A WIRELESS HANDHELD SYSTEM FOR INTERACTIVE MULTIMEDIA-ENHANCED INSTRUCTION

Carl D. Fulp[1] *and Errin W. Fulp*[2]

Abstract *— This paper introduces a new wireless handheld computer system (hardware and software) for interactive multimedia-enhanced instruction. This versatile system provides all the multimedia and communication functionality of a traditional desktop computer in a portable device. The system allows the instructor to manage a lecture presentation, access web pages, and control the classroom environment. To encourage classroom interaction, the system includes a web-server where students can anonymously pose questions and voice opinions via their computer. In our experience, over 90% of students respond to instructor questions in this fashion, which is considerably higher than in a traditional classroom setting. Furthermore, this system has a relatively small cost in comparison to conventional multimedia based systems.*

Index Terms — Handheld computers, Interactive instruction, Multimedia, Wireless networks

Introduction

The use of computers in the classroom has changed the nature of teaching, introducing new ways for students to interact with materials, teachers, and their classmates [1], [2], [3], [4], [5]. The instructor can incorporate audio and video with lecture materials, conveying information in a richer environment. In addition, Internet connectivity provides access to a diverse amount of information outside the classroom. Web-based materials can be introduced to clarify topics presented in lecture or encourage discussion of relevant issues. Classroom collaboration can be further enhanced with the use of communication software (e.g., distributed whiteboard and chat applications), where students can interactively address problems with others via their computer [2], [6]. Although the use of computers in the classroom can be a distraction, when combined with an engaging lecture their presence can have a beneficial effect [7].

As computers become smaller they create new and better opportunities for their integration in the classroom. Technological advances allow handheld devices (e.g., PocketPC and PalmPilot) to be equipped with faster processors and wireless interfaces, making the performance comparable to laptop computers. In addition, the smaller size and increased mobility of handheld devices makes their use convenient in a classroom setting. Handheld computers have been successfully used to encourage student collaboration and interaction in the classroom [2], [5], [6]. The Classroom Application Rapid Deployment System (CARDS) project used handheld computers for student and instructor collaboration [2]. Network applications developed for this project enable students and the instructor to communicate from machine to machine in a classroom environment (e.g. chat and whiteboard tools). Another example is Project Numina, which uses handheld PCs and web-forms for classroom interaction and feedback [5]. Using this system, the instructor can pose a question to the class by directing them to a particular web-page. The system tabulates and provides the results to the instructor, which helps identify the current student comprehension level [5]. While both projects support classroom interaction and collaboration, neither provides a mechanism for the actual lecture presentation. In contrast, the Pebbles system uses a handheld computer to control Microsoft PowerPoint presentations [6]. The system also includes distributed whiteboard application (PebblesDraw) that allows multiple users to send input to a common display. Although PebblesDraw does provide a means of interaction, the system does not have a classroom feedback component that allows students to ask or answer questions, as done with Numia.

This paper introduces a new wireless handheld system (hardware and software) for multimedia-enhanced instruction. The handheld system has a web-server that students access to answer questions posed by the instructor (similar to Project Numina). The system also allows students to anonymously ask questions of the instructor (the opposite of Numina). Shy students can pose questions during class more easily using this format, which in our experience, has resulted in greater classroom participation. In addition, the instructor can manage the presentation (e.g., Microsoft PowerPoint), access web pages, and control

[1]Carl D. Fulp, Information Systems, Wake Forest University, Winston-Salem, NC 27109, fulpc@wfu.edu

[2]Errin W. Fulp, Department of Computer Science, Wake Forest University, fulp@wfu.edu

0-7803-7444-4/02/$17.00 © 2002 IEEE

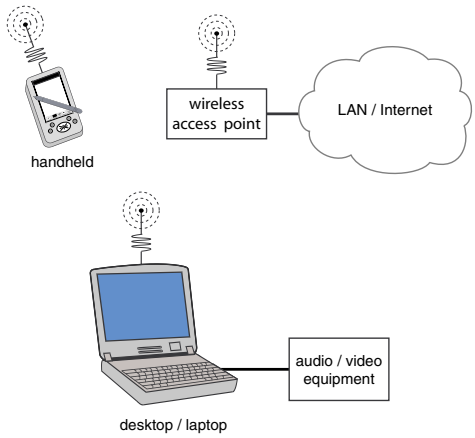


FIGURE. 1
THE MULTIMEDIA INSTRUCTION SYSTEM.

the classroom environment (lighting and speaker volume) using a single wireless handheld device (similar to the Pebbles system, but with more flexibility). We believe this system has great potential for enhancing teaching and learning; furthermore, this system has a lower cost than other multimedia systems.

