A Study about Influence of Visual Cues and Immersion on Sense of Direction and Distance

Maximilien Bellot*, Masashi Okubo*

Abstract – This paper describes sense of direction in virtual space. In order to evaluate spatial orientation in virtual environments, an experiment has been conducted assessing distance evaluation and sense of direction in a 3D virtual environment. During the experiment, the participant goes through a random generated track from a first person perspective. After the participant reaches a goal, he or she must guess his arrival on a 2D map. This position is then compared with the actual arrival. The participant repeats this experiment under different conditions, with or without head-mounted display (HMD), and with or without visual cues like compass. As expected, usually the more there were visual cues, the better the participants guessed. However, there were no significant differences between the patterns with or without head-mounted display.

Keywords: Vection, Motion Perception, Illusions, Space Recognition

1. Introduction

The illusion of self-motion is typically what happens when someone who stands on a motionless train thinks the train is moving by seeing another train departing. This type of reaction has been studied since a long time, one of the first being Mach in 1875 [1]. To describe such phenomena, the word vection appeared. It has been defined as “a conscious subjective experience of self-motion” by Palmisano et al. [2]. In other words, vection is the feeling (illusion or not) of the body moving. According to Riecke et al. [3], like real self-motion, this illusion should enhance perspective switches and helps to reduce disorientation.

Therefore, on one hand, this experiment is about experiencing different levels of vection in a virtual environment to confirm or not that people would tend to be less disoriented with good vection. On the other hand, the effect of several visual cues on orientation has been evaluated in the same virtual environment navigation type to confirm if they help orientation.

2. Experiment

2.1 Process

In this experiment, participants go through an open track, made from succession of rings, at a first person view in a virtual environment as shown in figure 1 upper part. More specifically, participants are first presented a map with a long straight way that leads on a point called the starting point of the experiment. From this point, the track is generated randomly. When ready, participants navigate through the long straight part, then through the randomly generated circuit moving in the horizontal plane with only left-right rotations and forward translations. When going through the random generated track, the rings behind the participant disappear and the rings after are only seen when below a certain distance in order to prevent the participant from having visual landmarks from the track itself that could make some tracks easier to remember than others. At the end of the track, the participant has to show on the same firstly presented map where the arrival of the previous track is (see figure 1 lower part). This position is then compared with the real one.

This pattern is repeated under several conditions affecting the 3D environment and the feeling of self-motion. There are four conditions affecting the representation of virtual space. The first called “nothing” is made in order that it does not give any orientation hint during the pattern. The second called “compass” adds information about the orientation. It brings a compass to head-up display, and a skybox indicating the cardinal directions. The sun-typed lighting of the virtual scene has a little angle in order that the shadows of the rings in the scene change with their orientation. The third called “scale” gives a grid under the track in order to give an idea of the distance travelled. The last called “all” is a combination of the two previous ones. All the changes from the conditions on the map and on the first person view can be seen figure 1.

Additionally, all these conditions are performed twice, once with a head-mounted display (HMD), in order to bring more feeling of movement, and once in front of a classic computer screen. To facilitate the experiment’s progress, all conditions with the HMD are performed in a row, same with those without it. Nevertheless, the order of conditions inside a phase with or without HMD is defined randomly. After such row of conditions, the participants are required to note on a scale from 0 to 6 how strong they felt motion. Once, they rate for the conditions with HMD, once for the conditions without it.

