Visualization, Animation and Simulation for Mobile Computers: Experiences from Prototypes

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Abstract

During the project iVISiCE (interactive Visualizations in Civil Engineering), which was started in 2001, a great number of Web based animations, visualizations and interactive Learning Objects have been developed to visualize and to simulate highly complex processes. Consequently, a lot of experience in the investigation of possibilities of using Multimedia in Higher Education has been gathered. Most of the material was created by using the Macromedia Flash Technology including Video and Audio elements and enabling interaction. It is now interesting to note that Civil Engineering personnel Ű very similar to medical personnel Ű are a highly mobile end user group. Construction managers, civil engineers and master builders working on the building site must communicate with the planning people, including architects and stress analysts. Often, small problems occur during the construction process, which every engineer would be able to solve with a calculator and tables Ű if these were at hand. Consequently, the need to develop simple, practical and robust applications for solving Civil Engineering problems via a mobile phone is increasingly necessary. Whereas the usual software needs high-end desktops, future tools will run on various mobile devices already at hand. In this paper we report on first experiences with Macromedia Flash for the use on these mobile devices.

Categories and Subject Descriptors (according to ACM CCS): D.2.2, H.5.2, K.3 [User interfaces, visualization, Computers & Education]: Simulation for Mobile Computers

1. Introduction

In 2001 the project iVISiCE (interactive VISualisations in Civil Engineering) was founded [TG01]. Originally, the aim of this project was to investigate the possibilities of Web use in Civil Engineering education. This original e-Learning venture focused on three major research topics – communication, interaction and visualization. One of the main questions during this time was *Does the use of interactive visualizations have a positive effect on learning*. During this time a lot of experiments were carried out [EH02], [EH03], [HE03, EZH03]. A lot of highly complex engineering models have been developed which need expertise both in the field of Civil Engineering and in Usability Engineering. In the last year, a sophisticated Self Assessment Tool (SATO) was built. Now we have expanded our vision from educational perspectives to the practical application of this education – at the building site where information needs to be obtained on the move. In this paper we introduce our current work, which concentrates on mobile applications and the support of engineers at the building site.

2. The importance of visualization & simulation

Teaching and learning by using visualizations and simulations have never been common in higher Civil Engineering education. Especially in the field of Civil Engineering, where sketches and drawings are absolutely necessary to explain complex engineering models, these new technologies are still rare. At the same time the access to complex systems in the real world for training in Civil Engineering is usually limited, risky and costly (Figure 1). Here, Visualization and Simulation can help to fill the gap (compare Figure 1 to Figure 2).

Figure 1: *Experiments in Civil Engineering are limited, risky and costly; appropriate visualization can gain insight into aspects which are not visible in reality. Here we see a typical experiment of a structural concrete beam. Deep understanding of this processes are essential and form the basis for in-depth learning.*

These interactive visualizations and simulations can also demonstrate the conditions of actions and events in the real world and subsequently support a constructivist learning approach [Hol02] which is more student centered [MPH02], [MPH05]. However, due to the fact, that the *speech of an engineer is his drawing* the development of such applications is not easy. A line is more than a line, because in connection with a certain situation every engineer knows how it must look. From this point of view, a visualization can be seen as a simplification of a complex model with the aid of moving lines and figures. It is a necessity to include aspects of Human-Computer Interaction and Usability Engineering into the development of such objects, in order to ensure that this specific end user is able to deal with these applications and to gain benefits out of their use.

3. The importance of interaction

Most of the material created since 2001 is interactive; consequently, these are called Interactive Learning Objects (ILO). One such ILO always consists of three major parts: an advanced organizer, the learning material and a problem.

An advance organizer [Aus60], [CBG88] is intended to provide information for the students, to scaffold their learning processes and to support them in navigation through the ILO effectively. It is essential that the students have to solve a certain problem. Another part of such an ILO is communication. Furthermore, specific discussion forums on the topic of the ILO's support the students. Finally there is always a small examination. Thus the major facts of the ILO have been proven and repeated. The students can check their knowledge by themselves. This is in close accordance with problem-based learning (PBL). However, this requires to put more emphasis on the User Interface [GSSK97], [Mar02], and even more importantly, the needs and demands and requirements of the users [Bev99].

4. From desktop to mobile applications

To design and develop mobile applications with a high acceptance, it is essential to obtain empirical insight into the work practices and context in which the mobile application will be used. Mobile applications are only useful when design and software validation aspects have been taken into account [HME04], [RMB*04], [KM02].

From previous and parallel current projects since 2001, when the project iVISiCE was launched, the authors have acquired expertise from desktop to mobile applications and from educational to real-life perspectives.

