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Developing Virtual Heritage application with 3D Collaborative Virtual Environments and Mobile Devices in a multi-cultural team: experiences and challenges

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Abstract

Until recently museums have been the sole repositories of an objective factual history. However, with the advent of online interactive media, there has been a shift to alternate forms of cultural exposition. This paper presents a project where 3D CVE is augmented with mobile devices in order to support a collaborative educational exploration of a famous historical site in Norway, where Battle of Stiklestad took place in 1030. This system can be used by both local and distant learning communities, working together towards a common goal. The paper presents a background for the project and describes the preliminary design. Finally, the paper discusses the challenges associated with developing educational augmented virtual heritage applications in a multi-cultural context.

1. Introduction

Until recently museums were largely confined to the domain of repositories of an objective factual history. They contained objects that bore testimony to a past reality. The objects contained created, what Benjamin [1] calls, an ‘aura’ associated with its ritualistic or ceremonial use. This can be extended to include places and spaces of cultural significance. However, with increasing pressure on sites of cultural significance, museums and heritage institutions are looking to alternative means for communicating the information gathered about these sites in a manner that has the least physical impact on the original. Hence, UNESCO and other organisations are encouraging simulation of heritage sites. Museums are responding by using multimedia displays to extend and compliment their objective collections. In the process, they are becoming curators of virtual sites. The museum becomes a place to inspire, instruct and inform in a dialogical discourse with its audiences rather than simply dusty repositories of objects.

These digital displays are increasingly accessible online. This shift to museums having an online presence also means their collections and expert knowledge associated with them is open to critique from a wider audience then before. Their displays can be used by others in ways not intended. They can be expanded and extended by the layperson determined to add their view of the history of that object, event, or record. How this modifies the relationship between museums and their audiences is not yet clear. Still, “museums must now face the realisation that their audiences” can play an active role in how this knowledge is received, perceived and controlled [2].

Two new media forms which are addressed in this paper are the 3D Collaborative Virtual Environment (3D CVE) and mobile devices. The 3D CVE was used in conjunction with mobile devices to allow for cross-cultural interaction with an historical, eleventh century event – the battle of Stiklestad.

3D Collaborative Virtual Environments (CVEs) can support learning communities in a number of ways, providing a social arena where learners can meet and work [3]. There exists a wide range of 3D educational virtual environments, supporting learning in different contexts, e.g. in Active Worlds Educational Universe [4]. Such virtual worlds are used for different educational purposes, especially for demonstrating concepts that are difficult to represent efficiently enough in real life. Examples include complex physical phenomena or 3D geometry, arts, scientific experiments, and historical places. In this case, we found 3D CVEs useful in exploring history and
knowledge of cultural heritage. The 3D CVE described here was used to support the re-creation (with different degrees of precision) of an ancient site of historical and sociological significance. All its features acted as a valuable addition to a ‘traditional’ educational process in history and related subjects. To-date, a number of similar historical reconstructions have been completed using 3D virtual environments [see e.g. 5, 6, 7].

However, many of the experiences in these virtual worlds are reported as disconnected with those of their real-world counterparts. The work in this paper reports on addressing this apparent incongruity and outlines a strategy for going some way towards reconnecting the virtual and the physical in a reconstructed historical context. This is done both by using the virtual world to strengthen the learning impact of visits to cultural sites, and also by having users in the real and in the virtual site exchange and enrich each others experiences. It requires the integration of the 3D CVE with mobile technologies that support mobile access and interaction. In general, while CVEs focus on collaboration among people that are geographically distributed, mobile and wireless services bring local issues back into the distributed virtual environment, recognizing the critical role of place and local communities in learning. Still, development of such an integrated and augmented system, especially in a multi-cultural team, is associated with some challenges, as outlined later in this paper. These challenges are related to both the technological and social/cultural aspects of the project.

The rest of the paper is structured as follows. The next section presents the original CVE system reconstructing the site of the Stiklestad battle. This section is concluded with a discussion motivating the necessity to augment the system with mobile devices, providing a brief overview of the related work in the area. Section 3 outlines the design of the corresponding system. Section 4 discusses the challenges associated with developing such a system in a multi-cultural context, while Section 5 concludes the paper.

2. Background

2.1 The original system

The initial project this paper refers to was conducted in Spring 2006. The goal was to create an interactive educational game based on the Battle of Stiklestad, as a part of a student project. Stiklestad is famous as the battlefield where King Olav Haraldsson fell on July 29, 1030. The Battle of Stiklestad represents the key event in the introduction of Christianity in Norway [8]. Therefore it is a very important part of the national and especially local history in the Trondheim area, where the Norwegian University of Science and Technology is situated. The place of the battle is now used as a museum area.

