The BrowsMouse - Computer Access with Eyebrows

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Abstract
If a person with a disability is to have access to a computer, alternatives to the standard mouse and computer keyboard must be developed. The BrowsMouse is a computer mouse that can be controlled with movement of the eyebrows. The headpiece comprises some electronics and infra-red light emitting diodes (LEDs) mounted discretely on a pair of spectacles. Using infra-red light, the position of the eyebrows is measured. These measurements are then amplified, digitally sampled and transmitted to the PC either as standard mouse commands or as sampled data, to be further interpreted by the PC. The hardware and software algorithms used for the BrowsMouse are described, as well as the results from initial testing.

Keywords:
Computer access, eyebrows, mouse.

1 Introduction

Operating a conventional computer can be very difficult for those who suffer from a physical disability. Modern software is based on the graphical user interface and requires good mouse skills to coordinate between hand and screen. On the other hand a computer equipped with a suitable user interface can become a valuable tool for those with disabilities. It can enable people with disabilities to access information, employment and recreation. It can also give them the means to control their own local environment.

Many varied projects are aimed at providing people with disabilities access to the internet. Websites are now being developed with blind or disabled users in mind [1]. Additionally, numerous disability agencies and disability resources are now available on the Internet making the computer (and internet access) indispensable for people with a disability. To complement these advancements, appropriate devices must be developed to allow a disabled user to control a computer.

With the majority of modern software applications, a simple text based interface is no longer an option. Graphical user interfaces are now the primary means for computer interaction. This usually involves a mouse. For a person with

a physical disability which restricts arm/hand and leg/foot movement, such as a spinal injury, moving an ordinary mouse is very difficult. Clicking the mouse buttons becomes even more of a challenge. The present research project has developed the BrowsMouse, a device in the form of a pair of glasses and an infra-red link to control a computer's mouse pointer by movement of the eyebrows. The BrowsMouse design, functionality and results of early tests are described here.

2 Design Philosophy

The design of aids for people with disabilities must consider a number of important issues. Some aspects are technical, some medical, some marketing, some ergonomic and psychological as well [2, 3]. Additionally, cost effectiveness might be a critical factor.

Some alternative computer access devices developed include:

The "Headmaster Set" is a large "head band" device with three ultrasonic transmitters. By triangulating the ultrasonic waves as the head is rotated or tilted, the mouse pointer can be moved. Clicking of the left mouse button is achieved by sucking or blowing into a mouth piece.

The "Jouse" is a mouth-operated joystick that moves the screen pointer. Clicking is also achieved by sucking on or blowing into the device [4].

The Headmaster Set is very easy to use and the Jouse takes a little getting used to. However, the Headmaster Set is a little cumbersome to wear and both devices have a price upwards of $2000.

The fact that many devices are expensive is a direct result of small turnover often associated with aids for people with disabilities. At one end of the spectrum are devices purpose built for one individual. This low "turnover" tends to make aids very expensive compared to other consumer items. This need not be the case. Convergent design is a simple principle whereby products and environments can be used with similar ease and advantage whether the user is able or disabled. A clear example of this is the inclusion of ramps in the curbs at traffic lights and other crossing places. They are required for wheelchair users, but their main traffic is shopping trolleys, prams and bicycles. A similar example of convergence and flexibility is the television remote control. It is the lazy man's perfect couch partner but to a person with a disability it is an indispensable tool. It enables a variety of devices to be controlled from a distance, including the TV, lights, telephone and with help of advances in home automation other devices around your home.

The BrowsMouse, developed in this research, has been designed with the above issues such as cost effectiveness and ergonomics in mind. The BrowsMouse can potentially be used by anyone looking for an alternative to the conventional computer mouse, even able-bodied people. For example, typists may no longer need to remove one hand from the keyboard to move the mouse - a simple raising of the eyebrows could achieve similar results. More importantly, however, if the BrowsMouse appeals to able-bodied computer users or even computer gamers, it will be available on the mass-market for relatively little cost. However, even

without a mass market, the BrowsMouse is already very cost effective at approximately $300.

The psychological aspects are primarily concerned with ergonomics and the user being identified as disabled. In discussions with potential users and people working in the industry, self-esteem is an issue to be considered in any new design. The less obtrusive the device and the more "normal" the device looks, the happier the customer. This issue can, of course, be seen from a different perspective - an obtrusive or ugly product can be deemed "normal" if it used or worn by the majority of the population. The walkman could be considered an example of this.

