Surgical Interactive Multimedia Modules: A novel, non-browser based architecture for medical education

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Abstract

Contemporary medical education faces new challenges as the climate of the health care delivery system transforms. Diminished length-of-stay and continuity-of-care have radically altered the way medical students are exposed to and learn about illness. These educational challenges are particularly pronounced in the teaching of surgery.

We developed a multimedia application, Surgical Interactive Multimedia Modules (SIMM), to utilize rich media objects and high-resolution video to overcome modern didactic challenges. The SIMM client was created using Macromedia Director MX and communicates using XML with an Oracle database containing the rich-media educational objects. The SIMMs integrate digital video, 3-D models, self-assessment tools, and current medical evidence to generate a dynamic learning environment encompassing core surgery topics. Students can access SIMM modules either via a high-speed network connection or by using a DVD. The interface was designed to focus on a narrative timeline that provided students with a familiar metaphor for interacting with the learning objects.

Students on the surgery clerkship are currently using four SIMM modules and feedback indicates that they are regarded as compelling and useful educational tools for learning about complex surgical topics. Future areas of research will address student ability to annotate the learning objects and to maintain a personal repository of medical education resources.

1. Introduction

Medical education is experiencing major, systemic problems that are the result of fundamental, long-term trends in the practice of medicine. In the clinical years of medical school, drastically reduced lengths-of-stay in hospital have truncated the student's ability to view the natural history of a patient's illness. Lack of funding for education and pressure on faculty to increase patient volume, turnover, and research have further hindered new educational initiatives.

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The Department of Surgery at New York University School of Medicine sought to address these widespread problems by creating a dynamic multimedia tool called the Surgical Interactive Multimedia Module (SIMM) that would simultaneously teach and assess the learner. Exploiting recent advances in information technology, it weaves the richness of an actual clinical encounter between patient and physician; illustrates complicated surgery with clear, three dimensional animations; and allows the student to follow multiple lines of inquiry through robust links to the medical literature and other educational sources.

The SIMM represents advancement in the use of multimedia technology in teaching surgery to medical students. The SIMM is not meant to replace contact with faculty or with patients; rather it is meant to augment these experiences with the strengths of digital video, 3-D modeling, and content integration of computer applications. It should be thought of as a new teaching tool, rather than a computerized version of older teaching methods.

Each module consists of a complete workup of a patient with a surgical disease. These modules are targeted toward third and fourth year medical students and currently cover four topics: diseases of the hepatobiliary tree, carotid stenosis and peripheral vascular disease, colon and rectal cancer, and adrenal adenoma.

2. Design Objectives

The complexities of clinical reasoning processes of medicine represented a significant challenge when designing the interface and architecture of this system. The initial efforts at developing this solution focused on the user interface. Our intent was to create an interface centered on the narrative timeline of a patient's illness. The timeline presents the constellation of educational, clinical and diagnostic information available to students using a familiar chronological/logical metaphor, one that preserves the learner's connection to the natural history of a patient and the progression of disease. This approach mandated the creation of a flexible presentation format that is user-driven and would allow teachers the opportunity to organize the rich media in a specified format, and learners the opportunity to branch off these narratives and pursue topics based on interest and knowledge levels.

The application had challenging technical requirements. To be effective at teaching a very visual topic like surgery, the SIMM needed to extensively use multimedia including composite video (e.g. layering, dynamic labeling etc.), 3D modeling, and animation. The quality and size of the video clips depicting surgical procedures demanded a large 640x480 pixel video window. The SIMMs needed to be available to students in a wide variety of locations and settings. Previous work has demonstrated that network latency or an unresponsive user interface severely impacts the usability and usage of an application [1,2]. The speed of the application itself as well as the network was of critical importance. Finally, since our institution is bi-platform any solution needed to be both PC and Macintosh compatible.

Initial prototyping and testing of our system was done with a web-based application that used an html front-end and XML to communicate with an Oracle digital repository containing our rich media objects (video, audio, images, etc.). Browser clients were not designed for the display of high-bandwidth video and are dependent on plug-ins, which vary in stability and function across platforms. The web-based prototype was limited by performance issues and frequent crashes that rendered the application nearly unusable when attempting to display video files larger than 100MB over the network.

Given those initial experiences we chose to develop a new client application that would replace the browser as the first tier of the application architecture. Creating our own client application, rather than relying on a web browser allows us to customize the client functionality for displaying and manipulating video. In addition, it allows for client-server

transactions to be "batched," decreasing the number of transactions and ultimately the load on the server.

We chose to develop the client using the Macromedia Studio MX suite which provides a unique feature set that made implementation of our application possible. On the client side, Director MX is able to dynamically load and manipulate large video files with speed and stability and provides for additional video functionality. In addition, Director MX is able to integrate multiple components into a single application, allowing our developers to utilize Flash MX for a more robust, object oriented development environment.

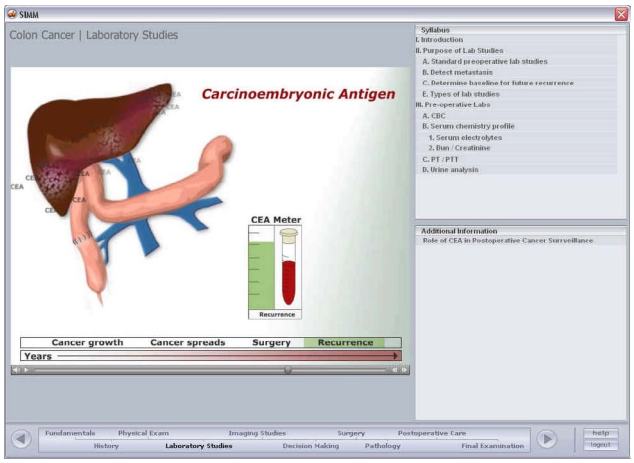
3. System Description

After a successful login, the SIMM client detects the user's network speed and determines the appropriate content location for optimal performance. If the network speed is fast enough, the high-bandwidth video content will be pulled directly from one of the school's file servers. For users on slower networks, the client has the option of accessing content from a DVD. The DVDs are made available to the students for sign-out from the medical school library.

