Two different time scales of development of VIMS

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Abstract. The study investigated development of visually induced motion sickness, or VIMS, in time scale. In the experiment, a 20-minute movie was exposed to 125 participants; the movie was made with a 3D-CG environment in which camera motion was reproduced based on analyzed global motion of the movie inducing an incident in 2003 in Japan. The measurements were performed of (i) a subjective score of general discomfort every one minute during the exposure, and (ii) SSQ immediately before and four times every 15 minutes after the exposure. The results showed that the discomfort scores clearly increased transiently when the global motion components in the movie increased; moreover, the scores maintained larger values for a few minutes even after the global motion components decreased. We conclude that there are at least two components of developments of VIMS in time scale.

Introduction

Recent evolution of imaging technique makes movies more enjoyable and video games more attractive. The images are created and edited by computerized system, and therefore, the creators can easily produce visual images, which simulate motion and actions in virtually three-dimensional space. The evolutions have not only positive effects but may have also negative undesirable effects. The moving images possibly raise the chance for us to suffer from visually induced motion sickness, or VIMS. One of the typical examples may be the term, “3D sickness,” which is often used by video game players for expressing VIMS caused with playing games of which visual images are realistic and dynamic.

An actual example of the visually induced motion sickness was reported in mass media in 2003 in Japan in 2003 and 2006, although the latter is uncertain as to whether it was VIMS. About the incident in 2003, a junior high school students, total of 294, had watched a 20-minitute movie presented on a large screen in an auditorium during class. During and after watching the movie, approximately 50 students described symptoms of nausea, cold sweat, headache and malaise. The video movie was taken with hand-holding video camera, and includes frequent motion of pan, tilt, roll and zoom. Therefore, the symptoms described by students can be identified as VIMS.

To reduce the possibility for us to be suffered from VIMS while keeping attractiveness of visual images created by latest technique, we need to investigate the effective factors for the sickness. As Lo and So (2001) categorized, there are three possible factors of cybersickness: (i) how moving image is presented, (ii) who watches moving image, and (iii) what is presented as moving image. This categorization is important and can be applied also to VIMS. In the categories, the third item, ‘what is presented’, is my concern in the present study, because visual motion might be a primary cause of VIMS while the other factors will enhance or attenuate the VIMS.

The literature reported effects of image rotation along each of the three axes, yaw, pitch and roll, on visually induced motion sickness (Lo & So, 2001; Ujike, Yokoi & Saida, 2004; Ujike, Ukai & Saida, 2004; Ujike, Kozawa, Yokoi and Saida, 2005). In our previous studies, we found that (i) visual roll motion can be the most effective and visual yaw motion can be the least effective, and (ii) a certain range of rotational velocity is effective for VIMS. Ujike, Yokoi & Saida (2004) showed that when the visual motion was one-directional rotation along each of the three axes, roll, pitch and yaw, the sickness-related scores were higher for the rotation speed ranging from 30 to 70 deg/s than for the other higher or lower speed, irrespective of the types of rotation, such as yaw, pitch and roll. Moreover, Ujike, Kozawa, Yokoi & Siada (2005) showed that when the visual motion was reciprocal rotation, the sickness-related scores can be mainly determined by velocity, but not frequency, and the velocity range that induced higher subjective scores depend on the rotation axes. For the effects of different types of rotation, the results analysed for individual participants by Lo and So (2001) showed that the roll axis oscillation had the highest value of mean nausea rating, while they focused on the fact that the yaw axis oscillation had the lowest rating value.

The visual motion of which effects were investigated was simple rotation, as described above. However, visual motion components usually included in video movies are very complicated. Therefore, to investigate effects of visual motion components included in video movies, we need to use those video movies that people watch in daily life.

In the present study, the experiment examined the effect of global motion combinations in time scale on VIMS, presenting global motion that was analyzed from the video movies that induced the incident in the local junior high school in Japan in 2003.

Methods

Visual stimulus. The stimulus was video movie that was comprised of five-minutes gray image, 20-minutes video footage, and another two-minutes of gray image, which were pre-sented in this order.

We used a 20-minutes video footages, which was made as CG movie of virtually produced city scene (Figure 1). The image was textured to inside wall of a sphere, at which center a virtual camera was set to make a movie image.

