Using a Handheld to Help People with Neuro-Muscular Disabilities

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ABSTRACT

People with Muscular Dystrophy and some other muscular and nerve disorders lose their gross motor control while retaining fine motor control. The result is that they lose the ability to move their wrists and arms so they cannot use a regular mouse and keyboard very well. However, they can still use their fingers to control a pencil or stylus, and so can use a handheld such as a Palm. We developed software so that the handheld can substitute for the mouse and keyboard of a PC, and tested it with four people (ages 10, 12, 27 and 53) with Muscular Dystrophy. The 12-year old had lost the ability to use the mouse and keyboard, but was able to use the Palm to access email, the web and computer games. The 27-year-old found the Palm so much better that he switched to using it full-time instead of using the keyboard or mouse. The other two subjects reported that our software was much less tiring than using the conventional input devices, so it enabled them to use computers for longer periods. We report the results of these studies, and the adaptations made to the software to make it better for people with disabilities.

Keywords: Assistive Technologies, Personal Digital Assistants (PDAs), Hand-held computers, Palm pilot, Muscular Dystrophy, Pebbles project.

INTRODUCTION

About 250,000 people in the United States have Muscular Dystrophy (MD), which is the name given to a group of noncontagious genetic disorders where the voluntary muscles that control movement progressively degenerate. One form, called Duchenne Muscular Dystrophy (DMD), affects about one in every 4,000 newborn boys [3]. With Duchenne, boys start to be affected between the ages of 2 and 6, and all voluntary muscles are eventually affected [11]. First affected are the muscles close to the trunk, and nearly all children with DMD lose the ability to walk sometime between ages 7 and 12. In the teen years, activities involving the arms, legs or trunk require assistance. Becker Muscular Dystrophy is a much milder version of DMD, and the onset can be in late adulthood.

Submitted for Publication

Figure 1. Ten-year old Jennifer using the Palm to control her PC.

A related disorder is Spinal Muscular Atrophy, which is an inherited neuromuscular genetic disease that causes weakness in the body, arms, and legs. It affects both boys and girls starting at 6 months to 3 years, and progresses rapidly [11].

Many other disorders also affect people's ability to control their muscles and use their hands, including Amyotrophic Lateral Sclerosis (ALS, also known as Lou Gehrig's Disease, which affects approximately 30,000 in the US [4]), Cerebral Palsy (which affects about 500,000 people in the US [16]) and Arthritis (affecting nearly 43 million Americans).

Increasingly, people with these disorders, like the rest of the population, are experienced with using computers. Unfortunately, these disorders often make it difficult for people to move their arms and wrists and therefore make the use of conventional keyboards and mice difficult or impossible. We are investigating how handheld computers, such as the Palm, can be used to enable people with disabilities to access their PCs (see Figure 1).

This paper reports on how we adapted our Pebbles software for the Palm to make it more appropriate for use by people with disabilities. In a preliminary study of four people with

Muscular Dystrophy, we found that our modified versions successfully allowed the use of the PC for extended periods for people who found it difficult or impossible to use a conventional keyboard and mouse. In summary, the changes we made included: environmental changes to the serial cables, stylus and lighting, providing multiple on-screen keyboards with the ability to turn off key-repeat, easier ways to pop-up the keyboard, on-screen buttons as modifiers and left and right mouse buttons, easier ability to tap to generate left mouse click events, and the ability prevent the Palm from turning itself off.

MOTIVATION

Children and adults with Muscular Dystrophy and other disorders use computers for the same purposes as everyone else: to send electronic mail, surf the web, write up homework and reports, play games, etc. People with disabilities may find that using a computer is even more valuable because they may be homebound more often and have less access to other forms of entertainment. In addition to the physical limitations imposed by the disease and by being in a wheelchair, often there is an increased susceptibility to infections. A simple cold can quickly progress to pneumonia and can be life-threatening due to a weakened respiratory system and heart. For example, Jennifer (Figure 1), who is one of our test subjects, is being educated at home because of her parents' concerns about respiratory infections [20]. Using a computer allows Jennifer to interact with her fourth-grade classmates and write up her homework in what her father calls "virtual mainstreaming" [20].

Muscular Dystrophy eventually makes it very slow or impossible to handwrite, so using a computer may allow a child to take notes in class, take tests, and perform other activities normally done by hand. Kevin (Figure 5) hopes that he will be able to use a Palm connected to a laptop next year so he can take notes and fully participate in a mainstream sixth grade classroom.

Two of our adult test subjects use computers to have some measure of employment. They help create and maintain commercial and non-commercial web pages for others, and interface with their collaborators through email. Web authoring is an attractive task since it can be performed at home at whatever pace is comfortable.

Of course, all of our subjects report using their computers for entertainment. Computers supply another option besides watching television that people with disabilities can handle by themselves. Using a computer can also be much more intellectually stimulating.

