A NOVEL DEVELOPMENT OF HEAD-SET TYPE COMPUTER MOUSE USING GYRO SENSORS FOR THE HANDICAPPED

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***Abstract*-- This paper describes the development of a novel head-set type computer mouse controlled by gyro sensors. This device operates on sensing the rotation of the human neck so that it may serve those who are physically disabled, for example spinal cord injuries and disabilities involving paralysis. For better performance, a novel hybrid operational mode is suggested, which combines the merits of an absolute pointing device and a relative pointing device. Actually, this device is a relative pointing device, but a hybrid mode can be accomplished by adjusting displacement rate of mouse pointer based on angular velocity of the head. The mouse click is controlled by eye blinking which is one of the most convenient behaviors in human behavior. Eye blinking is detected by measuring reflection of infrared rays exposed to muscles near eyes. Conscious and unconscious eye blinking is distinguished by the extent of reflection, because more infrared rays are reflected when user blinks his eyes consciously. This system can be attached to a head-set on virtue of its small bulk. Low cost, comfort and good performance render this system suitable for the design of a head-operating mouse for disabled people.**

***Index Terms*—gyro, computer mouse, eye blinking**

I. I INTRODUCTION

As advances in technology allow more functions to be done by computer, the computer becomes one of major parts of our lives. It can be used in acquiring new knowledge, communicating with others through website and having fun with leisure activities. The usage of the computer becomes necessary and inevitable rather than merely convenient. For disabled people, access and independent control over a computer system is also highly desirable and the ability to operate the computer mouse is becoming more important for these reasons.

Unfortunately, those who have physical problems such as spinal cord injuries or paralysis cannot use a standard computer mouse. It is necessary to invent a simple and comport computer mouse for the people with disabilities[1]. In this context, several alternative interfaces have been developed. Origin Instrument's HeadMouse and Prentke Romish's Head Master were made commercially. But they were expensive and processing requirement was not trivial[2][3]. A camera vision system would be an ideal solution to a head operated computer mouse because users need not wear any equipment. However, there are few available systems and their cost is so high. Laser diode and ultrasonic sensor also have been researched for head pointing[4]. The most analogous study to this research was a computer interface using tilt sensor[5]. It was a good development, but a sensor module and a signal-processing module were separated and its total size was a little voluminous.

In developing these interfaces for the disabled, several restrictions are discussed[6] and they are described as follows:

- It should be compatible with standard mouse
- It should be reliable.
- It is preferable not to use physical connection between users and their computer using wireless communication. However, if users should wear any equipment, it should be aesthetically pleasing, small, light and comfortable.
- It is desirable that the clicking of mouse buttons be integrated with the operational approach.
- It should be cost effective.

In this paper, we designed head operating computer mouse using gyro sensors for the handicapped considering above conditions. Gyro sensor is small, light and its sensitivity is suitable for detecting head movement. Though high price has been a big obstacle to using gyro sensor, its price has also decreased so that total cost of our system could be a reasonable value compared to that of previous research.

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According to the operational mode of the mouse, there are two types of device, a relative pointing device and an absolute pointing device. The representative example of the former device is a joystick and that of the latter is computer mouse. The operation mode of this device is relative pointing, strictly speaking. But the displacement per movement is adjustable based on the angular velocity of the human neck. Therefore, a hybrid mode can be achieved to have a good performance.

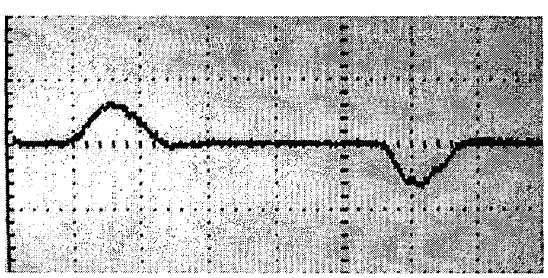
Conscious eye blinking was used for the mouse click. Infrared rays were exposed to muscles near the eye and their envelops of reflection were processed. When people blink eyes consciously, muscles near eye move more severely compared to unconscious eye blinking. This difference varies the quantity of the reflection of infrared rays, and this effect was used to distinguish conscious eye blinking and non-conscious eye blinking. Two transceivers are installed for both eyes so that right mouse clink is available as one blink of a single eye.

This research presents an application of gyro sensor in a head-operating computer mouse. We designed this device and its performance was verified by experiment.

