Augmented Reality, Diminished Reality and Reduced Reality

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ABSTRACT

The concept of Augmented Reality (AR) have basically aimed to provide a view augmented expression than a view of real world to user. In existing AR systems, the most common AR method of information support is to empower the user's field of view by "making invisible things visible" when the user wears a headset system combining a Head Mounted Display (HMD) and a Head Mounted Camera (HMC). In this paper, we explain the concept of Reduced Reality, which considers a specific areas of the field of view as unimportant to the user as visual noise, and reduces their presence to improve concentration and stress. Also, we introduce the visual noise-canceling head-mounted display (NCHMD) that embodies the concept of Reduced Reality.

1 Introduction

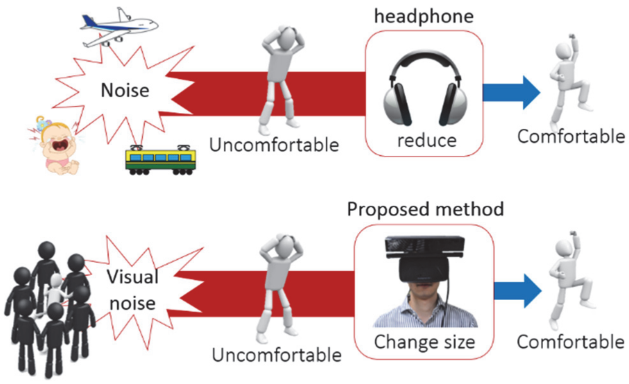

Fig. 1 Concept of Noise Canceling HMD

The concept of Augmented Reality (AR) have basically aimed to provide a view augmented expression than a view of real world to user. In existing AR systems, the most common AR method of information support is to empower the user's field of view by "making invisible things visible" when the user wears a headset system combining an HMD and a Head Mounted Camera (HMC). This is considered to be the equivalent of nearsightedness in usual eyeglasses. In general, there are various types of eyeglasses for various purposes. For example, sunglasses are used to "prevent bright sunlight" and "avoid high-energy visible light from damaging or discomforting" for the eyes. Therefore, in this research, we are considering applying the concept of sunglasses to an AR headset system. By applying the concept, we believe that we can realize new research field or at least applications of HMDs, such as "not to get tired of excessive visual information," "not to be disturbed by real visual information," and "to concentrate on a specific object by suppressing unnecessary visual information". The relationship between a normal AR HMD and a NCHMD with the concept of Reduced Reality (Fig. 1) is similar to the relationship between myopic glasses and glare dampening sunglasses. This paper describes Reduced Reality, which is a new concept of reducing a specific part of field of view that is less important to users.

2 Reduced Reality

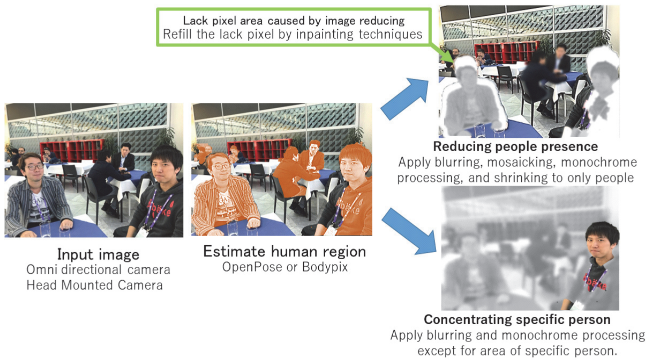

Fig. 2 How to implement Reduced Reality.

With the development of Diminished Reality (DR) technology [7], it is possible to erase certain objects in a video image without any a feeling of wrongness. However, in case of erasing people and objects in the field of view by using DR technics simply, the risk of collisions with people and objects may increase. For example, if some techniques of DR erase "warning signs such as road signs and billboards," "moving objects such as cars and bicycles," and "people who are talking to us," the information we can obtain from our field of view will be erased totally. And then, it is assumed that erasing something in the field of view may cause some problems in our daily and social life. Therefore, instead of simply erasing people and objects in the field of view, we considered applying a method to reduce their visibility and presence. In the early stage of how to realize Reduced Reality, we are considering blurring, mosaicking, monochrome processing, shrinking, and translucent processing as shown in the right side of Fig.2. In the next stage, we will implement some attenuation processing based on visual saliency. In the future, controlling the gazes directed at users from others, a field of view can be set to surveillance environment from other people intentionally.