The Virtual Stiklestad (VS) project game provided a 3D virtual environment where the users could ‘immerse’ themselves in the historical settings of the battle, perform a number of quests as a ‘part’ of the St. Olav’s army, and in this way learn more about the event in an informal and playful atmosphere. The prototype was developed using Active Worlds (AW) technology [4], which provides a number of basic features for virtual world creation, such as a library of pre-built avatars and objects, possibilities for object manipulations and features like chat and a contact list. AW also allows creating advanced scripts/bots by using the AW Software Development Kit (SDK). In addition to the standard library objects, the students working on this project created custom objects and avatars using tools such as 3D Studio Max.

During the preparatory phase, the students visited the Stiklestad historical site and museum and consulted the specialists there. With these consultations, the students designed avatars representing farmers and warriors, wearing costumes of the period of study, as well as some buildings (Fig. 1). Based on the map of the area, the students created a landscape in the virtual environment mapping the one of the physical site. Quests were implemented using web-based Flash applications, which the user could access from the in-built web-window of the AW browser.

When entering the environment, the user gets a short introduction on the Stiklestad event and the game. He/she wonders around and explores the world, meeting a number of static inhabitants/avatars. By clicking on an avatar, one initiates a corresponding quest in the web-window, such as archery training and fighting, to collect enough points to qualify for joining St. Olav’s army.

Due to the limited time the students had for the project, as well as some unpredicted conditions and AW limitations, not all the planned facilities in the game were implemented. While every attempt was made to recreate the avatars and objects in the world as authentic as possible, some ‘freedoms’ and use of imagination were used in reconstructing the site, sets, and characters. Still, for the purposes of a proof-of-concept prototype, the constructed sets were sufficient.

The system described above was originally planned only as an educational virtual demo and game to be used both in the local communities and among people outside Norway who wish to learn more about Norwegian history. The goal of this project is however more than simply visualization, but rather to recreate an ‘experience’; a way of interacting with a simulated
environment that includes the key elements of special cultural significance to that place, time, and event. Generally, virtual heritage reconstructions depend on the understanding of the traditional cultural values attached to specific landscapes, artifacts, and infrastructure. In this way, the user does not only become immersed in the realism of the simulated environments, but the historical narratives that go with those environments. However, such immersion and interaction can be complicated if the experiences in the virtual world are disconnected from the ones learners can acquire during the real visit. Also, collaboration among people who explore this historical site online in the virtual environment and those doing it in the real world is limited, thus missing an important cultural perspective. This is especially relevant when the online users are distant ones, e.g. accessing the system from a different country, while the onsite users are local inhabitants who could share their cultural and historical insight with the others.

Figure 1. Warriors and farmers in a historical village

2.2 Augmenting 3D CVEs with mobile devices

To solve the problems mentioned above and to enhance the sense of shared experience, we suggest integrating the virtual environment with mobile devices such as PDAs. The integration of mobile technologies and CVE aims at blurring the boundary between the communities of users online and onsite, supporting different forms of interaction and mutual enrichment of experiences, as well as adding a new layering of reality to the immersive experience. We have earlier developed an augmented system for social awareness support, consisting of a CVE and a PDA [9]. We suggest using the same principle for an educational exploration of cultural heritage.

The combinations of virtual environments, either 3D or text-based/2D with mobile devices to achieve additional accessibility, have been used in a number of areas. In a number of cases PDAs are used to provide a more familiar and convenient 2D interface in a 3D environment, for example to support collaborative navigation, communication and annotation on a virtual historical site [10].

Augmented system involving 3D visualizations and mobile units are extensively used in virtual archeological reconstructions (e.g. ARCHEOGUIDE [11] and MUSE [12]) and collaborative exploration of museum exhibitions (see e.g. [13]). The equipment used typically involves HMD (head-mounted display [13]), wearable laptops and tablet PCs [11, 12, 13] and PDAs [11, 13]. The positioning of the user is determined by direct user input, recognition of images of corresponding landmarks taken by wearable camera [11] or GPS [13]. During the tour, the user typically gets visualizations and reconstructions of the corresponding historical sites on the tablet screen or via HMD, sometimes with animations and elements such as virtual humans. These are often displayed and reconstructed over the actual, contemporary image of the site [11]. The user can receive audio explanation, as well as additional text- and simplified graphical information via the PDAs [11, 13]. The activities of the users can be mapped to the corresponding 3D virtual environment [13].