4.1. Multimedia visualizations

At the beginning of the project a lot of visualizations and animations were built (Figure 2). Essential topics of the lecture Structural Concrete were defined and animated in a end user friendly approach. It must be pointed out that the reduction from complex coherences, as we can see in nature, to a simple visualization has to be very carefully done. The central aim of this project was that the essential tasks must be carried out and unnecessary details neglected.

After the first use, during this lecture, the evaluation of the lecturers and the students showed that the new technology was a good support for explanation, but there was no measurable increase in learning success. Due to this fact, the project team expanded the animations with audio elements during the following years, because if the students like to learn they need additional explanation as to what they are seeing on the screen. This kind of information cannot be presented in a written form, because the students have to concentrate on the animations.

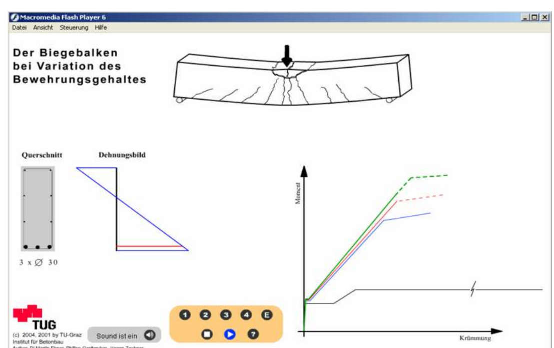

Figure 2: *A typical Multimedia Interactive Learning Object of the iVISiCE collection on a Desktop Computer; interactive Animation: Altering parameters makes the effects immediately visible.*

4.2. Multimedia interactive learning objects

The next step was the development of Interactive Learning Objects. According to the design principles of Gagné, we addressed the guideline *learning by doing*. This means that the students must interact with the ILOs alone subsequently, their learning processes were enhanced. The main problems during the development were the arrangement of the necessary small windows within the whole screen. After the building of prototypes, usability inspection methods; including thinking aloud and cognitive walkthrough; helped us to implement an end user centered application.

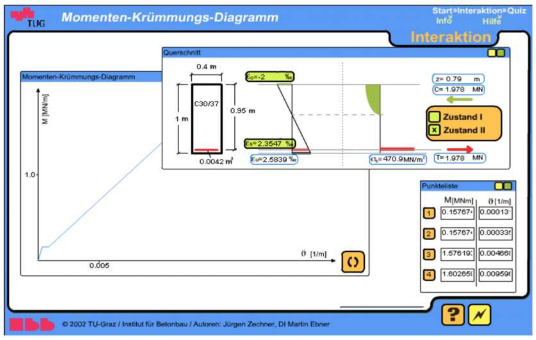

Figure 3: *Example of an Interactive Learning Object (ILO).*

4.3. SATO (Self Assessment TOol)

During the summer 2004, a sophisticated self-assessment tool, called SATO, was implemented. The aim of this tool is to allow students of civil engineering to learn about the analysis and calculation of normal stresses for a typical cross-section and material. SATO supports self-directed learning. Animations and Interactive Learning Objects with the experiences of the previous iVISiCE developments have been implemented. In Figure 4, a typical screen is shown. Drag & Drop functions, buttons, input boxes, etc. have been used in order to support the students' interactive learning.

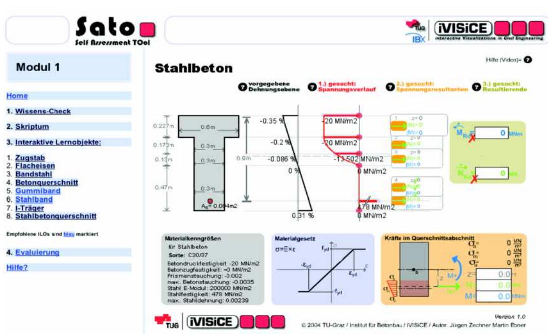

Figure 4: *Most advanced multimedia interactive learning with SATO.*

4.4. Mobile applications

The next step was to bring the content of the iVISiCE project to mobile devices. We did it prototypical with selected applications yet, but we will carry on and will demonstrate some interesting examples during the CEMVRC conference.

Figure 5: *A prototype of Mobile iVISiCE in action using Flash Lite as a pre-runner for the project SMACE (refer to Section 6).*

However, the first experiences with Flash Lite proved to be very good, although the focus on Usability Engineering of mobile devices is an absolute necessity. Former experience with Java-based applications on mobile phones have been available [HNM05] and was taken into consideration.