The remainder of this paper is structured as follows. The next section describes the new interactive multimedia system including the hardware and operating systems used. Software created for the system is then described, which consists of a presentation manager and classroom interaction/feedback tools. Experience using the system is reviewed, while the last section summarizes the multimedia presentation system and describes future work for this project.

A New Handheld Instruction System

The multimedia instruction system consists of a handheld device and a PC that are connected together via a wireless link, as seen in figure 1. The handheld device is the portable component used by the instructor to control the presentation material and interact with students. This includes changing presentations, controlling audio and video, accessing the network, and receiving feedback from students. The current handheld computer is a Compaq H3650 iPAQ. The iPAQ is pen based computer, that contains a 207 MHz 32 bit Intel RISC processor and 64 MB of SDRAM. Half of the memory is reserved for disk/file storage and the remaining portion for applications. Like many handheld devices, the iPAQ does not have an internal hard disk, which limits its ability to store presentation materials. A hard disk (microdrive) is available using an external pack; however, the single external port (cradle interface) was occupied by a wireless Network Interface Card (NIC). The iPAQ was installed with Windows CE, which is a 32-bit modular operating system developed by Microsoft. The operating system is message-based and supports multi-threaded applications.

Various handheld computers were investigated before selecting the Compaq iPAQ H3650. One notable pen-based platform not used was the PalmPilot. An advantage of this platform is support for the Java programming language. Although the language is platform independent, our experiments indicated that Java-based applications performed slower than similar functioning C++ applications. We believe this is a result of the Java Virtual Machine and the emulation of threads. Since true multi-threaded support is essential for our applications, we selected the iPAQ platform and the C++ programming language.

The other important component of the system is a desktop PC that is used to control the various multimedia devices (**not** the presentation or collaboration activities). The iPAQ sends information to the PC for display using the wireless connection. The current multimedia PC used in this project is a Windows98-installed IBM A20m ThinkPad (laptop computer) equipped with a wireless NIC.

Classroom Software

The accompanying classroom software consists of a presentation manager and web-based interaction/collaboration tools. The presentation manager accepts different popular presentation formats, including Microsoft PowerPoint, Adobe Acrobat, and HTML pages. The instructor can manage the presentation (changing slides, controlling audio/video, and accessing the Internet) using the iPAQ. This is accomplished using two applications, `iServer` (Individual Server) and `RMCServer` (ReMote Control Server), as seen in figure 2. `iServer` resides on the iPAQ and communicates with `RMCServer` executing on the desktop PC. `iServer` is used to control the content of the presentation. At start-up, the program establishes a connection to `RMCServer`, then requests name of the presentation file from the instructor, as seen in figure 3(a). Since the wireless bandwidth (capacity) is limited and varies over time, the actual presentation resides on the PC. As reported in [8], interactive audio and video (stopping, rewinding, and playing) can be

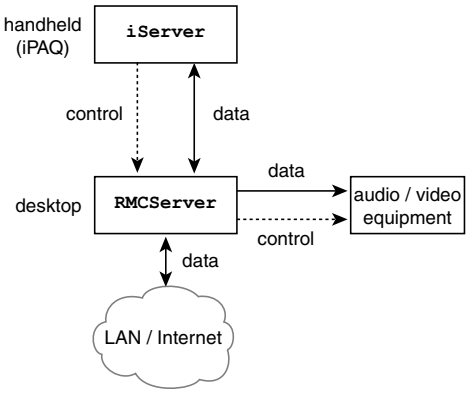


FIGURE. 2
THE TWO PRIMARY PROGRAMS (ISERVER AND RMCSERVER) THAT MANAGE THE MULTIMEDIA PRESENTATION.

sluggish using wireless devices, especially if other network programs are competing for the limited bandwidth. The *client-server* configuration of `iServer` and `RMCServer` eliminates the need to transmit large files from the iPAQ to the desktop; thus, improving performance.

