Storing and Replaying Experiences in Mixed Environments using Hypermedia

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ABSTRACT

This paper describes a model and tools to store and replay user experiences in mixed environments. The experience is stored as a set of hypermedia nodes and links, with the information that was displayed along with the video of the real world that was navigated. It uses a generic hypermedia model implemented as software components developed to handle mixed reality environments. The mechanisms for storing and replaying the experience are part of this model. The paper presents the goals of the system, the underlying hypermedia model, and the preliminary tools that we are developing.

Keywords

Store/replay user experience, mixed reality, hypermedia, video.

INTRODUCTION

Storing photos, videos, and objects that help to remember past experiences is an activity that almost everyone has done at some point in their lives. Sometimes these materials are also augmented with annotations that help to remember or add personal comments about the situation and events that took place. The content that is stored is mostly used to remember the events but also to compose them in new ways and create new content. This activity is becoming increasingly dependent of technological support and multiple media can currently be used. In a mixed reality environment, where users are involved in live activities, the replay and arrangement of such experiences is definitely a requirement. In mixed reality, people can participate in gaming or exploration activities either alone or involving other people and this is a perfect setting for generating interesting activities that people want to remember at a later time.

Previous work in this area, in mixed reality, includes [7]. Other related systems that help to store and retrieve previous related work involving storing user annotations or repurposing of captured materials include [2, 5, 6]. The Ambient Wood project described in [7] introduces an augmented physical space to enable learning experiences by children that take readings of moisture and light levels. The activities of the children that participate are recorded in log files. These log files are later replayed to enable further reflection on the experiences they had in the physical augmented outdoor environment.

In [6] the authors present a system for capturing public experiences and personalizing the results. The system accepts the different streams that are generated, including speaker slides and notes, student notes, visited Web pages, and it stores all this information along with the timestamps that enable synchronization. The playback interface has features for rapid browsing enabling to locate a point of interest in the streams that were captured.

VideoPaper [2] is a system for multimedia browsing, analysis, and replay. It has been used for several applications including meetings, news, oral stories and personal recordings. The system captures audio and video streams and key frames if slides are used. VideoPaper uses this data to produce a paper document that includes barcodes that can give access to digital information. This information can be accessed in a PDA or in a PC connected to a media server.

The SHAPE project [3] had the goal of designing novel technologies for interpersonal communication in public places, such as museums and galleries. The users can learn about antique artifacts and their history. Although the main focus of the system is not on replay of experiences some of the features are related. The users can search for objects in a physical setting and their positions are tracked. Later they can continue their exploration and obtain more information about the objects that they were searching in a mixed reality setting, with projection screens.

This area of research, storing the memory of past experiences, was also identified as one of the "Grand Challenges for Computing Research" [1]. The workgroup that produced the report identified several problems related with data storage and analysis, interaction with sensors, human computer interaction, that will shape future research in this area and that are key questions for the work that we describe here.

This paper presents an approach for storing the user experience using hypermedia structures, much in the way the history mechanism (that allows accessing previously visited nodes) is used in Web browsers. In this case the activities take place in the real world, may involve accessing digital documents and entering and navigating in virtual worlds. The paper presents the scenario of usage, the underlying hypermedia model, the specific mechanism for storing/replaying, and the tools that we are developing to support these mechanisms.

SCENARIO

The scenario of usage is a physical space, e.g. a museum, an art gallery, or even an outdoor space, where there are several interest points, e.g. paintings, objects, detected by the system. The user carries a portable wearable system that is able to capture the video of the real world scene, detect close objects or within the field of view, access a database using a wireless network, and display additional information over the real video.

If the option for storing the user experience is on, when the user moves around the space the video is being captured along with the information about interest points. The information presented at each interest point and thus stored for later replay can be video, audio, text, or images, or virtual worlds. The user experience involves the visualization of the physical space, the augmented information, and the navigated virtual worlds. All this data is stored as a hypermedia network using the mechanisms described in the next sections

HYPERMEDIA MODEL

Storing and displaying information is supported by a hypermedia model defined by a set of reusable components for application programming. The model includes the following types of components:

- Atomic: It represents the basic data types, e.g., text and image.
- Composite: It is a container for other components, including Composites, and it is used to structure an interface hierarchically.
- Link: It establishes relations among components.

Every component includes a list of Anchors and a Presentation Specification. Anchors allow to reference part of a component and are used in specifiers, a triplet consisting of anchor, component and direction, used in Links to establish relations between the different components of a hypermedia graph. The Presentation Specification describes the way the data is presented in an augmented interface. The interface structure is done with Composite objects that establish a hierarchy of visual blocks. Interfaces are presented (and removed) according to the sequence of events, as described next.

Events

Anything that happens and that it changes the information that is presented is considered and event. There are three main types of events as follows:

- Location of user in a space.
- Recognition of an interest point, identified by an optical marker or a RFID tag.
- User navigation or choice.