Based on the concept of Reduced Reality, the system uses attenuation rather than elimination of visual noise to prevent dangerous situations such as collisions in daily life from occurring or being triggered. In addition, as shown in the right side of Fig. 2, even if the noise is attenuated, the user can still guess the information roughly in the field of view and be aware of changes in the surrounding situation.

In the same way that the icons on the home screen of a smartphone vary greatly from person to person, we expect that setting HMDs, which are a more personal media compared to current smartphones, will be required to display information based on more and more personal preferences. We believe that in the future, people with wearing HMD are supposed to control their own field of view of daily lives.

Currently, such customization of the real-world view has been along with the basic concept of AR, which is to superimpose a visual information in the field of view. Existing research has mostly enhanced or added visual information to user's field of view. On the other hands, the concept of Reduced Reality, which reduces the visual presence of unimportant areas in the field of view as visual noise, can be seen as new visual information filtering. This means that Reduced Reality may be useful in the same way that spam filters are useful in e-mail.

As mentioned above, the relationship between concepts of current AR and Reduced Reality is similar to the relationship between myopic glasses and bright sunlight attenuating sunglasses. We believe that a new concept of reducing the less important visual areas for HMD users stimulate existing visual aid research field.

As one example study of controlling own field of view based on Reduced Reality concept, we developed an immersive video see-through HMD system (Fig. 3). It allows to adjust person size in the field of view of HMD. It is possible to reduce the discomfort caused by inappropriate interpersonal distance. In the next section, we explain the Noise canceling HMD system.

3 Controlling the interpersonal distance using the virtual body size

Maintaining a personal space is an important factor in leading a comfortable social life. Robert Sommer defined a personal space as an area that has an invisible boundary around the person to keep other persons out [1]. The range of personal space is always changing according to the environment, and even in the same environment, the appropriate distance differs with different persons. People, especially those who prefer far interpersonal distance, feel stress in a crowded place [2]. Because of these factors, it is difficult to constantly maintain an appropriate interpersonal distance. Many people feel uncomfortable in a crowded train or a small elevator because they cannot keep an appropriate interpersonal distance from others. Though these are extreme cases, these kinds of discomfort often occur in daily life.

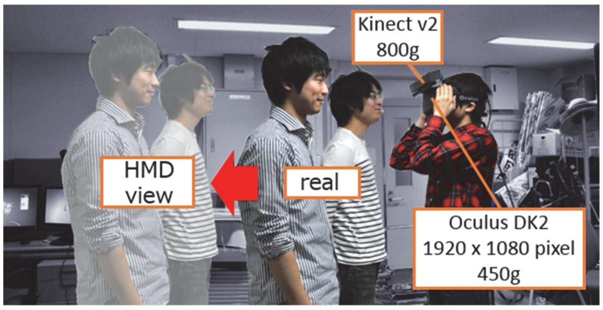

Fig. 3 Controlling the interpersonal distance using the virtual body size

In this study, we focus on Augmented Reality (AR) to reduce discomfort caused by inappropriate interpersonal distance. AR is a technology that overlays Computer Graphics (CG) on the real world. There are two ways to solve the problem instantly using AR. One approach is to diminish persons in a user's view so that the user does not feel uncomfortable. However, collision risks are increased because the user cannot determine how close another person is. It is dangerous to use this method in daily life. The other method is to replace the person with another person visually so that the user can remain at the same distance without discomfort and without collision risks. One problem with this solution is that the user cannot determine who is in front of him or her, and therefore cannot maintain an appropriate social relationship. It is difficult to lead a commonsensical social life with these methods. In this study, we try to remove discomfort caused by inappropriate interpersonal distance without changing the social relationship or environment. We propose a method that changes the size of persons in a head-mounted display (HMD) view to control interpersonal distance. To confirm the effectiveness of our method, we propose a video see-through system consisting of an HMD and an RGB-D camera as a concept prototype (Fig. 3). We implemented the proposed system for experimentation only; this system cannot be used in the real world without improvement.