Based on selected file type, the `RMCServer` (located on the desktop PC) starts an instance of the appropriate presentation software. `RMCServer` parses the current slide and sends the text and any annotated notes to `iServer`. `RMCServer` then displays the slide on the video projector. Graphics are not sent to the iPAQ due to their size and the limited capacity of the wireless network. `iServer` displays the slide information as well as a set of control buttons, as seen in figure 3(b). The instructor is able to control the presentation, changing slides, accessing the web, and/or changing presentations.

The system also provides a set of web-based interaction and collaboration tools. An iPAQ web-server allows students to answer and ask questions during class. The web-server is a multi-threaded application that supports the HTTP protocol commands `POST` and `GET`, where `GET` is used to obtain information from the web-server and `POST` is used to submit information to the web-server. Under testing, the web-server was capable of handling over 50 simultaneous requests without any perceived degradation of performance. Requests are handled by separate threads and are serviced in a round-robin fashion; therefore, a single request will not block others.

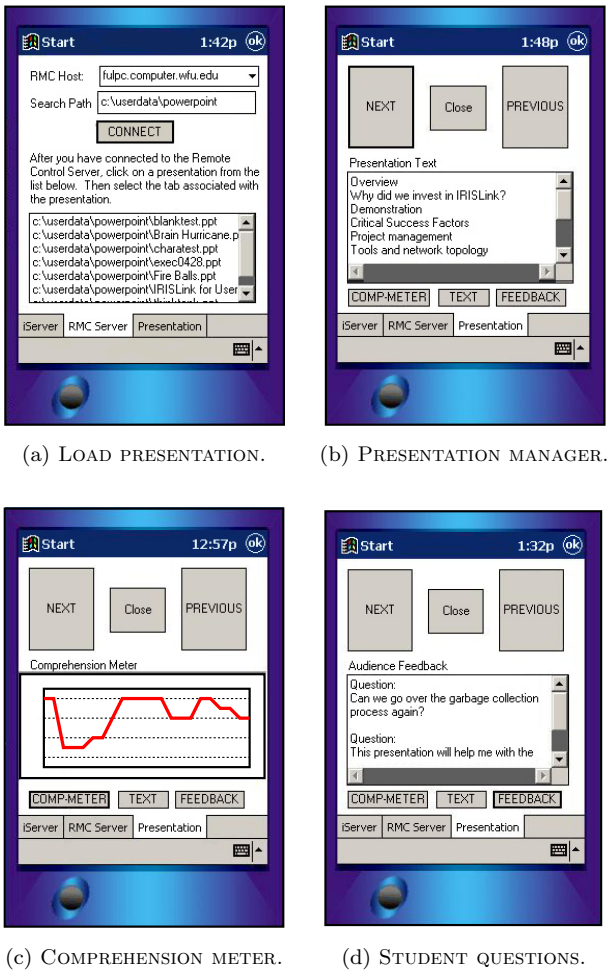
Using the web-server, students have access to a web-page that asks for their current level of understanding. The web-form requests the student to select a value from -10 to 10, where 10 represents "completely understand" the lecture topic. In this mode, the iPAQ web-server calculates the average score and displays the information in the form of a *comprehension-meter* (comp-meter), as seen in figure 3(c). The comp-meter gives the instructor important real-time feedback concerning the average comprehension of the material and can be viewed at anytime. Furthermore, students may feel more at-ease to provide feedback, since the opinions are anonymous. Similarly, students can send specific questions to the instructor using web-forms. The instructor can direct the students to a HTTP address served by the iPAQ, that contains a HTML-form for submitting a question. The iPAQ server gathers the submitted questions then create a list, which is available to the instructor, as seen in figure 3(d). Again, questions can be asked anonymously.

