Available online at www.sciencedirect.com

ScienceDirect

Procedia Social and Behavioral Sciences 2 (2010) 125–128

Procedia
Social and Behavioral Sciences

Security Camera Network, Privacy Protection and Community Safety

An installation of privacy-safe see-through vision

Masayuki Hayashi[*], Ryo Yoshida[*], Itaru Kitahara[*], Yoshinari Kameda[*], Yuichi Ohta[*]

[*]*University of Tsukuba, Tennoudai 1-1-1 Tsukuba, Ibaraki 305-8573, Japan.*

Received November 13, 2009; revised December 4, 2009; accepted December 10, 2009

Abstract

A number of surveillance cameras are in operation for security in outdoor scene in our modern community. However, it is often criticized for privacy problem. Our previously proposed see-through vision is a system that provides benefit for ordinary people who might be subjects of surveillance cameras. It enables people to see-through obstacles and watch places behind them. Since the see-through vision is a powerful tool that may violate privacy of other people, we then need a good solution that can make a good balance between the benefit and the privacy. In this paper, we propose privacy-safe see-through vision. Technically, we utilize a marker-based camera tracking for achieving the see-through vision which makes our system more reliable and easy set-up. We have demonstrated the system in a shopping mall in Kyoto. Comments from ordinary visitors indicate the system serves as what it is intended to be.

Keywords: Sensing-web; Outdoor Mixed Reality; Privacy Control;

1. Introduction

Increasing number of surveillance cameras has realized better public security in our society. However, as there are no other apparent benefits to ordinary people who are monitored by these cameras, it is often criticized by the negative effects of monitoring as a privacy problem. In order to ease the criticism and make our life better, a new service on which people can directly feel the advantage of the existence of these cameras should be delivered. We have proposed see-through vision(Kameda et.al., 2004) that empowers ordinary people with the cameras. It enables people to see-through obstacles and watches a variety of places behind them. However, since the see-through vision is powerful, it may violate privacy of other people. Therefore, we need a good solution that makes a good balance between the benefit and the privacy.

We propose a privacy-safe see through vision (P-S Vision for short) which utilizes images of the cameras (we won't call the cameras "surveillance cameras" because they are beyond the surveillance cameras). This new and unique enhanced vision lets people directly recognize the good aspect of the camera existence. P-S Vision is privacy-safe because we designed the system to work only when the privacy is not violated.

E-mail address: {mhayashi, yoshida}@image.iit.tsukuba.ac.jp, {kitahara, kameda, ohta}@iit.tsukuba.ac.jp

10.1016/j.sbspro.2010.01.025

P-S vision is an extended system of original see-through vision(Kameda et.al., 2004). The original see-through vision is a mixed reality (MR) based service that allows users to see objects behind occluders such as walls, covers, etc. The system combines the real world image and computer graphics image by a MR technique. Users hold a mobile computer that has a video camera (mobile camera) on it and direct it to occluders. Then they will see objects behind the occluders on the screen of the mobile computer.

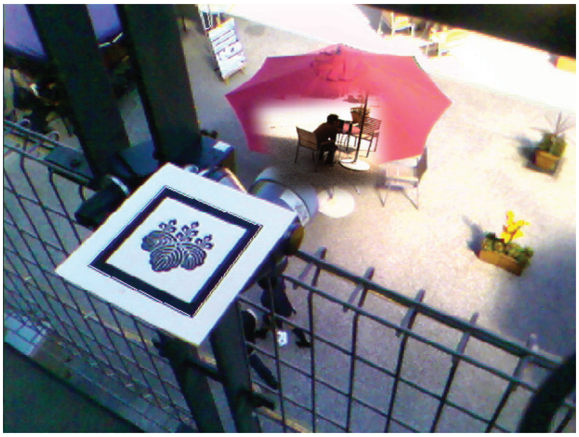

Fig. 1: An snapshot image of see-through vision. User can watch invisible space by the images from environmental camera.

Our system provides a privacy-safe vision. If the subjects of environmental camera have some relationship with the user, in other words if they share the same privacy level, the system shows clear and detailed images of the subjects obtained by environmental cameras on line (Fig. 3(a)). If not, that means the subjects are not the acquaintances of the user, the system shows blurred images and put human shaped icons (Fig. 3(b) and (c)). This privacy-safe presentation requires identification mechanism of subjects that will be given by a technological result of the "Content Engineering for Social Use of Sensing Information"(Minoh et.al., 2008).

We had demonstrated the system in a shopping mall in Kyoto. To realize our system, the system needs to know extrinsic parameters of both the environmental cameras and the mobile camera to synthesize the see-through vision images by a MR technique. We used ARToolkit (Kato et.al., 1999) and devised indirect parameter estimation for placing the subjects at right position.

