**TITLE:** eyeCU

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**OBJECTIVES**

The purpose of this study is to design an eye tracking system for a human-computer interface. In order to track the eye we will use an infrared camera. As an integral part of our eye tracking algorithm, we have enlisted the use of a near-Infrared LED to illuminate the eye. The result of using such a lighting method is to improve the spectral difference between the pupil against the iris, in the research field, this approach is called: bright pupil. Specific aims include 1) Safely illuminate the eye 2) Capture images of the eye 3)Perform signal processing on the image to determine pupil location 4)Analyze the difference between the current pupil location with respect to the previous location 5) Use the results of this analysis to control the cursor on a computer.

We wish to complete the design and implementation of the eye tracking system in time for the Electrical, Computer, and Energy Engineering Senior Design Capstone Expo by May 3rd, 2012.

**BACKGROUND**

Many individuals with paralysis have difficulty with daily tasks, especially individuals with full body paralysis. For those who still maintain the ability to use their eyes unhindered, there is the possibility of using eye tracking as a means of interaction with the world. Eye tracking is the process of tracing the movement of the eyes in order to control a computer cursor.

Currently, there are two types of eye tracking techniques commonly practiced: Bright Pupil and Dark Pupil. Bright pupil tracking employs the use of infrared (IR) illumination of the eye to create greater contrast between the pupil and the iris. In this configuration, the eye tracking robustness and accuracy is significantly improved; however, this technique is not effective in outdoor lighting due to interference from Ultraviolet light. The Dark Pupil technique does not require IR lighting; however, the algorithms for tracking pupils in this configuration are much more complex.

ANSI Z136.1 in the USA and IEC 6085.1 internationally, define classes of lasers depending on their output power and wavelength concerning the prevention of risk and injury. The maximum permissible exposure, MPE, is the highest energy density in , this measure is used to determine whether the light source has a negligible probability for creating damage to the physical structures of the eye. According to the International Commission on Non-Ionizing Radiation Protection, ICNIRP, the recommended daily maximum exposure is total irradiance for wavelengths 770-3000 nm for day-long continuous exposuresFor infrared LEDs, the potential hazards are thermal injury to the retina of the eye and thermal hazards to the lens of the eye.Due to the radiance limitation of LEDs, they cannot produce exposure level at the retina that even approach the levels that are known to cause retinal thermal injury

In terms of advancement of the overall knowledge in the field of eye tracking, this project will provide a significant learning opportunity for students.

**STUDY DESIGN**

The system design employs a pair of glasses with an infrared sensitive video camera to capture position as well as motion of the user’s gaze. To increase the spectral contrast between the salient features of the eye, a near-infrared light array will illuminate the eye. The device processes the images collected by the camera in real-time to generate the corresponding cursor movement which is transmitted to the computer.

The eyeCU offers two modes of operation. Mode one consists of using ‘eye gestures’ to control the cursor movement on a computer. In this configuration, when the eye looks left for example, the cursor will move to the left and stop when the eye moves back to the center. Mode two provides an intuitive set of commands in which the cursor follows the position of the user’s gaze on the computer display.

To meet the goals of the project, at least 3 subjects are necessary. An additional 2 subjects above the required are planned to be enrolled for a total of 5 subjects. The additional 2 subjects are to account for possible withdrawal or inability to gather data from a subject in the given timeframe.

Testing will be conducted in order to achieve proof of concept of the eye tracking system. The study will be conducted until May 3rd, 2012.

**ABOUT THE SUBJECTS**

The subjects/participants will be members of the research team their age range is 19 to 26 years of age. Data collected will be both male and female. The ethnic distribution of the subjects is Asian, Caucasion, and Middle Eastern. For this study, no third party/secondary subject population will be required.

**VULNERABLE POPULATIONS**

We will not be conducting research on vulnerable populations; however, our primary focus group will target the developers, who are the researchers themselves. Therefore, there will be no unduly influence nor coerced for participation.

**RECRUITMENT METHODS**

There is no recruitment involved in this project since we are only testing on ourselves.

**CONSENT PROCESS**

The researchers are all willing, though not required, to test the eye tracking system. Additionally, consent is nonbinding and may be withdrawn for any reason, and at any time, with no consequence to the researcher.

**PROCESS TO DOCUMENT CONSENT IN WRITING**

Interested participants will be directed to the PI to read the complete consent form. Consent will be obtained by signing the consent form. The consent form will be kept solely by the PI in a locked cabinet for the duration of the study.

