Computers and people with mobility disabilities

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Abstract. Persons with mobility disabilities have limited capabilities in moving, performing manual tasks and taking participation in some life activities. Muscular dystrophy, multiple sclerosis, spinal cord injuries, head injuries, amputations, arthritis, etc., are some causes of mobility disabilities. Since that mobility impairments can significantly make tedious, even in some cases quite disable using of information technology, it is required to make adaptations that will be enabling the full communication with computers by persons with this kind of disabilities. In this article are discussed some issues about communication between computers and persons with mobility impairments, and are presented a review of available assistive computer technology that make this communication possible. As information education is fundamental education in modern society, the special accent is given to the communication problematic between physically handicapped persons and computers.

Keywords. Mobility Disabilities, Assistive Technology, Orthopedic Disabilities, Alternative Devices, Physical Disabilites

1. Introduction

A wide variety of disabilities result in mobility impairments, and can range in severity from limitations of stamina to paralysis.[1][2][3] Mobility disabilities can be present at birth, while others are the result of illness or injury. Quadriplegia refers to the loss of function in arms, legs and trunk areas. Individuals with quadriplegia have limited use of their arms and hands and little or no use of their legs. Many require motorized wheelchairs. Arthritis causes inflammation in the body's joints, resulting in pain and mobility difficulties. Back disorders hamper the individual's ability to sit, stand, walk, bend or carry objects easily. Cerebral palsy is the result of brain damage before or shortly after birth; it may result in speech difficulties, walking problems, spasms and lack of muscle coordination.

Each mobility disability results in different levels of physical difficulties, and individuals vary in the way the disability affects them. Mobility disabilities can either be permanent or temporary but will affect how an individual accesses the CAP site and the computer workstation. For example, an elevator or ramp provides access to spaces when a staircase is insurmountable for someone who uses a wheelchair. Similarly, specialized hardware or software, called assistive or adaptive technology, allows people with mobility impairments to use computers. These tools allow a person with limited, uncontrollable, or no hand or arm movement to successfully perform in school and job settings. Adaptive technology can allow a person with a mobility impairment to use all of the capabilities of a computer. Special input devices for users with physical disabilities will depend on the user's specific impairment; numerous assisting devices are available. The potential for great benefit to people with different kind of disabilities is one of the unfolding gifts of computing.

2. Computer Access for People with Mobility Disabilities

Common supports and accommodations for people with mobility disabilities in the CAP sites might include accessible parking, priority registration, accessible facilities, lab or computer assistants, simple adaptive computer technologies (such as key guards), consideration of

workstation set-up and note takers during lessons.

A variety of issues must be considered before addressing access to the computer for people with mobility impairments. These include seating and posture, work surface, lighting, temperature, vibrations, noise, ventilation, keyboards (information input) and mouse access, monitor (information output) and accessories.

Computer access for people with mobility disabilities may be achieved through:

- keyboard adaptations,
- alternative keyboards,
- an expanded keyboard,
- a mini keyboard,
- mouse alternatives, and
- assistive technology software.

Simple solutions include the modification of key repeat rates and sequential keystroke selection. Keyboard macros allow the user to assign a few keystrokes to perform functions that would normally take multiple keystrokes. Word prediction software limits the number of keystrokes required to enter words and phrases.

Keyboard adaptations can be made with hardware or software.

Hardware includes key guards and key locks. Software adaptations include Easy Access (Mac) and Access DOS (IBM) alternative keyboards, including PowerPad, Big Keys Unicorn Expanded Keyboard, Intellikeys, TouchWindow and on-screen keyboards, Tash Minikeyboard, KeyLargo, chordic keyboards, Braille keyboards, and so on. Some alternative keyboards plug into the serial ports of any computer (Intellikeys). Other devices (Unicorn Expanded Keyboard) require additional equipment.

More involved mobility disabilities require alternative input, including:

- the TongueTouch Keypad,
- single-switch on-screen keyboard access with scanning,
- single-switch access using Morse code,
- voice recognition software,
- head mouse/head master and pointing devices,
- JOUSE - a joystick-operated mouse controlled with the mouth,
- voice input,
- eye gaze technology,
- head wands or Sip N' Puff, and
- on-screen keyboards with regular or alternative mouse access (track pads, joysticks, trackball).

3. Assistive Technologies for Persons with Orthopedic Disabilities

Orthopedic disabilities can result from many causes such as accidents, strokes, birth defects, viral infections and neurological disorders. The range of mobility impairment that result from such disabilities is enormously varied. This section addresses the access consideration of persons who can press all of the keys on a standard computer keyboard using either their fingers, a hand, head or mouthheld pointing device, toes or other body extremity.

For persons with disabilities that affect the upper body, productive use of computers should address three critical issues: keyboard positioning, keyboard access and typing speed.

