Signal Operated Lock And Security (SOLAS) system

Group 16

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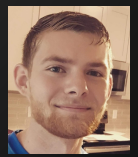
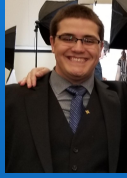
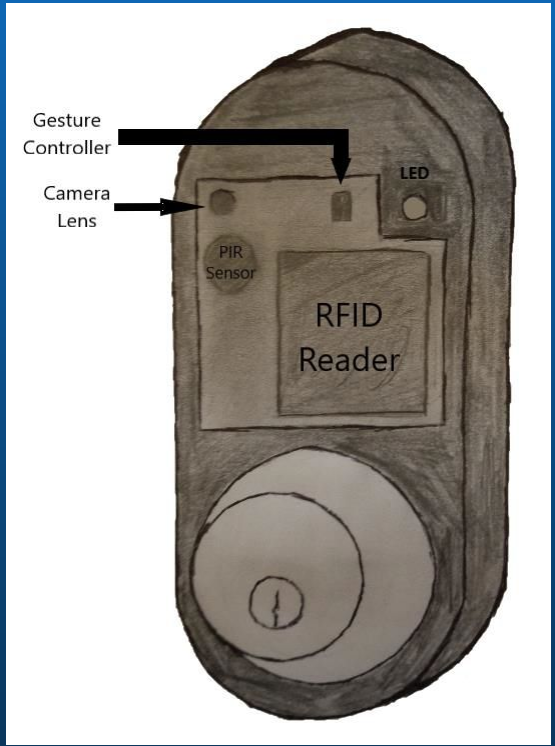




Introduction

- An electronic door lock system consisting of
  - RFID bracelet worn by the user
  - RFID reader in the door lock subsystem
  - Motion sensor to power on the system
  - Gesture controller-based password
  - Camera to document lock usage
  - A website the user can login to view activity at the door
- Motivation came from making grocery trips easier
- Inspiration from automatic proximity car door locks



Goals and Objectives

- The main goal for the SOLAS project is to make home entry easier for authorized users
  - The RFID subsystem eliminates the need to use physical keys, the gesture password is optional
- The system will also increase security
  - An RFID “key” as well as gesture password are used to gain entry
  - Camera documents all activity at the door, including highlighting when incorrect passwords are entered
  - Gesture password is more difficult to guess than number-based pins
- A web application that allows the user to monitor activity outside the door

Specifications

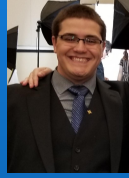
- Battery should last at least 1 year
- Infrared motion sensor should have a range of around 4 feet
- RFID subsystem should have a range of ~2 inches
- The lock should fit onto standard door designs
- Bracelet that comes in various sizes
- Camera to capture clear images of movement which the user can review and identify later
- Web application to modify lock settings and view photos taken by the camera
- After 10 seconds of inactivity in any powered on state, the system will return to a power saving mode

Constraints

- 3 Team members
- Cost: Budget funded by project members
- Time: Strict schedule to follow to complete SOLAS on time limits potential design choices
- Team meetings: Distance and other current conditions limit the amount of physical team meetings
- Size: The SOLAS system must fit in a reasonably sized enclosure
    - The system must be able to fit on a standard door