2. Privacy-Safe See-Through Vision

The system consists of a mobile hand-held device with a video camera and some environmental cameras, and both are connected via a sensor network given by (Minoh et.al., 2008). Fig. 2 and 4 shows an example situation of our scenario; there are some parasols on the ground level and a user is at a higher level. If the user wants to see the spaces beneath the parasols in order to find free space available and/or in order to know how his/her acquaintances are resting, he/she directs the mobile device to a parasol. An environmental camera shooting beneath the parasol captures an image and extracts an appropriate image segment. If the subjects are his/her acquaintances, the segment is sent to the mobile device so as to enhance his/her view (Fig. 4(c)). On the other hand, if they are not, our system then provides a privacy-safe visualization of which the procedure is shown below. It consists of two steps as illustrated in Fig. 3. At first, the image segment captured by the environmental camera is blurred to make it impossible to recognize any objects in the scene and it is sent to the mobile device. Then the system places human shaped icons over the blurred segment so that the user can count how many people are there.

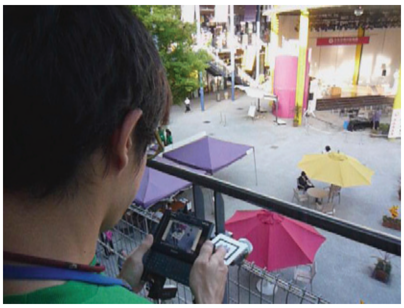

Fig. 2: An example situation. A user wants to see through a parasol.

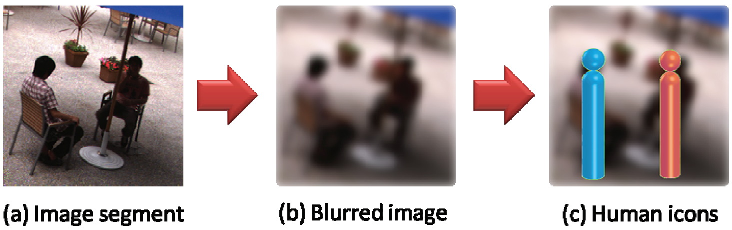

Fig. 3: Process of privacy-safe visualization. (a)An image segment captured by environmental camera. (b)Blurred image to make recognition impossible. (c)Human icons.

3. An Installation of Marker-based Camera Tracking

To realize privacy-safe see-through vision, we need to align image segments of the subjects to the right position in 3D space. Therefore, we need to calibrate both the environmental cameras and the mobile camera. We exploit ARToolkit(Kato et.al., 1999) and prepare two markers. Large one is temporally set for estimating the relationship between the environmental camera and the mobile camera, and the small one is permanently set in front of the mobile camera. We assume a situation illustrated in Fig. 5. There is a parasol on the ground level and a user is at the second floor. An environmental camera is shooting the target space beneath the parasol where the user cannot see directly, since the parasol occludes the space. As for preparation, we first put a large AR marker on the ground in order to let the system estimate the position of the target space under the parasol by ARToolKit. The large marker should be visible by both the environmental camera and the mobile camera. Then a small AR marker, which is used to estimate the motion of the mobile camera, is set rigidly in front of the mobile camera. Note that both markers should be visible at the mobile camera at the same time in our preparation step. We call the coordinate system of the mobile camera M and that of the small marker E. The origin of E is given by the center of the small marker.

Since the system now knows the position of the large marker and that of the small marker in M and ARToolKit can estimate the position of the mobile camera in E by observing the small marker only, it can always estimate the position of the target space in its image frame. As the large marker is not needed any more, it can be removed.

Since the ARToolkit has a low accuracy in vertical direction of the markers(Pentenrieder et.al., 2006), it is better to align the normal vector of the two markers when they are at large distance. Otherwise low accuracy in vertical direction takes bad effects to reduce accuracy of calculating the position of the target space.
Image segmentation on the environment camera is done by setting a rectangle at the position of the large marker. As both the environmental camera and the target space which is formally designated by the large marker are both fixed, the rectangle could be permanently set. After the privacy-safe image process described in section 2 is applied, the segment is finally fit to the virtual billboard, which is defined by the vertical board facing squarely to the mobile camera.

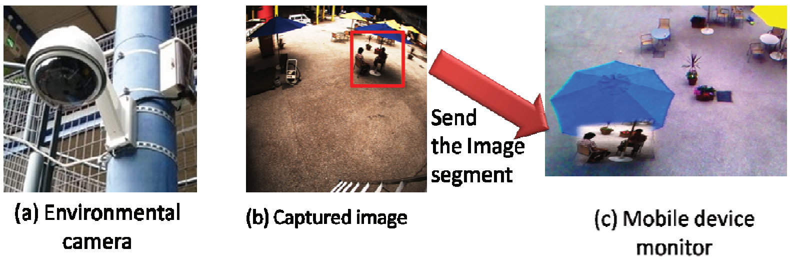

Fig. 4: An example situation of our scenario. (a)Environmental camera shooting space beneath a parasol. (b)The image segment extracted from the environmental camera image. (c)The image segment superimposed on the mobile device.