The position of a user in the space can also define an interest point. If the space has several subspaces (rooms, floors) moving from one to another will generate an event. Whenever an event is generated, new information is displayed, and the interface changes. A location event does not necessarily generate a change in the information and it can also occur in virtual spaces. In the physical space, where the user is, there are interest points that are detected by the system. When one of these points is detected new information is displayed in the mobile device of the user. When this point of interest is no longer detected the information ceases to be available unless this was a manual choice from the user. An information block that is displayed, as a result of an event, can be browsed by the user, thus originating a change in the content. Each navigation action made by the user creates a new event.

APPLICATIONS

We are developing several applications to test the hypermedia model in context aware augmented environments. The two applications where the development is more advanced are a museum/gallery information assistant and a game that takes place in the gallery environment.

The gallery experimental space consists of room with subdivisions to create a navigational need. The physical entities consist of paintings, and each painting is positioned in a different part of the room. Virtual 3D models related to these paintings have been created and used to enrich the information setting, augment the user interface and allow navigation within those worlds in search of new experiences and knowledge.

The user set up consists of a portable PC, with a wireless LAN card, and a camera to capture the real world video. There are two alternative user set-ups: in the first the visualization and interaction is done directly on the PC; and the other uses a Head Mounted Display, and a 2-3-button device for interaction purposes. We are currently using the Cy-Visor DH-4400VP video see through display. The main recognition process is accomplished through the camera device. There are markers associated with each painting that are optically recognized through an augment reality toolkit (ARToolkit) developed at the University of Washington. The system uses this recognition process to know the user position and orientation, although the components of the hypermedia model can accept input from different devices for location purposes. Once objects

are recognized, media data is added to the real world video capture, by accessing the remote hypermedia graph. When manipulating 3D data, such as the worlds that represent the paintings, a 3D behavior toolkit is used to superimpose the models over the real world video and navigate in them. There is one ARToolkit marker located near each painting. When this marker is recognized the system presents information about the painting and an iconic simplified 3D representation. If the user selects this model it will enter a complex and detailed virtual world representing the painting where navigation is possible and the game described next takes place. Adding to the gallery information setting, a mystery game was also developed. The story consists in solving a robbery that took place in the gallery. The user has to gather clues and interact with virtual characters to find the stolen item. To do so, the player has to move around the physical and virtual spaces. The game features several objects to be accessed or navigated during playtime, namely worlds, characters and clues.

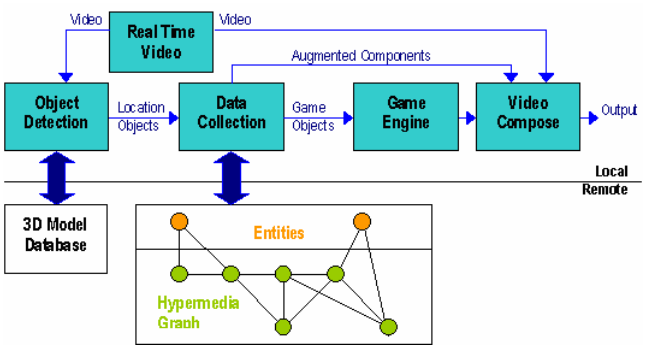

Figure 1: Application Architecture

HISTORY STRUCTURE

In a context aware application, the experience can be divided into several scenes, each of which triggered by a particular action. Each of such scenes has two main elements: the content of the interface, and the action that triggered the interface. Associated with the action is also its life period. Each scene is presented before another action is processed that leads to another interface content. For instance, in an augmented reality environment, the real video is needed to replay the experience, as well as the augmented information. The action is the command (or event) that caused the augmented content to be displayed. The experience history is build up of several scenes.

The hypermedia system models scenes with the Story and Entity components. Each scene is a Story link that points to an Entity component. The Story link contains the action and duration attributes. The Entity component is associated to a set of links that specify the data elements needed to replay the scene. The result of navigating in the system, a history instance, is a linked list of Story/Entity component pairs. The Entity components are linked together by Story components, forming a path of links and nodes. Figure 2 illustrates this structure.

This method of specifying history through a sequence of scenes yields to obvious possibilities of arranging it in a different order or introducing new media elements. This is a generic mechanism for repurposing these types of materials and building new applications (e.g., storytelling).

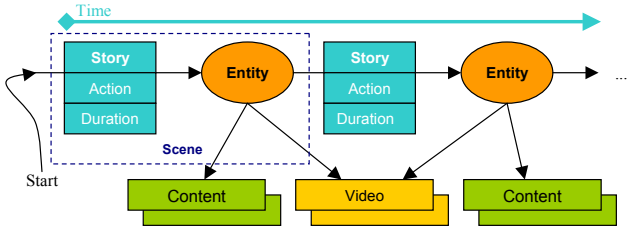

Figure 2: History Structure

Storage Requirements

It is necessary to store different sets of data in order to represent and later replay the user experience:

- Video of the real world scenes
- Events
- Information that is displayed

The main storage requirement is related with the video capture. This has to be continuously stored when the events are occurring. The only exception happens when the user navigates in virtual worlds. The real world video is stored in streams and it is referenced by Entity component, through Anchors and Content components, for each event that occurs. The streams are interrupted whenever the interface is a virtual world where the user navigates.