3.1 Noise Canceling HMD

We implemented a head-mounted system as shown in Fig. 4. The system consists of an HMD (Oculus Rift DK2 450g 1920×1080 pixel) and an RGB-D camera (Microsoft Kinect v.2, 800g, depth: 512x424, color: 1920×1080). The proposed system controls the visual size of a person with simple image processing.

We only considered about reducing human size, however, enlarging might also be effective in some situations. Therefore, we implemented both function of reducing human size and enlarging human size. The entirety of image processing and controlling input/output is performed by a laptop (Alienware 14, Core i7-4700MQ 2.40GHz, RAM: 16GB, NVIDIA GeForce GTX 765M GDDR5: 2GB). The proposed system changes the size of the person in the HMD view by following steps. First, we acquire an RGB image and extract a human region from the image according to depth information.

To extract the human region, we use information of "bodyIndex" from the "Kinect for Windows SDK" [3] . The proposed system enlarges or reduces only the human region and outputs the processed image to the HMD. Image processing is performed by functions of OpenCV 2.4.13 [4].

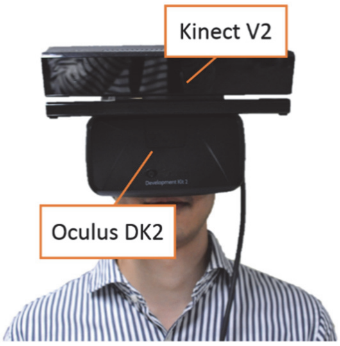

Fig. 4 Appearance of Noise Canceling HMD

If simply enlarging a square area that contains the human region, an unnatural boundary occurs, and the background becomes inconsistent. To avoid this problem, we redraw the original size background to a non-human region. Finally, a natural output image (1920×1080, not a stereovision) is extracted. When reducing the size, the system reduces the square area containing human region and redraw the original background to the non-human region, as is done with enlarging.

When the size of the person is changed, we cannot obtain the background behind the original human region. We cannot draw an appropriate background because pixels in this area contain no information regarding the covered background. Therefore, we refill the original human region using the inpainting function (based on Navier01) of OpenCV. The output image is slightly more natural than the inconsistent background. Thus, we use this image for the background image of the proposed system.

We consider that if the size of the person is changed in the HMD view, users tend to feel like the interpersonal distance is changed. We assume that we can reduce discomfort caused by inappropriate interpersonal distance by controlling the visual distance.

3.2 Experiment

This study is based on the premise that the visual distance changes according to the size of the person in the HMD view. Also, we assume that controlling the visual distance reduces discomfort caused by inappropriate interpersonal distance. It is known that an impression of a person changes according to the size of the person in static photographs [5]. However, there is a possibility that the impression of a person watched through HMD is not the same as in static photographs. Therefore, we must confirm that our method can reduce discomfort without greatly changing the environment. Thus, we conduct an experiment to confirm that the proposed system can reduce discomfort by controlling the size of the person. The system used in this experiment marked 10–15 frames per second (FPS), and latency was within levels that does not lack minimal reality.

After the preliminary experiment [6], we conducted a main experiment to confirm that the discomfort caused by inappropriate interpersonal distance was reduced by the proposed system. In addition, we proceeded to investigate whether the proposed system works satisfactorily when there was more than one person because insufficient interpersonal distance often occurs in crowded places. Hence, we placed two persons in front of the subject in the main experiment. We conducted the experiment in the following steps:

1. A subject wore the proposed system and faced the two persons who were targeted for resizing (targeted persons). The targeted persons maintained sufficient distance from the subject.
2. The targeted persons moved closer to the subject until the subject felt uncomfortable.
3. The subject changed the size of the targeted persons with the proposed system.
4. The subject answered a questionnaire about his or her impression.
5. The subject repeated steps 3–4 using four different sizes.