3 The Design

Figure 1 shows the BrowsMouse. Addressing the issue of ergonomics and the identification as disabled, the BrowsMouse has been kept as unobtrusive as possible. It primarily consists of a pair of safety glasses. A new design is adaptable to any pair of ordinary reading glasses. Additional to the pair of glasses is a battery pack containing two 'AA' batteries. The electronics are mounted directly on the frame of the glasses thus making the BrowsMouse self contained. There are no cables connecting the glasses to the PC thus making the BrowsMouse completely portable.

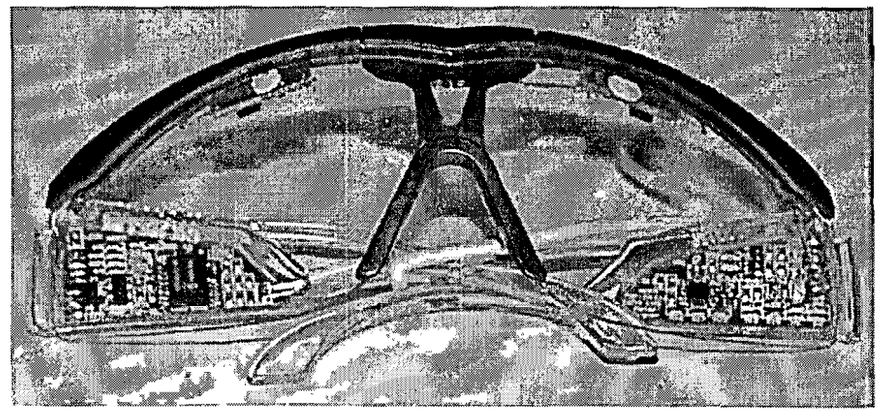

Fig 1. The BrowsMouse

3.1 The Hardware

To sense eyebrow movement a number of methods could be employed. These are either optical or mechanical. Optical sensing was chosen in favour of mechanical sensors as no moving parts are involved. To sense the movement of the eyebrows (or skin around the eyebrows) infra-red was chosen as it reflects off skin and hair reasonably well. By experimentation it was soon established that two infra-red LEDs (light emitting diodes) were needed for each eyebrow, one facing upwards at approximately 45 degrees, the other facing downwards; more on this later.

The four infra-red LEDs are driven alternately and samples of the reflected light are taken when the light pulse starts and when the light pulse stops. As shown in the block diagram of BrowsMouse (Figure 2), the infra-red signal is received and passed through a DC restoration circuit to counteract effects of ambient light. The signal is then amplified and sampled using an 8-bit analog to digital converter. The CPU, an 8-bit RISC microcontroller (with built-in A/D converter) then processes the signal. The CPU then transmits either the raw sample data to the PC via an infra-red serial link or transmits actual mouse commands, making the BrowsMouse look like an ordinary serial mouse.

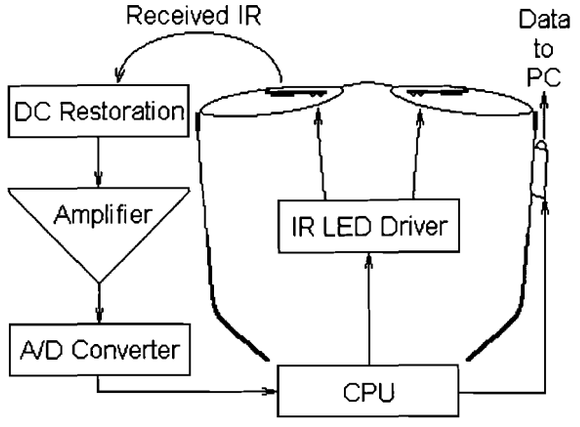

Fig 2. Block diagram of the BrowsMouse

3.2 The Signals

As mentioned earlier, the eyebrow position is measured using short pulses of infra-red light. Figure 3 shows a typical waveform as received by the infra-red detector for one eyebrow. Trace 1 shows the drive voltage for the two LEDs and trace 2 shows the received and amplified voltage level. As shown, the measurements are taken 10us after the LED is turned on or off. Measurements are taken when the LED pointing down is first switched on (point A), then when it is turned off (point B), followed by the upward pointing LED being turned on (point C) and finally when it is turned off at point D. The 10us delay between the switching on or off of the LED is needed to allow the response to reach its peak value. The graph shown in Figure 3 corresponds to the "relaxed" state of the eyebrows. Table 1 shows the sampled voltage levels in the relaxed state, the eyebrows up or "surprise" state and eyebrows down or in the "frown" state.

