Integration of Georegistered Information on a Virtual Globe

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ABSTRACT

In collaborative augmented reality (AR) missions, much georegistered information is collected and sent to a command and control center. This paper describes the concept and prototypical implementation of a mixed reality (MR) based system that integrates georegistered information from AR systems and other sources on a virtual globe. The application can be used for a command and control center to monitor the field operation where multiple AR users are engaging in a collaborative mission. Google Earth is used to demonstrate the system, which integrates georegistered icons, live video streams from field operators or surveillance cameras, 3D models, and satellite or aerial photos into one MR environment.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces —Computer-supported cooperative work

1 INTRODUCTION

Augmented reality (AR) and mixed reality (MR) are being used in urban leader tactical response, awareness and visualization prototypes [3]. Fixed-position surveillance cameras, mobile cameras, and other image sensors are widely used in security monitoring and command and control operations. The ability to let the command and control center have a view of what is happening on the ground in real time is very important for situation awareness. Decisions need to be made quickly based on a large amount of information from multiple image sensors from different locations and angles. The users must understand the relationship among the images, and recreate a 3D scene in their minds. It is a frustrating process, especially when it is an unfamiliar area, as may be the case for tactical operations.

Our objective is to integrate geometric information, georegistered image information, and other georeferenced information into an MR environment that reveals the geometric relationship among them. The system can be used for security monitoring, or by a command and control center to direct a field operation in an area where multiple operators are engaging in a collaborative mission.

On the reality-virtuality continuum, our work is close to augmented virtuality, where the real world images are dynamically integrated into the virtual world in real time [4]. This project works together closely with our AR situation awareness application, so we will refer it as an MR based application in this paper.

Although projecting real time images on top of 3D models has been widely practiced [1, 2], and there are some attempts on augmenting live video streams for remote participation [6] and remote videoconferencing [5], no work has been done on integrating georegistered information on a virtual globe for MR applications.

The novelty of our approach lies in overlaying georegistered information, such as real time images, icons, and 3D models, on top of Google Earth. This not only allows a viewer to view it from the camera's position, but also a third person perspective. When information from multiple sources are integrated, it provides a useful tool for command and control centers.

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2 METHODS

Our approach is to partially recreate and update the live 3D scene of the area of interest by integrating information with spatial georegistration and time registration from different sources on a virtual globe in real time that can be viewed from any perspective. This information includes video images (fixed or mobile surveillance cameras, traffic control cameras, and other video cameras that are accessible on the network), photos from high altitude sensors (satellite and unmanned aerial vehicle), tracked objects (personal and vehicle agents and tracked targets), and 3D models of the monitored area.

We use GIS or virtual globe systems as platforms for such a purpose. The freely available virtual globe application, Google Earth, is very suitable for such an application, and was used in our preliminary study to demonstrate the concept.

2.1 Projection

Figure 1: Video images of a parking lot and part of a building from a surveillance video camera on the roof top (left) and an AR user on the ground (right).

In general there are two kinds of georegistered objects that need to be displayed on the virtual globe. One is objects with 3D position information, such as icons representing the position of users or objects. The other is 2D imagery (Figure 1).

To overlay iconic georegistered information on Google Earth is relatively simple. Overlaying the 2D live video images on the virtual globe is complex. The images need to be projected on the ground, as well as on all the other objects, such as buildings (Figure 2). From a strict viewpoint these projections couldn't be performed if not all of the 3D information were known along the projection paths. However, it is accurate enough in practice to just project the images on the ground and the large objects such as buildings. Since it is difficult to recreate 3D models in real time with few images, we are projecting the images on known 3D models instead at least in the early stages of the study.

Figure 2: Recreated scene viewed with buildings on Google Earth.

To display the images on Google Earth correctly, we need to create the projected texture maps on the ground and the buildings. This requires the projected images and location and orientation of the texture maps. We used an OpenSceneGraph based rendering program to create the texture maps in the frame-buffer. This is done by treating the video image as a rectangle with texture. The rectangle's position and orientation are calculated from the camera's position and orientation. When viewing from the camera position and using proper viewing and projection transformations, the needed texture maps can be created by rendering the scene to the frame-buffer.

To create the texture map of the wall, an asymmetric perspective viewing volume is needed. The viewing direction is perpendicular to the wall. The viewing volume is a frustum which is formed with the camera position as the apex, and the wall as the base.

When projecting on the ground, we first divide the area of interest into grids of proper size. When each rectangular region of the grid is used instead of the wall, the same projection method for the wall described above can be used to render the texture map in the frame-buffer.

The zoom factor of the video camera can be converted to the field of view. Together with the position and orientation of the camera that are tracked by GPS, inertial devices, and pan-tilt readings from the camera, we can calculate where to put the video images. The position and size of the image can be arbitrary as long as it is along the camera viewing direction, with the right orientation and a proportional size.

2.2 Rendering

The rendering of the texture is done with our AR/MR rendering engine which is based on OpenSceneGraph. A two-pass rendering process is performed to render the shadows of the buildings.

In the first pass, all of the 3D objects in our database are disabled and only the camera image rectangle is in the scene. The rendered image is grabbed from the frame-buffer. Thus a projected image of the video is obtained. In the second pass the camera image rectangle is removed from the scene. The grabbed image in the first pass is used as a texture map and applied on the projection plane (the ground or the walls). All the 3D objects in the database (mainly buildings) are rendered as solid surfaces with a predefined color so that the shadows are created. The resulting image is read from the frame-buffer and used as a texture map in Google Earth. A post-processing stage changes the blocked area to transparent so that the satellite/aerial photos on Google Earth are still visible.

3 Results

We implemented an information integration prototype module with the Battlefield Augmented Reality System (BARS) [3]. This module is an HTTP server that sends icons and image data to Google Earth. The testing area is a parking lot and some buildings nearby. The left side image in Figure 1 is the video image from a fixed pan-tilt-zoom network surveillance camera (AXIS 213 PTZ) mounted on top of the roof of a building by the parking lot. This simulates a forward observation post in military applications or surveillance camera in security applications. Another AR user is on the ground of the parking lot; the image captured by this user is shown on the right side of Figure 1. The command and control center is located at a remote location running the MR application and Google Earth.

The images are projected on the buildings as well as on the ground and overlaid on Google Earth (Figure 2), together with the icon of an AR user and the icon representing the camera on the roof of the building. The parking lot part is projected on the ground and the building part (the windows, the door, and part of the walls) is projected on vertical polygons representing the walls of the building. When the texture was created, the part that is not covered by the video image is transparent so it blended into the aerial image well. The part of the view blocked by the building is removed from the projected image on the ground.

The result shows the value of this study which integrates information from multiple sources into one mixed environment. From the source images, it is difficult to see how they are related. By integrating images, icons, and 3D models, it is very easy for the command and control center to monitor what is happening live on the ground. In this particular position, the AR user on the ground and the simulated forward observation post on the roof top can not see each other.

4 Conclusion

In this preliminary study, we investigated the methods of integrating georegistered information on a virtual globe. The application can be used for a command and control center to monitor the field operation where multiple AR users are engaging in a collaborative mission. Google Earth is used to demonstrate the methods. The system integrates georegistered icons, live video streams from field operators or surveillance cameras, 3D models, and satellite or aerial photos into one MR environment.

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