An Authoring Toolkit for Mixed Reality Experiences

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Abstract: This paper describes a program of research to develop and implement an integrated system of data collection and authoring tools and a concomitant infrastructure for collecting and presenting a range of information about a specific location in a Mixed Reality experience. The system has been designed so that a wide range of users such as scientific domain experts, artists, or any user with a mobile phone, can author and "post" information to a particular site.

Key words: Augmented reality, mixed reality, mobile multimedia, wearable computing, environmental media, environmental art, location-based services, authoring, annotation

1. INTRODUCTION

Recent advances in communication and visualization technologies are resulting in the ability for a mobile user to effectively "browse" a physical environment and obtain site-specific information or access representations of real-time data about their immediate location. Based on a combination of mobile multimedia, artificial reality, and wearable computing technologies, initial research efforts have necessarily focused on the development of functional but cumbersome prototypes that address critical performance issues such as accurately tracking the user's location and orientation, providing precise registration of virtual imagery with the physical environment, and developing practical interface devices for accessing and interacting with the resultant composite environment. But it is not the hardware people might use that will determine whether these new technologies will coalesce to become a powerful medium - instead, it will be

the experiences that they are able to have that will drive its acceptance and impact. Consequently, a crucial next step for this unique combination of media will be the development of innovative tools and techniques for authoring the contents of mixed reality experiences.

While a greater part of research in this area of content development has been focused on the requirements of commercial, industrial, or training services in relatively structured environments, a specific goal of our research is to understand the unique needs and requirements for developing entertainment and educational content for access in unstructured outdoor environments. The objective is to provide a new capability for unique out-of-classroom educational and entertainment opportunities available to anyone, at anytime with the added benefit of being embedded in the rich context of specific places. A particular area of interest is the development of location-specific museum, game, and arts installations in which the 'virtual' contents are embedded on site and perceived through mobile 3D display or viewing devices.

Currently, the approach to developing content for such applications has been limited to the use of standard graphics authoring tools to generate a range of media types that are in turn embedded into a software process that has been custom developed for each application scenario. In order to make a more flexible authoring environment, a further objective of this research effort has been to develop an infrastructure system that can accommodate content published to it from a browser-based desktop authoring system as well as from location-specific data collection and authoring systems. In both scenarios, the intent is to develop an open system approach so that anyone can author contents for a specific location.

2. RELATED WORK

Although a number of research groups have started to address the issue of authoring content for industrial, commercial and training applications [1,2,3], there has been less focus on content development tools for outdoor unstructured environments or for entertainment and educational applications. Important early work based on the "stick e-note" concept for data collection has been done by the Project for Mobile Computing in a Fieldwork Environment at University of Kent at Canterbury [4,5]. More recently, researchers at Columbia's Computer Graphics and User Interfaces Lab have developed "situated documentaries" using their augmented reality system [6]. Other related work includes the development of pre-visualization tools for embedding audio information in physical environments at Xerox PARC

[7] and authoring tools for leaving "audio imprints" in outdoor locations in an augmented reality system developed at MIT Media Lab [8].

3. RESEARCH DESCRIPTION

At Keio University's Shonan Fujisawa Campus, the research program on *Ubiquitous 3D Communication* (U3DC) has been developed in response to recent environmental sensing developments in which many streams of real-time information and millions of electronic measuring devices, are starting to aggregate as huge amounts of data that will be available to us as we move through our environments and are gradually extending to become what Bell Labs has called a "communication skin". With countless developments like these, the amount of real-time data available to us about specific locations is increasing rapidly. A next major challenge then, is how to visualize this data in a way that is meaningful and useful for human users as they navigate through and interact with this rich combination of virtual and physical environments. A primary assumption of our research in this area is that the increase in data will both enable and require the use of more complex contents for mobile multimedia devices such as animation, 3D graphic visualization, and detailed location data.

