Discreet Markers for User Localization

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Abstract

This paper describes a localization method for wearable computer users. To realize applications of wearable computers like a navigation system, the position of a user is required for location-based services. Many localization methods in indoor environments have been proposed. One of the methods estimates user's position using IR beacons or visual markers. However, these methods have problems of power supply and/or undesirable visual effects. In order to avoid the problems, we propose a new localization method which is based on using an IR camera and discreet markers consisting of translucent retro-reflectors. In the proposed method, to extract the regions of the markers from the captured images stably, the camera captures the reflection of IR LEDs which are flashed on and off synchronously.

1. Introduction

In applications of wearable computers like a navigation system, the position of a user is required for location-based services. Especially in indoor environments, since a GPS can not be used, many localization methods have been proposed. One of the methods estimates the user's position using IR beacons[4]. Another method estimates the user's position by recognizing the visual markers which are pasted up on the ceilings or walls[3, 1]. However, both of these methods have problems of power supply and/or undesirable visual effects. In order not to impair the scenery, we propose a new localization method using discreet markers that consist of translucent retro-reflectors. In the proposed method, translucent retro-reflective markers, which are discreet and do not need power supply, are captured with an IR camera.

2. Localization System

2.1. Discreet Markers

The markers are set up on the ceilings or walls in indoor environments as infrastructures. The discreet markers consist of translucent retro-reflectors. When visual markers are set up on the ceilings, the markers impair the scenery as shown in Fig. 1(a). Fig. 1(b) shows the scene where discreet markers are set up. Since the markers are translucent, it is difficult for a user to observe. However, when the image is captured with a flash, the markers can be clearly observed as shown in Fig. 1(c). Because the retro-reflector reflects a light toward a light source, the reflection of them can be captured clearly by the camera which is located near the flashing light.

2.2. Localization System Overview

Fig. 2 illustrates the overview of the proposed localization system. Markers consisting of translucent retro-reflectors are set up on the ceilings or walls in indoor environments as infrastructures. The user equips an IR camera upward for capturing images. The camera captures the reflection of the IR LEDs that are attached to it. The re-

(a) Visual markers. (b) Discreet markers. (c) Discreet markers with a flash.

Figure 1. Markers of positioning infrastructures.

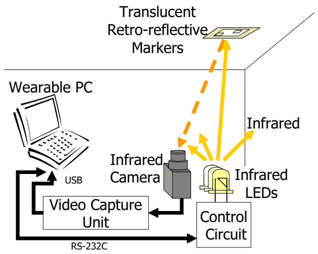

Figure 2. System overview.

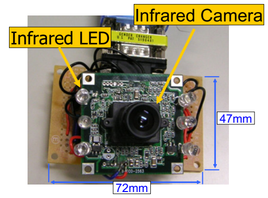

Figure 3. Infrared camera and IR LEDs.

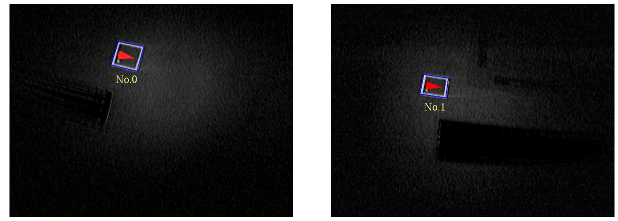

Figure 4. Results of marker recognition.

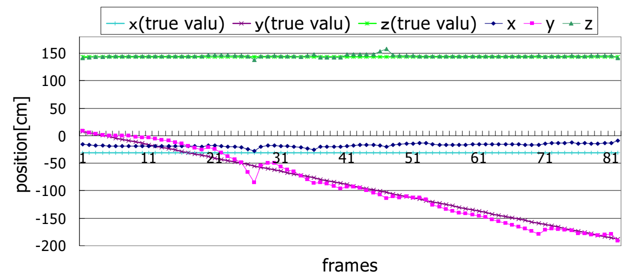

Figure 5. Estimated camera position.

flection of retro-reflector can be captured clearly by the IR camera. However, the images also capture lights other than the IR LEDs; for examples, fluorescent and sun light. To avoid such a problem, IR LEDs are flashed on and off synchronously under control of a wearable computer. The difference between the captured images when IR LEDs are switch on and off is calculated. Finally, to estimate the position of the user, the markers are recognized from the subtraction image. A position ID is associated with each marker. In addition to identifying the received marker, it is possible to estimate the relative position and orientation of camera with respect to the marker coordinate system from the four vertices of a square marker of known size using a standard computer vision technique[2].

3. Experiments

In this experiment, a small camera shown in Fig. 3 is used as an IR camera. View angle of the camera is $92.6°$, and IR LEDs are attached around the camera. We made a circuit which controls the LEDs using RS-232C serial communication with a PC. The used PC is a mobile computer "InterLink MP-XP7310 (Pentium M 1GHz)." The distance between the camera and the markers is about $1.8m$, and the image size is 320×240 pixels. The retro-reflective marker is a square whose edge length is $160mm$.

Fig. 4 shows results of marker recognition. In these images, the position IDs associated with the markers and cones that show the direction of the user are drawn. We confirm that the ID of marker can be correctly recognized. The system can calculate the relative position and direction of the camera with respect to the marker coordinate system. The estimated orientation is indicated by a cone heading north. The processing rate is about 15 frames per second, because two images when the IR LEDs are switch-on and switch-off are required for recognition.

Fig. 5 shows estimated camera position when the camera translates. The markers were set up on the ceiling, and the camera moved in parallel to the ceiling (y-axis). The distance between the camera and the ceiling was 144cm. We can confirm that the error of estimated camera position is at most about 20cm. We conclude that the accuracy of estimated camera position is comparable with the case of using visual markers.

4. Summary

This paper has proposed a new localization method based on using IR camera and discreet markers which consist of translucent retro-reflectors. In the method, user's position is identified by recognizing markers which are illuminated from IR LEDs. In order to eliminate the influence of infrared other than the reflection from retro-reflective markers, the IR LEDs are flashed on and off continuously. In the experiments, we have confirmed that the accuracy of estimated camera position is comparable with the case of using visual markers. In future work, we should investigate a method of marker setting.

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