# A STUDY OF APPLYING GAZE-TRACKING CONTROL TO MOTORIZED ASSISTIVE DEVICES

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**ABSTRACT**

One of the most difficult barriers to alleviating the effects of degenerative diseases is the severe retrogression they cause not only in communication, but also in the ability to manipulate devices designed to restore agency.

This project aims to reproduce the muscle control that people with ALS (PALS) have lost, using a low-cost gaze tracker as the input device for a motorized headrest. Eye movement is often the last remaining method of control in a number of progressive neurodegenerative diseases, and harnessing it as an input device allows a broad range of applications that can benefit users of this technology.

The tracker and associated electronics are connected to a motorized headrest, the first of its kind, developed on campus at the University of British Columbia (UBC). This system uses the Mirametrix S1 eye-gaze tracking device to take a user's commands and translate them into head movement, which allows for communication through predefined nods or shakes, the ability to self-direct an otherwise immobile individual's head position, and comfortable selection of a resting head position.

The development of our novel user interface demonstrates the utility of eye-gaze tracking as a functional and promising method to restore control to immobilized persons.

## 1.0 INTRODUCTION

1.1 Introduction to eye-gaze tracking technology

Eye-gaze tracking as a human-computer interface technology offers a high bandwidth of data on the user's interest: a person's gaze is strongly linked to where their attention lies. The advantage to this system is that it is accessible to people who may not otherwise be able to physically interact with machines. Assistive devices should be designed to accommodate a varied range of disabilities, and thus the best eye-gaze tracking technology for control must be the simplest and most adaptable. For this reason, a non-intrusive, free head motion, single-camera technology with no moving parts is ideal for pairing with assistive devices.

In this project the Mirametrix S1 gaze tracker (see Figure 1: Mirametrix S1) was used as a robust and low-cost eye-gaze interface. Its compact design allows for flexibility in its mounting.

The eye-gaze tracker utilizes the reflection of infrared light off of the user's pupils to compute the intended point-of-gaze on the screen. Two infrared light sources are located on opposite sides of a centrally positioned camera, which takes 60 pictures per second to determine the direction of the user's gaze (Hennessey, Noureddin and Lawrence).

Figure 1: Mirametrix S1

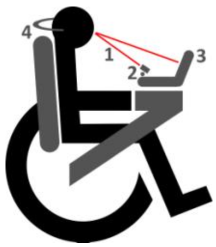
1.2 Motorized headrest

A motorized headrest is controlled by the eye-gaze tracker via a USB connection. The headrest is based on the AXIS Neck Brace, which was also developed at UBC. The headrest is designed for two degrees of freedom: vertical and horizontal. Two DC motors control the vertical and horizontal orientation.

The user's gaze is translated into controls by a Java application, which runs on a laptop and relays signal commands to the headrest's microcontroller. The microcontroller determines the desired function and engages the DC motors accordingly. The Java application offers buttons for simple yes (nod) and no (shake) movements in addition to directional arrows for the user.

The motorized headrest is powered by a 12V DC power source, which is in turn connected to a commercial off-the-shelf power inverter. The inverter provides 110V AC power for the laptop and eye-gaze tracker. Using a COTS inverter allows the system to accommodate wheelchair voltages of 12, 24 and 36V.

This is ultimately the most user-friendly way to install and use the system (see Figure 2: Eye-gaze-controlled motorized headrest).




1) infrared light is emitted from 2) the gaze tracker, which determines the control on 3) a custom software interface the user is visually selecting. This controls the positioning of 4) the motorized headrest.

Figure 2: Eye-gaze-controlled motorized headrest

## 2.0 PRACTICALITIES OF INSTALLATION

### 2.1 Limitations of eye-gaze tracking

Eye-gaze tracking has a number of limitations including low accuracy (approximately 40 pixels on a standard computer screen) and difficulty tracking the eyes in certain lighting (Stiefelhagen, Yang and Waibel). Care must be taken to compensate for these limitations in the overall design of the system.

One major limitation of free head motion eye-gaze systems is that the camera should ideally be 65 cm from the user's eyes and used within the allowable range of head motion (field of view) of the camera. As well, the system should be used in environments with a minimum of ambient infrared light, and may not work well with users who wear glasses. These concessions are understandable given the freedom the device affords, and recommended techniques for accommodating these limitations are discussed in the next section.

### 2.2 Hardware Accommodation for Disabilities

The simplicity of a control method that requires only direct eye contact is an incredible advantage to those with disabilities, but the technology is such that mounting the necessary equipment becomes a salient practical concern.