The overall intent of this research program is to enable a user to easily access embedded location-specific information in any site in order to make it a more "context-rich" experience. The interdependent objectives of the program are to develop innovative interface techniques and authoring tools for the development, display, and access of location-linked virtual environments, and to develop design guidelines on how to make explicit, and display for a mobile user, the layers of information and digital data that are attached to objects, people, places, as well as information about the relationships between them. Our preliminary approach has been to explore potential applications of location-based information services over wireless networks and, based on the development of a prototype "wearable environmental media" system (WEM) to link virtual environments to the physical world, it enables a mobile user to browse a spatially correspondent multimedia information database about a specific location as it changes over time. As a test bed to evaluate these concepts and configurations, an initial technology platform has been developed that consists of a very lightweight stereoscopic camera and display system that is mounted on a remote users head and body. Additional subsystems are added for: presenting visual and audio information; tracking the user's location and head orientation; interacting with virtual 3d icons; accessing and caching data about the

environment (both archived and local sensor data); and configuring or generating data to be displayed [9,10].

By tracking location and attention of the user as they move through the actual site, a wide variety of information virtually encoded in the site can be displayed in various formats. In effect, the user is able to browse a spatially correspondent digital information database about the site as it changes over time. Alternatively, the real-time video stream of the site as a user walks around can be transmitted to a remote location where observers can also experience the digitally augmented location or even request the on-site user to move to a different area.

More recent efforts extend this goal to develop comprehensive 3D representations of specific locations derived from both mobile and static real-time wireless sensing devices, and methods for capture, organization, and visualization of real-time, site-specific environmental information for users who are both remote and local to the site[11]. And new developments described in this paper enable a user to post location-specific information in an open system architecture using a variety of technology platforms and to access interpretive annotations posted by domain experts.

4. USER INTERACTION SCENARIOS

The prototype WEM system was based on a data organization in which 3D icons were placed wherever data was embedded in the physical environment and were accessed without any filtering capability for the user. To select an icon, the user aligned a virtual 3d cursor over it with a hand-held 3d input device. Upon selection, an image based, 3d computer generated menu showed additional information that could be chosen. But, as more data was made accessible to the user, isolating and selecting individual icons became extremely difficult. As an alternative to this approach, a new virtual data organization was designed for the system based on the traditional GIS layer model.

In parallel with this new layer-based data organization, a new interaction scenario has been developed using a java-based mobile phone input and selection subsystem rather than using a 3D input device to place a cursor on top of a 3D icon. This scheme is designed to simplify the data layer and icon selection for the user and subsequently simplifies the icon display for the graphics processor. As a first step, the user selects which data layer they would like to view by simple scrolling and selecting on the keitai handset. In response, only data that is within the user's field of view is displayed by a set of icons. Using the keitai keypad, the user can cycle through the available icon set and select which icon to activate by pressing a specific

key. When activated, the icon is changed accordingly and the user then navigates though data types available for that icon by using the up down keys on the handset.

5. ACQUISITION AND VISUALIZATION OF LOCATION SPECIFIC DATA

A more recent objective of this research is to develop comprehensive 3D representations of specific locations derived from real-time wireless sensing devices. The specific objectives are to develop methods for capture, organization, and visualization of real-time, site-specific environmental information for users who are both remote and local to the site. Until recently, environmental data collection has been dependent on *non*-real-time input from installation of expensive and fragile data logging equipment and/or intermittent onsite field note collection by researchers. Now, with the aid of high-bandwidth wireless Internet connections, inexpensive sensing devices, and high-resolution tracking technologies, site-specific environmental data can be captured and analysed in real-time. In addition, this data also can be made available in real-time to users while they are exploring a specific site, as well as to a wider audience of both professional and non-professional users. The U3DC project is developing an integrated "environmental data gathering and authoring system" with three primary subsystems: data capture and field-authoring system, database server system, and visualization authoring system.

5.1 Field-authoring and Data Capture Systems

A wireless network of mobile and static sensor stations, and remote-controlled camera stations has been assembled and installed to capture site-specific environmental information in real-time. In general, this information is provided to a user as part of the data layer structure and can be easily accessed by selecting this layer on the mobile phone interface of the WEM browser system.

