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Battle of Stiklestad: Supporting Virtual Heritage with 3D Collaborative Virtual Environments and Mobile Devices in Educational Settings

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Abstract

3D Collaborative Virtual Environments (CVEs) have been widely used for preservation of cultural heritage, also in an educational context. 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 a set of requirements for an augmented system, describes the corresponding design and outlines the technical implementation of a hybrid prototype.

1. Introduction

3D Collaborative Virtual Environments (CVEs) can support learning communities in a number of ways, providing a social arena where learners can meet and work [1]. There exists a wide range of 3D educational virtual environments, supporting learning in different contexts, e.g. in Active Worlds Educational Universe [2]. The metaphors behind the design of virtual places are quite diverse, from replication of real universities to other planets. Such virtual worlds are also 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 particular, CVEs can be useful in exploring history and knowledge of cultural heritage. Such environments can be used to support the re-creation (with different degrees of precision) of ancient sites of historical and sociological significance. From reconstructions recording historical information about these sites a realistic image of how these places might have looked in the past can be created. This also allows inhabiting of these reconstructed spaces with people and artifacts for users to interact with. All these features can act as a valuable addition to a 'traditional' educational process in history and related subjects. A number of historical reconstructions have been completed using 3D virtual environments [see e.g. 3, 4, 5].

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. This is made possible by supporting access to the virtual world for mobile users, and by supporting interaction between people interdependently in the physical and the virtual world, taking advantage of the specificity of the two different situations.

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. This not only supports interactions with "others around the world, but also – and, perhaps more importantly, with people nearby" [6]. The challenge therefore is to design, what Thackara calls, new geographies of learning, "configurations of space, place, and network that

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respect the social and collaborative nature of learning – while still exploiting the dynamic potential of networked collaboration" [7].

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. Section 3 provides an overview of existing augmented systems, especially for exploration of cultural heritage and historical sites. The following section presents a set of requirements for the Virtual Stiklestad augmented system. Section 5 outlines the design and implementation of the corresponding system, while Section 6 concludes the paper.

2. Background

2.1 Description of 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. With few exceptions, the new Christian kingdom was accepted after 1030, and it was to develop into a state later in the Middle Ages. The battle and Saint King Olav made it possible for Stiklestad to act as a symbol of both Christianity and the kingdom [8]. Battle of Stiklestad is therefore 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. It is also a venue for an outdoor historical play, "The Saint Olav Drama", which takes place during the yearly Saint Olav festival in the Trondheim 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 [2], 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, 2). Based on the map of the area, the students created a landscape in the virtual environment mapping the one of the physical site. Other landscape features, such as fields (Fig. 2) and forests were placed in the world, not necessarily to provide an exact mapping to the existing conditions in these days or in 1030, but mostly to create an appropriate atmosphere. Quests were implemented using web-based Flash applications, which the user could access from the in-built web-window of the AW browser (Fig. 3).

Figure 1. Warriors and farmers in a historical village

Figure 2. A warrior in the fields

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 (Fig. 3).

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, such as additional figures/avatars, the Nidaros cathedral where Saint Olav is buried and a scenery reflecting St. Olav's death. Also, not all planned quests were finished, including those focusing on historical knowledge and a 'viking' puzzle. However, it is planned to rework and extend this project given the historical importance of the Stiklestad event. 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. This is partially due to the time constraints and the limitations imposed by the technology. Still, for the purposes of a proof-of-concept prototype, the constructed sets were sufficient.

Figure 3. Archery training quest

2.2 Online and onsite communities

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 for their immersive realism on an 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, not allowing a mutual enrichment of the two forms of fruition of the cultural heritage. 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.

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 on line and on site, 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 next section presents some related work on augmented systems involving virtual environments and mobile devices, especially in the field of virtual heritage.

3. Mobility and CVEs: Related Work

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. The most prominent examples are the mobile versions of wide-spread messaging services: MSN, Yahoo, Skype, ICQ and so on. These are available on PDAs, smartphones and mobile phones. PDAs have also been used to provide access to shared workspaces in virtual environments, via textual or graphical interfaces. Examples include location-based games such as 'Feeding Yoshi' [10] and virtual campuses with mobile component like mCLEV-R [11]. In the latter example, students can gain access to a 3D virtual campus through a simplified graphical interface on a PDA. 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 [12].

Augmented system involving 3D visualizations and mobile units are extensively used in virtual archeological reconstructions (e.g. ARCHEOGUIDE [13] and MUSE [14]) and collaborative exploration of museum exhibitions (see e.g. [15]). The equipment used typically involves HMD (head-mounted display [13]), wearable laptops and tablet PCs [13, 14, 15] and PDAs [13, 15]. The positioning of the user is determined by direct user input, recognition of images of corresponding landmarks taken by wearable camera [13] or GPS [15]. 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 [13]. The user can receive audio explanation, as well as additional text- and simplified graphical information via the PDAs [13, 15]. The activities of the users can be mapped to the corresponding 3D virtual environment [15].

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. Also, our goal is not to provide access to the virtual world with the same interfaces as the desktop application. Rather, we 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.

4. Requirements overview

Based on the discussion above, we can arrive at a preliminary set of requirements for an augmented educational Virtual Stiklestad (VS) system, consisting of a 3D CVE and a PDA. This set of requirements acts as an extension and a supplement to the one presented earlier [9] and is structured along the dimensions of learner, place and artifacts.