The user can move through the various sections of each module using the narrative timeline interface bar at the bottom of the screen (Figure 1). The modules contain mini-lectures from the surgical faculty, digital video of simulated physician-patient encounters, operative footage and interactive animated simulations of surgical principles and procedures. The syllabus for each video-clip lesson is presented in the upper right panel of the screen. Each syllabus item contains a time code marking the specific point in the video it refers to. In order to jump to that section of the video, the user can click on the item. Finally, the 'Additional Information' section (lower right panel) contains links to videos and documents addressing topics related to the material presented in the main video screen. This section allows for extension of the narrative storyline through input from other disciplines and other materials on the web.

The client and server communicate with one another via XML. The XML communication layer between the client and server applications allows for flexibility of future developments using a variety programming languages. The majority of the logic resides on the server, leaving the client free to devote its resources to the CPU/GPU intensive task of displaying and manipulating video and 3-D objects. User navigation requests result in queries to an Oracle relational database that creates XML datasets to be passed directly to the client for display.
There are assessment components to each module that evaluate the student's knowledge of the presented materials. All assessment data as well as all usage data are logged for analysis.

Figure 1. Colon Cancer SIMM screenshot



4. Status Report

Three programmers were able to create a stable, functional SIMM application in six months. The resulting client is a 4MB file that is compiled in Mac OSX and PC formats. The SIMMS have been in use on the surgery clerkship throughout our medical school since July of 2003. Two of the SIMMS (hepatobiliary and carotid stenosis) have replaced traditional lectures on those topics. Use of the SIMMS now accounts for five percent of the medical students grade for the surgical clerkship. Eighty-nine students used the SIMMS between July 1st and December 1st and logged on to the modules a total of 1,336 times (Figure 2). The average duration of each session was 2.0 ± 0.6 hours. The daily intensity of student use corresponded strongly with the end of the rotations and final exams (Figure 3) suggesting that students valued it as a compelling and useful study tool.

Figure 3. Daily number of log-ins, July 1st – December 1st, 2003

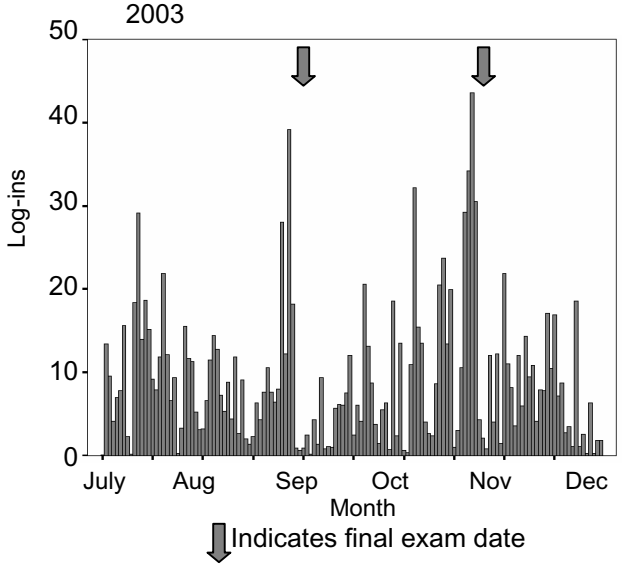
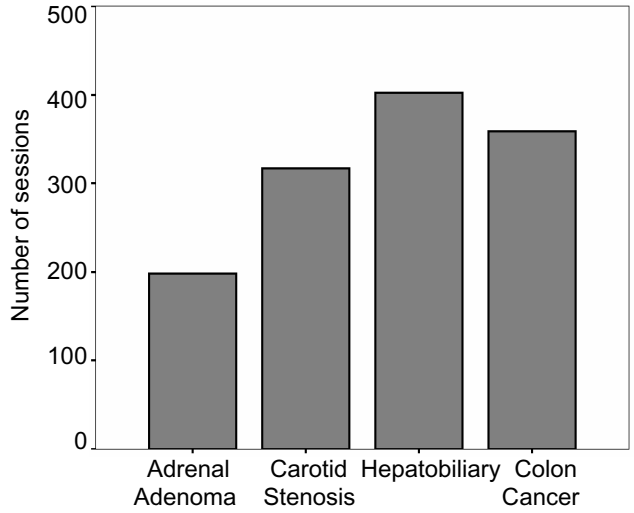


Figure 2. Usage of SIMM according to module, July 1st – December 1st, 2003



5. Discussion

The increasing use of multimedia applications for medical education has created a demand for a method to organize and display these large bandwidth, CPU intensive objects. The traditional three-tier architecture, which relies on embedding these objects in a web browser, has proven a cumbersome solution to this task. This project has resulted in a stable, fast and bandwidth adaptive client application that displays content based on XML datasets.

Preliminary usage data suggests that the medical students on our surgical clerkship are active users of the application and suggest that it's a valued learning tool. Future areas of research include the ability to collect, segment and annotate the existing content for use in personalized notes or collaborative workspaces. Ultimately we aim to allow the user to annotate rich media objects and store these annotations with pointers to the objects, in a personal repository. Additional development efforts are focusing on the creation of a system to reuse the multimedia learning objects created for each SIMM. This will let faculty create new SIMM modules by repurposing some of the content to tell different stories. Finally, as the scope of content development extends beyond surgery to other medical disciplines we expect to study the scalability of the approach and its impact on the medical school curriculum.

6. References

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