Standards

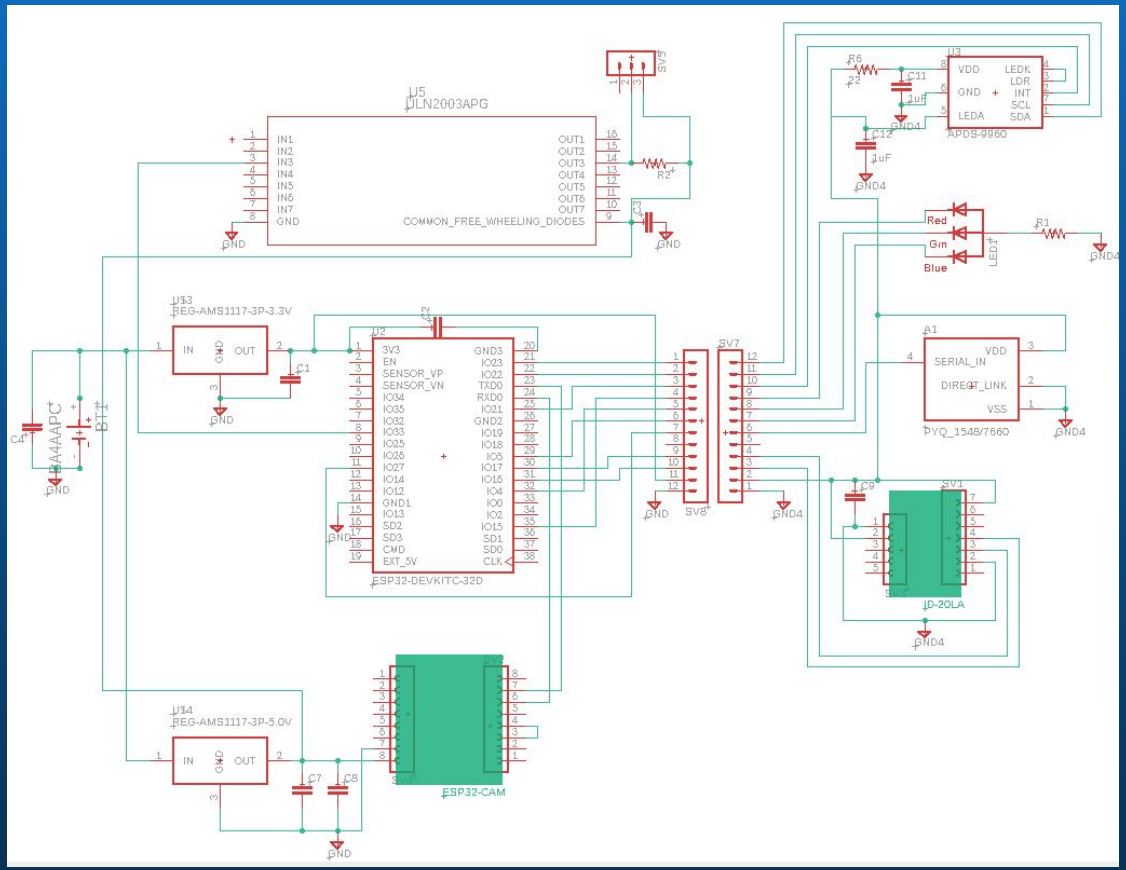
- RFID wave propagation distance/frequency
  - ISO/IEC 15693-2:2019
- Gesture controller “language”
  - ISO/IEC 30113-5:2019
- Camera resolution measurement
  - ISO 12233:2017

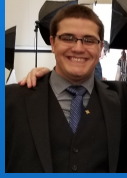


Hardware/components

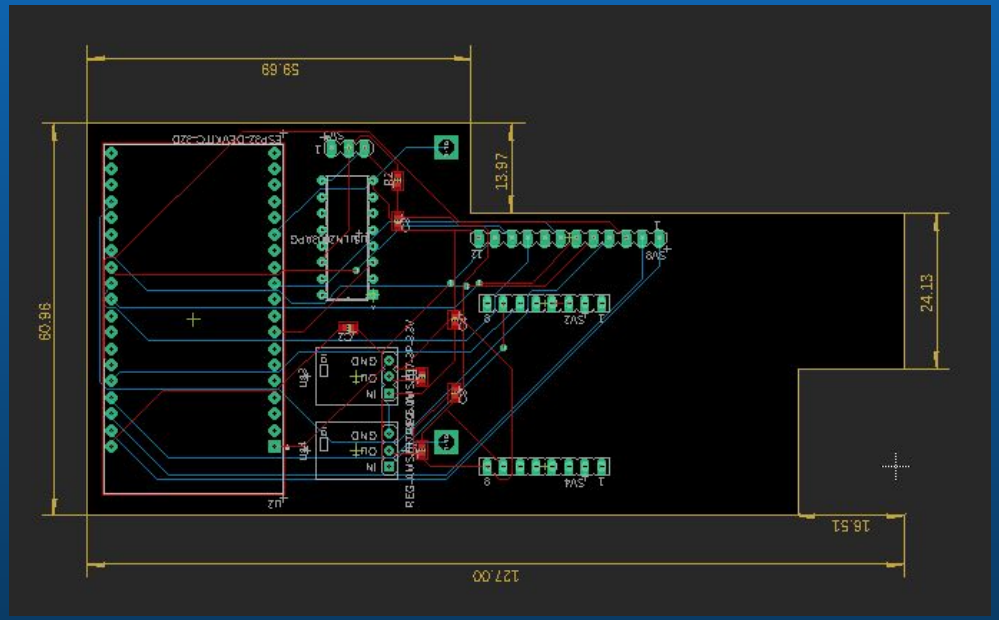
- Components that have been tested
  - ESP32 Microcontroller
  - ESP32-CAM Camera Module
  - ID-20LA RFID module
  - ULN2003 Motor Driver
  - RGB LED
  - BL412 PIR Motion Sensor
- Components that have not been tested yet
  - APDS-9960 Gesture Controller
  - 3.3V and 5V Regulators