Due to all these benefits, computers can help people with disabilities stay better connected with their friends and relatives, be less bored, and therefore have a more positive attitude. This, in turn, may contribute to better health and a longer, more fulfilling life.

Unfortunately, although there are a large number of assistive technology products available today (see next section), many people with muscular disabilities do not have an adequate device. One reason is that today's assistive devices are very expensive. Two different studies of students found that less than 60% of those who indicated that they needed adaptations to use a computer actually used adaptations [5]. When asked why they did not use adaptations, students overwhelmingly answered that it costs too much. Other reasons cited include that the devices are unavailable to students, the students do not know where to get devices, they do not know how to use the equipment, and equipment is too expensive to maintain [5].

By using commercially available consumer hardware and free software, we can deliver an adaptive technology for people with muscular disabilities at a very inexpensive price. For example, the least expensive Palm devices are around $100, compared to the $400 or so for specialized keyboard for the handicapped. Other advantages of using the Palm are that it is programmable and adaptable, so we can easily adjust the layout and functions (as described below). Another advantage is that our software combines the keyboard and mouse functions in the same, very small space, so only one device is needed.

RELATED WORK

There is increasing interest and work on assistive devices and making computers more accessible for people with disabilities. For example, the bi-annual ASSETS conference (the ACM SIGCAPH Conference on Assistive Technologies) will be held for the fifth time in 2002, and California State University, Northridge has an annual International Conference on Technology and Persons with Disabilities, which is in its 16th year [2].

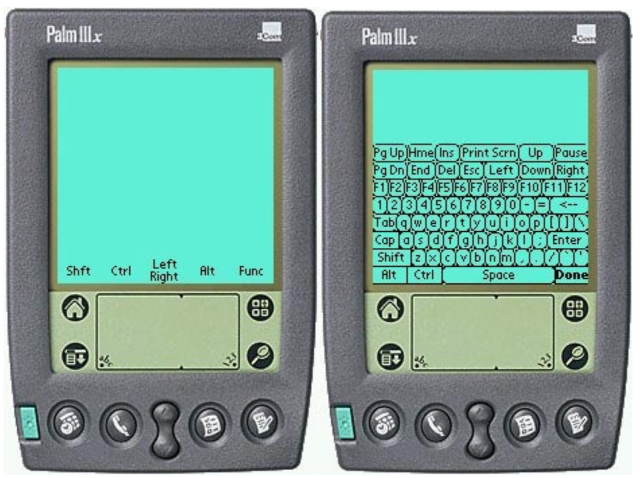
Research reported at these conferences discuss devices for the blind and deaf, ways to modify web pages to make them more accessible, and studies of speech recognition. There tends to be much less work on assistive technologies for neuro-muscular disabilities. Exceptions include Trewin's and Pain's report on a modeling technique to help evaluate problems with keyboard configurations [21], and there are also comparative evaluations of commercial devices (e.g., [6]).

Operating systems, including the Macintosh and newer versions of Windows, have built-in accessibility modes that enable allow people with disabilities to avoid having to press two keys at once, or to hold down the mouse button to perform operations. Microsoft has a large website devoted to accessibility (http://www.microsoft.com/enable/) which lists over 190 different keyboard enhancement utility products which might be of use to people with neuro-muscular disabilities. For people with no ability to use their hands, there are products such as head and eye trackers, chin and mouth controlled devices, "sip and puff" devices, speech recognition, etc. Of particular relevance to the work discussed here are the Enkidu products, which provide portable and handheld stand-alone interfaces, including a palm-size device with a soft keyboard that allows users to write sentences which the device will speak aloud using text-to-speech (see http://www.enkidu.net/). These devices sell for $2,700 to $3,700 each.

Other relevant research to our system is the work on new input technologies for handhelds, such as Quikwriting [18] and on new kinds of keyboards [9, 23]. In the future, we hope to use predictive input techniques such as in POBox [10].

REMOTECOMMANDER

As part of the Pebbles project, we have developed a wide variety of applications over the last few years to investigate how handheld devices and PCs can be used simultaneously [12]. These applications were aimed at business meetings, offices, classrooms, military command posts, and homes. The RemoteCommander program was one of our first applications, and the first version was put on the web for free downloading in February of 1998. Since then, it has been downloaded about 30,000 times from our site: http://www.pebbles.hcii.cmu.edu, as well as from handheld software repositories such as PalmGear.com and Handango.com.



(a) (b)

Figure 2. (a) The main screen in RemoteCommander is used as a touchpad. (b) The pop-up soft keyboard has all the PC's keys. The top blank area above the keyboard can still be used as a touchpad to move the mouse.

