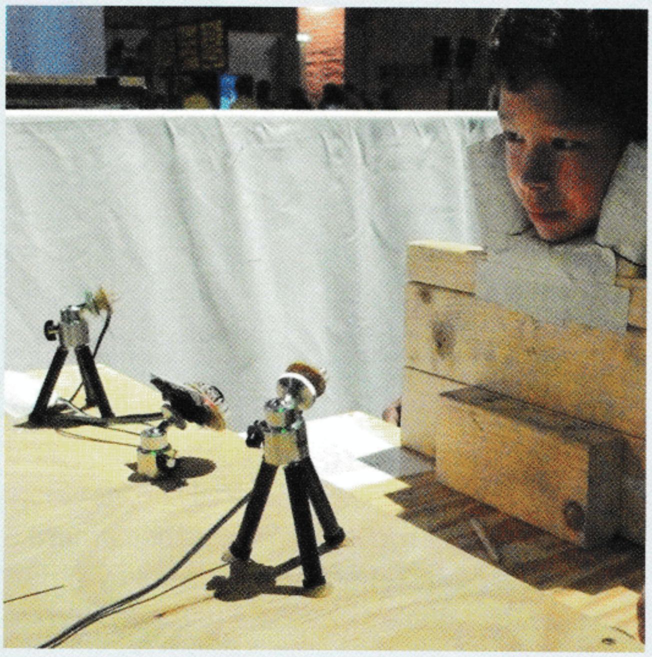
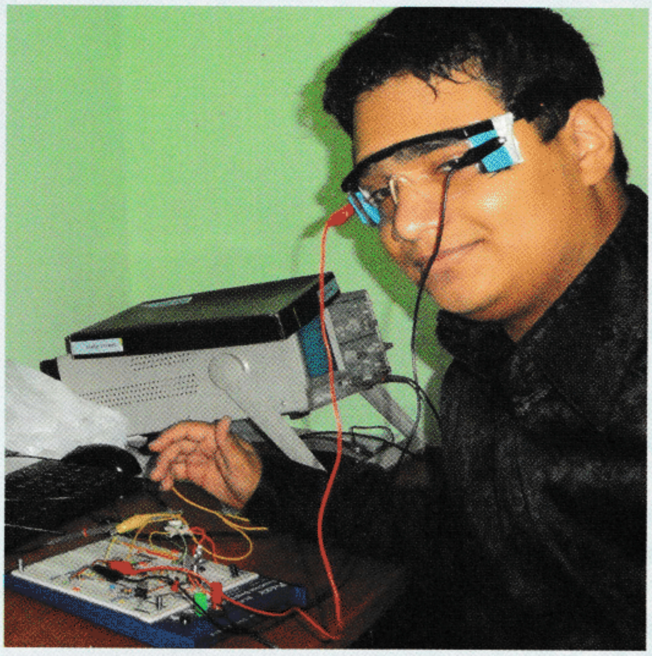
GATEWAYS TO THE SOUL

Two systems, EyeWriter and Eyeboard, let people draw, write, and connect using only their eyes.