**PROCEDURES**

Participants will wear the eye tracking system and participate in a 30 second calibration process, this enables the eye tracking system to gain information about physiological properties of the participant’s eye. During this process, the eye will be illuminated by an 830nm IR LED and his/her eye will be recorded by a video camera. The length of each of these sessions will last no more than 10 minutes in duration. Furthermore, successive testing must be separated by one hour for each participant. The data collected from each test will be recorded on Secure Digital memory (SD) which will then be archived on a password protected virtual private network (VPN). Additionally, each visit will be on an ‘as needed’ basis. Besides the recording of participant’s eye movements when wearing the eye tracking system, no additional video or audio recording will be conducted.

The datasheet for the video camera can be found attached to this document. The IR LED is VSMG2700, the datasheet for this component can also be found attached to this document.

**SPECIMEN MANAGEMENT**

No specimens are applicable.

**DATA MANAGEMENT**

Data will be stored on a password protected network account and periodically, the data will be backed-up on a password protected secure virtual network. Hard copy storage will be done by the PI as is customary with all Capstone projects.

**WITHDRAWAL OF PARTICIPANTS**

If at any time, any of the participants fail to abide by the terms defined for safe testing, then they will be withdrawn from testing. If the participant is withdrawn due to failure to abide by the terms defined for safe testing, then the data previously collected by the former participant will be destroyed. If participants are withdrawn, they will not be replaced.

**RISKS TO PARTICIPANTS**

Due to our adherence to the guidelines presented by the International Commission on Non-Ionizing Radiation Protection there should not be any risks to participants

**POTENTIAL BENEFITS TO PARTICIPANTS**

There are no overstated benefits to participants; however, participation may help us in the development of the project.

**PROVISIONS TO MONITOR THE DATA FOR THE SAFETY OF PARTICIPANTS**

As the project progresses, data will be collected in the lab. The researchers will monitor the supplied power to the near-Infrared LED as well as the current draw of the LED using multimeters. According to safety standards, all testing will be limited in time to only ten-minute intervals with at least an hour between successive testing. To time these sessions, a digital timer will be supplied and researchers will be responsible for monitoring their exposure times.

**PROVISIONS TO PROTECT THE PRIVACY INTERESTS OF PARTICIPANTS**

All testing and research will be conducted at the Capstone lab in the Department Electrical, Computer, and Energy Engineering on the CU Boulder campus. As the participants will already be attending the lab on a regular basis, no negative privacy interest impact is associated in terms of physical location. Instead of using the names of participants on recorded data, a number designator will be assigned to participants in order to protect participants and provide some anonymity.

**MEDICAL CARE AND COMPENSATION FOR INJURY**

Risk of injury is minimal; therefore, no medical care or compensation provisions are in place.

**COST TO PARTICIPANTS**

There is no cost to the testers for their participation in this project.

**DRUG ADMINISTRATION**

The project does not involve drug administration.

**INVESTIGATIONAL DEVICES**

No investigational devices will be used.

**MULTI-SITE STUDIES**

Testing will only be conducted in one location, the Capstone lab in the Department Electrical, Computer, and Energy Engineering on the CU Boulder campus.

**SHARING OF RESULTS WITH PARTICIPANTS**

Participants will be evaluating the collected data immediately. Each participant will have full access to all data collected.

**REFERENCES**

**[1]** International Commission on Non-Ionizing Radiation Protection (ICNIRP), “Guidelines on Limits of Exposure to Broad-Band Incoherent Optical Radiation (0.38 to 3*μ*m),” *Health Physics* 73(3), 539–554 (1997).

**[2]** International Commission on Non-Ionizing Radiation Protection (ICNIRP), “Light-Emitting Diodes (LEDS) and Laser Diodes: Implications for Hazard Assessment,” *Health Physics* 77(2), 744–752 (2000).

**[3]** Sliney, D. H. (2007). Radiometric quantities and units used in photobiology and photochemistry: recommendations of the Commission Internationale de l'Eclairage and Photobiology, 83, 8.

**[4]** Sliney, D. H. M. W. (Ed.). (1980). Safety with lasers and other optical sources: a comprehensive handbook(1 ed.). New York: Plenum Press.

**[5]** Mulvey, F., Villanueva, A., Sliney, D., Lange, R., Cotmore, S., Donegan, M. (2008) D5.4 Exploration of safety issues in Eyetracking Communication by Gaze Interaction (COGAIN), IST-2003-511598: Deliverable 5.4. Available at <http://www.cogain.org/results/reports/COGAIN-D5.4.pdf>