EXECUTIVE SUMMARY

Discovered in 1869, Amyotrophic Lateral Sclerosis (ALS), commonly known as Lou Gehrig's disease, has affected the lifestyles of not only those suffering from the disease, but also those around them. Although a relatively rare disease, with approximately 2 in 100,000 cases diagnosed each year, ALS is nonetheless a devastating disease due to its impact on patients and society [1]. During this time, patients begin to suffer from various symptoms such as twitching, tripping and falling, or dropping things: symptoms vary from victim to victim and increase with time. Over the course of this disease, the patient slowly loses all motor control, eventually passing away due to their inability to breathe and swallow. ALS is not only hard on patients; this disease imposes immense strain upon the families as the patient loses all means of communication. Fortunately, the movement of the eyes is retained for those suffering from the disease.

The EyeWriter uses a set of infrared light-emitting diodes (IR LEDs) to illuminate the pupil. This light is then reflected in the intraocular cavity and interpreted by a filtered camera that interacts with a computer interface. The software then translates this eye movement into corresponding mouse movements on a computer screen. The device allows ALS patients and spinal cord injury victims to communicate, write, and draw. The original version, which resembled a set of glasses in its hardware design, was created for graffiti artist Tony Quan (a.k.a. Tempt1), who lost his ability to draw due to ALS. This design - which did not allow for slight head movement and was difficult to keep calibrated - inspired the creation of Version 2.0, which is placed on or below a computer monitor and partially solves these problems; however, there are still issues. The project is currently an open source, do-it-yourself assembly which is not ready for mass production. The hardware is fragile, poorly contained, and has been known to malfunction when the device is moved even slightly. In addition, there is a noticeable lag time between the movement of the eye and what is displayed on the monitor, mostly caused by the Vertical Synchronization (VSync), which interacts between the system and the computer display. In order to address these issues, our sponsors, Daniel Reiss and Dr. Lisa DiPonio from the University of Michigan Department of Physical Medicine & Rehabilitation, have enlisted our ME450 group to redesign the current device so that it may be distributable to a wide range of patients inside and outside of the hospital. This device is intended to be robust, easy to use, and affordable.

Initially, Daniel Reiss provided us with a prototype which we used to test the functionality of the EyeWriter 2.0, and understand its shortcomings. We then brainstormed individually before collaborating to select the components which we used to make up our final design. The concept was chosen to be screen mounted, using extendable arms to position the LED arrays for 13-19" laptops. Ball joints are used in order to alter the orientation of LEDs with respect to the patient. A full description of this concept can be seen in the Prototype Description section of our final report. We decided that the prototype should be 3D printed to make the device durable, while closely matching the final product if it were injection or plastic molded. Using our prototype, we conducted tests to optimize the brightness and quantity of LEDs in the arrays and to verify that the device met our durability specification by conducting a drop test to simulate the device falling from a 3.5' hospital table. These tests were also used to show the validity of our structural and heat analysis through experimental data. In our final design, we updated the mounting mechanism to work on a broader range of laptops, and decreased complexity to allow the design to be plastic molded. By plastic molding the device, the final on-shelf cost including the cost of all of the electronic components, creating a mold, and manufacturing 500 EyeWriters would be roughly $176 per device, which is below the desired price of $400 specified by our sponsors. In the future, the EyeWriter can be improved by printing circuit boards to decrease the device size and weight, redesigning the camera circuit board to remove the VSync to improve durability, and implementing the PS4 camera to improve the frame rate, allowing for more responsive and robust eye tracking. The team would like to thank Dr. Lisa DiPonio and Dan Reiss for their support and funding, and Dr. Dan Johnson for his guidance throughout the semester.