The SimMed Experience: Medical Education on Interactive Tabletops

Ulrich von Zadow
Interactive Media Lab
Technische Universität Dresden
01062 Dresden, Germany
uzadow@acm.org

Sandra Buron
Dieter Scheffner Center
Charité-Universitätsmedizin
13353 Berlin, Germany
sandra.buron@charite.de

Kai Sostmann
Dieter Scheffner Center
Charité-Universitätsmedizin
13353 Berlin, Germany
kai.sostmann@charite.de

Raimund Dachselt
Interactive Media Lab
Technische Universität Dresden
01062 Dresden, Germany
dachselt@acm.org

Figure 1: SimMed in use

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Abstract
We present SimMed, a novel tool for medical education that allows medical students to diagnose and treat a simulated patient in real-time. The students assume the roles of doctors, collaborating as they interact with the patient. To achieve immersion and support complex interactions for gaining procedural knowledge, the hybrid user interface combines elements of real-time Virtual Reality with multitouch input. On the one hand, SimMed features a simulated, life-sized patient that is rendered and reacts in real-time. On the other hand, a more conventional touch input interface allows access to a large variety of medical procedures and tools.

Author Keywords
Collaboration; interactive surfaces; tabletop; multitouch; procedural knowledge; education; learning; medicine

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation (e.g. HCI)]: User Interfaces - Input devices and strategies; Interaction styles; Prototyping; User-centered design

Introduction
In medical education – as in other fields –, knowledge gained through memorization and lectures must at some point be applied in practice. Unique to medicine, however,

is that patient safety is crucial in this situation. Accordingly, a great deal of effort is expended to ensure a smooth transition to practice. One of the key issues here is that factual knowledge must be transformed to procedural knowledge – knowledge that can be applied directly in specific situations with specific tasks. Simulation scenarios using mannequins [2, 4] work very well in this situation, since they provide a safe environment in which life-like situations can be reenacted [3]. The main drawback of these simulators is cost (often higher than €100.000 for a full-scale mannequin). In addition, there are a number of symptoms that cannot be simulated easily, such as skin changes (rashes, color changes) or patient movement. SimMed was developed to address these limitations. Since the patient is virtual, it is inherently more flexible and supports a large variety of learning scenarios. Movement and skin conditions can be shown using animations and texture changes, and costs are significantly lower as well.

SimMed was implemented during a two-year research project by Archimedes Exhibitions GmbH and Charité Universitätsmedizin Berlin. The interdisciplinary team responsible included medical doctors, psychologists, software developers, interaction designers and 3D artists. A formal qualitative study of the system [8] revealed high immersion and engagement as well as strong evidence of a high learning potential and very productive teamwork by the students. The cited publication also describes the interplay between immersion, realism and successful achievement of training goals as well as the highly iterative development process used.

Related Work

In addition to the work on simulation in medical education mentioned in the introduction [2, 3, 4], we draw upon the body of prior work in collaborative learning on interactive tabletops, e.g. [1, 5, 6, 7]. Of these, two are particularly interesting in our context. A system by Kharrufa et al. [7] focuses on group problem solving and aims to trigger externalization of thinking. Antle et al. [1] present a system that supports experiential and constructivist learning. It is also one of the few systems that use simulation in the context of tabletop education. We found no prior work that aims to create an immersive learning experience or involves role-playing while using tabletops. Also, this is the first tabletop system that specifically targets procedural learning.

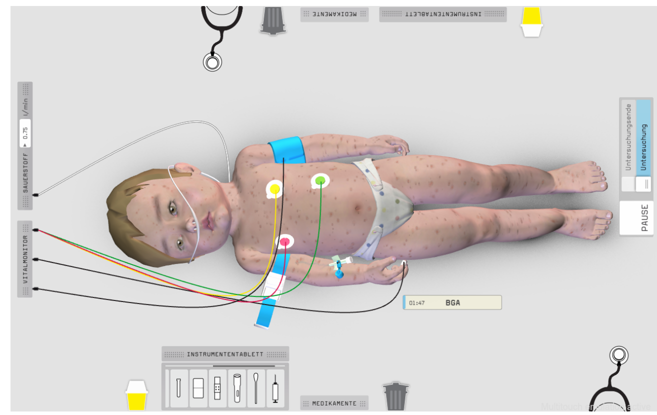

Figure 2: The main SimMed screen.

The SimMed System

The SimMed system is composed of a 50" tabletop with an additional 40" vertical output-only screen (See figures 1 and 2). Three to five medical students diagnose and treat a simulated virtual patient displayed on the tabletop. The primary system goal is teaching the students procedural skills such as practical differential diagnosis and the correct handling of treatment priorities. A strong secondary objective is practice of teamwork and associated communication skills.