Learner

- By learner in the VS augmented environment we understand both the onsite users who enter the environment via the mobile device and the online users who enter it via the virtual component.
- In addition to human users and players, the system should include agents/bots whose task is to facilitate the learning process and communicate with both online and onsite users, providing necessary guidance and assistance. This includes also assisting the onsite users to modify the virtual environment.
- The system should provide a mapping of the contact lists and user identities in both the virtual and the onsite components of the system and facilitate flexible communication between the users in both parts of the environment and the agents.
- The system should provide awareness of the status of the users in both parts of the environments. This implies the position of the users, online/onsite/offline status, activity level and notifications on various events.
- The system should be easy to use, robust and user-friendly for the users in both parts of the system.

Place

- By place in the VS augmented environment we understand the continuum where the mobile learners onsite and online learners in the virtual component are performing their activities.
- The augmented place should provide a framework for learners' activities. There should be possibilities for the flexible modification of the virtual place, both by the online and onsite users.
- The place in the virtual component should provide a close resemblance and mapping to the physical counterpart.
- The augmented environment should support differentiation of places for different roles by supporting private and public communication modes, and by assigning different gaming and educational tasks to different places within the augmented system.

Artifacts

- The notion of artifact and artifact manipulation in the VS augmented environment includes the artifacts in both parts of the environment as well as the ones used to facilitate collaboration across the borders of the two components.
- The system should allow both onsite and online users to contribute to the 'shared repertoire' of the community, so that onsite users could annotate, modify and create objects in the virtual component.

5. Design and implementation

5.1 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 wants to clarify some questions regarding the outlook of some constructions and asks either A or B to discuss these issues with the museum specialists, sending a screenshot of the construction in question. The museum specialist can also later log into the virtual environment and examine the constructions, commenting on their 'authenticity'. On another occasion, 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 projects.

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.

During their work, the students see that their history teacher, who is abroad on a conference, logs in from her PDA while waiting in an airport. She participates in the discussion and gives some remarks to the students. Later, when she arrives to the hotel, she logs into the 3D virtual environment from her laptop and visits the construction site. She examines the models there and gives her feedbacks and suggestions. When the students A and B see the teacher online and her position at a particular part of the reconstruction (indicating that she has examined the models created by the group) they ask her of her impressions. Later, when the Australian student D (who due to the time difference could not be present during the whole session) logs into VS, he can see the teacher's comments and annotations and alterations done during his absence by A and B. He examines their pictures from the physical Stiklestad, using this material for further construction work.

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 on-site 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 Section 4. The next subsection presents the major design components and discusses the corresponding implementation aspects.

5.2 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. 4). 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.

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 (Software Development Kit). The major software components are summarized in Fig. 5. The AwLibrary component is a C++ .NET project that encapsulates some of the functions in AW SDK and is used in another component, AwServer project, which constitutes a bridge between AW and the rest of the system. This program initializes the AW SDK, connects to the AW galaxy server, enters the correct world, and sends and receives messages from the galaxy server. Though AW SDK is written in C, the server application is implemented with .NET technology since it facilitates implementation of threads and sockets programming, which is essential for this project. The Server component deals with most of the communication between mobile users, and sends messages via the AwServer bridge to the AW galaxy server. SmartServerLibrary is used to contain some of the shared functionality that the server and the mobile client use. MobileUser is the actual PocketPc client application for the VS system.

Figure 4. The user interface of the PDA client

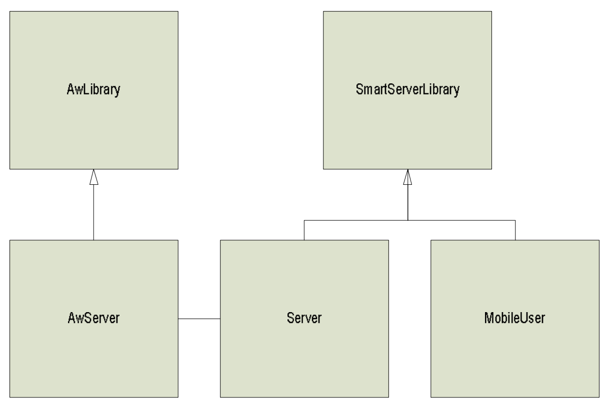

Figure 5. The major software components of Virtual Stiklestad

6. Conclusions and further Work

In this paper we have presented the design and implementation of a system called 'Virtual Stiklestad' for collaborative exploration of a historical site in educational settings, which combines a 3D CVE and mobile devices (PDAs). Some problems were associated with the implementation of the proposed design, mostly with the 'bridge' between AW and the server. These can be mostly attributed to the limitations imposed by Active Worlds. Overcoming these limitations will be a part of the future work. The evaluation of the resulting prototype is planned involving both local students from the Norwegian University of Science and Technology and foreign students from e.g. Australia. The major goal of this evaluation will be to identify to what extent the system will contribute to a better understanding of the Stiklestad Battle and the corresponding historical background, allowing the users to 'immerse' into the legend. Another issue to explore is whether adding the mobile devices into the system will create a 'bridge' between the onsite and online communities using Virtual Stiklestad. As a result, the design of the system will be revised or, alternatively, other system configurations will be proposed.

An important aspect to consider is the ability for non-Norwegian users to contribute and learn from the interaction with a different cultural heritage project. This extends 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 exploration of the corresponding cross-cultural issues will constitute yet another direction for future work.

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