The camera motion in the CG movie was basically reproduced based on the camera motion estimated in the video movie that induced the incident in Japan in 2003. The camera motion was obtained by analyzing the global motion components of the video movie. The analysis was in two steps. First, local motion components between each frame was obtained. The local motion components were motion vectors calculated at each points of 16 x 16 matrix on the image. Second, global motion components between each frame was obtained based on the local motion components. The global motion components obtained in the study were yaw, pitch, roll, and zoom, which correspond to

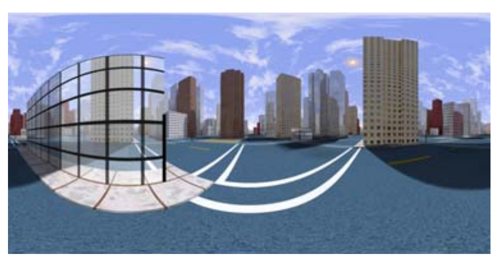

Figure 1. City scene textured to a sphere.

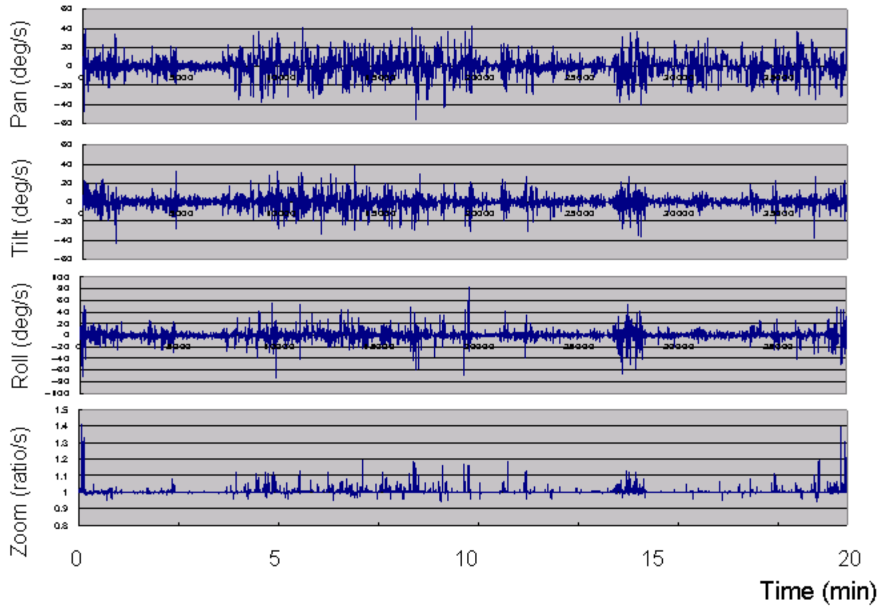

Figure 2. Camera motion used to obtain a 20-min movie, which was obtained by analyzing the global motion components of the video movie.

pan, tilt, roll and zoom as camera motion. The global motion calculated is shown in Figure 2.

Apparatus. Four different small experimental booths were set up side by side; each of the booths was mostly enclosed by blackout curtain, was set up with a LC display, the chin-, head- and arm-rests, with a viewing distance of 1.0 m. There were two dif-ferent size of the LC display, 20 inch (or 22.7 x 17.0 deg) and 37 inch (or 34.1 x 25.9 deg).

The height of the LC display was adjusted so that the center of the display was the same as vantage point of observers. The experimental room was light-proofed, and the light other than the display was turn off during the experiment.

On one of the armrest, a response box was fixed. The response box has a button and a four-way joystick. The button was pressed when a small red dot was appeared for a short period on a movie image, in order to keep the observers eyes on the display screen. The joystick was used for observers to evaluate discomfort in a four point scale.

Observers. Thirty-three adults, aged 19-52 years (36.2+/-8.7 years; 24 females and 9 males), participated in the study as observers, after giving their informed written consent in accordance with the Helsinki Declaration, and were free to withdraw at any time during the experiment. The study was approved by the Ethics Committee of the National Institute of Advanced Industrial Science and Technology. The observers were naïve as to the purpose of the experiments, and had normal or collected-to-normal visual acuity.

Procedures. Before the experiment, each of the four different movie was allocated to different ob-servers, so that total number, gender, age and susceptibility to motion sickness of ob-servers are almost equally appeared in each movie. Susceptibility to motion sickness was self-reported by each observer before the experiment.