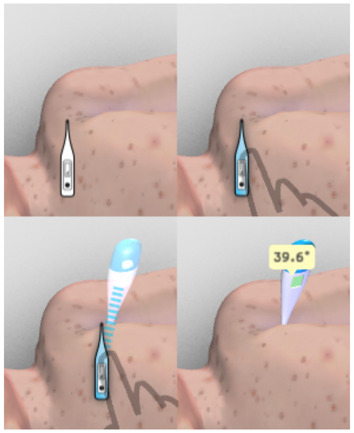

Figure 3: Instrument drag phases (from top left to bottom right: idle, while dragging, while dragging close to an active point, attached to active point)

Figure 4: Dragging menu

The students have a variety of diagnostic and treatment options available. They can measure temperature, blood pressure and pulse, listen to body sounds (auscultation), and examine skin, ear, mouth and eyes. Also, a virtual medical monitor can be attached that shows vital signs such as temperature and blood pressure on the secondary (vertical) screen. Virtual blood and mucus samples can be taken and sent in for testing. Further, students can insert intravenous cannula and give the patient medicaments through the cannula.

Scenarios
SimMed is implemented as a flexible base system that supports configurable scenarios. Currently, three scenarios are implemented, including a realistic emergency scenario involving a case of meningococcal sepsis. In this scenario, quick and correct action is necessary to save the patient. In all scenarios, the patient is an 18-month old child.

Interaction
To help in creating an immersive atmosphere, many of the SimMed user interface actions have roots in the corresponding clinical actions. At the same time, the complexity of the simulation would have been hard to handle with a pure Virtual-Reality (VR)-like interface while maintaining short training times. For this reason, the interface contains many standard touch interface components as well. This dichtonomy causes conflicts, and one of the major challenges of the project was finding appropriate ways to resolve these.

We distinguish two major types of interactions: direct examinations (e.g. feel the pulse of the patient, look at her skin) and actions with instruments. Both make use of active points (hot spots) on the body of the patient. Direct examinations are initiated using dragging menus (See figure 4) that avoid the need for a global interface mode change: Any touch on the patient opens a dragging menu. Dragging an item from the menu closes the menu; examinations are activated by proximity to an active point.

Instruments (e.g. thermometers) are initially 2D icons located in containers at the sides of the table. They can be dragged to appropriate active points to initiate actions. Since active instruments are attached to the body, they need to be rendered with the patient in 3D. The associated switch from 2D to 3D is handled by a carefully designed smooth transition (shown in figure 3). About twenty different instruments are available. As in real life, sequences of instrument actions can be combined to form longer procedures. Taking a blood sample, for instance, involves a sequence of five actions.

Discussion
We placed a high priority on creating an immersive atmosphere. Elements that support this are real-time interaction and rendering as well as the VR-like elements in the user interface. The vertical monitor is available to display additional simulation elements (such as the patient's relatives and medical devices) in the correct perspective. The child's anatomy is realistic as well and we have scenario-specific animations and textures that change in real-time as the simulation demands. At the same time, realism is limited by the platform used: Everything happens on two flat surfaces. There is no haptic feedback. Visual realism is limited by the resolution of the tabletop and the constraints of real-time rendering. Initially, it was not clear how immersion and learning would be affected by these limitations.

On a theoretical level, much of our reasoning in this context was based on research on simulation using mannequins. Dieckmann [3] postulates that realism is not a goal in itself: "The purpose of a simulation scenario is to create an experience episode from which participants can learn. It is irrelevant whether the scenario is realistic as long as it serves this function" ([3], p.65). He concludes that in the case of procedural learning, "the procedure needs to be performed and trained as it would be in clinical practice" ([3], p.119). Accordingly, we aimed to preserve the semantics of the actions and procedures involved as much as possible in the user interface. For instance, while we cannot train the complex sensorimotor skill needed to insert a needle in a vein, we can reproduce the corresponding sequence of actions and thus train situated, procedural knowledge.

This theoretical framework allowed us to achieve the very high degree of immersion and engagement we observed in our qualitative study [8].

Conclusion

In this paper, we presented SimMed, a real-time tabletop simulation system for medical education. SimMed's teaching goals include procedural skills and teamwork. Based on a sound theoretical grounding and using a hybrid VR/touch interface, we were able to produce an intriguing environment that fosters immersion and engagement. User interface elements like dragging menus and hybrid 2D/3D instruments contribute to this.

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