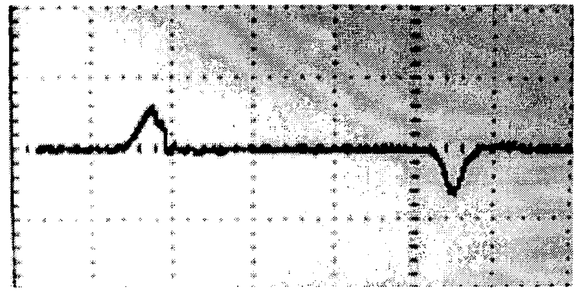
II. System Design

A. Gyro Sensor

Ceramic Gyro is a miniature angular rate sensor having a very simple construction that is made up of a single piezoelectric ceramic column printed with electrodes. The output of the gyro sensor is proportional to the angular velocity of one axis. In this research, two gyro sensors are located perpendicularly to detect up-down and right-left rotation. We used ceramic gyro sensors of CG-16D manufactured by Tokin. This is very small(8x20x8mm) and has a good sensitivity of 1.1 (mV/deg/sec). The maximum detectable angular rate is 90(deg/sec) which is suitable for detecting normal human neck rotation. The outputs of gyro sensors were amplified about 20 times by Op-amp and they were inputted to an A/D converter. When the human head moves, the output of gyroscope is represented in Fig. 1.



(a)



(b)

Fig. 1. The outputs of gyro sensors. (a) is with the left-right rotation and (b) is with up-down rotation. (The unit is 500mV/500ms.)

B. Infrared Rays Transceiver

A mouse click was performed by blinking the eye. When people blink their eyes, muscles near the eye move. This movement is more severe when humans blink their eyes consciously, compared to unconscious eye blinking. We used infrared rays to detect eye blinking. Infrared diode which has a directivity of 10° is used. The infrared ray transmitters send 5KHz rectangular waves to the muscles near the eye and the exposed infrared rays are reflected to the skin. It is exploiting the fact that these reflections change with muscle movement because muscles alter the shape of the skin. This phenomenon was shown in Fig. 2. As Fig. 2 shows, quantity of the reflection increases when the eye blinks consciously. However, we find another factor: the quantity of the reflection sometimes decreases according to positions of transceiver. Thus the threshold voltage which distinguishes conscious eye blinking and non-conscious eye blinking should not be fixed. Two transceivers are installed for both eyes. Left mouse click works when users blink their both eyes. Right mouse clink is operated as one blinks only the right eye.

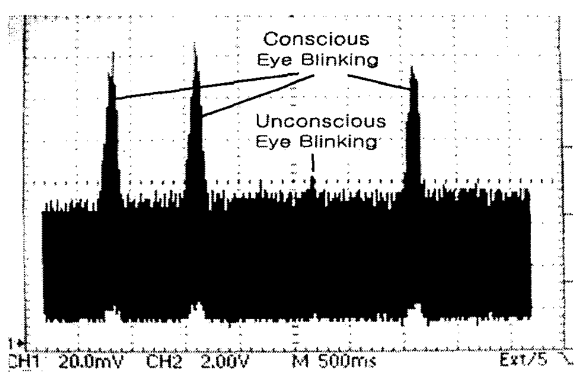


Fig.2. The output of infrared receiver when eyes blink consciously and unconsciously.

C. *Main signal processing module*

PIC16F711 which executed 4M instructions per second was employed as main controller. PIC16F711 manufactured by Microchip had 4-channel high-speed 8-bit A/D converters and 13 I/O pins. This controller calculates input data from four A/D converters and sends information of the mouse to IBM PC using RS-232. This total system is depicted in Fig. 3. This device is powered by an alkaline battery and power consumption was 45 mW.

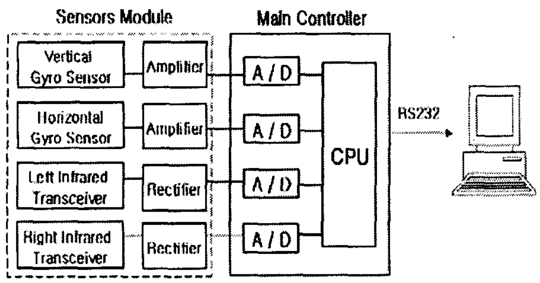


Fig. 3. The circuit diagram of mouse using gyro sensors and infrared transceivers.

III. Mouse Operation

The operational mode of this device is relative pointing such as a joystick. However, for better performance we proposed a hybrid operational mode, which combines the merits of a relative pointing device and an absolute pointing device.

Fig. 4 shows the output of gyro sensor when the human head rotates to right and stops for a moment and moves left to its original position. So the region of area A and area B is same, which represents each displacement of head rotation. In this research, area B is not considered except using of mouse pointer stop. Fig. 4 describes disposition according to three modes, absolute pointing(a), relative pointing(b) and hybrid pointing(c). In absolute pointing, area A becomes the total displacement of the mouse pointer, and area B is to be ignored. When relative pointing is used, displacement per movement is fixed as Δd_1 and the mouse pointer moves until counter rotation occurs with total displacement being area C. When hybrid mode was concerned, this device operates similarly to absolute pointing until t_1. After t_1, operational mode is changed to relative operational mode with displacement per movement being Δd_2. Thus total displacement becomes area D. For convenient use, we tested this device several times changing Δd_2 and then fixed it when it was considered to be adequate. This value is different between left-right movement and up-down movement.