SYSTEM USE

The Physics and Computer Science departments at Wake Forest University have used the handheld system in various courses during the past year. These freshman and sophomore level courses had enrollments ranging from 15 to 35 students. Classrooms were equipped with the necessary multimedia devices and each student had a laptop PC connected to the local area network.

Instructors using the system initially indicated that monitoring the iPAQ comp-meter, figure 3(c), and the student-question page, figure 3(d), regularly during lecture was not easy. Instructors would forget to check these items and the student question list would build over time. However, by the fourth lecture most instructors felt comfortable using the system and learned to check student feedback more frequently. As a result, the real-time feedback helped instructors dynamically adjust their presentation (e.g., providing more detail or reviewing concepts). Furthermore, all the instructors enjoyed the ability to roam about the classroom while still controlling the presentation.

Students quickly adopted the system, and asked questions and indicated their comprehension level with little hesitation. As a result of using this system, the amount of classroom interaction increased dramatically. On average, over 90% of the students responded to instructor questions using the system.



(a) Load presentation. (b) Presentation manager.

(c) Comprehension meter. (d) Student questions.

FIGURE. 3
Screen shots of the iPAQ applications.

This percentage is considerably higher than what is observed in a conventional classroom environment. Furthermore, we have received no negative feedback from students regarding the system. After using the system for a few weeks, all participants (students and instructors) believed it was beneficial for the classroom. As system use increases we hope to further refine this multimedia system, add new features, and adjust it based on instructor and student feedback.

Conclusions

This paper introduced a new wireless handheld system (hardware and software) for interactive, multimedia-enhanced instruction. The system provides all the multimedia and communication functionality of a desktop PC in a portable device (Compaq iPAQ handheld computer). This allows the instructor to move freely in the classroom, thereby encouraging more interaction with students. The system accepts different presentation formats (Microsoft PowerPoint, Adobe Acrobat, and HTML pages), allows audio and video, and incorporates an interactive student feedback tool. Interaction is performed in real-time using web-pages served from the iPAQ. Students can indicate their comprehension-level at anytime during lecture and/or anonymously ask questions of the instructor. The ability to anonymously ask questions is especially helpful for shy students. Using this system, classroom interaction has increased over 90% as compared to a traditional lecture environment.

Future work on this multimedia system will center around instructional tools. We have begun refining the iPAQ web-server to include audio and video streaming, as well as a teleconferencing tool. In addition, more web-forms are being developed to administer tests and quizzes on-line from the iPAQ. For example, students will be able to upload different file formats (e.g., Word documents or program files) to the web-server in response to classroom assignments.

References

[1] Wayne Burleson, Aura Ganz, and Ian Harris, "Educational innovations in multimedia systems," in *Proceedings of ASEE/IEEE Frontiers in Education*, 1999, pp. 12A3/6–12A311.

[2] Michael J. Jipping, Joshua Krikke, Sarah Dieter, and Samantha Sandro, "Using handheld computers in the classroom: Laboratories and collaboration on handheld machines," in *Proceedings of the ACM SIGCSE*, 2001, pp. 169 – 173.

[3] Rhys Price Jones, Fritz Ruehr, and Richard Salter, "Web-Based laboratories in the introductory curriculum enhance formal methods," in *SIGCSE Bulletin*, march 1996, pp. 160–164.

[4] Ryan McFall and Gordon Stegink, "Introductory computer science for general education: Laboratories, textbooks, and the internet," in *SIGCSE Bulletin*, March 1997, pp. 96–100.

[5] Paul G. Shotsberger and Ron Vetter, "Teaching and learning in the wireless classroom," *IEEE Computer*, vol. 34, no. 3, pp. 110 – 111, March 2001.

[6] Brad A. Myers, "Using handhelds and PCs together," *Communications of the ACM*, vol. 44, no. 11, pp. 34 – 41, November 2001.

[7] Tim Lougheed, "The internet as class distraction," *University Affairs*, pp. 26 – 28, January 2002.

[8] James Griffioen, W. Brent Seales, James E. Lumpp Jr., and Tom Kay, "Experience developing wireless networks for interactive multimedia instruction," in *Proceedings of ASEE/IEEE Frontiers in Education Conference*, 1998, pp. 1005–1010.