Full schematic from eagle

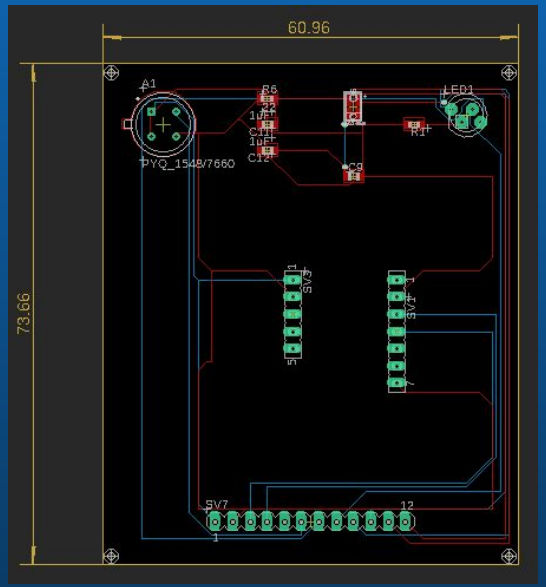




Current PCB Layouts



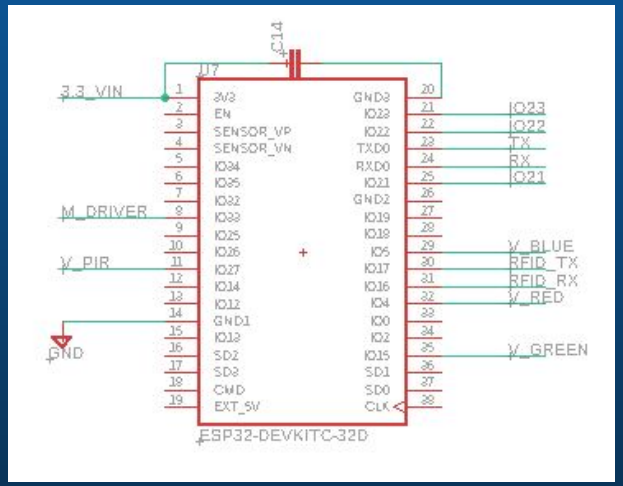
PCB for inside section

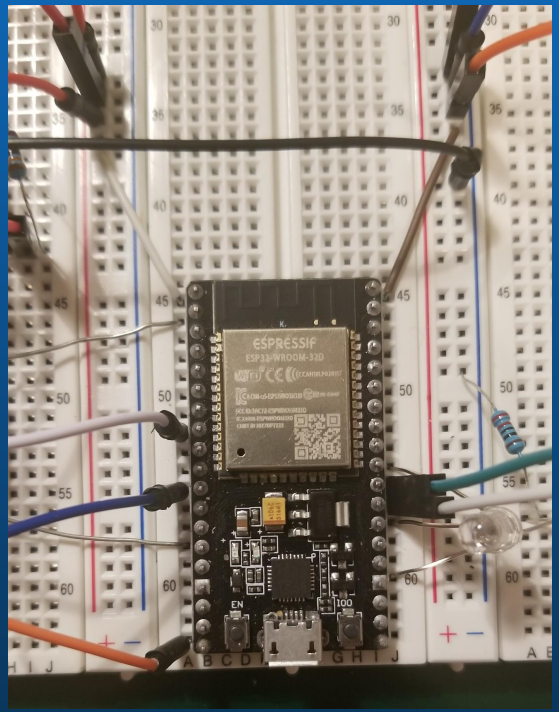


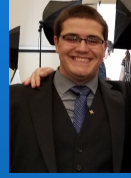
PCB for outside section

ESP-32S Development Board

- Uses ESP32-D0WD Chip
  - Integrated Wi-Fi and Bluetooth
  - Low Power and Low Cost
  - 34 GPIO pins
  - Various power/sleep modes
  - ROM: 448 KB, SRAM: 520 KB
  - 240MHz clock frequency