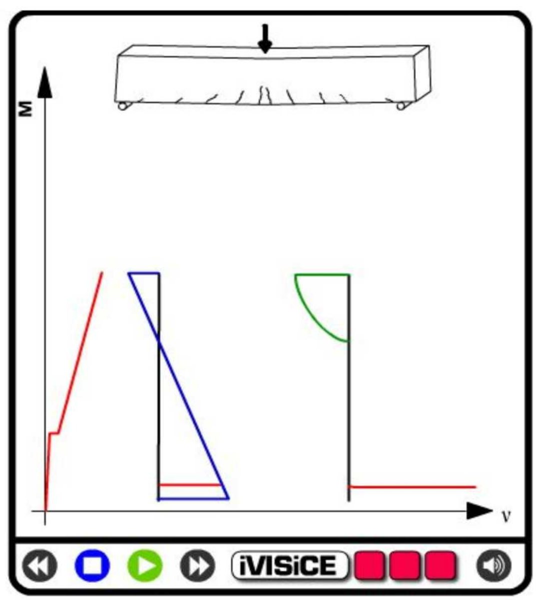

Figure 6: *A typical iVISiCE application for a mobile device.*

5. From Flash to Flash Lite technology

In the beginning of 2001, the project team decided to use the Macromedia Flash technology because of the great possibilities of drawing engineering models which it offered. Meanwhile, Vector graphics for the Web were gaining momentum through Macromedia's proprietary Flash technology resulting in a quasi Web-Standard [Qui03]. One of the advantages of Flash is the compact file size, due to the use of vector based graphics, for fast access via the Web. Further, the integrated programming language ActionScript allows the user to control the application and to work with it. In the last few months, the technology has also been made available for mobile devices, including mobile phones, smart phones and pocket PCs, causing a huge burst of new Flash content development. Macromedia Flash Lite [Mac05] is specifically developed for mobile phones. The constant growth is driven by the Flash rendering engine that delivers consistent experiences across various operating systems, processors, and screen sizes. The features of Flash Lite are exactly suiting our demands and can, according to Macromedia, be summarized as follows:

- **ActionScript Extensions:** allow authors to access phone-specific features directly (e.g. monitoring signal strength or battery level; sending SMS messages or dialing numbers).
- **Network Access and Connectivity:** Flash content that resides on a mobile phone can download new data from a web server by using various functions. Flash Lite 1.1 supports the `getURL()` action, which can be associated with the following keys: ⟨0⟩-⟨9⟩, ⟨*⟩, ⟨#⟩, or the ⟨Select⟩ key. The `getURL()` function can be used to load another resource over HTTP (http:) or Secure Sockets Layer HTTP (https:) requests, to send e-mail (mailto:), or to dial a phone number (tel:). It is also possible to load data and SWFs from a web server using the `loadMovie()`, `loadMovieNum()`, `loadVariables()`, and `loadVariablesNum()` functions.
- **Additional Audio Support:** support for MP3, PCM, ADPCM, and SMAF audio formats to the MIDI support. Hardware support for these formats is utilized; software implementations take over when it is not.
- **SVG-T Playback:** Operators and OEMs can license a single solution that supports Flash as well as animations created using SVG-T. MMS assets, WAP browsers, and other applications can be enabled to support Flash and SVG-T playback using Flash Lite 1.1.
- **Scaleable Rendering Engine:** is the de-facto standard for interactive content and supports vectors, gradients, bitmaps, user input, audio, and scripting.
- **Static, Dynamic Text and User Input:** Flash Lite supports static text and dynamic text fields. Static text describes elements whose contents and appearance are determined when the content is authored. Dynamic text fields display areas that update dynamically during runtime.
- **Navigation and Key Events:** Flash Lite 1.1 uses three keys for navigation within an interactive movie: ⟨Up⟩, ⟨Down⟩, and ⟨Select⟩. These keys correspond to the ⟨Shift+Tab⟩, ⟨Tab⟩, and ⟨Enter⟩ keys on the desktop versions of Flash Player. The keys ⟨0⟩-⟨9⟩, ⟨*⟩, and ⟨#⟩ are also available.

6. Conclusion

However, the availability of Flash Lite on mobile phones (Smartphones) is, at the time of this paper was written, not available in Austria. Therefore, we built prototypes by using the yet available version for PDAs (see Figure 6) which worked well and suited the needs of the users during our first end-user centered tests perfectly. The content creation can be made by civil engineers experts and existing content can be made downloadable everybody, see http://ivisice.tugraz.at for a download example.

7. Future outlook

In a planned project called Smart Mobile Agents for Civil Engineering (SMACE) we want to analyze the requirements and workflows in detail within a construction setting in real life and we aim to develop a new concept of mobilized *Quasi intelligence Smart Agents*.

The central focus of this project is to improve and to assist the current workflows of the people involved on the construction site as much as possible. The combination of Mobile Computing and Human-Computer Interaction research with inclusion of Usability Engineering methods [Hol05] will provide a step further into mobile interactive information.

Figure 7: *A sample scenario of the planned SMACE project: On the building site the civil engineer solves a problem interactively by assistance of the SMACE application.*

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