An Outdoor Augmented Reality System for Understanding Remote Geographical Information

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Abstract

Virtual reality aims the perception of the world with a immersion device in computer-generated artificial environment. But, Augmented Reality has the goal of enhancing a user's perception of surroundings. It is a powerful technology that provides us with new paradigm of human-computer interaction and communication. We have developed a monitor-based augmented reality system using wireless communication for augmenting geographic information on real scene image at a remote site. The system needs long range working area for acquisition of live image. We use a GPS (global positioning system) receiver for tracking the position and attitude of a CCD camera and a pair of wireless data communication devices for data transfer. Our system consists of two parts. One is a real image acquisition part which consists of a radio control helicopter equipped with the wireless CCD camera, a GPS attitude determination system (Trimble's TANS Vector) and a wireless data communication device. The other is a ground station that has a graphics system (SGI Onyx 2), a video editing system for composing the real image and the virtual image and a wireless data communication device. As a result, when combining rendered graphics image on video live image, we had registration error within 5 meters. So we can use the GPS receiver as a tracking system that is applied to our outdoor AR system.

Key words: Augmented Reality; GPS; Tracking system; Visualization;

1. Introduction

Virtual Reality (VR) aims the perception of the artificial world and *Virtual Reality System* is often used to describe a system that completely immerses a user in a totally synthetic, computer-generated environment made of 3D material such as graphics, sound and so on. Current VR systems typically use HMDs (Head-Mounted Displays) that track the user's head position and orientation, data gloves and haptic devices that allow the user to manipulate virtual objects. In VR, as the user is immersed in the virtual world, he can't see the real world around him. But, Augmented Reality (AR) allows the user to view the real world with virtual objects that are superimposed upon or composed with the real world. Therefore, AR can be thought of the middle ground between virtual environment and tele-presence, and enhances a user's perception of, or his interaction with, the real world [1][2].

Nowadays, there are so many kinds of activities that apply AR concept to applications such as medical, education, visualization, entertainment and military.

Most of AR applications are indoor systems and have short range working area, however, we need a AR system that is outdoor systems and has long range working area. When a user views the landscape, to catch the additional information such as building name, road name, etc., it is required to look it up in the atlas before the additional information is searched. So it takes many times to retrieve the information on the atlas each time. To solve this problem effectively, there is a need of AR systems for long range that combine the real world with the augmented information such as building name, road name and so on.

In this paper, we propose a monitor-based augmented reality system using wireless communication for long ranges. The system combines the real world with the information such as building name, road name in order to perceive remote geographical information. And It is composed of real scene acquisition system, tracking system for camera attitude, graphics rendering system and video editing system. For receiving live images of geographical information, We used the R/C helicopter fixed the wireless CCD camera and the GPS receiver to gain camera attitude data in real time. For real time rendering of virtual images, SGI Onyx graphics engine was used. Two types of images were combined with the video editing system – Sony video editing system. Because the ground station is physically apart from real image acquisition part, we use the pair of wireless data communication devices for data transfer from acquisition part. It is reasonable to apply the GPS receiver as a tracking system to AR system, because its accuracy is within few meters of position accuracy and within 0.3 degree of orientation accuracy. And we have developed the AR system for enhancing user's perception to apply to urban planning or unmanned aerial reconnaissance.

2. The Related Works

According to application area, AR systems can be classified into three types. The first type is the monitor-based AR system, and the second one is the optical see-through HMD AR system, and the last is the video see-through AR system [2]. And we are able to classify AR application as the range of working area. The classified items are as follows.

2.1 Short Range

Augmented Reality as a new technology is expanding area of research. We summarize the related research in this area. Feiner et al. has used augmented reality for laser printer maintenance task [8]. This system aids a user in the procedure required to open the printer and replace various parts. Wellner has developed an augmented reality system for office work having a virtual lamp on a physical desk and a virtual chair [9]. He can interact on this physical desk both with real and virtual documents. Bajura et al. has used augmented reality in medical applications, in which the ultrasound imagery of a patient is superimposed on the patient's live image [10]. Besides these examples, many researches are carrying out in the fields of various applications [11][12].