RemoteCommander allows strokes on the main display area of the Palm to control the PC's mouse cursor (Figure 2-a), and for Graffiti input to emulate the PC's keyboard input. There is also a custom pop-up soft keyboard that contains all of the PC's keys (Figure 2-b). As with the regular Palm keyboard, RemoteCommander's pops up when the user hits in the "abc" or "123" areas at the bottom of the Graffiti area. Since input is inserted into the PC's low-level input stream, RemoteCommander can be used to supply input to any PC application. As reported earlier [15], the original goal for RemoteCommander was to enable multiple people at a meeting to take turns controlling a PC by using their handhelds. Since the original release, we have ported the program to Microsoft PocketPC devices.

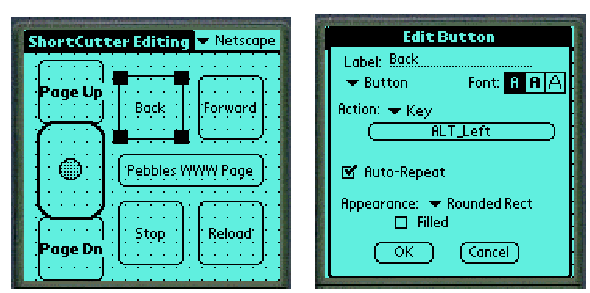
People with disabilities have found the RemoteCommander useful for providing keyboard and mouse input to the PC. The sections below discuss our modifications to make RemoteCommander especially well-suited for people with disabilities.

All of the Pebbles applications, including RemoteCommander, must communicate with the PC. Pebbles supports a variety of transport protocols, including serial cables (such as the cradle supplied with Palm devices or a regular cable), infrared (IR), or using a wireless local-area network technology such as 802.11b. For the current study, we used fifteen-foot serial cables donated by Synergy Solutions (see below). IR seems attractive since it is built into Palms already, but IR is directional and short range, and it is difficult to maintain a long communication between the Palm and the PC using IR. In the near future, we hope that Palms will support a better wireless technology such as BlueTooth or 802.11b that we will then support.

SHORTCUTTER

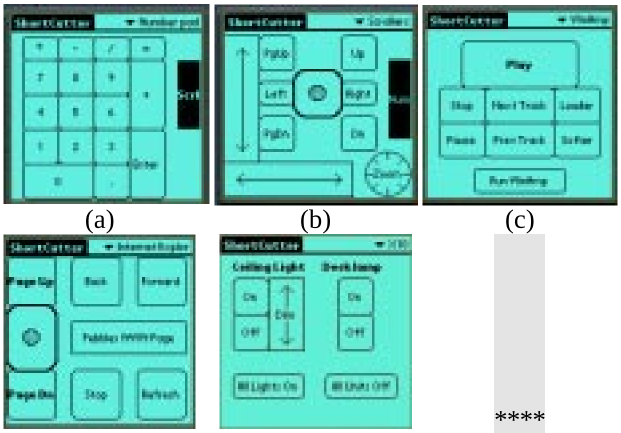
The Shortcutter application allows users to create custom panels of buttons, sliders, knobs, and pads to control any PC application. The buttons can be big enough to hit with a finger, or tiny so that many will fit on a screen. In edit mode, users can draw panels and assign an action to each item in the panel. Switching to run mode, the items will perform their actions. Figure 3 shows editing of a panel in progress, and Figure 4 shows a collection of panels.

The Shortcutter application was described in a previous paper [13]. People with disabilities have found the Shortcutter program useful for launching applications (see Figure 4-f), for providing a shortcut for long series of frequently used keystrokes, and for controlling games. In the future, we hope to explore more uses of Shortcutter to control devices external to the computer, such as appliances and the room lights (Figure 4-e).



(a) (b)

Figure 3. (a) The editing mode of Shortcutter with the Back button selected. (b) Setting the properties of the Back button so when you click on the Back button at run-time, it sends to the PC the keystroke Alt-left-arrow.



(d) (e) (f)

Figure 4. Panels created with Shortcutter. (a) A numeric keypad, (b) a collection of scrollers for scrolling the PC applications and a knob for zooming, (c) a controller for the WinAmp PC media player, (d) a panel for browsing in Internet Explorer, (e) a panel for controlling room lights through the X-10 protocol, and (f) a panel of buttons to launch various applications created by test subject Dan.

CASE STUDIES

The next sections discuss our four initial users with disabilities. After that, we discuss some tests we used, and the adaptations we made to the Pebbles software to take into account observations of their use of the programs.

Jennifer

Jennifer (see Figure 1) is a 10-year old girl with a type of Muscular Dystrophy known as “Spinal Muscular Atrophy, Type 2.” Her father found the original versions of RemoteCommander and Shortcutter on the web, and tried them out as a way for Jennifer to more easily use her computer. It was so successful that he created a web page to help other people with disabilities use the Pebbles applications (www.pdacontrols.com). He then contacted the MD national magazine, which wrote an article about RemoteCommander [20].

