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Video Monitoring System for Security Surveillance based on Augmented Reality

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Abstract

To resolve existing problems in conventional video monitoring systems, we propose a novel approach to video monitoring based on Augmented Reality, and discuss its availability and possibility. Based on the proposal, we develop a simplified monitoring system and indicate that the new system can be realized inexpensively by commonly used equipments. This system assists quick and intuitive understanding for the whole situation on the monitoring spots by presenting facility's model and reconstructed objects at the same time.

Key words: video monitoring, Augmented Reality, 3-D reconstruction, real-time, volume visualization

1. Introduction

1.1 Background

Real-time video monitoring plays more and more significant role in surveillance systems in various facilities like power plants or airports. However, conventional video monitoring systems have some problems for multi-point surveillance. A typical system of conventional video monitoring connects each video camera directly to corresponding display screen. Therefore we have as many screens as video camera. In such kinds of system, serious problems can occur when the scale of the monitoring system grows larger than the human capacity. Security personnel must map in head each 2-D screen to the corresponding 3-D place in the real world. It requires experience and training. We have difficulty in understanding the whole situation in case the facility is too large. This becomes especially critical when there is in panic in the monitoring facility. Our research interest lies in this point how to provide a solution for these problems smartly and inexpensively.

1.2 Proposal of Novel Approach

As a solution for the above problems, we propose a moving 3-D miniature model as a microcosm of the real world. It is an Augmented Reality system for video monitoring, which consists of inexpensive PC and video cameras. To build up this system, we construct a 3-D model of the target facility in advance. We then reconstruct moving 3-D objects from video cameras and synthesize both the facility model and moving objects. Finally we present it as an interactive 3-D model. This miniature model assists quick and intuitive understanding for the whole situation on the monitoring facility.
Furthermore it has a possibility for extension using valuable information acquired in the process of reconstruction. For instance, it will be possible to present the moving path of a suspicious person. It will be a good extension to integrate a facial database. To be brief, this system provides Augmented Reality for surveillance by extracting and augmenting important information from real world.

2. Design and Implementation

Along with the basic concept described above, we developed a simplified system as shown in Figure 1, and constructed a miniature model for video monitoring as shown in Figure 2, which we can view from arbitrary point interactively by mouse operation. This model was constructed by video inputs as shown in Figure 3.

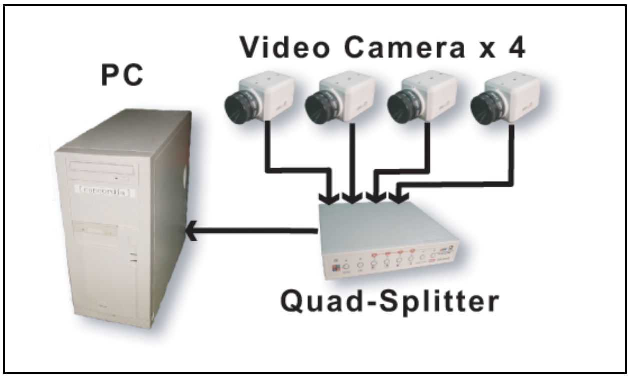

Fig. 1: System configuration.

2.1 System Configuration and Preparation

The monitoring target of the system is a simple room the shape of which is a rectangular solid ($3.45m \times 6.00m \times 2.70m$). Four video cameras are attached on the ceiling of each corner adjusting the camera direction to the center of the room. Each of them is connected to the general PC through a quad-splitter, which synthesizes 4 screens in one screen as shown in Figure 3. The resolution of the synthesized screen is 320×240 pixels. The PC has Pen-

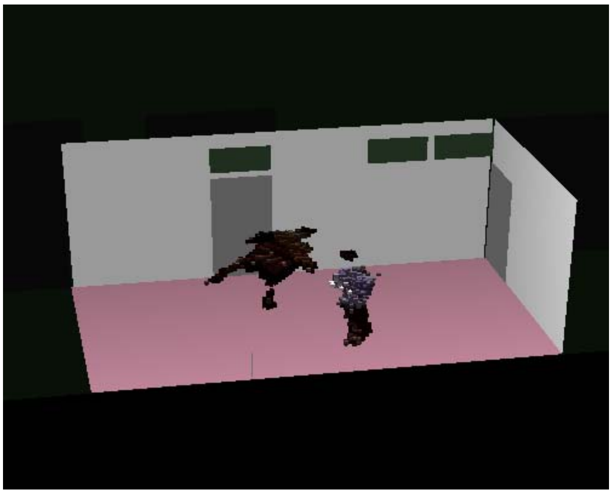

Fig. 2: Moving miniature model.

Fig. 3: Input video images.

tium III 1.26GHz as CPU and 512 MB memory. Before running the system, we give geometry information of the room and the video cameras to the system. And then we calibrate each video camera for accurate mapping of 2-D video images to 3-D view volumes.

2.2 Detection of Moving Objects

In actual use, it is very important to recognize and identify each moving object in the monitoring spots. For simplification, we detect moving objects simply by difference of inputs and backgrounds in this implementation. To realize a more fully-fledged system, some interesting works[1][2] can be referred for object identification.

2.3 3-D Reconstruction and Data Structure

Moving objects inside the room are reconstructed using silhouettes method[3] in the voxel space ($69 \times 120 \times 40$). The resolution of each voxel corresponds to a cube 5 cm on a side in the real world. We adopted a redundant data structure to accelerate the reconstruction process. This method takes more memory, but less processing time compared to the non-redundant one. In this data structure, each pixel in the 2-D input image has a corresponding view volume structure, which has a set of voxel indices as Figure 4 shows. Constructing this redundant data structure in advance, reconstruction process can be accelerated as shown in Table 1.

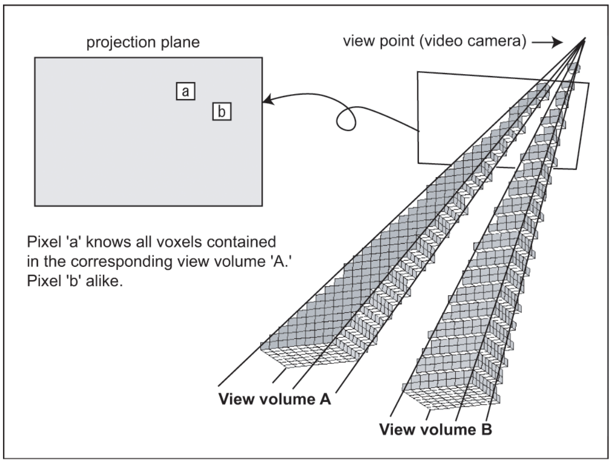

Fig. 4: Redundant data structure for real-time volume reconstruction.

Table 1: Reconstruction speed.

	non-redundant	redundant
processing time(msec)	3700	6.4
required memory(MB)	1.3	5.1

2.4 Rendering and Results

In the process of reconstruction, most voxels are removed from the voxel space because they are out of the view volumes. Remained voxels are rendered as cubes to represent moving objects inside the room. Each rendered cube is colored by corresponding pixel of video image as shown in Figure 2. They are processed in real time (8 fps) using OpenGL.

3. Conclusion

We have proposed a novel approach to the real-time video monitoring for security surveillance based on Augmented Reality, and implemented a simplified system based on our idea. This system can be realized with general and inexpensive equipments. Developing a larger system and its operation test on site are left for future work.

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