The experiment was mostly done using all four different stimulus displays (the two for 20 inch, the other two for 37 inch) simultaneously, depending on observers’

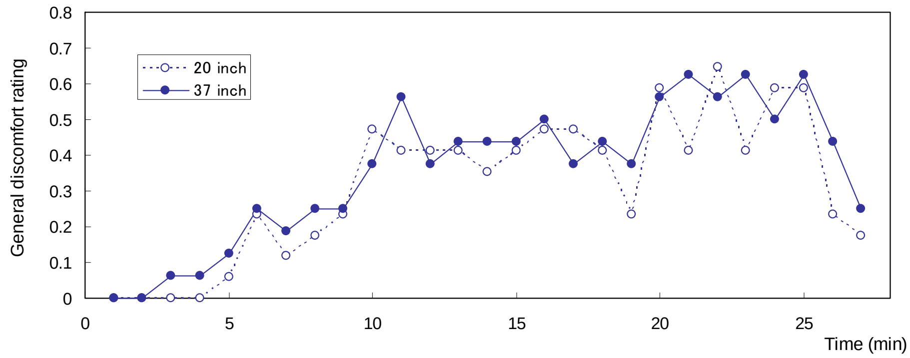

Figure 3. General discomfort ratings as a function of time in a trial. The data were averaged across participants for each display size.

participation. Each experimental session started with asking observers to do Simulator Sickness Questionnaire, and then, observers fix their heads at chin- and head-rests, and their arms on armrests. They watched the video movie for 27 minutes; during this time, observers were asked, every one minute, to report about one of SSQ score, "General discomfort" in four alternatives: "None," "Slight," "Moderate," and "Severe"; they report the score using the four-way joystick. The observers also need to respond by pressing the button on the response box when a small red dot was appeared for a short period on a movie image; the position and time (three times every minute) of the appearance of the was randomized. Just after finishing watching the video movie, they started, again, SSQ, and then they did it another three times every 15 minutes.

Results

General discomfort ratings. The averaged data among participants for each of the display size are shown in Figure 3. In the graph, the time period in which the video movie was presented is from 5 to 25 min. The graph shows that the discomfort rating increased gradually after the video movie started at 5 min. The rating value reached a first peak at around 10 to 11 min, and then, the value continued to be a constant for several minutes. After this flat, the value seems once decreased, and then, it becomes more higher values from 20 to 25 min. These temporal change does not depend on the different display size. Therefore, the temporal change of the value might be correlated with changes of visual motion components, which will be examined in the discussion section.

Simulator Sickness Questionnaire. The total scores of the SSQ are shown in Figure 4, as a function of measurement time. As is expected, the TS becomes the highest immediately after watching the movie, and it gradually decreased with time.

There is no clear difference of TS between the different display size. One possibility may be that the participants in the size of 20 inch may be more susceptible to VIMS, because the ratio of people reported her-/himself as susceptible to motion sickness was a little bit higher for 20 inch

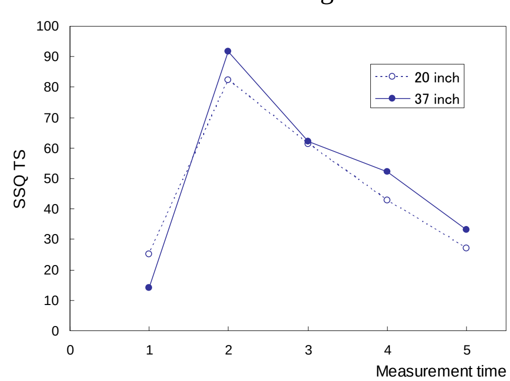

Figure 4. Simulator Sickness Questionnaire Total Score as a function of measurement time.

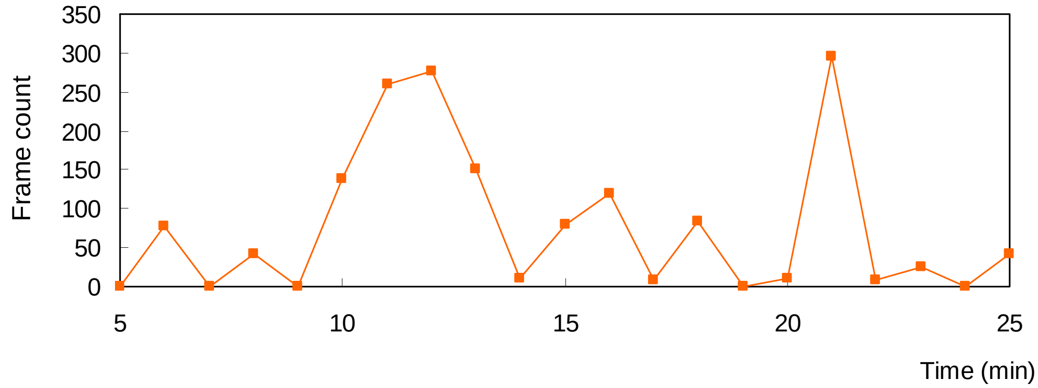

Figure 5. Number of frames that inculdes global motion of which velocity exceeds the value determined by the data obtained in our previous research (Ujike, Kozawa, Yokoi and Saida, 2005)

than for 37 inch. Therefore, the data of the general discomfort ratings from two different display size condition will be merged for the discussion in the next section.