Jennifer lives in New York, and we have not had any direct observation of her. Jennifer’s father reports that:

> “Jen uses the Palm about 50% of the time. She has greater speed in using the regular keyboard and mouse, but she fatigues much more rapidly using them. The Pebbles software permits her to use the PC over a much greater amount of time, though slower. That is very important.” *by email on 14 Apr 2001*

Jennifer’s father also contacted us, which inspired our interest in this application of our software. As a result, we wrote an article for the Pittsburgh area MD newsletter, asking for volunteers. The other three subjects contacted us as a result of the newsletter.

Figure 5. Kevin using two hands to control the stylus on the Palm.

Kevin

Kevin is a 12-year old boy with Duchenne Muscular Dystrophy (see Figure 5). He has used computers since he was in first grade, and was able to use a regular keyboard and mouse at that point, but with difficulty. He never learned to type, and does not know the QWERTY keyboard layout. He has very little strength in his fingers, and cannot move his arms at all. He has completely lost the ability to use a keyboard and mouse at this point. He tried using a small commercial touch pad, but found the buttons to be too difficult to press. He also tried speech-recognition software, but could never get it to work well enough. With our RemoteCommander, he was able to use a stylus to move the cursor and select letters from the pop-up soft keyboard. He held the stylus in his right hand, but he found it most effective to use his left thumb to help move the stylus, especially to tap on letters on the left side of the screen (see Figure 5). He was able to use the mouse feature without looking down at the Palm, but had to look down to use the soft keyboard.

Dan

Dan is 27 years old and also has Duchenne Muscular Dystrophy. He started using a Atari computer with a joystick when he was 8 or 10 years old, and used Macintoshes in high school and had an IBM at home. He went to college, where he was able to use a mouse while resting his arm on a wristpad. Starting a few years ago, he lost the ability to type, but discovered that he could still press the keys using the eraser ends of two pencils (see Figure 6). He reports, “it works, but sometimes my fingers get sore, because of the pencils.”

About two years ago, he lost the ability to use the mouse, and found a trackball that worked for him (also shown in Figure 6). Dan needs someone to move his hands into position before he can begin using the devices. He has dictation software, but never uses it. Dan reported that he “spends a decent amount of time on the computer” and sends and receives about 10 emails a day. He also runs a web page for a golf game.

Figure 6. Dan was typing using two pencils before he started using the Palm. His trackball is on the wristpad.

Figure 7. Dan using the Palm one week later.

After we delivered the Palm, he started using it exclusively. Originally, he tried the on-screen soft keyboard, at one point trying out two styluses at once. However, he stopped using the soft keyboard because his neck got sore from continually looking up and down. He learned the Palm's Graffiti language and now uses it for all text entry. He no longer uses the trackball either. As shown in Figure 7 taken after one week of practice with the Palm, he has put the trackball aside and said he only uses the real keyboard to turn on the computer. He created a Shortcutter panel for himself to launch his favorite applications (see Figure 4–f).

Subject4

Subject4 is a 53-year old man with Becker Muscular Dystrophy. (Unlike the other subjects, he prefers to remain anonymous.) He was employed as a teacher and an engineer but left in 1995 on disability. He currently works at home on authoring and maintaining sophisticated database-driven web pages. Subject4 is still able to use a conventional mouse and keyboard, but he has great difficulty moving his hand to and from the mouse. He uses his fingers to help "walk" his hand across the desk. The Palm software was appealing to him because it has the keyboard and mouse control together in the same small place.

After a week with the Palm, Subject4 reported:

> "I have been using the Palm primarily for the mouse functions when I am near the keyboard. I have found the Palm most useful when I am sitting at my desk (away from the keyboard). I can use it to bring up email and other functions [so] I don't have to [move to] be right in front of the screen."

Since movement is difficult for people with MD, the ability to stay where they are and still perform some computer commands can save time and effort.

PROCESS

All of our information on Jennifer has been through electronic mail from her father. For the three local subjects, we visited them in their homes. In exchange for allowing us to observe them, we loaned them a Palm IIIx (or an IBM Workpad which is the same except it is black). Palm and IBM donated the devices, and we hope to acquire new devices so we can leave the current devices with the subjects. After interviewing the subjects about their background, daily routine, and computer use, we asked them to show us how they use computers today. (With Kevin, we also interviewed his mother.) We then installed our software on the Palm and on their PCs, and performed an initial evaluation of how well the Palm software seemed to be working for them. Many of our observations and software changes described below were a result of the difficulties we observed in this initial use. We left the software, and then came back a week later for a follow-up visit to observe how the subjects were doing. We ran the mouse and keyboard tests again to see if there was any improvement.