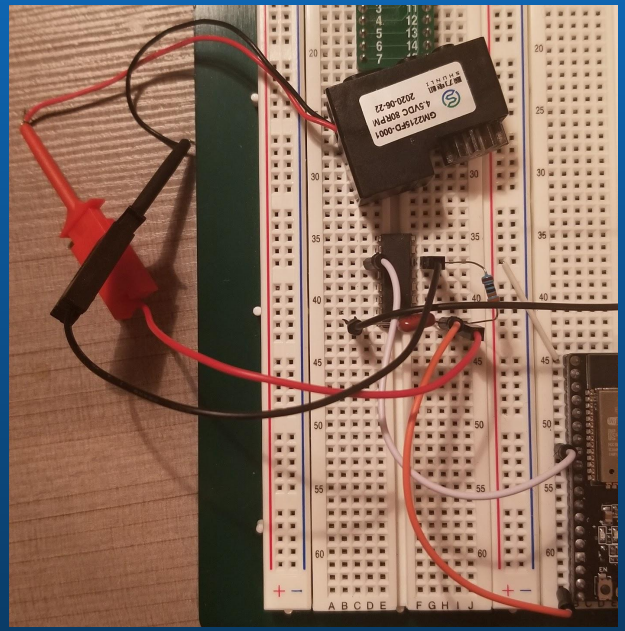






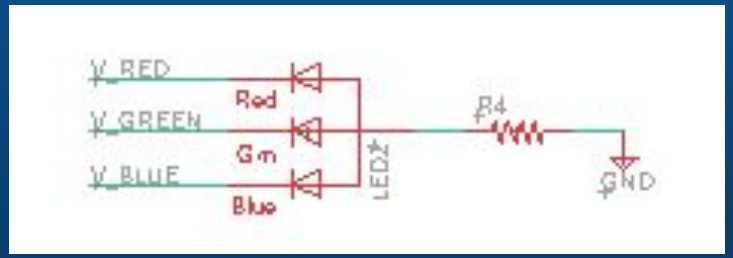
ULN2003 Motor Driver

- Used to operate Motor
  - Used to unlock SOLAS Deadbolt
  - GM2215FD-0001 DC Motor

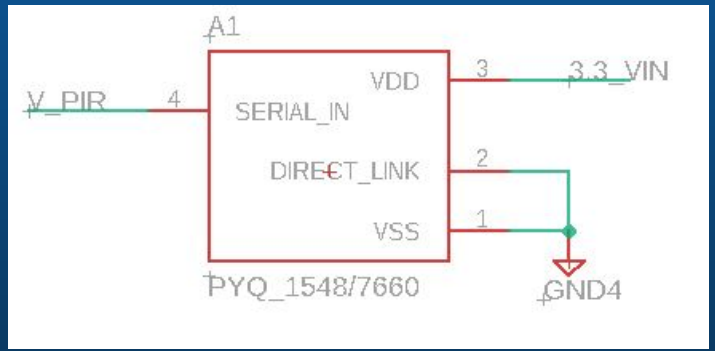


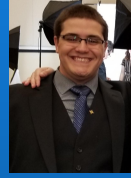
RGB LED & BL412 PIR Motion Sensor

- Used to indicate:
  - When system is on
  - If door is unlocked
  - If RFID tag rejected

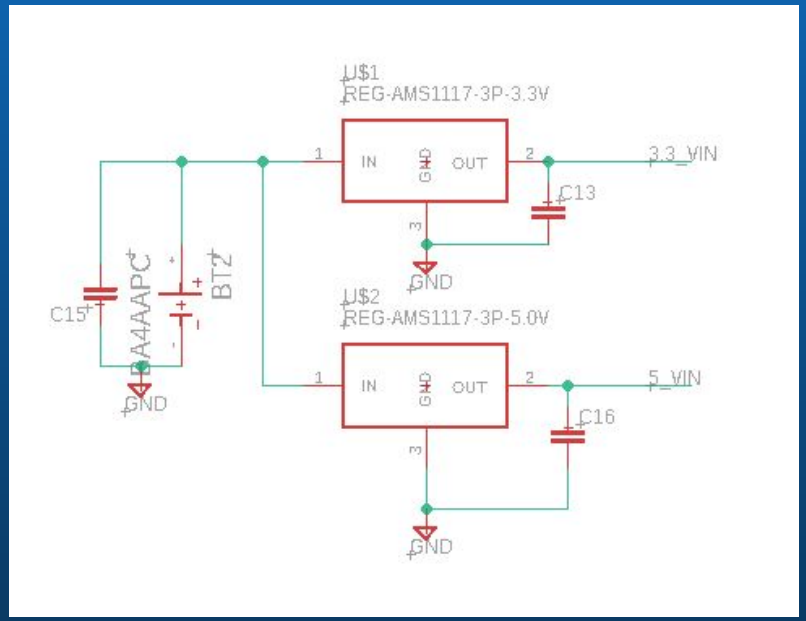


- Used to turn on system
- Long range (5-6 m)





