Collaboration Infrastructure for a Mobile Situational Visualization System

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Abstract

The Situational Visualization research project focuses on developing a mobile visualization of a user's surrounding environment. The user can interact with the visualization, add and modify features, make annotations, receive new information, and collaborate with others. This enhances the user's comprehension of the surroundings and helps to capture that understanding for later examination and sharing with others. A wide variety of applications are possible, such as surveying and navigation. This paper discusses the spatial metaphor for collaboration used as well as the design of our location server, a directory of users and data servers.

Keywords:

Augmented reality, virtual environments, mobile users, collaboration, location server, situation awareness, spatial model of interaction.

1.0 Introduction

At Georgia Tech, we are developing the notion of Situational Visualization, which gives users a mobile visualization of the surroundings outdoor environment [1]. We are developing data management, display, and interaction techniques to help users understand the environment, prioritize elements, and project how that environment will evolve.

Our research will employ mobile computers, head mounted displays, GPS, and wireless networking to present a 3D visualization of terrain, aerial photography, 3D buildings, weather, and positions and inputs from other collaborators. We allow users to both visualize the environment immediately surrounding their position as well as regions of the Earth miles away. Since we allow the user to navigate so freely, we must support real-time navigation and interaction in a large dataset. We are using VGIS, a 3D whole Earth visualization system that provides continuous multiple levels of detail for a variety of GIS data [2,3,4]. Sometimes we present a top-down map-like view, rather than a see-though graphics overlaid view of the world (Figure 1), differing from related augmented reality work [5]. At other times we present a line-of-sight view that can be aligned with what the viewer sees in the real world (Figure 2).

This infrastructure will support a number of tasks in such areas as meteorology, emergency response, firefighting, on-site construction engineering, and surveying. Collaboration is key to many of these applications. There are several modes of communication we aim to support, including voice, text messaging, and file sharing. In a surveying application, it is necessary to trade data between all members of the survey team. In applications where a team is highly coordinated, such as search and rescue, team members must remain aware of each other's location and status, and be able to communicate.

In this paper, we will discuss the spatial metaphor used for collaboration and the location server, which helps users become aware of other potential collaborators.

2.0 Spatial Metaphor

A 3D spatial metaphor or presentation has been applied to a variety of CSCW applications. The success of the metaphor has varied. One common class of such applications has been collaborative virtual environments for meetings over distance. There are perhaps compelling reasons for such use. Spatialized audio may afford many advantages [6,7,8]. It is also easier to deal with a single unified display area for teleconferencing instead of different document cameras, room cameras, and computer displays. It has also been argued that virtual environments would be ideal teleconferencing spaces because of the ability of virtual environments to mimic natural human interaction (gestures, presences, etc) with others in a simulated space. Nevertheless, adoption has been low and problematic. Perhaps replication of face-to-face communication should not be the ultimate goal [9]. Overall, the immature state of the technology in display, networking, user interface, and socio-cultural aspects have largely crippled such applications. In time, efforts such as the Office of the Future project [10] may address some of the technological shortcomings, but teleconferencing in a 3D collaborative space is not yet compelling. However, we feel that collaboration in a 3D environment such as our outdoor mobile visualization system, where the user is actively engaged in moving around and interacting with the real 3D world, would be compelling.

2.1 Appropriateness

For a mobile system such as ours, a spatial metaphor for collaboration is highly appropriate since a user's physical and virtual positions are both key to tasks they wish to perform. Furthermore, task completion may depend on the position of others.

There are two types of location that can be displayed in our system. A user's physical location is displayed, which has important meaning. A user's virtual location is also displayed. This shows the region of the virtual environment that the user is viewing, which shows a user's interest in a particular region. These locations may not be coincident, but both are rich in meaning. Some applications, such as VR teleconferencing, require users to position their avatars. Meaning does not flow automatically from a user's actions. For example, social expression, communicated by gestures, proximity, and location, is dependent on a user's skill in navigation.

Users can also see the type of environment others are in. This presents a common point of reference to collaborators. It gives an idea of real world relationships in distance and direction between remote users. One advantage is that this helps initiate both virtual and real world encounters.

Other systems have struggled with difficult-to-use navigation. Most navigation in the VGIS application is from a top-down view and is similar to two-dimensional navigation in difficulty. In other view modes, degrees of freedom are restricted to aid navigation.

Users may unfavorably compare teleconferencing with collaborative virtual environments with video conferencing or physical meetings. A recent system promoted peripheral awareness by animating 3D avatars according to a user's computer desktop activity (Nessie World) [11]. Since these efforts are attempting to replicate collocation, they invite comparison and user dissatisfaction. Our representation is a refinement of map pins and military sand boxes, and thus, perhaps, does not invite comparisons with "being there".

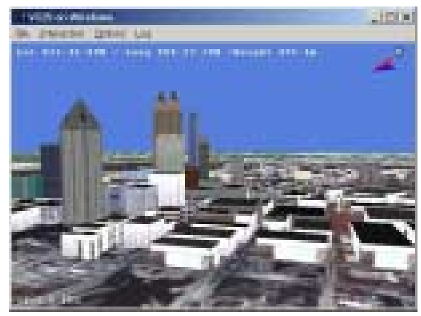

Figure 1: "Line of Sight" View of Atlanta.

