INTRODUCTION

Computers can be a source of tremendous benefit for those with motor impairments. Enabling computer access empowers individuals, offering improved quality of life. This is achieved through greater freedom to participate in computer-based activities for education and leisure, as well as increased job potential and satisfaction.

Physical impairments can impose barriers to access to information technologies. The most prevalent conditions include rheumatic diseases, stroke, Parkinson’s disease, multiple sclerosis, cerebral palsy, traumatic brain injury, and spinal injuries or disorders. Cumulative trauma disorders represent a further significant category of injury that may be specifically related to computer use. See Kroemer (2001) for an extensive bibliography of literature in this area.

Symptoms relevant to computer operation include joint stiffness, paralysis in one or more limbs, numbness, weakness, bradykinesia (slowness of movement), rigidity, impaired balance and coordination, tremor, pain, and fatigue. These symptoms can be stable or highly variable, both within and between individuals. In a study commissioned by Microsoft, Forrester Research, Inc. (2003) found that one in four working-age adults has some dexterity difficulty or impairment. Jacko and Vitense (2001) and Sears and Young (2003) provide detailed analyses of impairments and their effects on computer access.

There are literally thousands of alternative devices and software programs designed to help people with disabilities to access and use computers (Alliance for Technology Access, 2000; Glennen & DeCoste, 1997; Lazzaro, 1995). This article describes access mechanisms typically used by individuals with motor impairments, discusses some of the trade-offs involved in choosing an input mechanism, and includes emerging approaches that may lead to additional alternatives in the future.

BACKGROUND

There is a plethora of computer input devices available, each offering potential benefits and weaknesses for motor-impaired users.

Keyboards

The appeal of the keyboard is considerable. It can be used with very little training, yet experts can achieve input speeds far in excess of handwriting speeds with minimal conscious effort. Their potential for use by people with disabilities was one of the factors that spurred early typewriter development (Cooper, 1983).

As keyboards developed, researchers investigated a number of design features, including key size and shape, keyboard height, size, and slope, and the force required to activate keys. Greenstein and Arnaut (1987) and Potosnak (1988) provide summaries of these studies.

Today, many different variations on the basic keyboard theme are available (Lazzaro, 1996), including the following.

- Ergonomic keyboards shaped to reduce the chances of injury and to increase comfort, productivity, and accuracy. For example, the Microsoft® Natural Keyboard has a convex surface and splits the keys into two sections, one for each hand, in order to reduce wrist flexion for touch typists. The Kinesis® Ergonomic Keyboard also separates the layout into
right- and left-handed portions, but has a con-
cave surface for each hand designed to minimise
the digit strength required to reach the keys and
to help the hands maintain a flat, neutral posi-
tion.
- Oversized keyboards with large keys that are
easier to isolate.
- Undersized keyboards that require a smaller
range of movement.
- One-handed keyboards shaped for left- or right-
handed operation. These may have a full set of
keys, or a reduced set with keys that are
pressed in combinations in the same way a
woodwind instrument is played.
- Membrane keyboards that replace traditional
keys with flat, touch-sensitive areas.

For some individuals, typing accuracy can be
improved by using a key guard. Key guards are
simply attachments that fit over the standard key-
board with holes above each of the keys. They
provide a solid surface for resting hands and fingers
on, making them less tiring to use than a standard
keyboard for which the hands are held suspended
above. They also reduce the likelihood of accidental,
erroneous key presses. Some users find that key
guards improve both the speed and accuracy of their
typing. Others find that key guards slow down their
typing (McCormack, 1990), and they can make it
difficult to see the letters on the keys (Cook &
Hussey, 1995).

The Mouse

A mouse is a device that the user physically moves
across a flat surface in order to produce cursor
movement on the screen. Selection operations are
made by clicking or double clicking a button on the
mouse, and drag operations are performed by hold-
ing down the appropriate button while moving the
mouse. Because the buttons are integrated with the
device being moved, some people with motor impair-
ments experience difficulties such as unwanted
clicks, slipping while clicking, or dropping the mouse
button while dragging (Trewin & Pain, 1999). Trem-
ors, spasms, or lack of coordination can cause
difficulties with mouse positioning.

Trackball

Trackballs offer equivalent functionality to a mouse,
but are more straightforward to control. This device
consists of a ball mounted in a base. The cursor is
moved by rolling the ball in its casing, and the speed
of movement is a function of the speed with which
the ball is rolled. Buttons for performing click and
double-click operations are positioned on the base,
which makes it easier to click without simulta-
neously moving the cursor position. For dragging,
some trackballs require a button to be held down
while rolling the ball, while others have a specific
button that initiates and terminates a drag operation
without needing to be held down during positioning.

Thumb movement is usually all that is required to
move the cursor to the extremities of the screen, as
compared to the large range of skills necessary to
perform the equivalent cursor movement with a
mouse.

Joystick

The joystick is a pointing device that consists of a
lever mounted on a base. The lever may be grasped
with the whole hand and have integrated buttons, or
may be operated with the fingers, with buttons
mounted on the base. The cursor is moved by moving
the lever in the desired direction. When the lever is
released, it returns to its original, central position. Of
most relevance are models in which the cursor
moves at a fixed or steadily accelerating rate in the
direction indicated by lever movement and retains its
final position when the lever is released. The buttons
are often located on the base of such models, and a
drag button is generally included since it is difficult
to hold down a button while moving the lever with a
single hand.

Isometric Devices

Isometric devices measure force input rather than
displacement. An example is the TrackPoint device
supplied with IBM laptops: a small red button located
in the center of the keyboard. These devices do not
require any limb movement to generate the input,
only muscle contractions. As it has been postulated