HUDware

Sanghoon Lee, David Meschisen, Jori Platt, Minwo Wang
Faculty Advisor: Prof. Paul Siqueira

Abstract

HUDware is a hands-free, augmented reality, heads-up-display (HUD), that connects a skier to their mobile device. It is an attachment for the skier's existing goggles that displays data and lets the user control the information shown through winking.

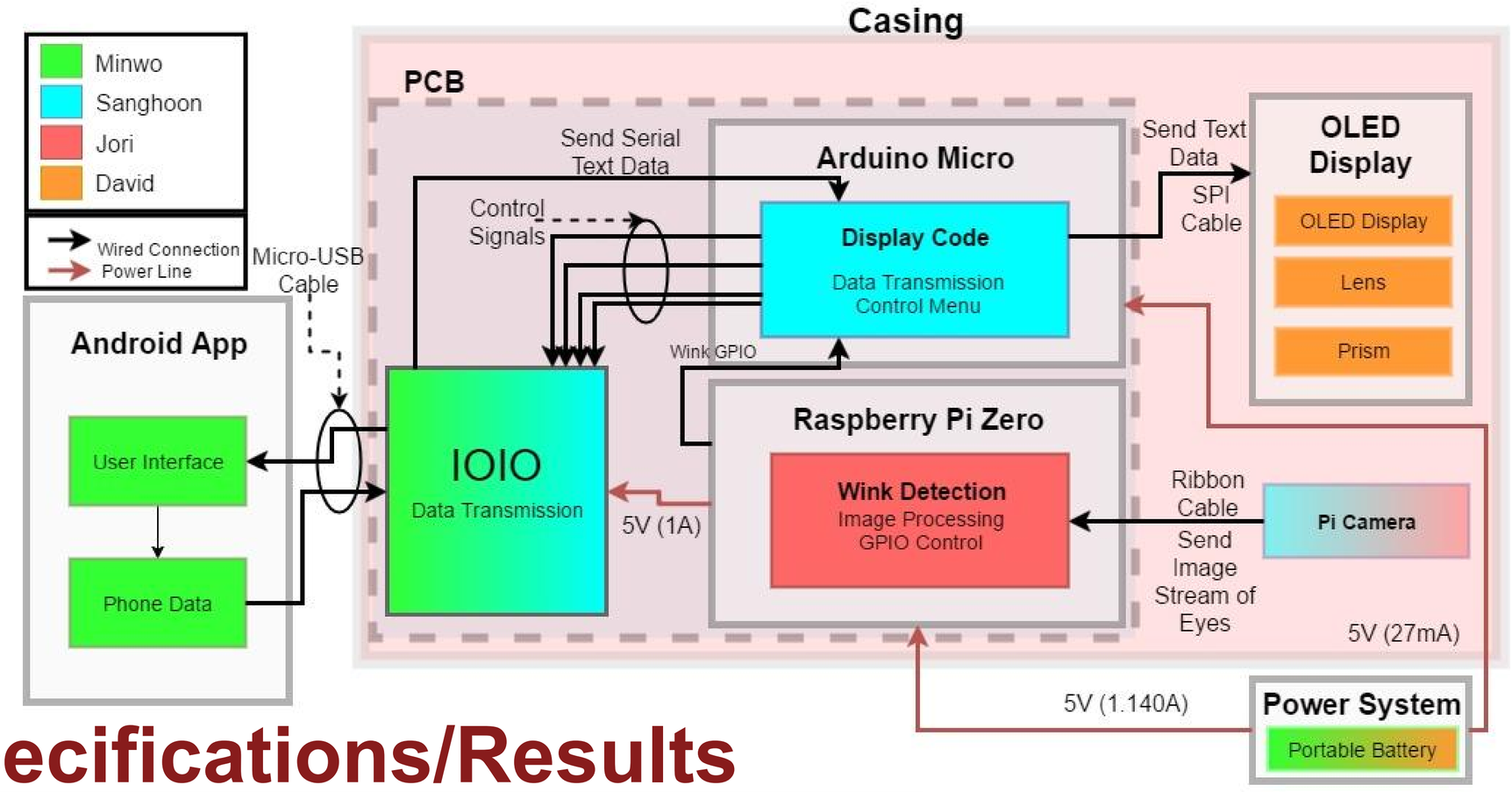
Group

System Overview

HUDware collects data such as GPS, text messages, and song information from the user's mobile device and displays it in their field of view unobstructedly. A video stream is taken by the Pi Camera, fed to the Raspberry Pi Zero which uses image processing techniques to determine which eye is closed. Once calculated, it sends respective GPIO control signals (left/right wink) to the Arduino. The Arduino requests and receives data from the phone application via an open source PIC microcontroller, IOIO, depending on the winks. The Arduino formats the data to display on the Organic Light Emitting Diode (OLED) display, which projects an image in the user's vision. The main components of the system are:

- Phone Application
- IOIO
- Microcontrollers (Arduino, Raspberry Pi Zero)
- Wink Detection
- OLED Display