3. Design of Virtual Stiklestad

The primary goal of the system proposed in this paper is to create a learning community across the borders of the virtual world and provide the users with an interface that is as undisruptive and accessible as possible. Therefore, as opposed to many existing applications, we seek to avoid using extensive and costly equipment such as HMD and carry-on tablet PCs. We rather want to take advantage of the different modalities of access provided by the PDA: awareness of what is happening in the augmented environment and simplified interaction with its inhabitants. In this way, we can make the system as simple as possible, avoiding the necessity of having an advanced graphical interface on the PDAs. Therefore, the following major requirements can be identified:

- The system should provide a stimulating, rich and informative environment to support an efficient educational process in an uninhibited atmosphere.
- The system should support communication and joint activities between the online and onsite users.
- The system should be robust, user-friendly and easy to use.
3.1 Usage scenarios

Based on the requirements and the discussion above, we suggest 2 scenarios for the use of VS, involving onsite and online users working together in synchronous and asynchronous manner.

**Scenario 1.** A group of students works on a project as a part of their history class. Their task is to extend the reconstruction of the VS environment described earlier. Two of the students, A and B, are working on the actual historical site. The other two students C and D work on the construction in the VS world. C is a local inhabitant while D is a student from Australia participating in the project on a distant basis. For D it is especially interesting to participate in the project to learn about Norwegian history and culture as he has never been to Norway.

The two students on the site are working in their corresponding areas, collecting material, talking to museum employees and generally getting new impulses and ideas for design of the environment. Via their mobile devices (PDAs), A and B communicate with each other and students C and D working in the virtual environment. For example, student C goes to a specific location in the VS world and asks student A to come to the corresponding location on the real historical site. The two students discuss and compare what they can see from and around this point in the reality and virtuality and plan some changes, e.g. moving some virtual objects, to make the mapping more accurate. Later the chat log of the group discussion is reworked by one of the students and submitted as an answer to the theoretical part of the project. Students A and B can also take some photos and place them on the web. These pictures are then linked and displayed in designated places in VS world, to serve as a reference for future work. The onsite students can also leave some comments on the virtual constructions that need to be changed for a better authenticity, or change them directly. This is done by communicating with agents online in the virtual world and giving them commands to modify or create corresponding objects.

**Scenario 2.** When the project is finished, the Australian student D wants to share his knowledge of Norwegian culture and history with his friends ‘down under’ who do not have the possibility to see the Stiklestad site ‘live’. A group of Australian students logs into the Stiklestad virtual world, exploring the settings and performing quests. They play together with a group of Norwegian students who are situated at the physical Stiklestad site with their PDAs. These students can perform some of the quests by communicating with agents/bots in the virtual world via their PDAs, answering to historical questions and so on. As they are on the site, they can get help to some questions from museum exhibitions and employees. At the same time, while being on a particular place, the onsite students can get information of interest from the bots working in the corresponding location in the virtual environment. Both the quests and the information given to the students onsite are to a great extent determined by their location within the Stiklestad area, which is known to the bots and online players by e.g. GPS devices in the students’ PDAs.

During this game, students can help each other. For example, when a Norwegian and an Australian student are on the same location in correspondingly the physical and the virtual Stiklestad, they can exchange their impressions and together work on the quests related to that area. During the game, the Australian students will get a more ‘immersed’ experience when interacting with their partners on the actual site. The Norwegian students, on the other hand, can benefit from studying history put into context. When sharing their understanding of the Stiklestad battle with people from other culture who have never been to Norway, they can enhance their own understanding of the topic but also become more aware of cross-cultural issues.

To realize such scenarios, we propose a system design as elaborated below, based on the requirements in the beginning of this section.

3.2 Design and implementation of Virtual Stiklestad

The major components and domains of the Virtual Stiklestad augmented system include the mobile user domain, server domain and Active Worlds domain:

**Mobile user domain.** Due to the size of the PDA screen, it is important to ensure that the interface of the VS PDA client is user-friendly and easy to use, but also that communication and activities in the augmented environment are properly supported. To obtain acceptable efficiency and to reduce mental complexity, the metaphor of tabs is used (Fig. 2). The ‘Users’ tab displays the contact list, with status indications such as online in the virtual world, onsite via PDA, offline (denoted by different icons) and location coordinates. In the same window, the user can send private messages to the contacts, independently of their ‘location’. The ‘Public Chat’ tab shows ongoing chat, both among online and onsite mobile users, with an ‘input’ field. The text communication appears the same to both ‘virtual’ and ‘mobile’ users. The former see the latter through their entries in chat and static avatar figures. The support for gestures for mobile
users was omitted to keep the system as simple as possible.