We used a form of the *contextual inquiry* method for the interviews [8], since it provides information about tasks and actions in the appropriate context (and also because it is the method taught to our students in HCI classes).

It is interesting to note that the subjects were for the most part not able to articulate problems they were having or ideas for improvements. It was only through directly observing and interacting with the subjects, as recommended by contextual inquiry, that we were able to gain insights into possible improvements.

KEYBOARD AND MOUSE TESTS

To help us measure their computer use, we implemented a keyboard test and a mouse test from the literature.

For the mouse test, we used the classic pointing experiment from Card, Moran and Newell [1] (Experiment 7B, pp. 250). A picture of the test application is shown in Figure 8. The test consists of clicking between a central stationary target and two outlying targets. The current target to click in is shown in red, while the other targets are shown in black. The current target also changes in a particular pattern, alternating from side to center to other side and back again. Each time the subject clicks in the center target, the new current target will also change in width and distance from the central target in a random pattern. The outer targets could have one of three widths (16, 64, or 128 pixels) and be two distances from the central target (36 or 144 pixels) for 2 x 3 = 6 possible conditions. The sequence of target conditions was randomly generated beforehand and used for every trial. Subjects practiced clicking on the rectangles, and then performed one or two trials of 30 seconds each. The number of times the mouse is clicked in the correct place and in incorrect places (errors) are measured.

The typing test is shown in Figure 9 and is based on a test by Soukoreff and MacKenzie [19]. A phrase is displayed and the user is asked to type it exactly, followed by the ENTER key, at which point a new phrase would appear or the test would end. Phrases may contain capital and lowercase letters, quotation marks and other punctuation. All subjects saw the same phrases in the same order. Subjects would type a practice phrase or two, and then start the test. We ran tests that lasted between two and five minutes, depending on the expertise of the subject.

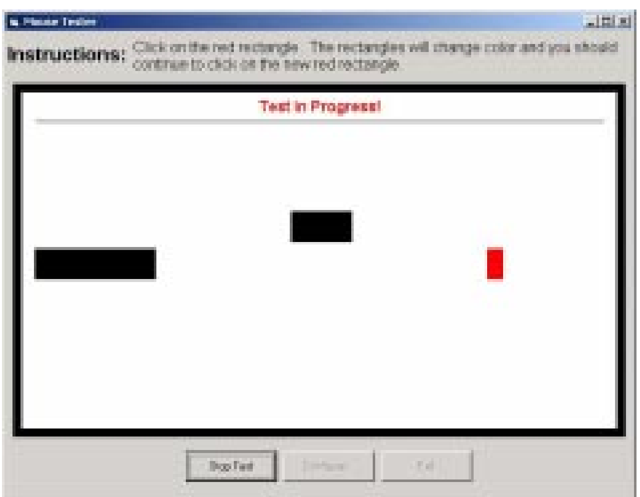


Figure 8. Screen for the mouse test.

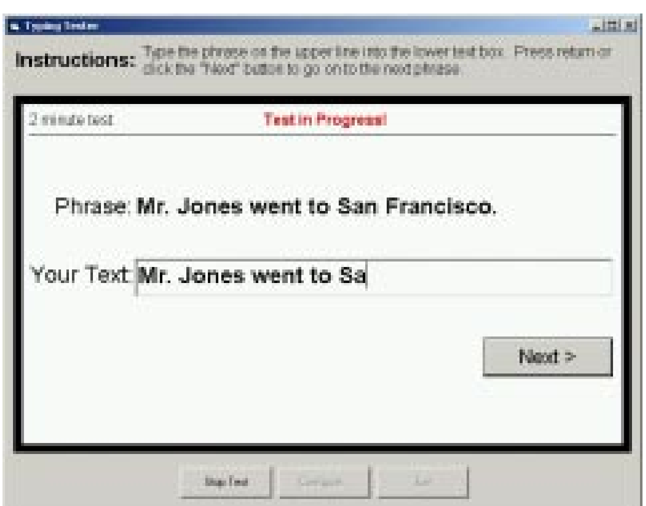


Figure 9. Screen for the typing test.

Test Results

We primarily used the tests as a task for the subjects to do so we could observe their typing and mouse movements. With only four subjects, all with different conditions and situations, it is clearly not possible to get statistically significant results. Still, some of the observations from the data are interesting.

# rects	Before	Initial Palm	Later Palm
Dan	30	7	18
Jennifer	21	--	16
Kevin	--	13	--
Subject4	29	19	--

Figure 10. Results for the mouse test. The values are the average number of rectangles hit successfully in 30 seconds (larger numbers are better).

Figure 10 shows the preliminary results for the number of rectangles successfully hit during the mouse test. The "Before" column is using the regular input techniques (such as a regular keyboard and mouse) before using the Palm. The "Initial Palm" column is immediately after getting the Palm, and the "Later Palm" column is at least one week later.