Block Diagram



Specifications/Results

Specification	Result
Application Provides Rich Functionality	Reads messages, controls music, accesses GPS, speed, and accelerometer data
Battery Life - 4 hours	Calculated - 9.7 hours
Display Brightness - 90 nits	Measured - 91 nits
Display Legibility	User Tested - Met
IOIO - Communicates to all relevant subsystems	Data Transmission Bandwidth - 600 kB/s
Wink Detector Speed - 2 fps	Measured - 3.51 fps
Wink Detector Accuracy - 90%	Sampled Result - 85%
Lightweight Attachment	Casing Weight - 260 g
MCU Temperature - < 80°C	Measured (Average) - RPi (53°C), Micro (22°C)

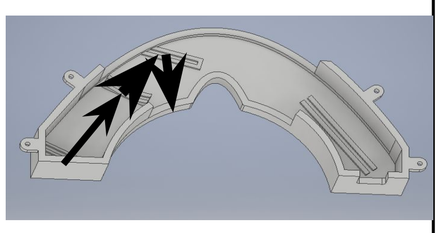
Project Website

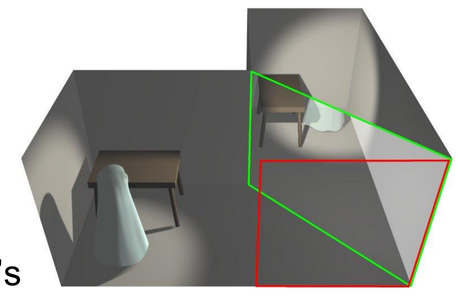
Acknowledgements

Professor Paul Siqueira - Advisor
Professor Douglas Looze - Evaluator
Professor Tilman Wolf - Evaluator
Francis Caron - Lab Director
Professor Kris Hollot - Course Director

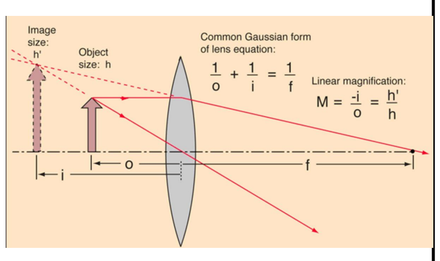
OLED Display

The display for HUDware is driven by an OLED display with a resolution of 128 x 128 Pixels. The control chip for this particular OLED is an SSD1351. The display is mounted on the left side of the goggle and projects an image which is mirrored through a 10cm focal length lens which is then reflected back into the user's eye.





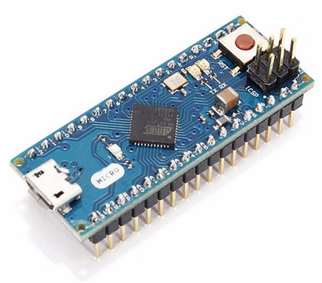
- Pepper's Ghost Effect
  - OLED acts as light source
  - Piece of Plexiglass as reflective film
  - OLED image is inserted into user's field of view without physically being there
- Virtual Image
- Human eye can only see 25cm and beyond
- 10cm Focal Length lens to create virtual image at ~ 40cm away



Microcontroller

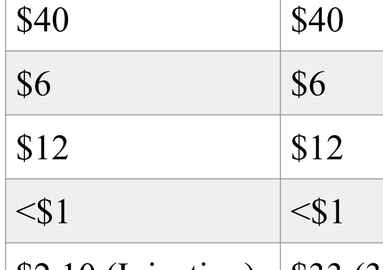
The information generated by the PiCamera or the Phone Application is handled and transmitted bi-directionally through the microcontrollers, the Raspberry Pi Zero and the Arduino Micro.

- Zero receives image from PiCamera → Wink Detection Algorithm → GPIO signals (left/right wink) are sent out to the Micro
- Micro receives GPIO signals from the Zero → notifies Phone Application through IOIO to request information pertaining to the user's selected option (GPS, Text Messages, etc.)
- Micro receives serial data information from Phone Application → Displays information on the OLED Display



IOIO

Android IOIO-OTG board is a development board that uses an open source PIC Microcontroller