*: Graduate School of Science and Engineering, Doshisha University

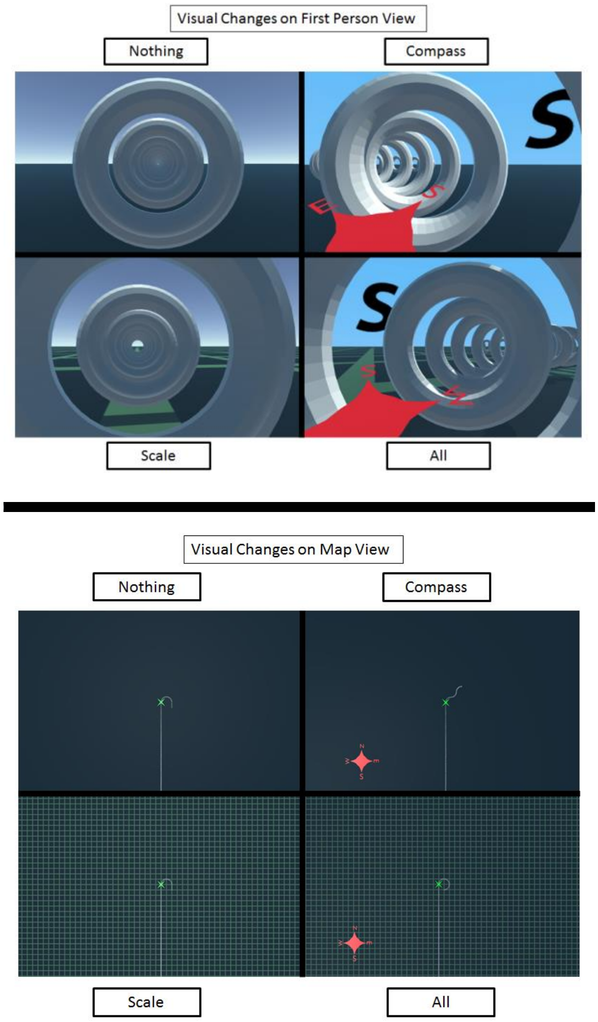


Fig.1 Visual changes from the conditions

2.2 Vection and Motivations

Different types of vection are distinguished according to the type of movement it represents. The intensity of movement felt differs from such types. According to Trutoiu et al. [4], rotations combined with linear translations give what is called curvilinear vection which gives approximately the same convincingness results as circular vection. This experiment is designed to take advantage of curvilinear vection to have compelling illusion with natural movements. The random generated track is generated with two parts: one straight and one in the shape of an arc of circle to go either left or either right as depicted in figure 2.

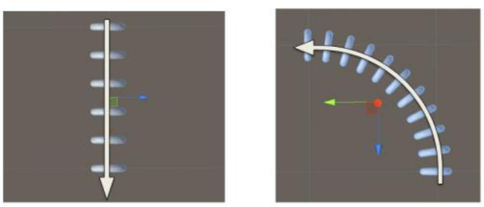


Fig.2 Parts of the random generated track

Vection is also known to be felt quite late in experiments with onset times varying from more than 10 seconds up to approximately 30 seconds depending on the type of vection studied [4]. Therefore, in order to already feel movement during the random generated circuit, the participant goes through a long straight part before during more than 30 seconds.

2.3 Experimental Tools

In order to add immersion, the HMD used in the experiment is the Oculus Rift DK2. It provides stereoscopic 3D and tracking information on the participant's head orientation and position through infrared system which can be used on a real time basis to move the viewpoint of a virtual scene according to the real movement of the participant's head to provide more immersion.

To create the experiment's program, the game engine Unity (version 5.2.3f1) has been used.

2.4 Data Collected from the Positions Comparison

At the end of a pattern, participants indicate their guessed position. This position is compared with the real one by computing a distance and an angle as depicted in figure 3. The distance has no unit as it is taken in a virtual space. However, the basic reference is that one straight part (figure 2) is of length 10. The angle is a measure comprised between 0° and 180° computed from the unsigned angle formed by the indicated point, the starting point from where the random generated circuit begins, and the actual arrival point.

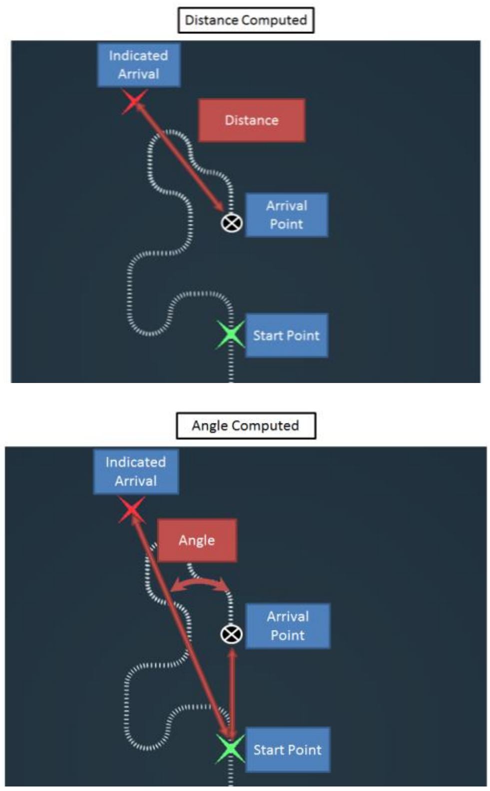


Fig.3 Comparison between indicated and actual arrival

3. Results

3.1 Participants

The 15 participants are all students from Doshisha University aged between 20 and 25. 10 participants experienced the Oculus Rift for the first time, 4 participants already had few uses with it and 1 participant used it often.