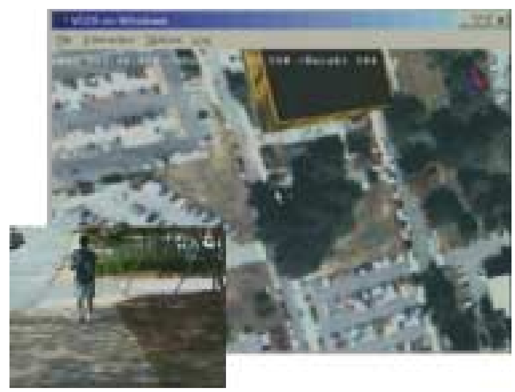

Figure 2: A Mobile User. (The white arrow indicates user's position, tracked by GPS.)

2.2 Details

Benford and Fahlen's spatial model of interaction is a common model for awareness and interaction for virtual environments [12]. We feel that with modifications, it can be used to model collaboration in a mobile visualization system, or even an outdoor augmented reality system. There are three main components in this model: focus, aura, and nimbus. The modifications to each component are necessary since users will have both a physical position in the world, and a virtual position, based on the area of the world that they are examining in the virtual environment.

The focus is the region of interest, where the user is aware of objects and activity. Since a user has both a physical and virtual location, she should be made aware of potential collaborators in each area. Both visual and aural methods of raising awareness can be employed. Furthermore, a user may wish to create other focus regions and attach them to arbitrary locations or objects. For example, leaving a focus region on a picnic area may inform a user when a coworker is eating lunch. One could also conceive of attaching focus regions to particular users, or to activities and patterns, such as when people gather. Furthermore, registering focus regions with particular servers will cause the servers to send information about those focus regions, such as weather or traffic.

The aura is the interaction region. When two auras intersect, two users may interact. In our Situational Visualization system, we use the aura to initiate direct communication. When a user wishes to initiate contact, she will navigate her virtual body to the proximity of another user's physical body and establish a two-way communication channel. Since users may wish to stay in contact even if they move apart, the channel must be explicitly closed. Direct communication could be through messaging, voice, or file sharing.

Nimbus is the region for which a second user may become aware of a first user. Other users may see both the virtual and physical embodiments of the user, but for most applications, it may not be necessary to see each user's virtual embodiment.

3.0 Location Server

With the potential for large numbers of mobile users, it is necessary to have a systematic way of publishing and retrieving user locations and the list of data servers. We are designing a location server as a directory for publishing the location and network address for users as well as the network addresses for data servers and the areas of the earth that they cover. It functions much like a domain name server (DNS), except that instead of resolving text strings to IP address, it resolves a geographic area into a set of IP addresses. This also differs from servers used in systems like WorldBoard [13], and other geographically oriented web-like servers in that this is a host address lookup rather than a data lookup system. Another difference between this location server and a DNS is that the geographic locations of these IP address will quickly change and there is a certain amount of inaccuracy or uncertainty in these locations. Location information is much more dynamic and uncertain than domain name data.

There are several sources of uncertainty. One source of uncertainty is the inaccuracy of the location determined by GPS or other tracking system. With GPS, this will be dependent on atmospheric conditions, locations of trees and buildings, and other factors. An unreliable network is assumed (we use UDP packets over wireless LANs), so updates may not be received as often as they are sent. Furthermore, the exact period of location updates is the choice of the client as long as it remains shorter than a preset keep-alive period (currently 30 minutes). A final source of uncertainty is the need for privacy. Clients can chose to deliver a less accurate location update to prevent exact localization.

Users who wish to query the server may also wish to adjust the parameters of their queries to likewise prevent exact localization.

3.1 Commands

There are five basic commands to send to the location server, and two responses (Table 1). Clients can communicate their existence to the server with the REGISTER packet. This packet also communicates the IP address and port that is available to receive messages. Clients then periodically update their position by sending a LOCATION packet. If a client has information about a geographic extent, they may communicate a non-zero radius. When clients want to go offline, they can send a SIGNOFF packet. Since a client's location is already on the server, if a QUERY packet is sent with a radius specified, the server will respond with a series of ENTRY packets, detailing the positions of clients in the specified area.

Since this is a research prototype, we are not focusing on security and authentication issues. One approach, among many, to address scalability issues would be to forward REGISTER and CLIENTS requests to an appropriately situated server and inform the client to directly contact that server for further requests.

By publishing and allowing clients to query for other users, we can facilitate virtual and real encounters. Furthermore, clients will be able to register their focus regions with appropriate servers to receive updates on information such as traffic and weather.

Type	Data
REGISTER	Hostname, Username, IP Address, Port
LOCATION	Hostname, Username, Latitude, Longitude, Height, Radius
SIGNOFF	Hostname, Username
QUERY	Hostname, Username, Radius
ENTRY	Hostname, Username, IP Address, Port, Latitude, Longitude, Height, Radius
PING	Hostname, Username, IP Address, Port
ALIVE	N/A

Table 1: Location Server Packets

4.0 Conclusion

We feel that a spatial metaphor for collaboration is limited in application to virtual reality teleconferencing systems, but is more appropriate to mobile systems, such as this Situational Visualization system or other forms of augmented reality, where users are moving in the physical world and in a 3D visualization of the world. By modifying the spatial model of interaction, we can construct a metaphor to structure collaboration and awareness.

We are also developing a location server to help implement this model of collaboration. With systems that track users, there are often concerns about privacy. However, there are groups such as couples, families, co-workers, and close friends who work together closely and wish to exchange location information. Furthermore, with the ability to control update rate and accuracy, gradients of privacy are available. A future privacy feature would be to allow clients to form groups and limit access to other users in that group.

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