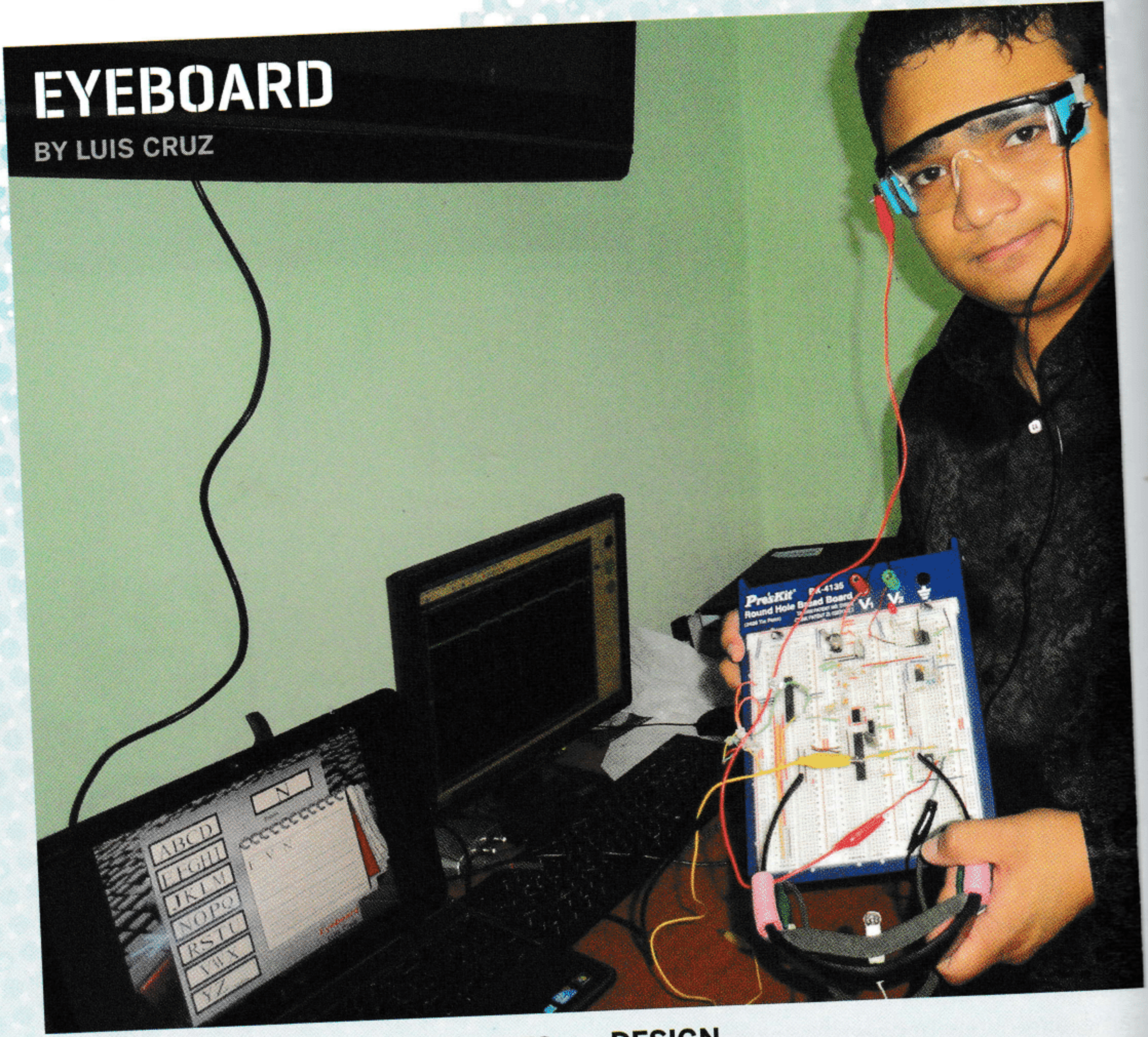


People at all ability levels can move their eyes, and here are two projects that turn these movements into useful control inputs.

The EyeWriter interprets an infrared-illuminated webcam image of the eyes, while Eyeboard picks up signals from medical electrodes on the face. The Eyeboard is less accurate and only detects horizontal movements, but is also cheaper and easier to build and integrate with microcontrollers or other circuitry. EyeWriter uses complex software to analyze the video, which makes it harder to interface with, but it can be configured (in Mac OS X) to control a mouse pointer for any application.

