International Journal of Information Technology and Knowledge Management
July-December 2010, Volume 2, No. 2, pp. 185-187

EYE MOTION TRACKING FOR WHEELCHAIR CONTROL

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This paper proposes a new algorithm, the coherence algorithm, for eye movement tracking. Researchers continue to restore some functions lost by handicapped people using some powered electrical and robotic wheelchairs. This paper presents an application of eye tracking method to such wheelchairs. The coherence algorithm tracks the movement of eye towards left or right. The eye blinking feature is also used by the algorithm to control the starting and stopping of wheelchair.
Keywords: Coherence algorithm, eye movement tracking, wheelchair model, obstacle detection.

1. Introduction

Eye tracking is a technique whereby an individual's eye movements are measured so that the researcher knows both where a person is looking at any given time and the sequence in which their eyes are shifting from one location to another. The annual report of the Ministry of Public Health and Welfare states that 0.73 million people have a motor disability on the legs and arms [8]. For people with these disabilities, many different kinds of electrical and robotic wheelchairs have been designed. These people have problems to use a conventional wheelchair. A recent clinical survey [1] indicated that 9%–10% of patients who received power wheelchair training found it extremely difficult or impossible to use it for their activities of daily living, and 40% of patients found the steering and maneuvering tasks difficult or impossible. These people are dependent upon others to push them, so often feel powerless and out of control [3]. So, an eye tracking system is proposed here.

2. Eye Movement Tracking

Eye movement tracking is used in this project to determine the motion of eye. Based on this direction of motion of eye, commands are given to an electrically driven wheelchair. The eye motion tracking hardware includes a USB web camera which is mounted on a cap worn by the user. This camera is adjusted so that it lies in front of one of the eye of user. The camera has inbuilt light source, so that it can capture bright images if darkness appears under the cap. The drivers of the camera are installed in a PC to which the camera is plugged in. The software module for image processing works on three different modules: video capturing, frame extraction and pixel color detection. The image processing program performs these three steps based on the coherence algorithm explained below.

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2.1. Coherence Algorithm

The coherence algorithm works for detecting the motion of eye. This algorithm operates on the frames extracted from the video of the eye. From the frame, the algorithm extracts the pixels which lie on the vertical edges of the rectangular area selected by the user. These pixels are then processed to determine the RGB values. When the user is looking straight in font, the pixels on both the vertical lines are black. This is interpreted as the "center" direction of the user's eye. When user looks towards left, the pixels on the left vertical line are black, but the pixels on the right vertical line are white. This can be seen in the Fig. 1 shown below. The closed eye condition is also recognized by the software. This condition is then used to determine the blinking of the eye. The natural blinks of eye are distinguished from the unnatural blinks. The user has to blink his eye for a second if he wants to start moving or stop moving the wheelchair.

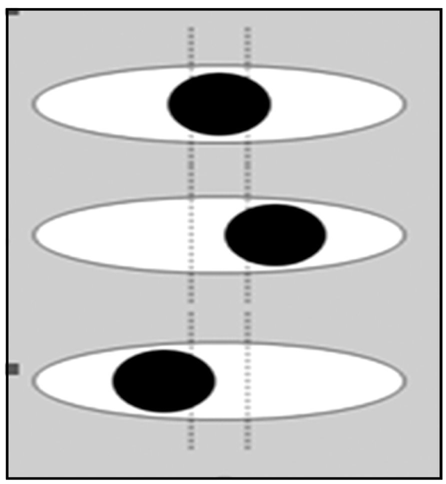

Fig. 1: The Two Scan Lines for Detecting the Motion of Eye

2.2. Wheelchair Operation

When the left or right motion of the eye is detected, the wheelchair can be controlled to move in that direction by giving commands to the wheelchair. Theses commands are transferred to the wheelchair using electrical signals which are used the drive the left or right motor of the wheelchair. There are basically two motors connected to the left and right wheels of the wheelchair. The electrical signals are transferred to these motors using some hardware ports, called the communication ports. Generally, the communication port is the parallel port. There are some basic predefined pins of this parallel port which accept the commands given to the wheelchair in the form of electrical signals. For the purpose of demonstration of wheelchair movement using eye motion, a wheelchair model is designed in this project, which works on batteries. This model wheelchair is shown in fig. 2 below.

