Pocket PCs as Tools in Digital Circuit Laboratories

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Abstract

Digital circuit laboratories are notoriously brimming with high-technology instrumentation and all sorts of gadgets that can boggle the mind of students entering any electrical or computer engineering program. These labs are generally the first electrical or computer laboratories encountered by students, since introductory digital topics do not require the math or physics prerequisites needed by electronics or systems courses that come later in the program. Because these are the first labs encountered by students still adjusting to their chosen major, it is important to dazzle the students with plenty of high-tech gadgetry in order to entice them to continue in the program, but it is also important not to intimidate them with too much daunting complexity.

The latest high-tech wrinkle in the world of personal computers is the hand-held, or "pocket" PC. The Department of Electrical and Computer Engineering at the University of Minnesota Duluth has required each freshman student entering the program since Fall, 2001, to purchase such a pocket PC, in particular the Compaq(HP) iPAQ device. This paper details some of the iPAQ application programs that have been developed for use in the Electrical and Computer Engineering program. These applications serve two purposes. First, they provide students with tools that are useful in completing their lab exercises in the program. Second, they give students an opportunity to apply the latest in PC technology while simultaneously learning material in lab exercises.

Using the iPAQ pocket PCs in digital circuit labs exposes students to the latest in high-tech mobile computing, while also providing them with tools that aid in lab experiments. Students are excited about applying the latest technology, while at the same time they benefit from an enhanced educational experience using the iPAQs as tools in the lab.

What is an iPAQ pocket PC?

The iPAQ is a hand-held programmable computer offering touch-screen input/output, audio input/output, and infrared communication with other iPAQs. The original model used in 2001 included 32 MBytes of RAM and contained a 200 MHz processor. Technology has improved constantly, and the model currently used by students in this initiative includes 64 MBytes of RAM and a 400 MHz processor. Technology will continue to improve, making these devices more and more powerful. In addition to their use as programmable computers on their own, the iPAQ device uses a plug-in wireless card to allow wireless access through appropriate hubs to the internet for interaction with other computing systems. Applications for these devices are limited only by the imagination of the person writing the software used on them.

Given the glowing description above, it would seem that the iPAQ, or competing pocket PCs, are the answer to mobile computing's challenges. However, there are limitations to the use of iPAQs that restrict their applications, all arising from the limited input/output capabilities of the device. For user input to custom software, only the touchscreen is available. Handwriting recognition using a stylus is available, but is limited to a speed of only a few words per minute, very frustrating to a computer user used to a conventional keyboard. "Typing" on the iPAQ screen using a displayed keyboard and touch sensing to detect key "pushes" is also possible, but that technique, too, is very slow. Conventional textual input to application programs is therefore difficult, and something to be avoided. Graphical input using the stylus, however, or menu selection from a displayed list of options, is fast and easy. For graphical output, the only output device available is the color screen, smaller than a 3" x 5" index card. If software is written to take the screen size into account, the output can be effective. However, if the screen is used to attempt to display a typical web page off the internet, only a portion of the page can be viewed at a time, and scrolling around on the page to see other portions is clumsy. Audio and infrared input/output, although included in the iPAQ, are not easily interfaced to custom software. The conclusion is that the iPAQ certainly is a powerful computing tool and meets the needs of applications that can be designed around its limited input/output capability. The iPAQ will not, however, replace a desktop, laptop, or tablet PC for general purpose computing.

How is the iPAQ used?

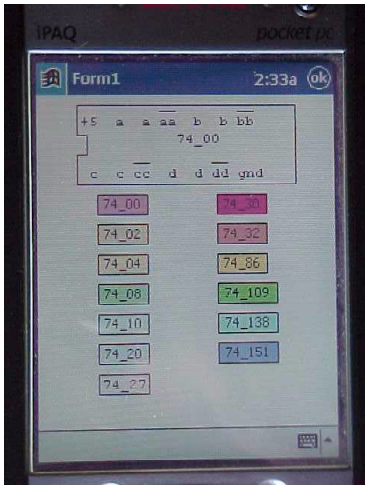
Through the experience of trying to incorporate iPAQs into engineering curricula, three types of uses have emerged for the devices. First, they make excellent data storage devices. With 64 MBytes of storage available, a lot of information can be loaded into the iPAQ for retrieval by the user. This information can include tables as traditionally found in reference books, but also can include graphical information or audio clips as appropriate for the application. Although using the iPAQ merely to store data is a waste of the computing power available, it is still a convenient application for the device. A second use for the iPAQ is as an access mechanism for internet resources using the wireless communication capability. Although widely touted as a great feature of the iPAQ, the limited input/output restricts what can be done with resources meant to

be used on a desktop computer. The third, most promising, type of application that has been used in courses under this initiative is custom software, written specifically for the iPAQ, to address a specific need. Each of these three types of applications is discussed separately below.