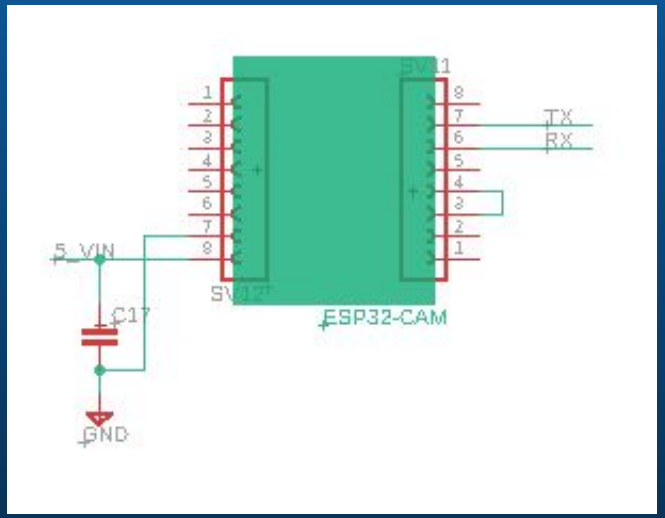
Voltage Regulators



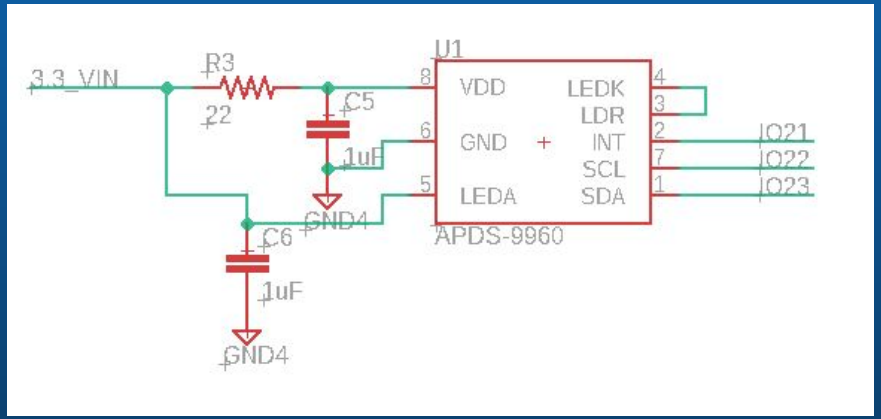
- 5-Volt regulator
  - ESP32-CAM
  - Motor Driver
- 3.3-Volt regulator
  - Microcontroller
  - RFID module
  - PIR sensor

ESP32-CAM Camera Module

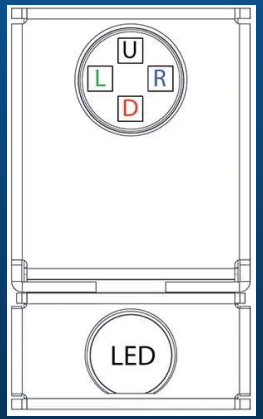
- Capture image when motion is detected
- OV2640 2MP Image Sensor
- 1600 x 1200 Resolution
- WiFi enabled
- SD card slot



APDS-9960 Gesture Controller

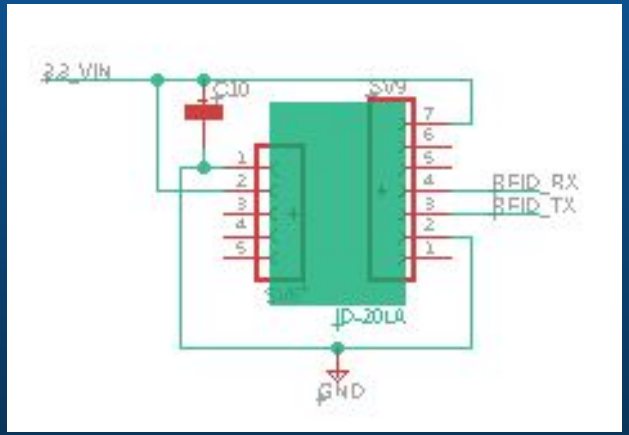


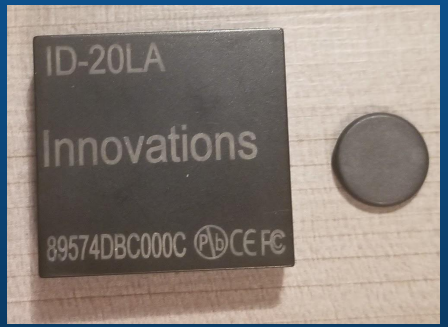
- Used as secondary password
- Four photodiodes used to detect reflected IR energy generated from an integrated IR LED to convert physical motion to digital information.

