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PRELIMINARY INVESTIGATION OF A SEMI-AUTONOMOUS ROBOTIC WHEELCHAIR DIRECTED THROUGH ELECTRODES

Holly A. Yanco and James Gips

MIT Artificial Intelligence Laboratory
545 Technology Square, Room 705
Cambridge, MA 02139
holly@ai.mit.edu

Computer Science Department
Boston College
Chestnut Hill, MA 02167
gips@cs.bc.edu

ABSTRACT

Many people with disabilities do not have the dexterity necessary to control a joystick on an electric wheelchair. Our system allows a semi-autonomous robotic wheelchair to be commanded by head and eye movement using electrodes placed around the eyes. Once the user issues a high level command such as "forward," the wheelchair system will perform the command while avoiding obstacles and taking care of any necessary driving adjustments. Since our system will automatically avoid obstacles and make motor corrections, less effort is required by the user to drive the system. We present preliminary results on an experimental system that combines the Wheelesley robotic wheelchair with the EagleEyes system for controlling a computer through electrodes.

INTRODUCTION

In recent years, researchers have started to experiment with putting computer control and sensors on an electric wheelchair (see, for example, Gomi and Ide 1996). We have developed a semi-autonomous computer controlled wheelchair that provides driving assistance by taking over low-level control. Our system provides a new method for driving a wheelchair through the use of electrodes (Figure 1). This system is intended to allow people who do not have the dexterity necessary to drive a joystick controlled system to move around the world.

There are two levels of control in our system: high-level directional commands and low-level computer-controlled routines. The person using the system has the highest level of control. The user's head and eye movements are translated to screen position using the electrode system. The command at the calculated position is then sent to the robotic wheelchair. Once given a command by the user, the computer acts to keep the wheelchair out of trouble using the sensor readings. For example, if the user instructs the chair to go forward, the chair will carry out the command by taking over control until another command is issued. The chair will not allow the user to run into walls or other obstacles. If the chair is completely blocked in front, it will stop and wait for another command from the user. If it is drifting to the right, it will correct itself and move to the left. This allows the user to expend less effort when driving the chair than a person issuing all of the necessary motor commands. It can also help to mediate for people who have trouble with fine motor control but who have the ability to issue high-level commands.

Our system is composed of two parts. The Wheelesley robotic wheelchair system provides the low-level system that avoids obstacles and makes driving corrections and the high-level interface between the user and the wheelchair system. The EagleEyes system allows the user to control the Wheelesley system with eye movements.

THE WHEELESLEY ROBOT

Wheelesley (Yanco et al., 1995), a robotic wheelchair system, allows the user to tell the robot where to move in gross terms and will then carry out that navigational task using common sense constraints such as collision avoidance. The hardware was built by the KISS Institute for Practical Robotics. For sensing the environment, the robot has 12 infrared sensors, 4 ultrasonic range sensors, 2 shaft encoders and an instrumented front bumper.

Wheelesley has a user interface that runs on a Macintosh Powerbook. This interface takes commands from the user (forward, right, left, back and stop) and sets the computer controlled wheelchair in motion. The wheelchair uses its sensors to avoid obstacles and to maintain proper heading in accordance with the user's commands.

EAGLE EYES

EagleEyes (Gips, Olivieri, & Tecce 1993) is a technology that allows a person to control the computer through five electrodes placed on the head. Electrodes are placed above and below an eye and to the left and right of the eyes. A fifth electrode is placed on the user's forehead or ear to serve as a ground. The electrodes measure the EOG (electro-oculographic potential), which corresponds to the angle of the eyes in the head. The leads from these electrodes are connected to two differential electrophysiological amplifiers. The amplifier outputs are connected to a signal acquisition system for the Macintosh.

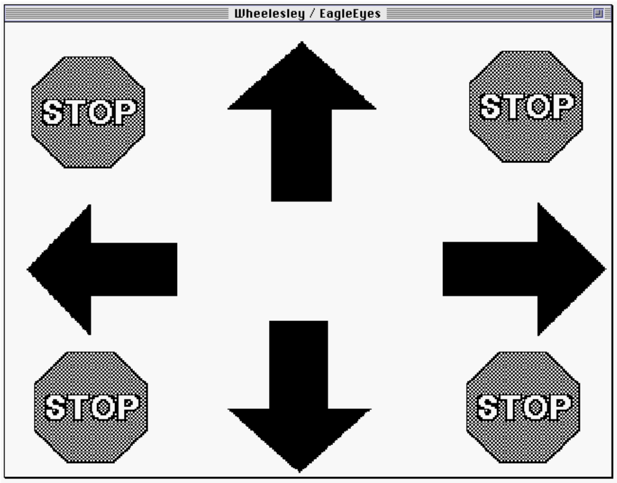
Custom software interprets the two signals and translates them into cursor (mouse pointer) coordinates on the computer screen. The difference between the voltages of the electrodes above and below the eye is used to control the vertical position of the cursor. The voltage difference of the electrodes to the left and right of the eyes controls the horizontal position of the cursor. If the user holds the cursor in a small region for a short period of time the software issues a mouse click.

Children with profound disabilities have been using EagleEyes for the past 18 months as a way of enabling them to control the computer and communicate (Gips et al., 1996).

DESIGN OF THE INTERFACE

The user interface screen (Figure 2) has been designed to accommodate the needs of the EagleEyes system. Large buttons are easier to use with an electrode system than small ones. We have four large direction arrows and four large stop buttons. We provide four stop buttons so that the user will be near a stop button regardless of where the cursor is placed on the screen.

SEMI-AUTONOMOUS WHEELCHAIR / ELECTRODES



DISCUSSION

Since the signal measured by EagleEyes corresponds to the angle of the eye in the head, the user can control the robot through eye movements. For example, look to the right to make the robot move to the right or look up to make the robot move forward. To issue a command, the user needs to hold gaze at the same spot for a fraction of a second to cause the mouse to click. This allows the user to look around without issuing commands to the chair. We envision a system where the user would not need to look at the computer screen to drive the wheelchair.

In our initial driving experiments on the system, the user has been able to control the Wheelesley robotic wheelchair system using the EagleEyes electrodes system. We are experimenting with variations in the interface and high level control actions.

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Holly A. Yanco
MIT Artificial Intelligence Laboratory
545 Technology Square, Room 705
Cambridge, MA 02139
617-253-8829
holly@ai.mit.edu