Global motion analysis. To examine the effect of global motion components included in the video movie on the general discomfort ratings of participants during watching the movie, I quantified the amount of global motion components based on the basic data of sickness-related subjective score as a function of reciprocal rotation velocity along each of three axes, yaw, pitch, and roll, and also zoom. The analysis was performed as follows: First, the each of the global motion velocity was averaged for 0.5 sec, because of the integration time of the global motion reported in the previous literature. Second, the frame was count if the averaged velocity exceeds a certain value more than 0.5 s, or 15 frames; this count was performed separately for each of the global motion. Finally, the frame count was summed every one minute for all the global motion. The result was shown in Figure 5.

The graph shows that the frame count clearly increased between 10 and 13 min., and also at 20 min. after the movie was started. These time zone seems consistent with those of the general discomfort ratings increased, which shown in Figure 3.

Discussion

Comparison between general discomfort ratings and global motion components. As we see in Figure 3 and Figure 5, the increment of the general discomfort ratings and the number of frames that include effective velocity of global motion components. Thus, I re-plotted both data in a single figure, Figure 6. The graph shows that the time around which the general discomfort rating increased was consistent with the time of the frame count increased; in particular, 10 and 20 minutes after the trial started. However, the general discomfort rating keeps the value for a few minutes; from 11 to 18 min after the peak of the frame count at 10 min, and from 22 to 25 min after the peak of the frame count at 21 min. This indicates that there are at least two temporal components for developments of VIMS.

To look at this more closely, the frame count was averaged across eight minutes with some weights, and calculated the difference between such integrated sum and the general discomfort ratings. This is shown as “Difference” data in Figure 6. As

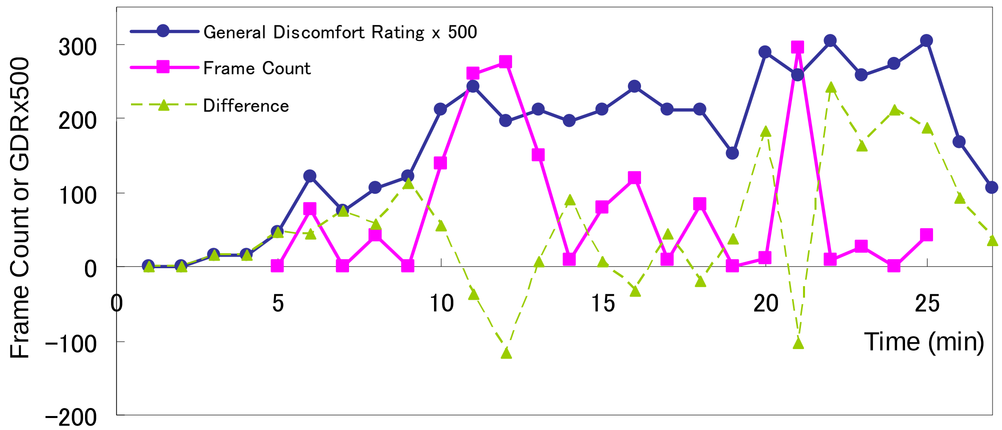

Figure 6. Comparison of the general discomfort rating and the number of frames that includes effective velocity of global motion components.

it can be seen, the value was around zero from 10 to 19 min, which indirectly supports the two components; however, the value increased clearly from zero after 21 min, which may indicate that there is another accumulating components.

Conclusions

There are two possible time components of development of VIMS: transient and sustained. We may also need to consider another effect of accumulation of exposure to visual motion.

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References

Lo, W. T., & So, R. H. Y. (2001). Cybersickness in the presence of scene rotational movements along different axes. Applied Ergonomics, 32 (1), 1–14.

Ujike, H., Ukai, K., and Nihei, K. Survey on Motion Sickness-like Symptoms Provoked by Viewing a Video Movie during Junior High School Class. Displays (in press).

Ujike, H., Yokoi, T., and Saida, S. (2004). Effects of virtual body motion on visually-induced motion sickness. Proceedings of the 26th Annual International Conference of the IEEE EMBS, 2399-2402.

Ujike, H., Ukai, K., and Saida, S. (2004). Effects of motion types and image contents on visu-ally-induced motion sickness. Transactions of the Virtual Reality Society of Japan, 9 (4), 377-385.

Ujike, H., Kozawa, R., Yokoi, T., and Saida, S. (2004). Effects of rotational components of yaw, roll and pitch on visually-induced motion sickness. Proceedings of the 11th International Conference on Human-Computer Interaction.