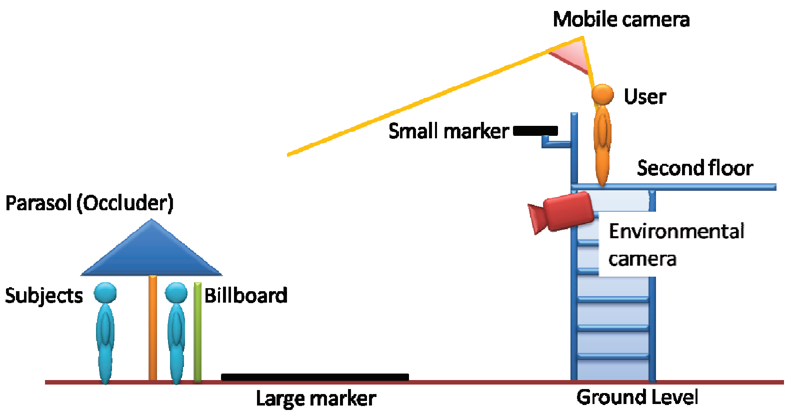

Fig. 5: Layout of experiment at a shopping mall. Two markers are installed at preparation. After the calibration is made, the large marker is removed.

4. Experiment

We installed the P-S Vision system at a shopping mall named “Shin-puh-kan” in Kyoto and conducted demonstration. We installed two environmental cameras and selected two parasols. Fig. 6 is a snapshot of the demonstration. In this experiment, privacy information and the number of the subject under the parasols were given manually. We asked users to evaluate the system in two aspects. One is the evaluation of the original see-through vision itself and the other is concerning the privacy-safe aspect. For the see-through vision evaluation, some users reported uncomfortable feeling about difference of view angle between the user and the environmental cameras. We can ease the problem by using multiple cameras that shooting the same space from different positions and selecting proper camera that has the nearest view angle to the user's viewpoint.

In the situation of sharing the same privacy level with the people under the parasol, the system provided clear and detailed image segments (left of Fig. 6). Users can understand how many people are in the space. Most users also satisfied with the functionality of watching the people beneath the parasols. Some users complained that they could not see the people beneath the parasol well. One reason of the problem may be the smallness of the monitor of the mobile device, so they could not see the image in detail. The other is the lighting condition. Sometimes image from environmental camera become too dark to understand.

Fig. 6: A snapshot at the experiment. A user can have a clear views under the left parasol because they share the same privacy level. On the other hand, the privacy of people beneath the right parasol is protected.

At the parasol with privacy protected process by enabling the privacy-safe service, users satisfied the method of visualization using blurring and human icons.

5. Conclusion

We have proposed a privacy-safe see-through vision. The system provides not only see-through vision but also privacy-safe visualization when the subjects behind occluders are not the acquaintances of the user. In privacy-safe visualization, the system blurs image segments captured by environmental cameras and puts human shaped icon over the segments.

We demonstrated the system in a shopping mall. As a result of the experiment, ordinary visitors could check the number of people in the space beneath the parasol. Although, most people satisfied the functionality of watching people, some were not satisfied. In order to solve the problem, we need to provide effective visualization that is easy to understand such as a zooming up in our future work.

References

Kameda, Y., Takemasa, T., & Ohta, Y. (2004). Outdoor See-Through Vision Utilizing Surveillance Cameras. *Proceedings of 3rd IEEE and ACM International Symposium on Mixed and Augmented Reality*, 151-160.

Kato, H., & Billinghurst, M. (1999). Marker Tracking and HMD Calibration for a Video-Based Augmented Reality Conferencing System. *Proceedings of 2nd IEEE and ACM International Workshop on Augmented Reality*, 85-94.

Minoh, M., Kakusho, K., Babaguchi, N., & Ajisaka, T. (2008). Sensing Web Project - How to Handle Privacy Information in Sensor Data. *12th International Conference on Information Processing and Management Uncertainty in Knowledge-Based Systems*, 863-869.

Pentenrieder, K., Meier, P., Klinker, G., & Gmbh, M. (2006). Analysis of Tracking Accuracy for Single-Camera Square-Marker-Based Tracking. *Third Workshop on Virtual and Augmented Reality of the GI-Fachgrouppe VR/AR*, 4.