Using a regular mouse or trackball is still faster for all the subjects except for Kevin, who was unable to use a mouse at all. However, with practice, the performance using the Palm is almost as good as the mouse. As reported by Jennifer and Dan, the Palm may still be useful even though slower, since it is less tiring for them to use.

words/min	Before	Initial Palm	Later Palm
Dan	9.2	7.2	14.4
Jennifer	15.0	--	9.8
Kevin	--	4.7	--
Subject4	23.3	9.6	--

Figure 11. Results for the typing test. The values are the average words per minute typed (larger numbers are better).

Figure 11 shows the preliminary results for the number of words per minute (wpm) the subjects could type with the various technologies. Dan's "Before" time is using pencils to type (see Figure 6), and his "Initial Palm" time was using the on-screen soft keyboard. However, his "Later Palm" time is using Graffiti. Kevin was not able to use Graffiti and didn't know the keyboard layout, so his time includes searching for key locations.

Jennifer's father reported that the keyboard was still preferred but the Palm was used because it was less tiring. Subject4 could still type with a regular keyboard fairly well.

By way of comparison, touch-typing on a full-size QWERTY keyboard for people without disabilities is around 50 wpm. Skilled touch typists can be up to 150 wpm [7]. Graffiti rates range from 20-30 wpm for experienced people without disabilities. MacKenzie & Zhang measured around 20-30 wpm in an experimental session with an on-screen QWERTY keyboard, and some experimental keyboard layouts are faster with sufficient practice [9].

OBSERVATIONS AND MODIFICATIONS

As part of our analysis of the needs of people with disabilities, we made a number of observations, which led to a number of changes in the software and environment. These are described in the following sections.

Requirements

Although our subjects are able to move their fingers, they are very weak, and cannot exert much pressure. This meant, for example, that they are unable to press the physical buttons on the Palm. They also will tap the Palm screen lightly.

Since they have limited range of movement, it is best if all of the important functions are clustered together in a small area. Even moving to the far side of the small 3¼ inch diagonal LCD display screen of the Palm was difficult for Kevin.

Physical Interface

One of the first challenges was getting the Palm into a convenient position for the subjects. The Palm comes with a cradle (Figure 12-a), but pressing on the Palm screen while it is in the cradle causes it to rock, and sometimes even fall over. It is also too high and at the wrong angle for our subjects. Therefore, we tried the Hotsync serial cable sold by Palm (Figure 12-b). Unfortunately, this is very short and the subjects could not get the Palm in a good position with the cable plugged into the back of their computer. Synergy Solutions gives away a 15-foot serial cable free to people who buy their SlideShow Commander product (www.slideshowcommander.com), and they were kind enough to donate ten cables for use by this research. These worked very well for our subjects, and can be seen in Figures 1, 5, and 7.

(a) (b)

Figure 12. (a) Palm cradle and (b) serial cable.

(a)

(b)

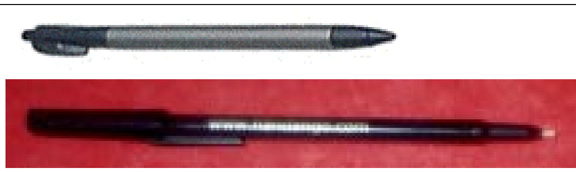


Figure 13. (a) The standard Palm IIIx stylus and (b) the stylus donated by Handango.

The next physical issue was the stylus. The Palm III comes with a short metal stylus that fits into the back of the case (see Figure 13-a). Unfortunately, our subjects found this stylus to be too heavy to hold comfortably for long period of time. Also, Kevin found the stylus to be too short to reach all the way across the Palm screen from his normal hand position. We tried a longer stylus but discovered another problem. Kevin holds the stylus at a very low angle (see Figure 5), and the side of the stylus, rather than the tip, occasionally hit the screen. Therefore, we needed a long, light, tapered stylus. We happened to have a souvenir stylus from a conference that Dan liked, and Handango.com graciously donated 60 more to this research. These worked well for our subjects, and can be seen being used in Figures 1, 5, and 7.

An environmental problem is that all three of our local subjects often used their computer in a dark part of the room. Normally, this isn't a problem since the monitor gives off light. However, it was difficult to see the Palm screen since it is reflective. This problem was made worse since the Palm screen was normally sitting on the table and therefore at an angle from the viewer. Turning on room lights helped, but we had to bring over an extra table lamp next to the computer so Kevin could adequately see the Palm screen.