Data Storage Examples

At right is an application written for students in the Electrical and Computer Engineering (ECE) program at UMD that guides students through satisfying the requirements of the program. Students can identify courses in the program that they have completed, and then the program suggests courses to take for the upcoming semester. No computing to speak of is involved in this application. The program simply records the various program requirements and summarizes them for students. Students could, of course, accomplish the same thing themselves using printed bulletin material and other program descriptions, but the experience in using this software indicates that students are more likely to follow program guidelines if the computer tells them what to do than if they simply determine courses to take on their own.

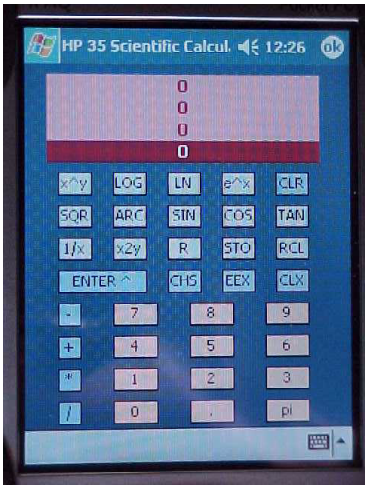
Another program made available to ECE students is shown at right. This program simply displays the pinouts for various components used in the introductory digital circuits course. Again, there is nothing here that students could not find by looking in a data book or checking some reference sheet, but the ease with which students can look up the information on their personal iPAQ computer makes the application attractive. The drawback to this type of program is that someone has to write the program and enter the data, which can be a time-consuming process that many faculty are unwilling or unable to undertake.



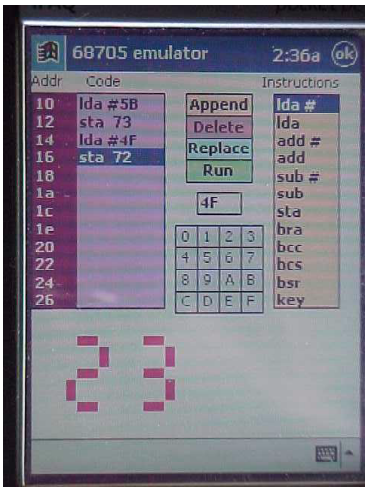
Internet Interface Examples

Using the iPAQ to access the internet is an option that has limitless possibilities. A wealth of information is available on the internet, and various computing resources can also be accessed through internet connections. However, a student trying to do the typical things that he does with his desktop computer on the internet will be disappointed and frustrated due to the limited input/output available on the iPAQ. Standard web pages, though viewable, are not very usable, as users have to scroll around on the page to find the data of interest. As iPAQs and similar devices become more prevalent, internet facilities will be designed to accommodate their limitations, but current information on the internet is not easily accessed from the iPAQ, limiting this type of application.

Mobile Computing Examples



The real power of iPAQ pocket PC computers becomes obvious when custom software is written to take advantage of the unique features of the device. At right is a simple program that emulates an HP-35 calculator using the touch screen in the iPAQ as input and output. Additional capabilities can be added to such a program that far surpass any traditional calculator's options. Certainly graphing and graphical analysis are features that the iPAQ can support. The possibilities are limited only by the imagination of the programmer. Again, however, this type of application requires a user who is capable of writing software for the iPAQ and who has the time to develop and implement the application. Such commodities are not always available to faculty developing course applications.



At right is another application program written for ECE students. The program emulates a specific microcontroller, and allows students to write programs in that microcontroller's assembly language that are then "executed" using the emulator software to display results. Since each student in this initiative has his/her own iPAQ, this software gives each student the ability to write programs for the emulated microcontroller and test them without requiring any additional hardware or lab stations to support that activity.

Summary

The iPAQ pocket PC device puts computing in the pocket of every student. How well the device meets the computing needs of students depends upon how the device is used. Storing data to provide handy access to information is one way to use the iPAQ effectively. Through wireless connection to the internet, the iPAQ can access a vast array of information or computing resources but with the current emphasis on desktop/laptop/tablet computers, the information is not formatted to make its use on the iPAQ convenient. Finally, the way to achieve ultimate benefit from the iPAQ is to write custom software to make effective use of its limited input/output to address specific application needs. This last category of application demands creativity and programming ability, but offers the biggest payoff to the user.

References

1. Carroll, C. R., "Handheld Computers as Tools in Freshman Courses," *2002 ASEE Annual Conference Proceedings*, Montreal, Canada (2002).
2. Web page http://www.hp.com/country/us/eng/prodserv/handheld.html for information on the iPAQ.
3. Visual BASIC manual and documentation, used for applications included here.

Biography

CHRISTOPHER R. CARROLL
Christopher R. Carroll received a Bachelor of Engineering Science from Georgia Tech, and M.S. and Ph.D. degrees from Caltech. After teaching in Electrical Engineering at Duke University, he is now Associate Professor and Assistant Head of Electrical and Computer Engineering at the University of Minnesota Duluth. His interests include special-purpose digital systems, VLSI, and microprocessor applications.