape.

Hypothesis 2 People follow the route with the majority of other objects.

3. Experiments

3.1. Overview

We verified the model described in the previous section by observing the directions taken by participants at T junctions in a virtual maze under the existence of moving objects. The maze was created on a computer using 3DCG. In the maze, the participants could see everything around them through a head mount display (HMD) and they could walk around using a controller. There were some objects overtaking the participant in the maze. Their speed was about 4.5 m/s, which is the speed at which people run. There were about 5 objects in the participant's view. Figure 1 shows examples of the par-

DOI: 10.2312/egve.20181377

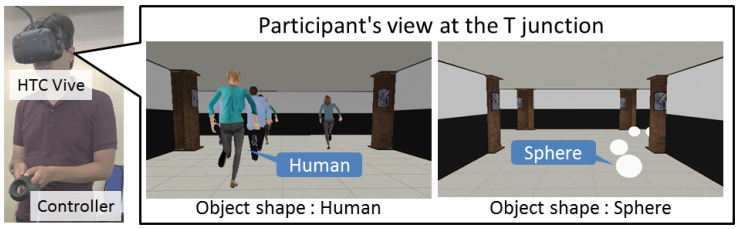

Figure 1: *The conditions of experiments and examples of the participant's view*

Table 1: *The number of the directions taken by participants*

Experiment 1

Setting	Object Shape	Same	Opposite
A	Human	104	14
B	Sphere	92	26

Experiment 2

Setting	Object Shape	Same	Opposite
C	Human	81	37

ticipant's view. We employed Unity for creating the virtual maze, and HTC Vive as the HMD and its controller.

Experiment 1 The purpose of Experiment 1 was to confirm whether the appearance of moving objects affected the following property. We prepared two appearances for the objects: a human and a sphere as shown in Figure 1. In this experiment, all objects turned to the same direction at a junction. Whether objects turned left or right was random at each junction. We used moving objects with a human shape for setting A and moving objects with a spherical shape for setting B. The participants proceeded unless they turned at up to 4 junctions for each setting. We counted the number of times that the direction in which the participants turned was the same as the direction in which the objects turned.

Experiment 2 The purpose of Experiment 2 was to confirm whether the participants followed the route with the majority flow. In this experiment, 80% of the objects, which was the majority, turned to one direction and the other turned to the opposite direction at a junction. Whether the majority turned left or right was random at each junction. We used moving objects with a human shape for setting C. The participants proceeded unless they turned at up to 4 junctions. We counted the number of times that the direction in which the participants turned was the same as the direction in which the majority turned.

3.2. Results and Discussion

In these experiments, we recruited 30 participants. Table 1 shows the results. "Setting" means the settings of each experiment, classified as A through C. "Object Shape" means the shapes of the moving objects. "Same" and "Opposite" mean the frequency of match or mismatch, respectively, at each junction between the participant's and the object's direction in Experiment 1 and the participant's direction and the direction in which the majority of objects proceeded in Experiment 2.

Experiment 1 First, we verified the effect of the existence of moving objects on the following property. As a test method, we employed Fisher's exact test and calculated p-values for each result. Assuming that they do not affect the behavior, the direction taken by participants at a junction should be random. For testing, we formed the null hypothesis that "the existence of objects does not affect the human behavior." The p-value between A and random and between B and random were less than 0.0001. Therefore, the null hypothesis was rejected. This suggests that people tend to follow moving objects regardless of their appearance, which counters Hypothesis 1. In addition, we assessed whether the following property has some relation with the appearance of the moving objects. We formed the null hypothesis that "the difference in appearance between human and sphere shapes does not affect behavior." The p-value between A and B was 0.051. As it was larger than 0.05, the null hypothesis was not rejected. This means that the effect of the difference in appearance was not confirmed.

Experiment 2 We verified the effect of the number of objects on the following property using Fisher's exact test for each result. As with Experiment 1, we formed the null hypothesis that "the number of objects does not affect human behavior" and calculated a p-value. The p-value between C and random was 0.0057. As it was less than 0.05, the null hypothesis was rejected. This suggests that people are apt to follow the majority, supporting Hypothesis 2. In addition, we assessed whether the following property has some relation with the number of objects. We formed the null hypothesis that "the difference in the bias of the number of objects does not affect behavior" and calculated a p-value. The p-value between A and C was 0.0042. As it was less than 0.05, the null hypothesis was rejected. This suggests that there is some correlation between the number of objects and the probability of the participant's selection.

4. Conclusions

In this paper, we clarified part of the behavioral characteristics, which are necessary for creating digital replicas of the physical world, using virtual reality. Without constructing an experiment environment in the real world, we conducted experiments allowing participants to select a route in a virtual maze. The results suggested that people tend to follow moving objects regardless of their appearance as well as the majority.

There are still some issues to be investigated on the following property such as the influence of the difference in appearance of moving objects. We will verify it by subdividing factors that affect the following property such as the object's size, speed, and so on.

References

[AG51] ASCH S. E., GUETZKOW H.: Effects of group pressure upon the modification and distortion of judgments. *Groups, leadership, and men* (1951), 222–236. 1

[FFPR95] FADIGA L., FOGASSI L., PAVESI G., RIZZOLATTI G.: Motor facilitation during action observation: a magnetic stimulation study. *Journal of neurophysiology 73*, 6 (1995), 2608–2611. 1

[HMN97] HAYASHI H., MUROSAKI Y., NISHIGAKI T.: Effects of passage illuminance and passage width on choice of egress route at a t-junction in a building. *JOURNAL OF ARCHITECTURE PLANNING AND ENVIRONMENTAL ENGINEERING* (1997), 1–6. 1

[Hok84] HOKUGO A.: Experimental study on escape direction – analysis of responses to pairs of slide projections. *Architectural Institute of Japan 339* (1984), 84–89. 1