A final physical problem is the power for the devices. Normally, a Palm is not expected to be used continually for long periods of time. Furthermore, running the serial port drains a noticeable amount of extra power. The Palm III runs on two AAA batteries, and the subjects frequently needed to replace them. Dan measured that he got about 17 hours of use over four days before his batteries needed replacing. Originally, he had tried running the Palm with the backlight on, to solve the brightness problem mentioned above, but then the batteries only lasted a few hours. The best solution would probably be to switch to a Palm device that can run off of wall-power. For example, the Palm V series and the Palm IIIc use rechargeable batteries, and can be used while plugged in. The Palm IIIc has the additional advantage that the screen is in color and is backlit, so it is very bright. Unfortunately, although the supplied cradles for these devices enable both recharging and serial connection to the computer at the same time, there are no readily available cables that do both—the travel cables provide recharging or a serial connection but not both, so custom cables would probably need to be manufactured. Another problem is that the V and IIIc are much more expensive than the IIIx's we used.

Software Changes

In order to make our applications more useful for people with muscular disabilities, we continually have evolved the software based on our observations and feedback. Most of these changes have been to the Remote Commander program and are reflected in the options available in the preferences screen (Figure 14). These changes will be discussed next.

In the original Remote Commander the hard-buttons (which normally switch to different Palm applications) are used as modifiers and to "press" the mouse buttons. This proved very successful for most people, but it was difficult to remember what each button does, especially since they are assignable. Therefore we added labels, as shown in Figure 2-a. Our subjects with disabilities were not able to push the physical buttons, however, so we made the labels into on-screen soft buttons. Now, the user can press a hard button or tap on the screen. An interesting issue arose about how the modifiers should work. With the hard buttons, users can hold down the physical button while they make a Graffiti stroke. For example, with the configuration in Figure 2-a, holding down the phone button while making the Graffiti "z" stroke will send control-z to the PC. For the soft buttons, you cannot hold the stylus on the soft button and at the same time perform a Graffiti stroke, so all the soft buttons were made into toggles. For the left and right mouse buttons, this makes it easy to drag objects. The tradeoff is that sometimes users forget to turn off the modes, so extra characters become shifted. As a compromise, possible some of the modifiers should be automatically turned off after the next character, in the same way as the Palm's built-in keyboard, but this has not been implemented yet.

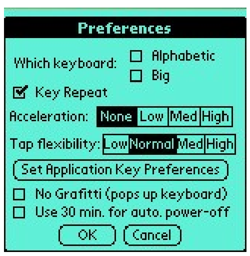


Figure 14. New RemoteCommander preferences screen.

As an alternative to the soft buttons, tapping on the blank part of the screen which serves at the touch pad will send a mouse left click. The subjects, however, had a difficult time getting this to work, because they would tap too slowly and move slightly while trying to tap, and the software would think it was a regular move. An option was therefore added to make the tap determination more flexible, and then all the subjects were able to generate taps without problems. We were worried that this might increase the occurrence of accidental taps (sending a left click event when the user just meant to move the cursor), which might do unexpected operations on the PC, but this did not appear to be a problem in practice.

Very early on, it was noticed that the subjects often got multiple characters when using the on-screen keyboard, due to the built-in auto-repeat of the keys. An option was therefore provided to turn key-repeat off. When Kevin tried using RemoteCommander to play some PC games, we discovered another problem. We were not sending separate key down and key up events, so there was no way to hold a key down using RemoteCommander (just a click of each keyboard key was generated). Many games depend on the keyboard keys being held down.

Three of our subjects were experienced keyboard users before coming to Remote Commander, but Kevin was not. Consequently, he found it difficult to locate the desired letters on the default keyboard (Figure 2-b). Therefore we added an alphabetic keyboard (Figure 15-a). We pushed all the letter keys to the right, along with Shift and Enter, to make them easier for Kevin to reach, since he found it more difficult to hit letters on the left of the screen. We also added larger versions of both the QWERTY and alphabetic keyboards (Figure 15-b) because some of the subjects initially had trouble hitting the tiny keys. However, with experience, the subjects were better able to hit the keys, and they liked not having to move as far. Furthermore, they liked the ability to use the blank area at the top to still control the mouse while the keyboard is displayed.

(a) (b)

Figure 15. New keyboards created for RemoteCommander.

In the future, we plan to investigate other keyboard configurations, such as those reported in the literature [9, 23]. Adaptive keyboards and predictive input techniques [10] are also likely to be useful.

We encouraged the subjects to experiment with the Palm on their own, and Dan became quite facile with the Graffiti gestures. However, Kevin could not perform Graffiti very accurately, because his gestures were too slow and wiggly. He therefore decided he would like to always use the keyboard. Since he had trouble hitting in the small "abc" area that pops up the keyboard, we provided an option where tapping anywhere in the Graffiti area pops up the keyboard.