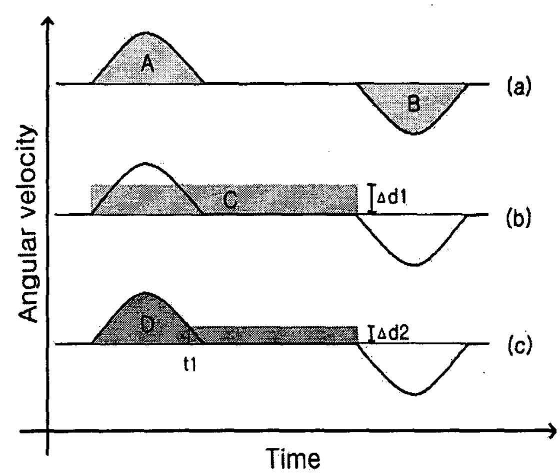


Fig. 4. Displacements of mouse pointer based on different operational mode.

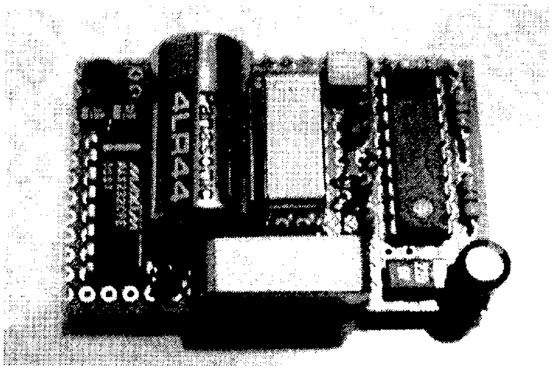
IV. Results

This system was able to detect head rotation sensitively. Because the output of gyro sensor was amplified about 20 times, sensitivity was around 20 (mV/deg/sec) which is enough value, considering the normal human neck has a rotation of 30 -100 (deg/sec).

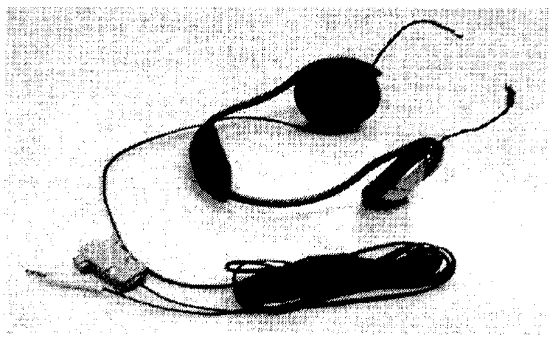
The joystick-style of operation was easier to use. A relative pointing device requires less precise head positioning than an absolute pointing device. When the hybrid mode is exploited, users need not rotate their heads several times to let the mouse pointer be placed where they want. And they can rest their heads in a relatively large dead band position until the mouse pointer reaches the destination. If users hoped to let the mouse move more quickly, they could do it by rotating their head more swiftly. One significant result is that movement of left-right is more accurate and convenient than that of up-down. The hybrid mode was well operated the in left-right moving, but relative operational mode was dominant in the up-down movement. This is shown in Fig. 1.

Infrared transceivers recognized blinking of the eyes. When the transceivers were headed for eyebrows of users, it worked more stably.

Gyro sensors and the main signal processing module were attached to the back of a head-set and the infrared transceiver was located on the near ear speaker as shown in Fig. 5. The dimension of the main signal processing module with two gyro sensors was only 50x35x15mm so that it could be installed to the head-set easily. It weights roughly 50 grams and the total cost was under $65.



(a)



(b)

Fig. 5. (a) is the picture of gyro sensors and main controller and (b) is the total system attached to head set.

V. Evaluation

This device was tested with ten users including five people with disabilities. After around 10 minutes training, all users operated this system successfully. As stated, users could perform the left-right moving more easily and more conveniently than the up-down moving. It is speculated that this was due to the structures of the human neck bones.

VI. Conclusion

This research reported on the design of a head-set type computer mouse for disabled people. We can design a small and comfortable computer mouse on virtue of gyro sensors. Suggested hybrid mode was more convenient to operate and could be easily adapted to the users. Exploiting blinking of the eyes, which is one of the most familiar human behaviors, users could click mouse without burdensome muscle movement. Because the head-set is widely used, users need not wear other equipment additionally. Small size, light weight, aesthetic appeal, and good performance of this device would enable disabled people to operate their computers more comfortably.

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