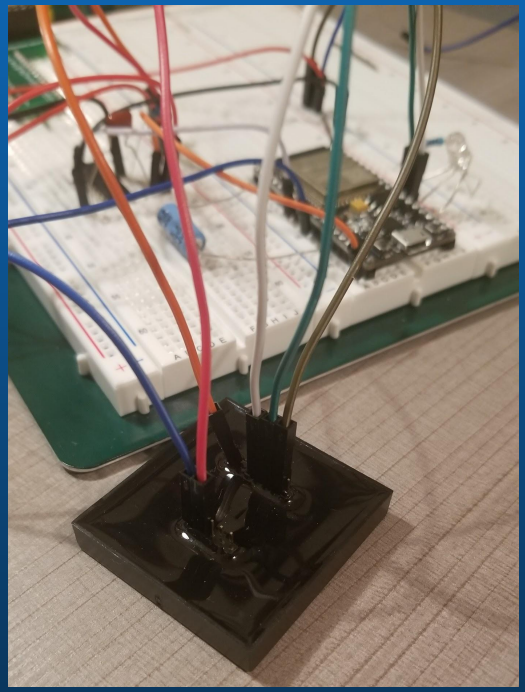


ID-20LA RFID Module

- The RFID subsystem is responsible for regulating who is able to enter the door
- It was chosen due to it’s small size and passive technology
- RFID reader module comes with integrated antenna
- 18 - 25 cm Range
- 125 kHz frequency between the reader and tag

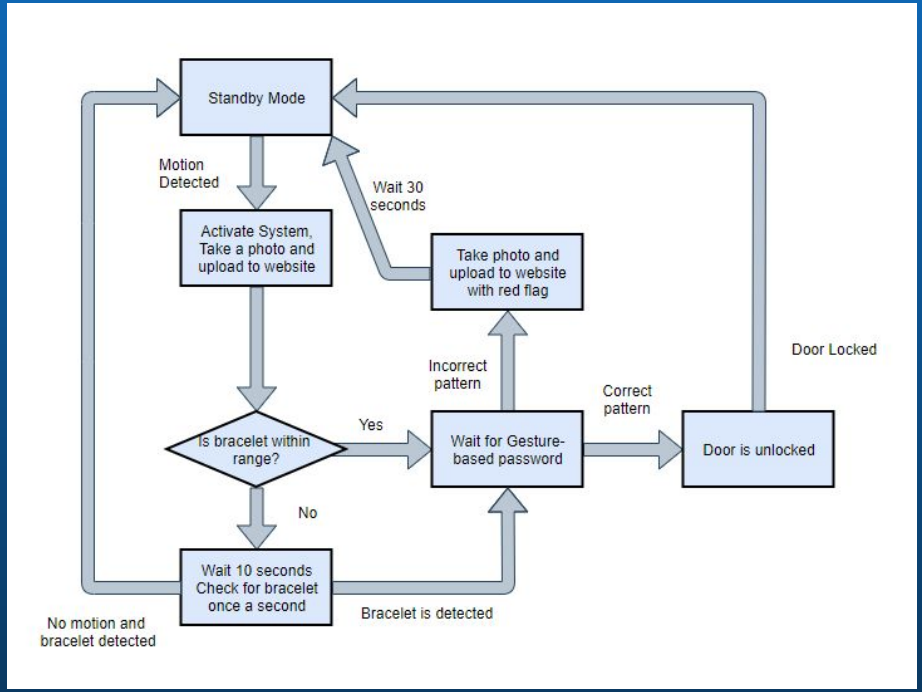






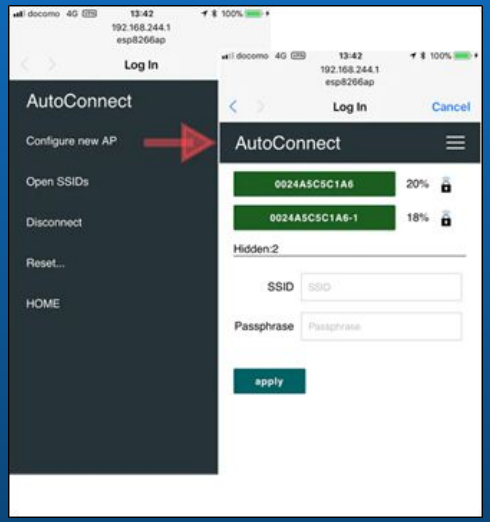
Software State Diagram

- State diagram used to help model desired behavior
- Use of interrupts from sensors to switch between states
- Implement design using Arduino IDE in the C language



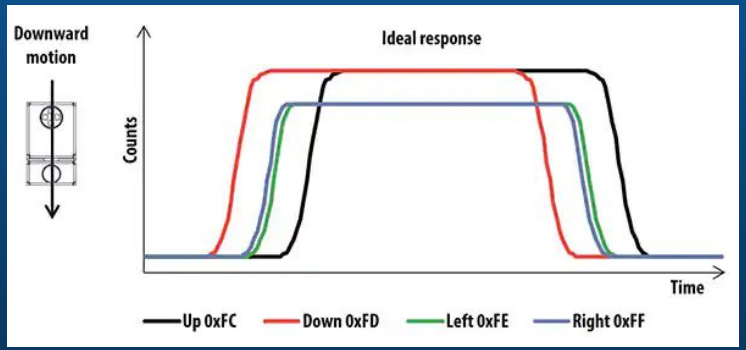
Microcontroller Software Design Approach