The Palm screen is only 160 pixels across, but PC screens can be 1280 pixels across or even more. Therefore, the mouse control in RemoteCommander operates in relative mode, like a laptop's touchpad. Movements across the Palm screen move the PC's cursor an equivalent amount across the PC's screen. We built in a little acceleration into RemoteCommander, so faster movements on the Palm would move further on the PC. However, our subjects with disabilities still found it tedious to move large distances, since they tended not to move the stylus very quickly, and were not able to make large strokes. Therefore we added additional levels of acceleration so smaller movements on the Palm would make bigger movements on the PC.

Subject4 still found the movement somewhat awkward, and wondered whether an absolute mode might be useful. Here, just tapping on a part of the Palm screen would move the cursor to the equivalent part of the PC's screen. We already supply a similar feature on the PocketPC version of RemoteCommander [14], but it seems less useful here. There is nothing on the Palm screen to indicate where the cursor will end up, so the position can only be an estimate, and since the resolution of the Palm is so much lower than the PC, there would be no way to get acceptable accuracy in absolute mode. We continue to investigate this issue, however.

A final fix to RemoteCommander was an option to diable the auto-power-off feature of the Palm. To save batteries, the Palm turns itself off after 1, 2, or 3 minutes of non-use. Some of our subjects with disabilities were not able to turn the Palm back on by themselves, so having it turn off was a big problem. In some of our other applications, we disable the auto-off completely, but we were worried that here the users would end up leaving the device on until the batteries ran out. Therefore, we made an option that it would go off after 30 minutes of non-use, which seemed long enough to indicate that they were not at the computer.

In addition to all these changes to RemoteCommander, we also added to Shortcutter the ability to control some room devices. For example, Shortcutter can to send signals to the inexpensive ActiveHome home control device [22], which uses the standard X-10 protocol for sending signals through the power wires. For a computer with two serial ports, the Palm can be connected to one and the ActiveHome device to the other, and then Shortcutter panels can be used to turn on and off lights (see Figure 4-e). Subject4 already owned the ActiveHome controller, but unfortunately his computer only had one serial port. Dan wanted to be able to control his TV (beyond just on and off) which is not possible with X-10. Other research in the Pebbles project is investigating how handhelds can control appliances and other devices [17], and all the subjects agreed that coupled with wireless communication, this might be very useful. We might even be able to use the Palm to control the wheelchair, and then the Palm could be a “personal universal controller” [17] controlling all the technology for people with disabilities. However, there are some significant safety and liability issues with controlling a wheelchair that would need to be resolved first.

FUTURE WORK

We have just begun our study of how handhelds can be used to help people with neuro-muscular disabilities, and there is much work left to be done in many areas. We will continue to follow-up with our initial subjects, to see what further modifications would be useful. So far, we have only studied people with forms of Muscular Dystrophy, but occupational therapists tell us that our software may also be useful for some people with ALS, cerebral palsy, and arthritis. In the near future, we plan to test the system on people with these diseases and see what further modifications would be useful.

New applications might make handhelds useful for other people with disabilities. In other work as part of the Pebbles project, we developed an interaction technique called “semantic snarfing” [14] where the PC’s screen contents are sent to the handheld where detailed interaction is performed. Sometimes a screen capture of the PC is sufficient, but other times, the PC application’s data (semantics) must be grabbed and reformatted for display on the handheld. These features were designed for group use in meetings, but they might prove useful for people with disabilities. For example, the handheld might reformat the PC’s screen to be much larger or the text to use a larger font to help people with limited eyesight. The text that is snarfed to the handheld could be read by a text-to-speech engine for people who are deaf.

CONCLUSIONS

The RemoteCommander and Shortcutter programs discussed above are available for free use and can be downloaded from our web site:

http://www.pebbles.hcii.cmu.edu/assistive/

We hope that this software will be useful to a wide range of people, and that we can continue to investigate new ways that handhelds can help people with disabilities. It is gratifying to help this group, to which relatively little assistive technology and assistive research have been directed. Furthermore, working with people with disabilities is beneficial to us as well because the observations and changes we have made to our software as a result of these studies will improve the software for all the users of our applications.

ACKNOWLEDGMENTS

For help with this research, we would like to thank Drew Rossman, Amy Lutz, John Lee, Susan E. Fridie, and our subjects. Thanks also to *** for help with this paper.

The research reported here is supported by equipment grants from Palm, IBM, Synergy Solutions and Handango. The Pebbles project is supported by grants from DARPA and Microsoft, and equipment grants from Hewlett Packard, Lucent Technologies, Palm Computing, Symbol Technologies, IBM, and SMART Technologies, Inc. This research was performed in part in connection with Contract number DAAD17-99-C-0061 with the U.S. Army Research Laboratory. The views and conclusions contained in this document are those of the authors and should not be interpreted as presenting the official policies or position, either expressed or implied, of the U.S. Army Research Laboratory or the U.S. Government unless so designated by other authorized documents. Citation of manufacturer’s or trade names does not constitute an official endorsement or approval of the use thereof.

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