3.2 Evaluation of Motion

Figure 4 shows the results for sensation of motion with and without HMD.

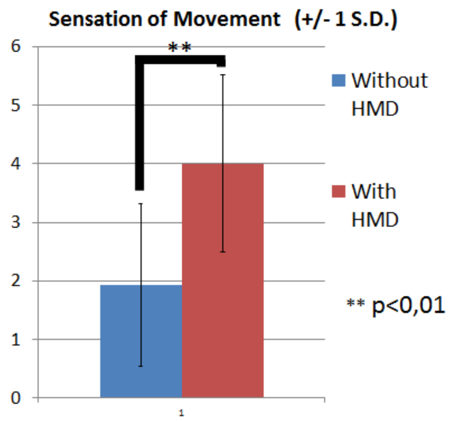
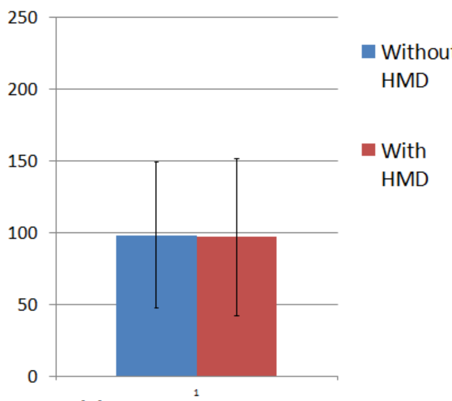


Fig.4 Results for sensation of motion

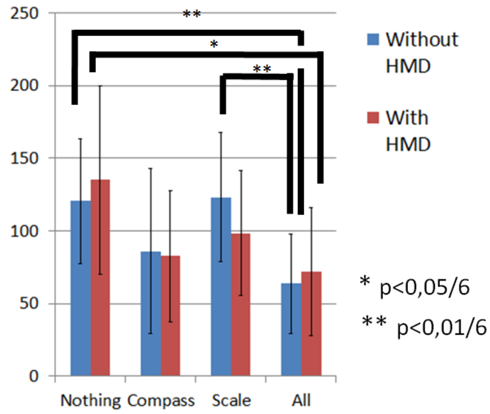
There is a statistical difference ($p<0.01$ according to Wilcoxon signed-rank test) between the sensation felt with and without HMD.

3.3 Distances and Angles

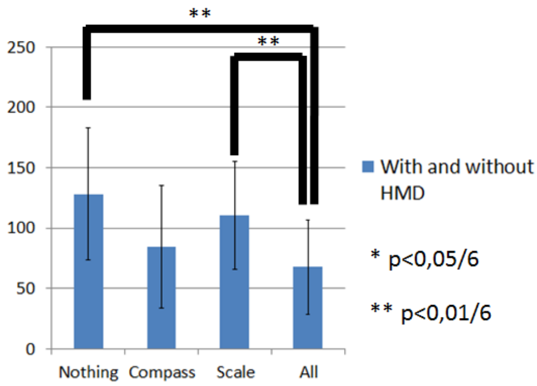
Figure 4 shows the average and standard deviation (S.D.) for the distance, between indicated arrival and actual arrival. First is presented the whole averages comparing with HMD and without it. Secondly is presented the average and standard deviation for each condition, with or without HMD. Last presents the whole average and standard deviation for each condition.



(a) Whole Average Distances (+/- 1 S.D.)



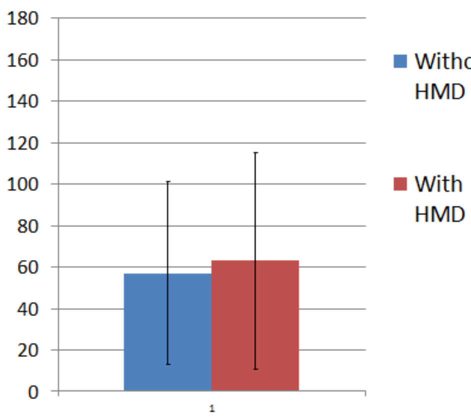
(b) Average Distances for Each Condition (+/- 1 S.D.)