- AutoConnect used to connect the microcontroller to wifi
  - Allows auto-reconnection to same wifi anywhere without hard-coding credentials
  - Removes the necessity for user to use app, as well as developers to make an app for sole purpose of wifi connection
- Images uploaded over this wifi connection to the website
  - Images uploaded with red flag in the case of incorrect password

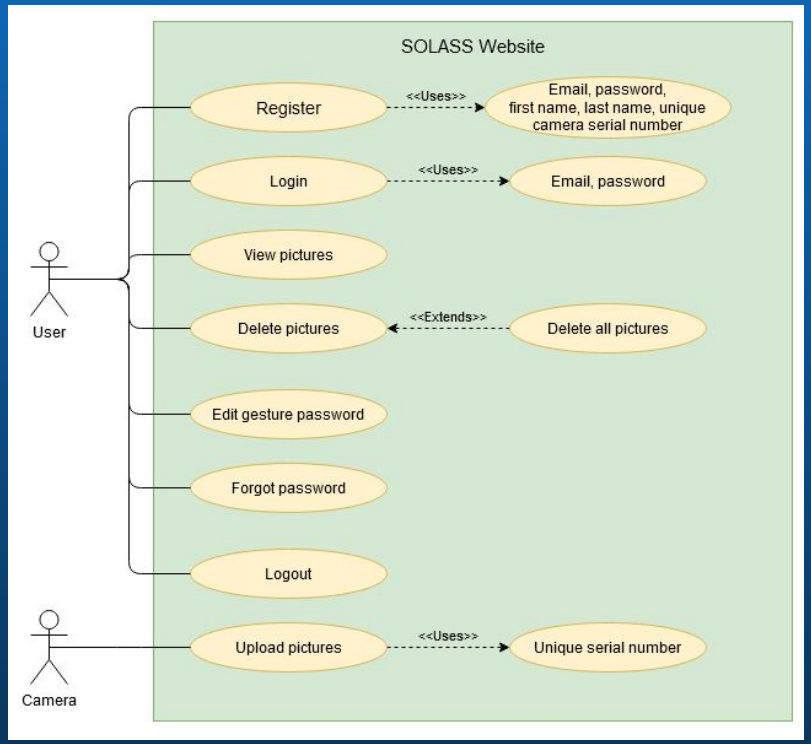


Microcontroller Software Design Approach

- RFID system calibrated by reading in ID sent by RFID tag
  - All further communication compares received ID to the stored ID
- Gesture controller uses the 4 photodiodes to sense direction
  - Four basic directions are already programmed into the sensor
  - Gesture inputs are reduced to a integer, 0 - 4

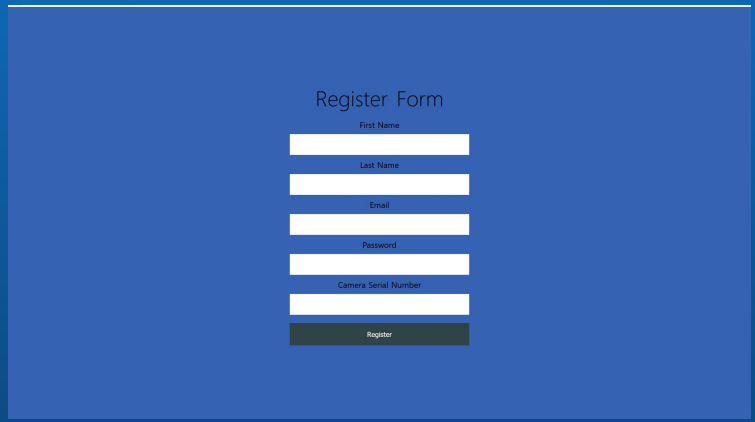


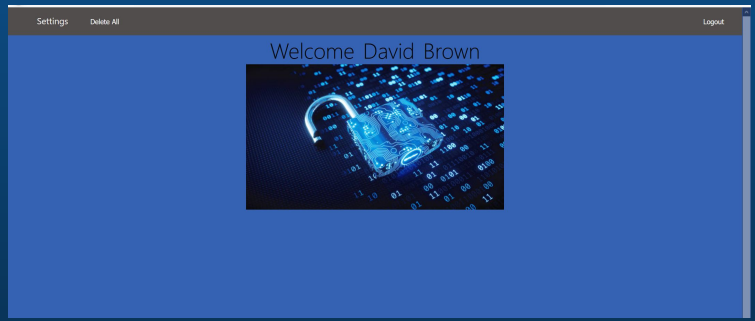
Website Use Case Diagram



Web Application

- Constructed using MEVN(mongoDB, Express.js, Vue.js, and Node.js) stack with Nuxt framework, deployed to heroku
- Simple login and register forms, with a home screen to display pictures taken
- User registers with the camera's serial number, used to pair user accounts to cameras
- Will have settings page to change gesture password
- Forgot password feature utilizing user's email