3.1. Keyboard Positioning

The keyboard can be the biggest obstacle to computing for a person with a mobility impairment. Fortunately, those who lack the dexterity or range of motion necessary to operate a standard keyboard have a wide range of options from which to choose. Correct keyboard positioning will allow persons with moderate levels of orthopedic disability to minimize physical exertion and thus reduce fatigue. Properly positioned keyboards also help to decrease the spasticity and resultant keyboarding errors that occur from straining to reach portions of the keyboard. Repositioning the keyboard to the floor can allow someone to use his feet instead of his hands for typing.

3.2. Keyboard Access

Assistive technologies that provide keyboard access are vitally important. The multiple keystroke commands common to many computer applications can be an obstacle for persons with virtually any degree of orthopedic disability. How, for example, can a one-handed typist or headstick user, hold down a key on the left-hand side of the keyboard while simultaneously pressing another key on the right-hand side of the keyboard?

3.3. Specialized Adaptations to Control Keyboard Functions

One of the most useful access tools available for individuals with orthopedic disabilities are programs that provide control of keyboard operation. If physical disabled computer users find that using the standard keyboard works for them but that some aspects are slowing them down, then keyboard modification software may be just what they need. For many disabled persons, use of such an adaptation may be all that is required to gain computer access. Programs of this type should meet the criteria that follow.

Such assistive tools should be utility programs that can be easily loaded into the computer. Keyboard modification software allows users to keep using their ordinary keyboard, but provides some vital assistance just where it's needed. In this way, the disabled computer user can readily move from computer to computer without being dependent on specialized hardware modifications attached to a single computer system. Before purchasing a complex keyboard option, evaluate the accessibility features that are built-in to current popular operating systems. For instance, the Accessibility Options control panel in current versions of Microsoft Windows™ contains a variety of settings that make a standard keyboard easier to use. The Macintosh operating systems have similar features in the Easy Access control panel.

The automatic key repeat function common to many computer keyboards can be a serious obstacle to many physically disabled individuals. Limitations in fine motor control may take the quick release of keys difficult or impossible. Keyboard control programs should be capable of turning off or modifying the key repeat function.

Simultaneous, multiple key commands create a significant barrier for one-handed or touch-stick computer users. Many widely used computer programs make extensive use of special keys on the keyboard such as the Ctrl and Alt keys to carry out commands.The complex feats of manual dexterity required by many programs tax the skills of individuals with a complete set of digits; without keyboard control programs, such programs are virtually inaccessible to persons with significant orthopedic disabilities. Keyboard programs should be capable of electronically "latching down" the Ctrl, Alt and Shift keys individually or in combination. The program should provide an automatic release feature to "unlatch" these special keys after a second, nonspecial, key has been pressed.

For moderately orthopedically disabled computer users, one of the most frustrating aspects of using a physical keyboard is the unintentional pressing of keys. Individuals with limited fine motor control often brush unwanted keys with a protruding finger or misdirected pointing device in the process of pressing the desired key. A great deal of time is thus spent erasing unwanted characters from the computer display. The traditional approach to solving this problem has been through the use of key guards. A keyguard is a sheet of flat metal or plastic designed to prevent accidental keystrokes and to provide a convenient place to rest hands when doing data entry. The guard has finger-sized holes, one for each key. In order to press a key, user must insert his/her fingers into one of the holes on the guard. Also, if user is using a mouth stick or head stick to type, the guard can help him/her to increase accuracy and prevent typos. The benefits of a keyguard also can enjoy nondisabled computer users. [6] This same result can be attained using keyboard control programs which, in effect, tell the operating system the amount of time the keys on the keyboard must be held down before sending a letter to the screen buffer. By introducing a very small delay factor, the great majority of accidental keystrokes can be eliminated without significantly reducing typing speed.

In order to provide the disabled computer user with complete access to the full range of commercially available software, the keyboard control program must not interfere with the simultaneous operation of other programs.

The keyboard control program should provide a method for program start-up using a previously chosen selection of keyboard control options.

3.4. Enhancing Typing Speed

For individuals with mild or moderate orthopedic disabilities, it is a relative simple task to provide greatly improved access to the computer keyboard. Persons, whose disabilities prevent them from typing at a rate greater than 10 to 12 words per minute, may also require assistive technologies that enhance the rate of text production.

One solution might be word completion programs, which make surprisingly accurate predictions about word choice, while a sentence

is actually being written. Using a history of the user's word frequency patterns and word choices preferences, such systems can predict the completion of a word being written, based on its first, second or third letter. The user is shown a list of likely choices and may elect to complete the word or phrase by pressing a single key. Such systems also automatically manage the tasks of inserting the correct number of spaces after punctuation marks and beginning each new sentence with a capital letter. Some word prediction software automatically collects new words as they are used, and consider a person's common vocabulary when predicting in the future.