2.2 Long Range

In AR, trackers to track the position and orientation of a real camera are very important for more accurate registration of virtual images on real images. But few trackers are built for accuracy at long range, since most of developed AR applications do not require long range. Many applications related with AR also tether the user to a limited working volume mostly [4]. To apply AR at long range, it is required that trackers draw out of the position and orientation of the user by the accuracy needed for visual registration. The commercial tracking devices that are useful in tracking a user at long range are motion capture system, scalable tracking systems for HMD and GPS (Global Positioning System)[6]. Motion capture systems are useful in tracking the position of a user's movement, but not the orientation. Scalable tracking systems can be expanded to cover any desired range, simply by adding more modular components to the system. Although scalable tracking systems can be effective, they are complex and, by their nature, have many components [5]. GPS might be considered as tracking device for AR systems. However, it isn't suitable to AR, because it can track only the position of a user, as a general rule.

In this paper, we propose the design and implementation of the monitor-based AR system to be used for long range. We use the GPS Attitude Determination System, the TANS Vector, made by Trimble for tracking the position and orientation of the wireless CCD camera. And we also use the pair of wireless data communication devices for augmenting geographic information on real scene image at a remote site.

3. System Overview

In this section, we present the architecture of the monitor-based augmented reality system using the pair of wireless data communication devices. The wireless CCD camera fixed the radio control (R/C) helicopter acquires real scene image of the outdoors. And the GPS receiver tracks the position and attitude of the CCD camera and sends the tracked values to the ground station through the wireless data communication devices. In real time, the graphics system in the ground station renders geographical information image using the values from the GPS receiver. Finally augmented image that is superimposed by geographical information on real scene image ise produced by a video editing system and displayed at a monitor.

3.1 System Requirements

All principal components of our system are commercial devices except the pair of wireless data communication devices and the R/C helicopter. Our system consists of

- One R/C helicopter
- One wireless CCD camera made by RF Lab., attached to the R/C helicopter
- One TANS Vector (GPS Attitude Determination System)
- One SGI Onyx with Open Inventor
- One Sony FXE-100 video editing system
- One transmitter for transmitting real scene image by 1.2GHz frequency bands
- One receiver for receiving real scene image by 1.2GHz frequency bands
- A pair of wireless data communication devices by 450MHz frequency bands.

3.2 System Configuration

Our system is made up of two parts: real scene acquisition part (R/C helicopter), and processing and visualization part (ground station). (Fig. 1) The former consists of the wireless CCD camera, the GPS attitude determination system and the wireless data communication device. The latter consists of 3D geographical modeling data, a navigation program, the wireless data communication device, the video editing system and the monitor.

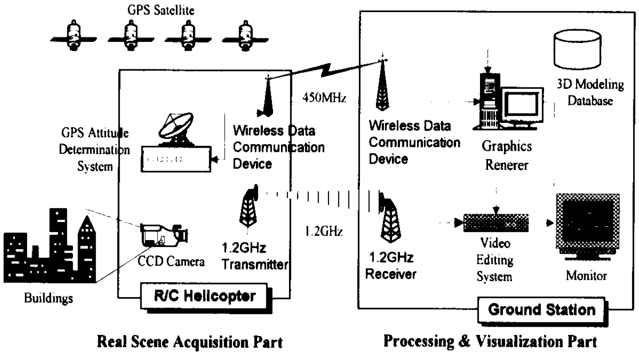

Fig. 1. System Configuration

3.3 Real Scene Acquisition and GPS

We use the TANS Vector which is called Attitude Determination System to track the position and orientation of the wireless CCD camera (Fig. 2)(Fig. 4). To improve its position and orientation accuracy, it uses Differential GPS correction with a DGPS reference station. The use of DGPS correction improves the position accuracy to better than 5 meters RMS, and the orientation accuracy is about 0.15 degree RMS.

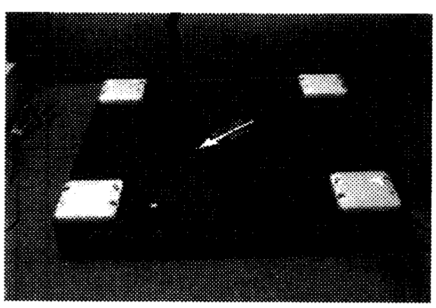

Fig. 2. TANS Vector

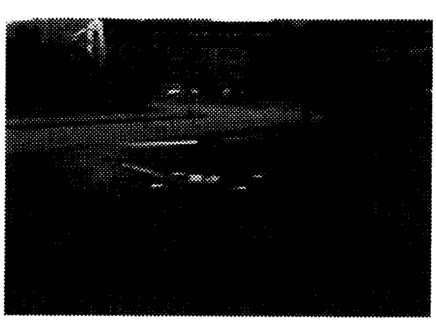

Fig. 3. R/C Helicopter

It is insufficient for AR systems in short range, however, we can ignore a few registration errors because the goal of our system is to enhance a user's perception of building location and additional information in the pattern of text or wire-frame, and so on. Fig. 3 describes the R/C helicopter with GPS receiver and the wireless CCD camera, and Fig. 4 is the wireless CCD camera we used.

