**Method of Work**

The dashboard eye-tracking device (DETD) is designed to be affordable and efficient to ensure it is easily integrated into any vehicle. The ability for the eye tracker to detect fatigue effectively is critical in the design of the device. The design of the device builds on traditional eye trackers but aims to make the device as accessible and affordable as possible. A process description shows the major steps in operation of the device in detail. Benefits and challenges presented in designing the product are also included in this section.

**Eye Tracker Design**

The *dashboard eye-tracking device (DETD)* is a small device that uses a built-in camera to analyze a driver’s eye movements and determine whether a vehicle driver is falling asleep. The device functions by outputting infrared light that is reflected on the driver’s eye allowing the device’s camera to take high shutter speed pictures. An algorithm then processes the images, determines whether the driver is showing signs of drowsiness, and alerts the driver with a loud noise if necessary.

The physical design of the DETD is simple and allows easy replacement of parts. The casing for the device is 50 mm wide by 60 mm long. The device’s built-in camera measures 40 mm wide and 50 mm tall, taking up most of the device’s area. A 4 by 2 mm infrared emitter sits atop the camera, and a speaker with a diameter of 20 mm and a depth of 3 mm sits in front of the camera, below the lens. A 25 mm by 64 mm Arduino board, which interfaces with all other parts of the device, sits behind the camera. See Figure 1 for the general layout of the device.

The device requires minimal interaction from the user so there will be minimal ways for the user to interface with the device. The device will have a power button that a user may click in case of malfunction. The power button will be linked to the Arduino board and allow complete restart of the device. USB will be the default power source for the DETD as most cars have a USB port. Other power options will be available, such as a converter from USB to car lighter port.

\*\* device layout figure here

**Step 1: Infrared Light is Emitted.** During this step, the camera sends out infrared light from the built-in infrared emitter. The chosen infrared emitter (*Everlight IR204*) allows for an exact light wavelength to be chosen. Infrared light is used because it is invisible to the human eye and thus will not be noticed by the user.

The infrared light is sent out from the device then reflected by the user’s eyes. This allows the device’s camera to take pictures in any conditions. The device will work equivalently at nighttime and in direct sunlight. The infrared light reflected on the driver’s eyes is captured by the device and allows accurate snapshots that are processed in the next step.

**Step 2: The built-in camera takes high-definition pictures.** Every 1-2 milliseconds a high-definition image is captured by the device’s camera. The camera uses the light reflected from the driver’s eyes to capture a precise image of both the user’s eyes. The image is taken of the driver’s left and right eyes together as gaze detection requires analyzing the patterns of both eyes to detect meaningful patterns. The images taken at this stage are continuously given as input to the Arduino and processed.

**Step 3: Algorithms process the images.** The eye tracking software will be contained in the Arduino board and take care of efficient processing of the images being continually input into the Arduino. The algorithm programmatically takes an image frame, locates the face region, locates the driver’s corneas, and saves the cornea locations to an eye template for comparison to the surrounding frames. If at any point the algorithm fails to locate what is required for a certain stage, it will simply go to the next image frame. This algorithmic process is detailed in the flow chart below, Figure 2.

\*\* Flow chart of algorithm decisions here

All of the image processing will be done by the processor of the Arduino board. The Arduino board has a 32-bit CPU running at 64 MHz. This processing power offers more than what is needed to connect to a camera, process images, and finally release an audio to alert a driver who is showing signs of drowsiness.

**Step 4: Eye pattern detection and potential alert to driver.** In this step, the system makes a decision on the patterns found in step 3. Drowsiness is detected if any if the following patterns occur:

* Consecutive frames where the cornea is not detected, and closed eyelids are detected
* Consecutive frames where gaze is nonmoving and directed away from the road
* Eyelids fluttering

If any of the above scenarios occur, the device will release several loud bell noises to alert the driver that they are showing signs of drowsiness. If the device alerts the driver of drowsiness three or more times within 10 minutes, the device will release a verbal message, “It is unsafe for you to be driving. Please, pull over.”

While the driver is being alerted, the device continues to gather image data as described in step 3. If none of the drowsiness implying scenarios occur, the device continues the image processing described in Step 3.

**Benefits**

The main benefit of the DETD design is that it is affordable and can be easily integrated into any vehicle. This is of utmost importance as the goal of producing this product is to decrease casualties/injuries due to drowsy driving. An affordable product with easy installation and repair will allow most anyone who wants this product to get one. Also, the affordability may entice large vehicle companies to integrate the DETD into the vehicles they sell. The estimated cost of the necessary parts for the DETD is as follows:

* Casing: $0.22
* Arduino board: $18.89
* Camera: $20.99
* Small speaker: $1.63
* Infrared emitter: $1.99

The total price per unit is $43.72. This total does not take into account the lower prices that would be obtained when buying in bulk. Commercial assembly of the product will cost an additional small amount of money. Even so, the DETD is projected to be developed for under $50 per unit. Other dashboard cameras with similar functionality to the DETD range from $45.00-$150. The DETD is clearly on the lower end of this price range but still offers superior performance.

By default, the DETD will be USB powered as most vehicles have a USB outlet. Users are given the option to choose other power source options, such as a converter from USB to car lighter port, if necessary. This allows for customization and integration into every vehicle. The size of the DETD totals to about 60 mm by 60 mm which is small enough to sit on a vehicle dashboard without obstructing the driver’s view.

Overall, the chosen design of the DETD promises efficiency, affordability, and easy integration into the majority of vehicles. These factors make the DETD attractive to individuals and car manufacturers alike. The affordability and easy integration align with the team’s goals of making the product accessible so that its impact of decreasing car accidents is far reaching.

**Challenges**

The main challenge in producing the DETD is ensuring the accuracy of the fatigue detection. If the device accidentally alerts a driver when they are not drowsy, or does not catch all cases of drowsy driving, users will likely lose confidence in the device and possibly remove it from their vehicle, thus diminishing the purpose of the device.

Fine-tuning the fatigue detection algorithms will take a large amount of the project’s time and must be tested thoroughly to ensure the accuracy of the DETD. Tests performed in real vehicles will be required to verify the reliability and accuracy of the device. Testing to this extent will require time, funding, and energy that may be difficult to come by.