To separate factors of discomfort from a person's appearance, such as body height and some other impressions among participants, we fixed two persons as targeted persons throughout the experiment. The targeted persons were male, aged 23 and 24, and 181 cm and 178 cm in height. Fifteen subjects (fourteen males, one female), ranging from 22 to 25 years of age and from 163 to 183 cm in height, participated in this experiment. The size magnification was ×1.0 (original size), ×0.9, ×0.8, and ×0.7. These magnifications were determined based on the preliminary experiment [6]. The images generated with these magnification ratios provided a quite natural feeling to the subjects in the preliminary experiment. The subjects watch the targeted persons with all sizes in advance to get accustomed to the feeling of each size. This was done to prevent confusion caused by changes in the view after each resizing operation and any resulting fluctuation in the evaluation. Each subject was shown the size magnifications in different orders to prevent order effect.

In the questionnaire, we asked the subjects to provide seven different impressions: "Uncomfortable/Not uncomfortable", "Close/Not close", "Feels pressure/Does not feel pressure", "Awkward/Not awkward", "Offends the eye/Does not offend the eye", "Feels real/Does not feel real", and "Strange-Not strange".

The subjects evaluated these impressions for each of the four sizes. The question about reality and strangeness were mean to confirm how reality is modified by using the proposed system; the other questions were to confirm the capability of the proposed system to decrease discomfort.

After the main procedure, we asked “Did the system reduce the discomfort?” and “Which was the most comfortable size?” in interview.

3.3 Result and Consideration

We obtained similar results for “Uncomfortable/Not uncomfortable”, “Close/Not close”, “Feel pressure/Does not feel pressure”, “Awkward/Not awkward”, and “Offends the eye/Does not offends the eye”. These five items showed the same tendency. The original size’s evaluation value is the lowest for each evaluation. As the size becomes smaller, the evaluation value rises. The size ×0.7 shows the highest evaluation value. In the final questionnaire, fourteen of fifteen subjects chose ×0.9, ×0.8, or ×0.7 as the most comfortable size.

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The details are as follows:Four subjects chose ×0.9, eight subjects chose ×0.8 and one subject chose ×0.7. The one subject who did not choose these sizes answered that there were no differences among all the sizes. Also, fourteen subjects chose “Yes” for the question “Did the system reduce the discomfort?”

Feels real / Does not feel real and Strange / Not strange showed a similar tendency. However, this is different from the tendency of the five items previously described. The evaluation value for size ×0.7 is the lowest. As the size becomes bigger, the evaluation value rises. The original size shows the highest evaluation value.

Five evaluation items for proposed system’s capability of reducing the discomfort showed the same tendency: the evaluation scores increased as the size of the person was reduced. This indicates that the proposed system can reduce discomfort caused by inappropriate interpersonal distance. This tendency was also observed in the preliminary experiment. The proposed system is useful when there is more than one person in the field of view. In the questionnaire, almost all subjects chose a size that was different than the original size as the most comfortable size. According to this result, the proposed system worked efficiently.

In this study, we used only simple image processing for the proposed system; however, it worked efficiently and proved that our concept is useful. The proposed system changes only the size of the person and preserves other environmental information, which we consider to be a large contribution of this study. We expect that high technology such as DR [7] will improve the proposed system’s capability.

The point of the concept of NCHMD is that discomfort caused by inappropriate interpersonal distance is reduced while maintaining a sense of realism.

As a result, we found that the evaluation of “Close/Not close”, “Feel pressure/Does not feel pressure”, “Awkward/Not awkward”, and “Offends the eye/Does not offends the eye” showed the same tendency: evaluation became better when the size of the person was reduced. This means that even the prototype system, with simple image processing, can reduce discomfort caused by inappropriate interpersonal distance.

4 Conclusion

The NCHMD with concept of Reduced Reality can reduce discomfort caused by inappropriate interpersonal distance without significantly changing sensory information, unlike typical AR methods such as the diminishing of all people or replacement of persons with others. We expect that if we can solve the problems of the device size and weight in future, the concept is useful in a crowded place like a train or a small elevator. However, a collision risk is still remaining. Therefore, it is difficult to use our proposed system while moving in the present circumstances.

We believe that this concept of Reduced Reality can be applied not only for real world but also for virtual situation such as remote collaboration work.

Acknowledgment

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