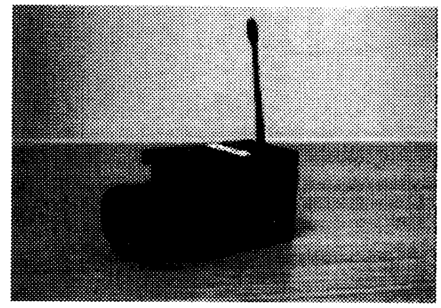

Fig. 4. Wireless CCD Camera

3.4 Wireless Data Communication

We use the 4000RSi (made by Trimble) established on top of a building of our institute for the reference station (Fig. 5). It sends DPGS signals by 457.150MHz frequency band.

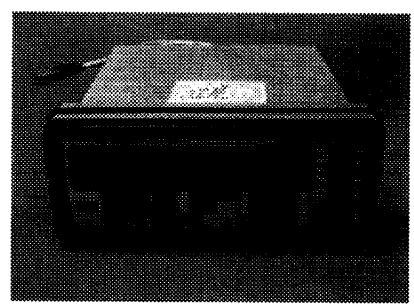

Fig. 5. 4000RSi

Our system has a pair of wireless data communication devices (Fig. 6). One is established in R/C Helicopter and the other is installed in the ground station. The first one in the R/C Helicopter catches DGPS signals and provides the TANS Vector with them. TANS Vector computes the values of position and orientation about the CCD Camera in DGPS mode and then, gives the wireless data communication device the result values. Then the first one transmits the result values to the second one in the ground station by 451.200MHz frequency band. Because the frequency band received from the reference station is different from the frequency band transmitting to the ground station, the wireless data communication devices work well. The received signal at the ground station is used by processing and visualization part

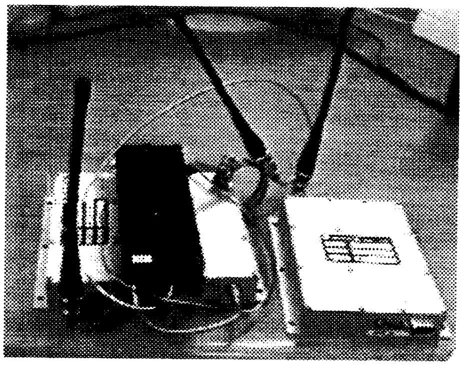

Fig. 6. A pair of Wireless data Communication Device

3.5 Image Registration

Using the received data through the wireless data communication device in the ground station, the graphics system (SGI Onyx) generates the virtual geographical images to register video images in real-time.

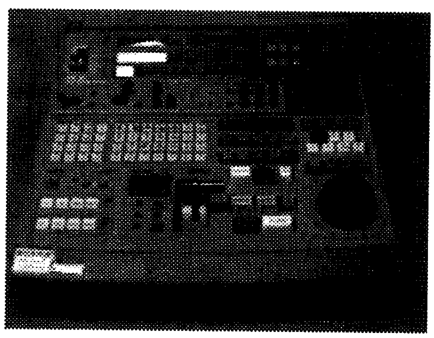

Fig. 7. Video Editing System

The transmitter of wireless CCD camera sends real scene image to processing and visualization part by 1.2GHz frequency band. The real image from wireless CCD camera is put in the video editing system. The video mixing is accomplished with SONY's video editing system. The superimposed virtual image on real image is displayed at a monitor.

3.6 Experiment

The pilot study area of this system is Systems Engineering Research Institute (SERI) region and Korea Advanced Institute Science Technology (KAIST) region in Korea. We make it 3D modeling data about the geographical information to navigate that area. This data is superimposed on real scene image obtained from the wireless CCD camera, and displayed at the monitor.