Sampling point	Eyebrow Position			LED that is on
	"Frown"	Relaxed	"Surprise"	
A	3.1V	2.9V	2.9V	Upward
B	1.8V	1.9V	1.9V	-
C	4.9V	4.8V	4.4V	Downward
D	0.1V	0.3V	0.6V	-

Table 1. Sampled Voltage levels

It can be seen from the voltage levels measured in the various eyebrow positions that it may not be possible to distinguish between certain eyebrow positions based on one LED alone. For example, there is no difference between the voltages recorded in the relaxed and surprise positions of the eyebrow when only the upward facing LED is on. This is the reason for employing both an upward and downward facing LED.

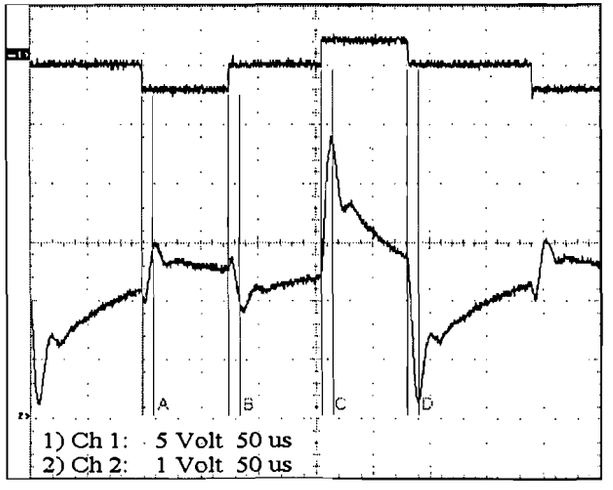

Fig 3. A typical measurement of one eyebrow

3.3 The Software

When the BrowsMouse is first switched on, the user must train the mouse by raising, lowering and relaxing his eyebrows once. From these training values further movement can be ascertained. To establish if an eyebrow is up, down or relaxed a score is determined according to

$$score = 1 / (current\ sample - trained\ sample) \qquad (3.3.1)$$

Other methods have been trialed, but Equation (3.3.1) gave the best consistent results. A score is established for each of the trained values (up, down and

relaxed). The highest score indicates the current state of each of the eyebrow. The most common state is the relaxed state. While the BrowsMouse is in the relaxed state, the training values are "re-tuned" automatically so that the BrowsMouse is robust against small movements of the glasses up and down the user's nose.

Left Eyebrow	Right Eyebrow	'Mouse' movement
Up	Up	Up
Down	Down	Down
Up		Left
	Up	Right
Down		Left Click
	Down	Right Click

Table 2. BrowsMouse movements

Once it is known whether the eyebrows are relaxed, up or down, the information is encoded according to Table 2. The table shows how the various functions of a standard mouse can be achieved by moving each eyebrow.

4 Tests

Some initial testing on a variety of people has been very successful. Most people (disabled or not) have the ability to raise and lower their eyebrows. This is the first stage in the learning process. By moving eyebrows up and down, the mouse pointer can be moved up and down the screen. The next step is to learn to move each eyebrow independent of the other. During the learning process, some controlled left and right movement is already visible after only 30 minutes. It is estimated that after approximately 7 hours (an hour a day for one week) the BrowsMouse can be used as a fully functional mouse.

The BrowsMouse has also been praised by people with disabilities for its light weight and small size. Suggestions for improvement include tilt sensors mounted on the glasses. Tilt sensors can be used so that tilting of the head would move the mouse pointer whereas moving the eyebrows would still perform the clicking operation.

Full field trials will also indicate what disabilities the BrowsMouse is suitable for. The BrowsMouse was developed primarily for use by quadriplegics. There are indications, however, that the mouse's application range will be much broader.

5 Conclusion

The BrowsMouse is a novel approach to computer access for people with a disability. The device has thus far been well received. However, extensive field trials need to be conducted before the BrowsMouse becomes a commercial reality.

In the near future the BrowsMouse's application will move away from just providing computer access. Further development sees the BrowsMouse integrated into home automation systems. This integration will empower a person with a disability to control more of their living environment. Consequently it will make people with a disability more independent and improve their quality of life.

Acknowledgment

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