Difficulties

- Website
  - User authentication and cookies
  - Deployment to Heroku
- Microcontroller software
  - Uploading images taken to user website
- Hardware
  - RFID pin size
  - PIR motion sensor range

What went well

- Website
  - Database is intuitive, easy-to-use
- Microcontroller software
  - Taking pictures and saving to SD card
  - Connection to local Wifi
  - Connection to website over wifi connection
- Hardware
  - Motor is given enough power to turn the deadbolt
  - RFID module reads RFID tag from a sufficient distance

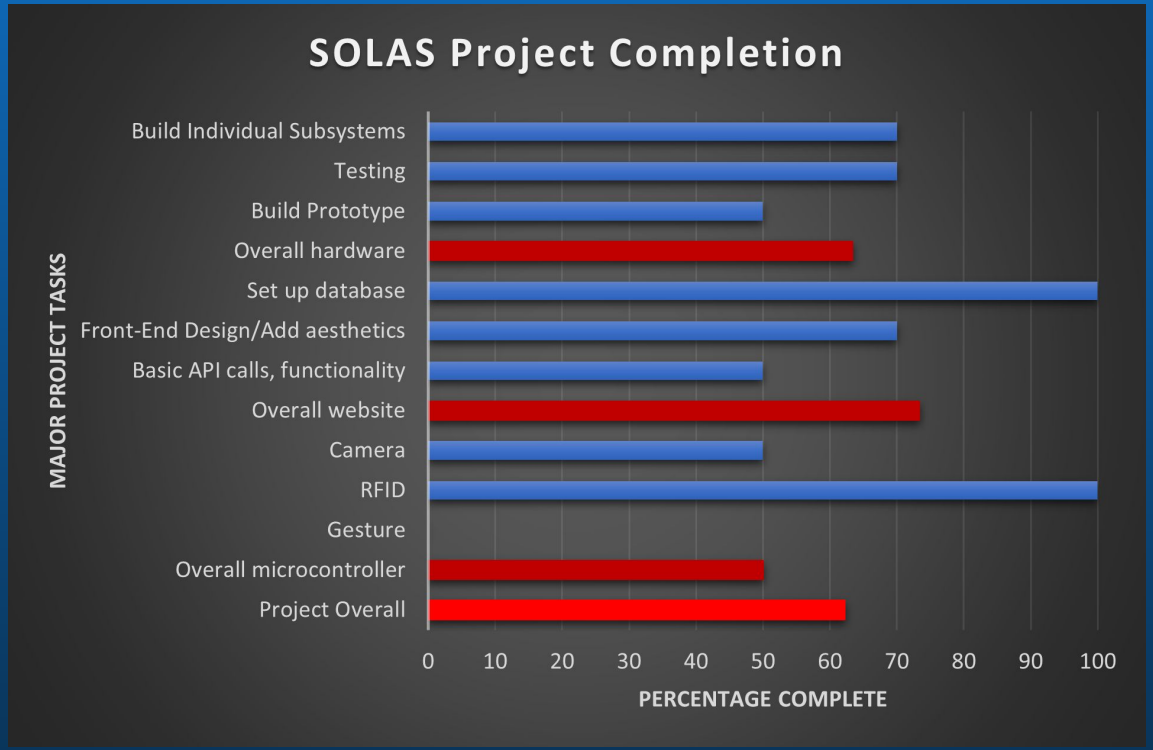
Group member contributions

Matthew Guevara	Devon Anselmo	Keanu Zeng
• Circuit/PCB Design • Microcontroller Connections • RFID operation • Motor Operation • Motion Sensor Connections	• Website construction • Database setup • Wifi connection • RFID communication • Budget and expenses tracking	• Website construction • Integrating Gesture Controller • Microcontroller • Camera programming

Budget and Expenses

- Expenses incurred so far:
  - Bracelets, Door lock, Camera module, microcontroller - $71.25
  - Rfid tag and reader - $46
  - Sd card for camera - $14.15
  - Resistors and Capacitors - $12.73
  - Proximity/motion sensor - $7.08
  - Gesture controller - $14.22
  - Total: $165.43
- Further expected expenses by vendor:
  - Heroku - $28
  - PCB manufacturing - $70
  - Door handle, Enclosure - $40
- Total estimated project budget: $303.43, $3.43 over original desired budget

SOLAS progress



Immediate tasks

- Begin programming and testing Gesture controller
- Work on having esp32-cam show images from database on front-end
- Implementing PIR motion sensor into SOLAS hardware
- Testing power usage of SOLAS system
- Obtaining Voltage Regulators

Thank You