Fig. 8 shows the augmented image blended the geographical information of this 3D modeling data with the real image obtained from the wireless CCD camera attached to R/C helicopter. Of course, the user has the option to see the augmented image, only the real image, or the virtual image. And besides, the user is able to render the virtual world in either solid type or wire-frame type.

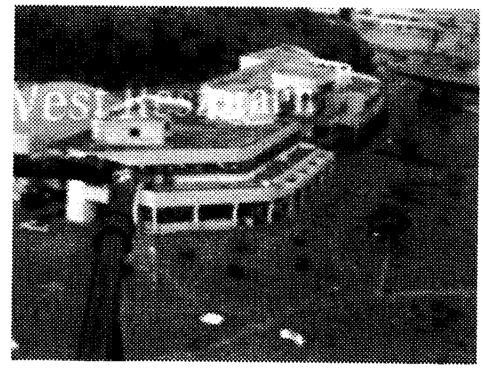

Fig. 8. Superimposed Geographical Information on a Real Scene

4. Conclusions

We introduce the monitor-based augmented reality system using a pair of wireless data communication devices. Unlike most AR systems, this system is designed for long range working area in order that the user may see the augmented image to be overlaid the existing building image and the geographical information such as building name, road name, etc. Therefore, this system can help the user to easily find his destination building, as showing the building information with the landscape of the real scene.

5. Future Works

Our system has to improve a few things in the future. The most important thing of these is the accurate registration problem between the real scene image and geographical information image. Until now, the trackers for long range are inaccurate. The GPS receiver, TANS Vector, used for our system comes to the same thing. And besides, the geometry of this assembly has error by itself. Each and every component such as the wireless CCD camera, the TANS vector and etc., is not rigidly interconnected and is not rigidly attached to the R/C helicopter. Therefore, it is necessary to develop the method for the more accurate registration between the real and virtual image of outdoors.

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References

1. Milgram, Paul, and Furnio Kishino: "A Taxonomy of Mixed Reality Virtual Displays",. IEICE Trunsuctions on Information and Systems E77-D, 9 September (1994)
2. Milgram, Paul, Haruo Takemura, Akira Utsumi, and Fumio Kishino: "Augmented Reality: A Class of Displays on the Reality-Virtuality Continuum", SPIE Proceedings volume 2351: Telemanipulator and Telepresence Technologies, pp 282-292, (1994)
3. Rolland, Jannick, Rich Holloway, and Henry Fuchs: "A Comparison of Optical and Video See -Through Head-Mounted Displays", SPIE Proceedings volume 2351: Telemanipulator and Telepresence Technologies, pp293-307, (1994)
4. Sowizral, Henray, and James Barners: "Tracking Position and Orientation in a Large Volume", Proceedings of IEEE VRAIS '93, pp132-139, (1993)
5. Ward, Mark, Ronald Azuma, Robert Bennett, Stefan Gottschalk, and Henry Fuchs: "A Demonstrated Optical Tracker with Scalable Work Area for Head-Mounted Display Systems", Proceedings of 1992 Symposium on Interactive 3D Graphics, pp 43-52, (1992)
6. Azuma,R.: "A Survey of Augmented Reality", SIGGRAPH 1995 Course Notes #9 (Developing Advanced Virtual Reality Applications). (1995)
7. M. Bajura and U. Neumann, "Dynamic Registration Correction in Video-Based Augmented Reality Systems", IEEE Computer Graphics and Application, Sep. 1995, pp52-60. (1995)
8. S. Feiner, B. MacIntyre, and D. Seligmann, "Knowledge Based Augmented Reality", Comm. ACM, Vol. 30, No. 7,July 1003, pp. 53-62.
9. P. Wellner, "Interacting with paper on the digital desk", Comm. ACM, vol. 36, no. 7, July 1993, pp. 87–96. (1993)
10. M. Bajura, H. Fuchs, and R. Ohbuchi, "Merging Virtual Reality with the Real World: Seeing Ultrasound Imagery within the Patient", Computer Graphics (Proc. SIGGRAPH), ACM Press, 1992, pp.203-210. (1992)
11. J. P. Mellor, "Enhanced Reality Visualization in a Surgical Environment", A.I. Technical Report No. 1544, Jan. (1995)
12. T. P. Caudell and DW Mizell, "Augmented reality: An application of heads-up display technology to manual manufacturing processes". Proc. IEEE Hawaii International Conf. On Systems Science, (1992).