To allow for freedom of head motion within the limits of the tracker's field of view, the tracker is mounted above the track pad of the user's laptop, resting on a centred stationary mount that is installed on the wheelchair. Ensuring that the tracker has a consistent view of the user's head in motion requires a mount that either can move or is positioned well enough to accommodate a wide range of motion. The camera mounting options are between:

- Movable camera
- Movable mount
- Stationary mount with a wide-view angle

Of these options, the simplest solution for retroactive installation in wheelchair models is stationary mounting, as moving cameras require calibration, and a moving mount introduces a level of mechanical complexity that the task does not warrant.

## 3.0 USER INTERFACE DESIGN

### 3.1 Development of the user interface

With the expected rise in quality and ubiquity of built-in cameras, an appropriate user interface design may well be more important than the physical tracking technology itself (Betke, Gips and Fleming). In compliance with the ISO standard definition of usability: "the extent to which a product can be used by specified users to achieve specified goals … in a specified context of use" (ISO), the requirements for the user interface were that it could be operated entirely by gaze control to achieve directional commands, and in the context of motorized assistive devices.

These guidelines and the desire to use freely available Dwell-click software (detailed in section 3.2) defined the user interface. Reports have suggested (Ohno, Features of Eye Gaze Interface for Selection Tasks) that selection by a combination of Dwell and eye-gaze tracking does not necessarily require a long dwell time to be accurate, but can be accelerated by clearly delineating active areas. The unornamented design that was decided upon (see Figure 3**:** User interface), features large and simple buttons that provide the necessary delineation. Ample buffer zones also ensure there is a place for the mouse to rest, avoiding the "Midas touch" phenomenon (Gee and Cipolla), where a dwell-based gaze interface frustratingly selects nearly every on-screen item that the eye casually passes over. The application's window is sized to fit a 15" screen, which is the ideal size for the S1.

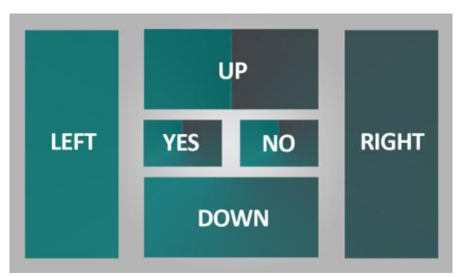



Figure 3: User interface

### 3.2 Actuating commands

Converting gaze position on screen to a head movement requires two steps: 1) recognizing a form of "click" and 2) converting this data into mechanical movement.

As myriad clicking methods have been developed with disabilities in mind, spanning puff/sip switches, the predictable blink or wink methods, and haptic switches, there are many options for the best method for "clicking".

A dwell-type clicking method counters false positives from involuntary blinking, and matches the design requirement of gaze being the sole faculty required of the user. This method operates under the principle that hovering over one specific region for a predetermined duration constitutes a "click."

For controlling mechanical movement, the Arduino Nano is an ideal microprocessing platform, in part because of its simple and flexible programming language, and also because it easy communicates over a USB connection.

The specifics of the interfacing between the eye-gaze tracker and the microprocessor are shown in Figure 4, below.

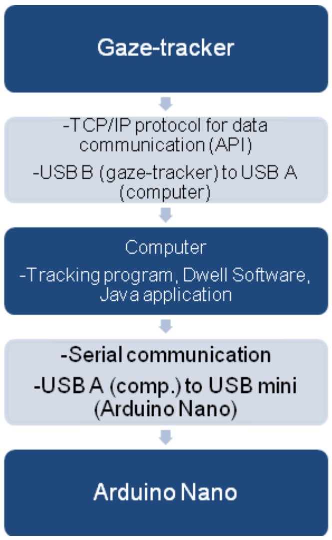



Figure 4: Interface between Gaze Tracker and Microprocessor

## 4.0 INCORPORATING EYE-GAZE CONTROL IN CUSTOMIZED APPLICATIONS

The pairing of an eye-gaze input to a motorized system can be applied to many customized applications, providing an affordable solution to individual needs.

In particular, the combination of the Mirametrix S1 gaze tracker, a Java application, Dwell software, and the Arduino microprocessor shows promise as a reliable and flexible means of providing control to nearly any motorized device.

## 5.0 CONCLUSION

Equipping assistive devices with eye-gaze control is a simple combination with tremendous potential. The result is a device that can accommodate a wide range of disabilities as it does not assume any more capability than that of gaze control. In summary, our research has shown that designing a user interface that accommodates the unique difficulties of eye-gaze tracking simply requires attention to buffer zones and clearly delineated on-screen buttons. Additionally, controlling motorized equipment can be managed competently by off-the shelf microcontrollers.

This project has demonstrated that, for either the customized solution or a manufactured product, the technology necessary to integrate eye-gaze tracking into an assistive device is both affordable and realizable.

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