Figure 2. The user interface of the PDA client

Active Worlds domain. The design of the Virtual Stiklestad world in AW is already presented in Section 2. The major additional effort in this context is directed at supporting communication between the AW users and the onsite mobile ones in a flexible and seamless way. The messages between the two environments are mediated by agents/bots, placed in the VS virtual environment. To enable private conversations, every PDA client needs to be represented with own avatar/bot inside AW. Also, these bots allow mobile users to annotate and modify objects in the virtual component via text commands.

Server domain. The server interprets received messages and performs the appropriate action for the particular message type, serving as a bridge between the other two domains.

The implementation of the system is based on the AW SDK and focuses on creating a bridge between the mobile and the virtual parts of the system. It is described in more detail in [14].

4. Discussion

The realization of this project in a multi-cultural team allowed us to identify a number of challenges associated with developing educational virtual heritage systems, especially with a mobile component. These challenges can be summarized as follows:

Compatibility between different platforms. Generally, one can expect significant difficulties with establishing communication between the mobile devices and the virtual environments, especially when the latter are independent commercially-based systems. As we have no control of such a system and no access to the source code, the behavior can in some times be rather unpredictable while customer service is limited. Also, the major changes in the system such as version upgrade can lead to disruptions in the established functionalities. For example in our case a version upgrade resulted in a breakdown in the communication between the AW server and the mobile application, so the implementation had to be revised. Generally, one has the trade-off between the availability and easy accessibility of a commercially available platform versus the effort and uncertainty associated with developing a customized system.

Cross-cultural issues. During the preliminary development of the virtual part of the system and the subsequent development of the mobile component, a number of tensions and misunderstandings arose among the multi-cultural members of the team, consisting of ethnical Norwegians, Australians, Russians, Spanish and Vietnamese. These problems considered language problems, time differences when communicating with the Australian part, different views on how the process should develop, as well as cooperation patterns. One of the remarkable aspects has been the Norwegian-Australian conflict as the Norwegians wanted as little as possible interference (when developing the graphical VS environment) from the Australian part while requiring more resources from the Australian server. The reasons behind can be both attributed to the feeling of exclusive ownership of the virtual heritage content and the different conventions in teacher-students relations in the two countries.

The quality of reconstructions vs. available resources trade-off. As mentioned in Section 2, not all planned reconstructions and quests were implemented as planned. There are a number of reasons for that. First, even the specialists at Stiklestad museum could not with certainty answer some questions concerning the clothing and design of the buildings belonging to the studied period. Therefore, the developers had to take some freedoms and choices when designing these objects. We believe that such problems are rather common in most virtual heritage related projects. Second, not all the planned features were finished or implemented due to limited resources, e.g. due to the time constraints of the students projects. Therefore, in similar projects where time or financial resources are very limited, special attention should be paid at focusing on certain parts and prioritizing from...
the very beginning. Third, the technology used imposed some unexpected limitations, with the result that lower-quality solutions (e.g. flash-based quests instead of 3D based ones) had to be adopted. Therefore, the technology to be used should be tested carefully versus the actual goals.

**Designing mobile devices to be used in augmented systems.** As both experience and the related literature shows, integrating mobile devices with 3D CVE is not always straightforward. For example, existing irregularities with wifi coverage might complicate the communication between online and onsite users and thus diminish the user experience. 2D PDA interface, though providing the required minimum of functions and ensuring simplicity, will inevitably complicate the onsite users' activities and manipulation in the virtual component compared to the online users. Also, due to the significant differences in the interface between the mobile and virtual part of the system the onsite and online users' representation of the overall system will differ to a greater degree. This will, on one hand, enrich both parts, but on the other hand, complicate mutual understanding and collaborative activities.

**Educational aspects.** To create an engaging but at the same time informative educational system, it is important to find a balance between the entertaining elements such as quests and the historical content. In the case of an augmented system, there is an additional challenge to harmonize and connect online and onsite activities to support collaboration between the two learner communities. Also, the system should be flexible enough to be adjusted to different educational situations, learner groups and courses, to allow different modes of usage depending on the current needs.

**6. Conclusions and further Work**

This paper presents a project where 3D CVE is augmented with a mobile device in order to support a collaborative educational exploration of a historical site. Based on the experiences acquired during this project, we have discussed the challenges associated with developing educational augmented virtual heritage applications in a multi-cultural context.

An important outcome of this project will be the ability for non-Norwegian users to contribute and learn from the interaction with a different cultural heritage project. This extends the role of the traditional museum, but also the inherent value in sharing local cultural events with people from different cultures. In turn, their contribution to interpretation of the events via the CVE and/or the PDA opens the possibility to better understand the scalability of this system to other cultural heritage reconstruction projects. The further exploration of the corresponding cross-cultural issues will constitute yet another direction for future work.

**References**