Word prediction programs should operate transparently with commercial software applications, allow for "on-the-fly" addition of new words and phrases, and constantly adjust word usage frequency tables to enhance the speed and accuracy of word prediction. Word prediction is often used with a virtual keyboard to increase accuracy and typing speed. For those who type much faster than 13-15 words per minute, however, use of word prediction can actually decrease typing speed, because the user is required to look in two places – the keyboard and the screen.

Spell check and correction programs that continuously monitor spelling and offer to correct errors automatically as a document is being written can substantionally reduce the amount of time ordinarily required for such tasks. The kinds of spelling errors that sometimes occur as a result of miskeying due to limited fine motor control can be instantly corrected.

Within the last ten years, great strides have been made in the development of fast, accurate, large vocabulary speech recognition systems for microcomputers. Speech recognition systems can serve as a supplement, or even a replacement, for data entry on a physical keyboard. However, it is required to be carefully with speech input systems because they have severe limitations about distinguishing between similar sounding words or phrases so they are likely to make mistakes. Therefore, for the system to be effective, careful consideration of the person and the task involved is required. [8]

4. Technologies for Students with Severe Physical Disabilities

Students with severe physical disabilities are a heterogeneous group. For some, mobility is the greatest barrier they face. For others, caring for their personal needs is a tremendous challenge. Still others face overwhelming obstacles in communication. The data indicate that approximately 48.000 students with orthopedic impairments in the United States [5] were served in the public school system for the 1995 year, slightly more than 1% of all students with disabilities who are currently receiving special education services. Fortunately, a variety of new technologies have been developed to help individuals with physical disabilities overcome their challenges and function well in school, work, and home environments. These innovative assistive technologies are readily available and extremely functional. Following are descriptions of several computing tools that have been effectively used by individuals with mobility impairments. This list is not exhaustive and should not limit the person with a mobility impairment or the adaptive technology practitioner form trying other approaches.

Alternative Input Devices for Students with Physically Disabilities

Switches

The keyboard doesn't have to be on the desk to be useful. Users can display a picture of the keyboard on the computer screen using an on-screen software package. After that, it is possible to control the on-screen keyboard using single or multiple switches. When the desired key is illuminated or highlighted, users can select it by clicking a switch. Switches control the flow of electrical power to a device that the user wants to turn on or off. There are a variety of input methods that rely on switches. Scanning and Morse code are two of the most popular. Switches can be activated by almost any part of the body a person is able to voluntarily and reliable control – for example, switches are available that can be activated by the use of an arm, hand, finger, leg, foot, head or chin. They also may be controlled by less obvious movements of the eyebrow, or the rib cage with access through controlled breathing. While the movement does not have to be big, it must be controllable and reliable, and often considerable training is required before the use of the switch is reliable. Morse code is a more direct method of

control than scanning and with practice can be a very efficient input methods.

Alternative Keyboards

Alternative keyboards permit users with physical disabilities to enter information into the computer with a keyboard that molds to individual needs. Basic adaptive adaptations that assist physically disabled students to use computers include replacing standard keys with larger keys that are easier to see and touch, reducing the number of keys on the keyboard, placing letters keys in alphabetical order, and providing keys that are brightly colored and easy to read. Other keyboards are much smaller than their tradicional counterparts and have keyboard surfaces that are much more sensitive to touch. These keyboards are excellent for individuals with a limited range of motion or for individuals who have a difficult time applying pressure to keys. Also, many alternative keyboards have a sticky-key feature to lock and hold Shift, Alt, and Ctrl keys, transforming keystrokes that ordinarily take two hands into a single-handed operation.

Touch Screens

Touch screens are very popular with young computer users and with individuals who have severe developmental of physicaldisabilities. The user needs only to point with a finger to make a selection. Many touch screens come complete with multiple screen overlays that can be used to perform a variety of tasks. Similarly, many companies provide additional software that enables the users to create their own overlays. High-precision touch screens increase the range of possible applications, especially if they are mounted in a position that is convenient for pointing and reading (30 to 45 degrees form the horizontal).

Infrared Sensors with Pneumatic Switches

Use of an infrared sensor worn on the head, along with use of a pneumatic switch, can enable physically disabled students to interact with the computer. As the user looks at the computer screen, the cursor follows the user's head movement. Moving the head to the left moves the cursor in the same direction on the screen. Thus, users can position the cursor anywhere on the screen by moving their head left, right, up, or down. This kind of switches are called head-pointer switches, because they are operated by relative head movements. The pneumatic switch, which is activated by inhaling or exhaling through a plastic tube, enables the user to use the mouse. When the user sips or puffs on the switch, the computer responds as if the mouse button had been clicked. In this manner, the user can move a cursor and click on items displayed on the computer screen. This kind of switches are called breath switches because they are operated by breath or sip-and-puff control. Special software is used in conjuction with these movements to allow the user to type out information on facsimile of a keyboard that is displayed on the computer monitor.