The Story components in the scene list contain the events and the associated information. For each event a new Story component is created with the event parameters. Simultaneously an Entity component is created with the necessary Content connections to reproduce the state of the interface after processing the event.

The state of the interface is a set of Content connections with the corresponding dynamic behaviors, for each information item displayed in the interface at a given instant. The necessary data for later replay are copied from the original components and referenced in Content links through specifiers. The behavior of the interface is reproduced with the Presentation Specification of the Content links.

REPLAYING THE EXPERIENCE

In order to replay the experience we are developing a set of applications. These applications assume that as a result of a previous navigation session a hypermedia graph, as described above, was produced and added to the main graph, that contains the overall information (Figure 3). This hypermedia graph describes the experience, including video, events and user interfaces. It includes all the structural and timing information needed to provide a view of a past experience in an augmented environment.

In order to replay the experience we are considering different levels and tools, described in the next subsections.

PC Player

Player/editor of the experiences stored as a hypermedia history, for later browsing. This is a tool that enables to browse the stored materials at a later stage, in a setting that can be different from the one where the experience took place. The typical usage is on someone's personal computer. This is the first tool that we are implementing and it is essentially a video player that displays the video that was captured during the navigation in the real world. Superimposed to this video, the augmented materials that were presented in the original navigation are presented. Besides the traditional video player control buttons (play, stop, pause, resume) it includes buttons for Next/Previous, which allows going back and forth in the history list. This navigation mode is exactly the same as going to the next/previous interest point that was defined in the physical space. Additionally, the tool allows adding annotations to a given point in the video stream.

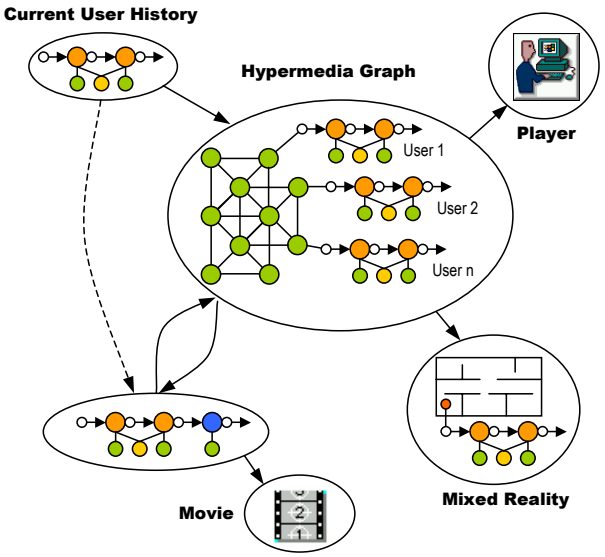

Figure 3: Information storage and repurpose scheme

Mixed Reality Player

This player allows to access stored experiences when the user is in the physical setting. When the user reaches an interest point it can follow the links for further information or it can access previous content that she or others have browsed at that time. This mechanism can be used in gaming settings or it can also be used to leave personal information attached to physical spaces, as memory for future visitors.

Movie

The navigation in the real world combined with access to virtual worlds can be viewed as a movie. As such, we intend to explore this option by defining a set of montage and editing rules that can be applied to the overall hypermedia network in order to generate a movie. This movie will integrate the different elements: the original video, augmented information, and navigation in virtual worlds into a coherent narrative structure.

Authoring Environment

Besides these applications we are building an authoring environment for mixed reality applications that will also be used to browse and edit hypermedia networks that resulted from previous experiences. This allows to add additional materials at a later stage, for example, to provide more insights about a given interest point. This corresponds to add more components to the hypermedia graph or remove them. The authoring environment includes a graph browser and space representations (2D and 3D). It allows attaching Entity components to physical spaces and additional content.

CONCLUSIONS AND FUTURE WORK

This paper presents an approach for replaying experiences in mixed reality using hypermedia mechanisms. The main advantage of using hypermedia as support for this type of activities comes from the fact that hypermedia mechanisms provide a powerful and well-tested way to structure information and provide support for navigation. When extending the existing hypermedia mechanisms to the real world many concepts can be used including navigation aids, annotations or bookmarks, and path/history mechanisms. The history mechanism, common in most hypermedia systems, namely the Web browsers, is the main concept that supports the work that we are doing. The history, as list of visited nodes, provides a simple and flexible mechanism for structuring information captured from the real world along with virtual elements. The applications that we are building explore different ways to replay the events, ranging from a player to be used in a normal PC to exploration in the place where past events took place. Additionally, we are exploring the possibility of generating a movie out of the raw materials that were captured and stored.

The current status of the system includes an implementation of the hypermedia model, testing applications (the information and gaming environment mentioned above), and preliminary tools for replay (the player for later browsing, in a PC setting). Further work includes the tools for replaying the experience where it took place. Also, editing the result of a session is a way that we want to explore in the context of the authoring environment that we are building. Editing can be as simple as adding or removing materials, but it can include transforming and repurposing the materials using storytelling and cinematographic techniques.

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