EYEBOARD

BY LUIS CRUZ

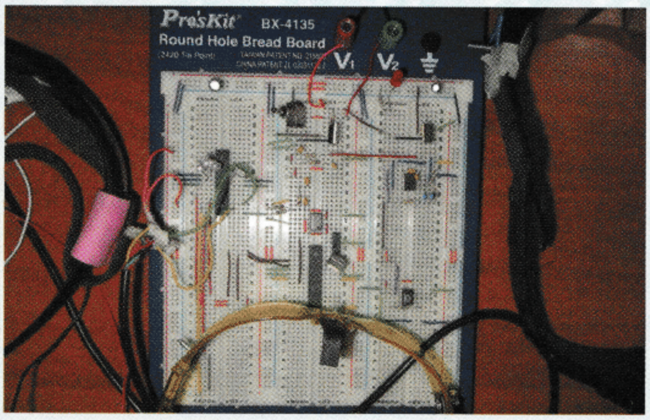


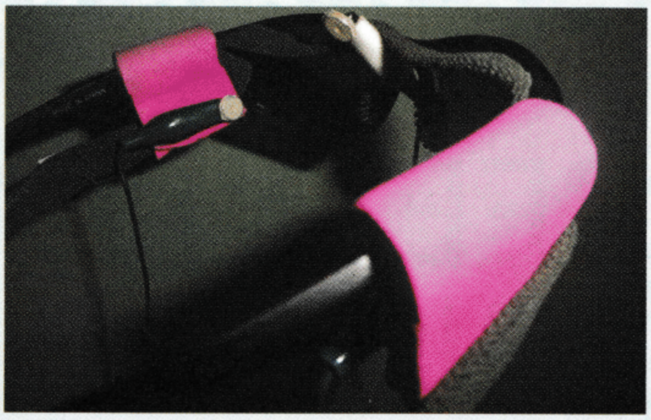
ONE OF MY HIGH SCHOOL CLASSMATES is quadriplegic, and from meeting him and hearing about others with similar conditions, I learned that many people with disabilities can't afford technologies that could enable them to communicate — especially in places like Honduras, where I live. The systems are way too expensive.

This motivated me to build an inexpensive yet reliable human-computer interface that detects eye movements using electrooculography (EOG), a biomedical technique based on picking up signals from electrodes placed around the eyes. EOG interfaces let users who can't manipulate a mouse or trackpad with their hands move a cursor on a computer screen. I knew that a cheap EOG system could be beneficial to many people.

DESIGN

The eyeball generates a voltage of 0.4mV–1.0mV (millivolts) between its cornea in front and retina in back. If you attach electrodes on opposite sides of the eye, they'll pick up some of this voltage, depending on where the eyeball is pointing. Looking straight ahead, with the cornea and retina equidistant between the electrodes, there will be no voltage. But with the eyeball angled to one side, you can measure a microvolt-level signal between the electrodes nearer the cornea and the one opposite. EOG can track both horizontal and vertical movements, but horizontal is easier and more useful. My system, like many others, only tracks horizontal using 3 electrodes: one right next to each eye, and the ground electrode centered on the





bridge of the nose or forehead.

A processor chip or even an oscilloscope cannot detect such small voltages, so the EOG system must amplify them, while also filtering out any noise from nearby electrical devices and wiring. You can see the circuit I built to accomplish this, along with step-by-step instructions for building my EOG system and programming its microcontroller chip, at makeprojects.com/v/29.

To amplify the signal initially, I use an INA118 instrumentation amplifier chip configured with a 100Ω resistor between pins 1 and 8, which gives it a gain of 501. The INA118 chip's high CMRR (common-mode rejection ratio) of 110dB eliminates common signals that go into both inputs, which removes some noise at the start of the signal path.

Noise from electrode circuits tends to come at high frequencies, so mine uses 2 passive low-pass filters in sequence, to reduce this noise above their cutoff frequency of around 16Hz. With the circuit I used, the formula for the cutoff is $1/2\pi RC$, where R is resistance and C is capacitance, so with a 100kΩ resistor and a 0.1μF cap, this comes out to 15.9Hz, which is fine; eye movements aren't so fast that filtering cuts out anything important.

Finally, a capacitor zeroes the signal by removing the DC offset added by the resting potential between the eyes, and a voltage follower circuit lets you connect a higher source impedance device than the EOG output's impedance, which is useful to connect an oscilloscope or multimeter for troubleshooting. To power the system, I use two 7805 voltage regulators wired in a trick way to supply the circuit with +5V, −5V, and ground (0V), eliminating the need for a dual power supply.

To process the amplified signal when the eyes move horizontally, I feed it into the analog-digital converter pin of an AT-mega328P microcontroller that's programmed to send the data to a computer via serial port. A Python script on the computer then sends the data to a C++ applet I wrote, which lets the user spell out messages. Looking to the left scrolls down through letters, and looking to the right selects them. To make wearing the electrodes more comfortable, I mounted them to some glasses modded with a headband and super glue. I've built several prototypes of these EOG glasses with good results.

I'm still improving this EOG system, including looking for ways to make it more comfortable to wear. I'm pleased to have developed a system for less than $200 that enables disabled people, like my classmate, to communicate, when commercial versions of the same cost a minimum of $10,000. I'd also like to create inexpensive EOG-interface systems for other applications, such as controlling a wheelchair or a television. I just graduated from high school, and what I need most of all in order to pursue these ideas is a scholarship, sponsor, or other funding source so that I can study electrical engineering in the United States.

Luis Cruz is an 18-year-old developer in Honduras who wants to pursue electronics engineering and contribute to the advancement of technology. For videos, downloads, and more info about this and other projects, or to donate to his college education and research, visit intelsath.com.