Voice Recognition

Using voice recognition software, the user can bypass the keyboard and just speak to the computer. By programming the computer with a set of predefined instructions, the user can control the computer by verbally issuing commands into a microphone. In most cases, the reliability of the system can be enhanced by having the user "train" the computer to recognize his or her speech patterns. Such systems are called speaker-dependent systems. Also, there are speaker-independent systems that are beginning to be reliable enough for certain commercial applications. Quiet environments, head-mounted microphones, and careful choice of vocabularies improve recognition rate. Voice recognition systems enable students to operate a variety of application programs, to dictate to a word processor, and to enter data into spreadsheets.

Reading systems

An individual who has a difficult time holding printed material or turning pages may benefit from a reading system. These systems are typically made up of hardware (scanner, computer, monitor, and sound card), Optical Character Recognition (OCR) software, and a reading/filling program. The system provides an alternative to reading printed text. Hard copy text is placed on the scanner where it is converted into a digital image. The image is then converted to a text file, making the characters recognizable by the computer. The computer can the read the words back using a speech synthesizer and simultaneously present the words on screen. Use of such a system may require assistance, since a disability that limits manipulation of a book may also preclude independent use of a scanner.

5. Conclusion

The specific need for adaptive technology is unique to the individual. Trial and error may be required to find a set of appropriate tools and

techniques. The person with a mobility impairment should play a key role in determining her goals and needs when selecting her adaptive technology. Once basic tools and strategies are initially selected, she can test drive, discard, adapt, and/or refine. The end user of the technology should ultimately determine what works best. For example, switches can be activated by any part of the body, allowing students with physical disabilities to control many aspects of their environment independently – from using a toy or radio for their own entertainment, to communicating with their nondisabled peers in the classroom, to controlling a computer or other high-tech or AAC device. Today, switches can be used with a number of adaptive devices that enable students with severe physical disabilities to successfully operate a computer independently, including turning the power on and off, inserting and removing a disk or CD from a drive, copying files, accessing a modem, and using a keyboard. A number of alternative input devices can be connected to a standard computer to assist or replace the use of a traditional keyboard, which is often the greatest barrier to computer use for students with physical disabilities. Adaptive keyboards, infrared sensors, and voice recognition systems, all have proven to be highly effective in helping students with physical disabilities use computers to participate in many educational activities that would not be available to them through other means. These devices range in price from less than 100 $ for some switches to as much as 9000 $ for higher-end, voice-activated systems. Trackballs, external touchpads, handheld pointing devices, and head-controlled pointing systems (such as HeadMouse™ or HeadMaster™) are some of possible choices that may be effective to control a cursor on the computer screen. Holography would present the important role in improving life's quality for persons with mobility impairment. So, people with mobility impairments will be able to easily communicate with relatives and friends and be less lonely with face-to-face contact. It will be make their lives happier and easier.

The previously mentioned technologies have grown increasingly sophisticated and are becoming more familiar in classroom settings, and still other technologies are being developed for use in the near future. For example, a number of research labs are examining the use of devices such as robotic arms, which can help individuals who are physically disabled accomplish such daily activities as eating, retrieving objects, turning pages in books and magazines, and even play cards. Although it may be years before these technologies become commonplace, some robotic devices are already in use, and more sophisticated devices are continually under development. In time, they too may be commonplace, and technologies that have yet to be envisioned for use by students with severe physical disabilities will be moving into the limelight.

References

[1] Joseph J. Lazzaro: *Adapting PCs for Disabilities*. Addison-Wesley Publishing Company, 1996

[2] Microsoft Accessibility - Types of Assistive Technology Products http://www.microsoft.com/enable/at/types.aspx#mobility [3/4/2004]

[3] Working Together: Computers and People with Mobility Impairments http://www.washington.edu/doit/Brochures/Technology/wtmob.html [3/4/2004]

[4] Holographic Communicator, Future Communication http://www.columbia.k12.mo.us/mce/gkirchho/ptech.doc [3/4/2004]

[5] Teaching Students with Disabilities Web Page - Disability Accommodation in Science Education http://www.as.wvu.edu/~scidis/text/index.html [3/4/2004]

[6] Assistive Technology for CAP Sites - Mobility Disabilities http://www.nsaccess.ns.ca/cap/textpage/assmob.html [3/4/2004]

[7] Christopher R. Murphy: Computers Assisting The Handicapped http://courses.cs.vt.edu/~cs3604/lib/Disabilities/murhpy.AT.html#Cattoche [3/4/2004]

[8] Ben Shneiderman. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. Third Edition. Addison-Wesley Longman, Inc.; 1998

[9] Jenny Preece *et al.*: *Human-Computer Interaction*. Wokingham, UK: Addison-Wesley, 1994