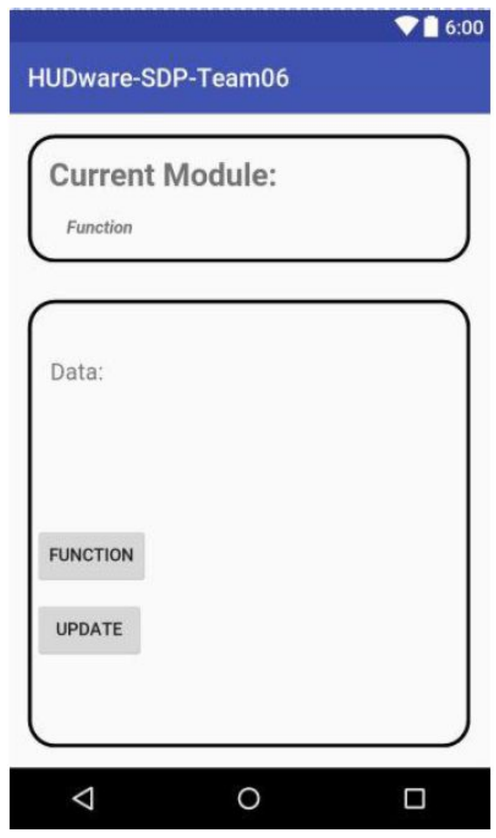


- 2 pairs of serial data communication
- 46 GPIO pins, Analog Input, SPI, and I2C interfaces with external hardwares
- Android Open Accessory (AOA) protocol over Android Debugging Bridge (ADB) Protocol, which means IOIO USB communication does not require the phone to be in Android debugging mode
- AOA protocol has twice the transmission bandwidth than ADB protocol

Cost

Price Per 1000	Price to Develop	Component
$0.34	$33	PCB
$5	$5	Raspberry Pi Zero
$20	$25	Arduino Micro
$30	$40	IOIO
$39	$39	Camera and Cable
$20	$20	Battery
$10	$10	Cables
$40	$40	OLED
$6	$6	Optical Lens
$12	$12	Fisheye Lens
<$1	<$1	LEXAN Plastic Prism
$2.10 (Injection)	$33 (3D Print)	Casing
$185	**$264**	**Total**

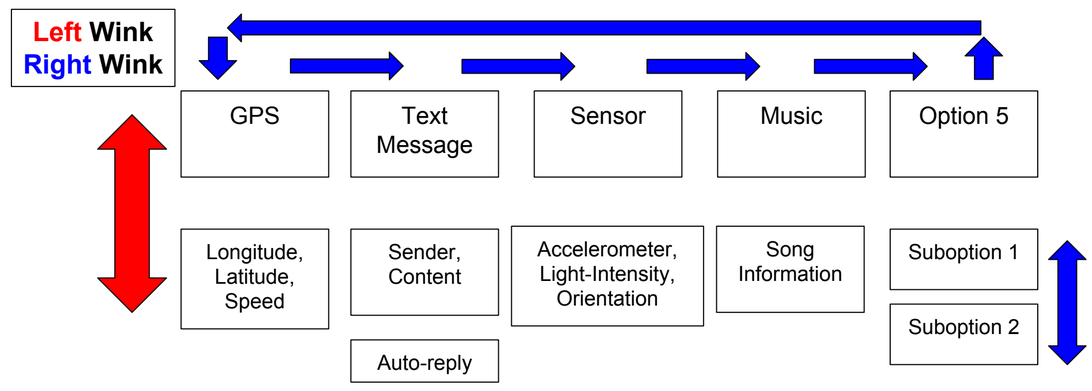
Phone Application



Phone application sends data to the OLED display and reacts upon Wink Detection signals. There are four main functions for the App: Message, GPS, Music, and Sensor Data. The function set's menu is shown in the following section. Here are brief descriptions for each function module:

- Message: provides access to users to view message content and sender information
- Music: allows users to start, stop, and skip songs
- GPS: sends longitude, latitude, and speed information
  - Speedometer is implemented through Haversine formula
- Sensor Data: shows user accelerometer, light intensity and other information

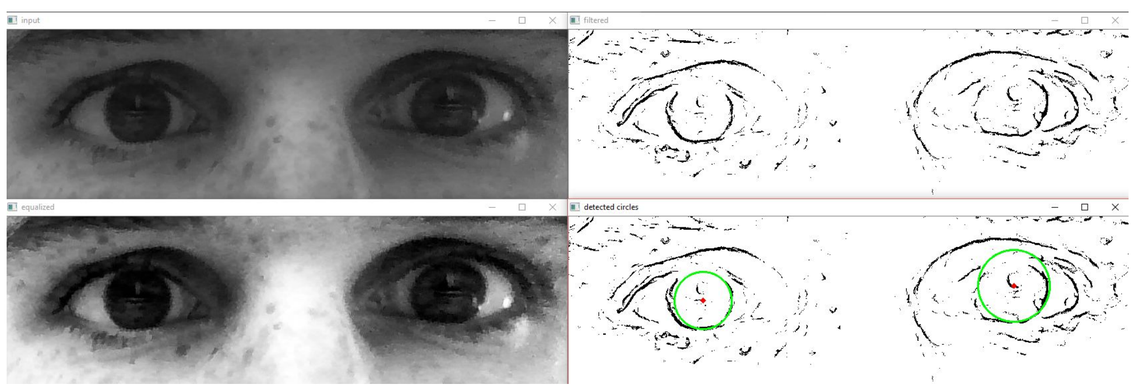
Control Menu



Wink Detector

The user controls HUDware by closing one eye or the other. The Wink Detector determines if only one eye is open and sends the corresponding GPIO signal. The system uses the following steps:

- Cropping and Gaussian Blurring
- Histogram Equalization
- Gaussian Thresholding Filter
- Hough Circle Transform - Detects circles in the iris or pupil



Casing