The mobile data capture and field-authoring system includes a small video camera with built in HTTP server, a small GPS unit, a custom sensor array, and a java-based mobile phone handset. As a user moves around a specific location, a simple handset interface is used to select which sensor array to activate. Voice, audio and text information can also be recorded and transmitted by the handset. All of the collected data is stamped with time and location information and sent by wireless Ethernet to a remote database.

Although the content provided by this system is currently extremely simple, a novel aspect that it provides is the capability for a user to effectively annotate the immediate environment with a range of site-specific data and personal notes or remarks. These graphics and annotations can be seen and/or heard by selecting the mobile sensor layer while using the WEM head-mounted display system. A similar but simpler mobile data input capability has also been developed using the short mail messaging service (SMS) standard on Japanese mobile phones. With this interface, a user can send text messages to a virtual mailbox on a site using any mobile phone. Other visitors to the location can access these "chat-like" annotations either through another layer selection in the WEM browser system or with another mobile phone.

Other data capture systems include several static sensor stations that have been designed and implemented around the test site to continuously add to the database a range of basic environmental data such as temperature and humidity level. In addition, a wireless video camera system has also been installed onsite to capture imagery of the test location to the database. A java-based mobile phone interface was developed to control the camera remotely.

5.2 Database system

This database system receives and archives the multimedia information gathered by the Data Capture Systems. Currently the database is installed on a Linux system running PostgreSQL. As data collection and site documentation continue, it will also contain existing imagery and data about the test site such as satellite imagery, aerial photographs, IR imagery, topographic maps, and personal photographs collected in order to compile a comprehensive, site-specific database of information.

5.3 Desktop Authoring and Pre-visualization System

The desktop authoring system is a simple browser-based authoring toolkit for linking information to specific physical locations. Written in Java, the current system is based on a 2D map of the testbed site and the primary intention is to provide a simple tool for domain experts to author information about a specific site using existing data, graphics, or other media types. By clicking on any point of the site map, the author can insert an icon, attach a data file to the icon, and then publish the new data configuration for display in real-time to a user browsing the physical site with the Wearable Environmental Media System.

The WEM user can access the resulting content by selecting the 'expert' layer on their java mobile phone interface. A next version of this system will include an interactive 3d computer generated model of the site into which users can insert spatially correspondent media objects and data visualizations. In addition to authoring site-specific content, this system will be used to preview or pre-visualize the experience of the WEM user at the physical site and can be achieved by viewing the annotated 3D site model by means of an immersive display headset.

6. SUMMARY AND FUTURE WORK

In conclusion, this paper has described a program of research to develop and implement an integrated system of tools and concomitant infrastructure for collecting and presenting a range of information about a specific location. The system has been designed so that a wide range of users such as scientific domain experts, artists, or even any user with a mobile phone, can "post" information to a particular site. All together, these tools can be used to author a variety of virtual tours through a specific location depending on the viewpoint and expertise of the user. Given the development of such an authoring environment and infrastructure, a long-term goal of this project will be to evaluate the unique advantages and opportunities that these media can provide as a learning technology in such applications areas as virtual fieldtrips, ecological literacy, environmental awareness, and context visualization [12]. Eventually, we hope this direction of research can provide the foundation for a new kind of educational and entertainment media infrastructure where anyone might be able to use a simple consumer device like a mobile phone handset both to ask questions about things in the environment around them wherever they are, as well as to input information or provide annotations of interest for other users.

7. ACKNOWLEDGMENTS

This research has been supported in part by NTT DoCoMo, Inc; the Japanese Ministry of Education's Center of Excellence at Keio University; and by The High Speed Research Consortium at Keio University. Software for providing GPS correction data over the Internet was developed by the Wide Project at Keio SFC. Kawashima Lab Co., Ltd. has provided software support and Open Network Co., Ltd has provided additional support for GPS hardware. Also thanks to Prof. Kenji Kohiyama for his support and research collaboration; to visiting professors, Henry Minsky, Mark Bolas, and Ian

McDowall for their participation in this research effort; and to all of the student members of the U3DC Kenkyukai and Project Team who helped to implement this prototype.

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