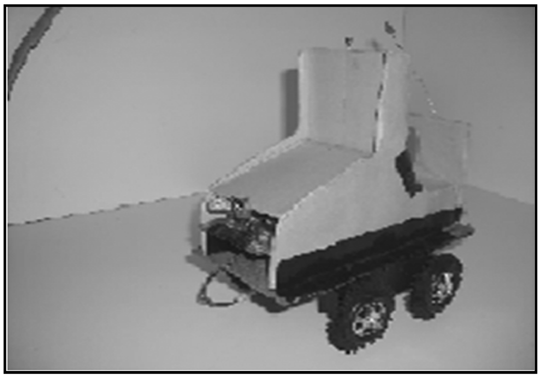

Fig. 2: Model Wheelchair

Four wheels are used in the wheelchair for proper balancing. The movement of wheels is controlled by DC motors which are attached to the wheelchair. Two wheels located on left side of the wheelchair are controlled by one motor and similarly the wheels on the right side are controlled by the second motor. The motors used in this system are small powered, geared DC motors which are generally used in toy cars. The other circuitry built into the wheelchair includes the transmitter and receiver circuits and the obstacle detection circuit. The obstacle detection circuit can be seen in Fig. 2 in the front portion of the wheelchair and the DC motors and the receiver circuit is mounted under the wheelchair. The signal transmitter from the system has an antenna for better range. The commands are transmitted from the image processing software to the parallel port. The 25-pin parallel port connector receives the command in the form a binary number. Based on the binary number received on the pins, voltage is generated on the pins, due to which the transistors connected to the parallel port connector are switched on or off. There are four transistors, one for each direction i.e. left, right, forward and backward. Then, the corresponding signal is transmitted from the transmitter in the circuit to the receiver circuit. Also, an obstacle detection module is added to the system for safety of the user. It involves two IR signal emitters which emit IR signals continuously. When some obstacle appears in front of the wheelchair, these IR signals are obstructed, and reflected back. These reflected signals are then detected by the IR sensor present just at the side of the emitters. As the IR signals are detected, a circuit is connected to the buzzer, and the buzzer beeps. At the same time, signal is transmitted back to the image processing software in the system so as to stop the wheelchair.

3. EXPERIMENTAL RESULTS

The system is tested on equal terrain and indoor environment. The USB INTEX night vision camera is attached to the cap which is worn by the user. The camera starts capturing as soon as it is plugged in. Then, we have to start executing the VB program so that the user interface is displayed on the screen. It can be seen in fig. 6, at the top left corner, there is a list box which displays the list of camera driver objects. There is only one camera driver listed in the list box. First, we select the camera driver from the list and then click "Start Camera View". As a result, the video captured by camera starts displaying in the rightmost picture box. Then, "Start eye detection" is clicked. As a result, the same video starts displaying in the first picture box. At this time, the image processing program has been started and the video in second picture box is the continuous input to the program. Now, a small rectangular portion inside the cornea of the eye (first picture box) has to be selected by the user, with the help of the mouse. It can be seen as a red portion in fig. 6. The vertical edges of this small rectangular portion form the two scan lines of the coherence algorithm. From the frames extracted, the coherence algorithm determines the direction of eye gaze. In Fig.6, the position of the eye is seen as left in the label below, because the pixels lying on left scan line are black.

Fig. 6: Eye Motion Detected as Left and Wheelchair is in Running Condition

The starting and stopping of the wheelchair is also controlled by blinking of the eyes. When the user blinks his eyes for a second, then the wheelchair starts or stops moving. That is, if the wheelchair is in moving condition, then after a blink, it stops and vice versa. The direction arrows shown in the figures below are used for testing purpose at the time of demonstration. Beside these arrows, a circle is seen with green color. When some obstacle is detected in front of the wheelchair, this circle becomes red, a buzzer beeps and the wheelchair stops. Note that this circle doesn't appear red for natural stopping of wheelchair by blinking. Table 1 below shows the test results for wheelchair movement. The wheelchair and its circuitry required two 1.5 V batteries and three 9 V batteries. The camera used, is a USB camera which can be directly plugged in and used. The camera drivers should be loaded in the system before use.

Table 1
Test Results for Wheelchair Movement

Item	Capacity
Frame Capturing Speed (of camera)	20 fps
Maximum Speed of wheelchair	5 km/h
Braking distance	1 to 2 feet (at 5 km/h)
Minimum Radius of rotation	1 feet

4. CONCLUSION

The proposed wheelchair system is easy to operate by the user. The cap worn by the user is light weighted carrying only a small camera with LEDs. The user has to only look left or right to move the wheelchair towards the desired direction. The diagonal motion is achieved when user looks left or right for only small duration of time. The experimental results are satisfactory which are shown in table 1. The actual implementation of the project requires changes in the wheelchair construction.

REFERENCES

[1] S. Stoddard, L. Jans, J. M. Ripple and L. Kraus, “Chartbook on Work and Disability in the United States, 1998”, An InfoUse Report, U. S. National Institute on Disability and Rehabilitation Research, 1998.

[2] L.Fehr, W. Edwin Langbein, and S. B. Skaar, “Adequacy of Power Wheelchair Control Interfaces for Persons with Severe Disabilities: A Clinical Survey,” J. Rehabil. Res. Develop., 37, No. 3, Pp. 353–360, 2000.

[3] R. C. Simpson, “Smart Wheelchairs: A Literature Review,” J. Rehabil. Res. Develop., 42, Pp. 423-436, 2005.

[4] Rafael Barea, Luciano Boquete, Elena Lopez, Manuel Mazo, “Guidance of a Wheelchair using Electrooculography”, Electronics Department University of Alcala. Alcalá de Henares. Madrid. SPAIN.

[5] “Non-Invasive, Wireless and Universal Interface for the Control of Peripheral Devices by Means of Head Movements”, Proceedings of the 2007 IEEE 10th International Conference on Rehabilitation Robotics, June 12-15, Noordwijk, The Netherlands.

[6] “Oral Motion Controlled Intelligent Wheelchair”, SICE Annual Conference 2007, Sept. 17-20, 2007, Kagawa University, Japan.