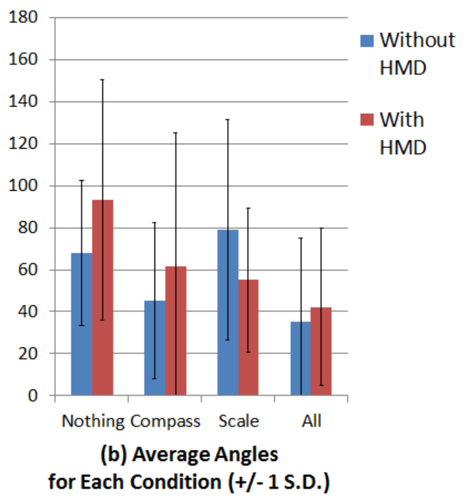
(c) Average Distances for Each Condition (+/- 1 S.D.)

Fig.5 Results for distances

Similarly, figure 6 provides the averages for the unsigned angle formed by the indicated arrival point, the starting point and the actual arrival point.



(a) Whole Average Angles (+/- 1 S.D.)



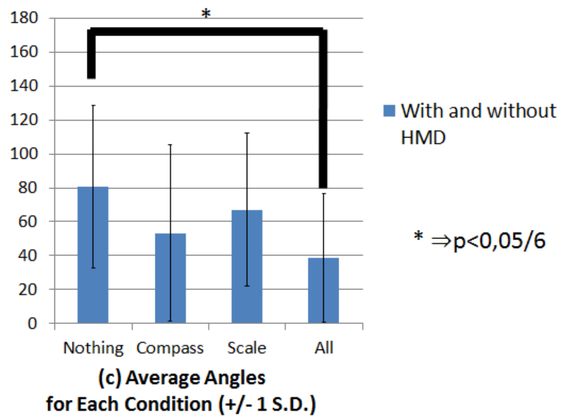


Fig.6 Results for angles

Statistical tests are done according to t-test with Bonferroni correction (6 comparisons).

4. Discussion

4.1 Sensation of Motion and Orientation

Surprisingly, though participants felt more the movement with HMD than without (figure 4), there is no significant difference for the whole averages (figure 5 and 6). According to Riecke et al. [3], better results were expected for the patterns with HMD. However, one can suppose that wearing such HMD perhaps confused some participants in the first place because they were not used to it.

4.2 Visual Cues and Orientation

According to the results from figures 5 and 6, because of the results and the statistical differences between "nothing" and "all", "nothing" tends to be the worst condition and "all" tends to give the best results has one could expected.

However, it seems that "scale" did not help much the participants. The grid's purpose was to give an idea of the distance one travelled but some participants reported that it was very difficult for them to use it. Furthermore, the real effect of helping the understanding of distances is quite difficult to extract from the results. As the aim was not to help the orientation but the distances travelled only, the more the mistake for angles is big the more it affects the present results in terms of distance.

Even if statistically there is no significant result it seemed that "compass" gave good results and several participants stated that they often used it.

5. Conclusion

Through this experiment, an evaluation of the sense of direction in virtual environment has been conducted using or not HMD, with several visual cues tested. Even if participants reported better feeling of motion with HMD, the results provided were not confirming that it helped orientation. However, as expected, significant improvements were found with help of visual cues compared to when there was none.

In further studies, it may be interesting to reconsider the way the direction was evaluated, either in modifying the protocol of the experiment or by considering another type of data to collect. Indeed, whereas such combination of angle and distance could report a possible improvement between no visual cues and all visual cues, it is difficult for the present data collected to report the real improvement of the two conditions "compass" and "scale" due to the influence of the distance error on the angles collected and the influence of the angles errors on the distances collected.

This study is also only limited to movements restricted to the horizontal plane. It may be interesting in future works to check the same type of hypothesis with adding up and down translations or rotations. Although it may be more difficult to evaluate and may less correspond to natural movements.

Acknowledgment

This work was supported by JSPS KAKENHI Grant Number 26560016.

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