PARK SHARK

GROUP D

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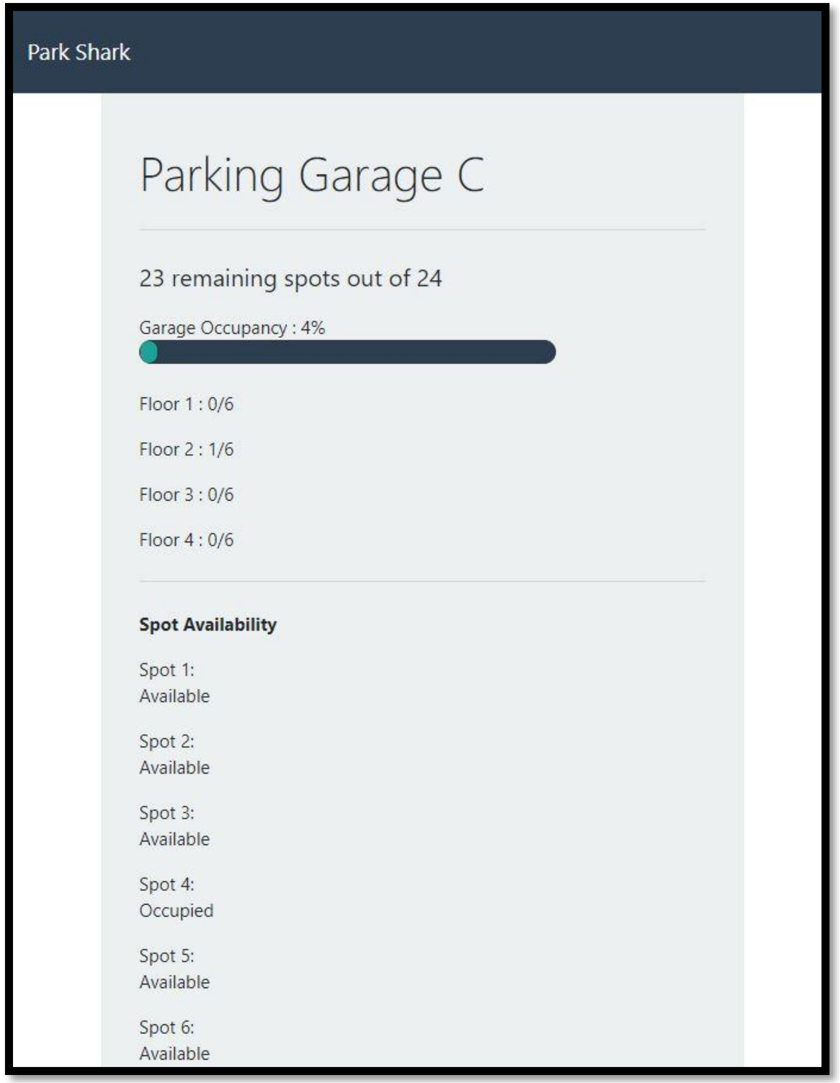
Motivation

- UCF's current system is extremely inaccurate
  - Uses sensors at the entrance to each garage
  - Online information not useful for finding parking
  - No information on where parking is available

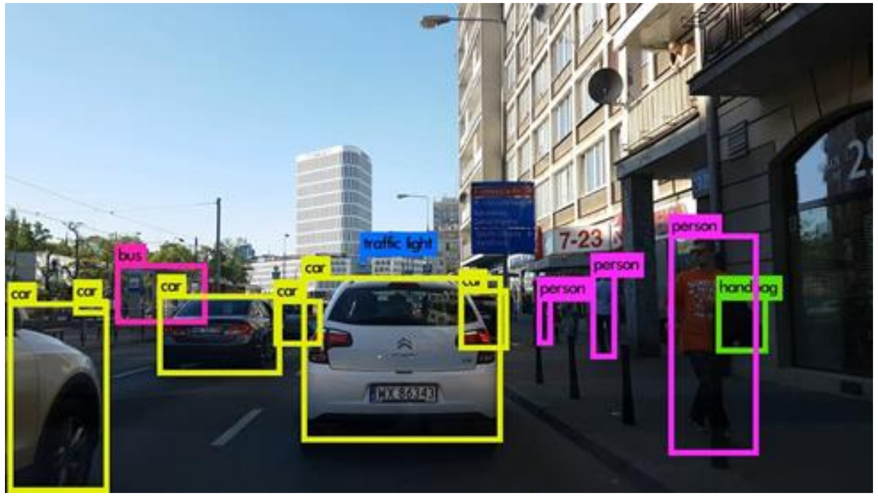
Goals and Objectives

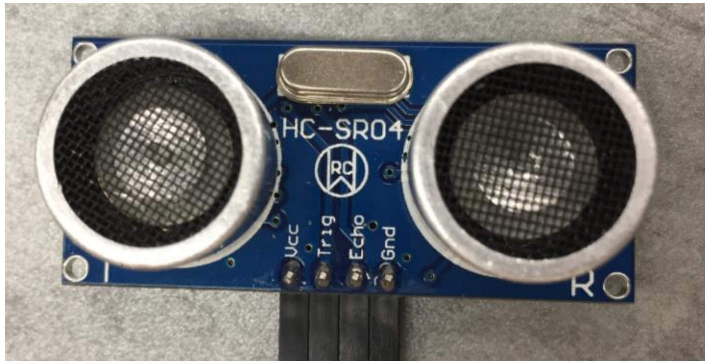
- Accurate parking/floor availability
- Display information simply and effectively
- Multi-sensor approach
- Inexpensive



Project Overview

- Detection:
  - Computer Vision: Object Detection
  - Ultrasonic Sensor
- Information Display:
  - API
  - Website
  - App





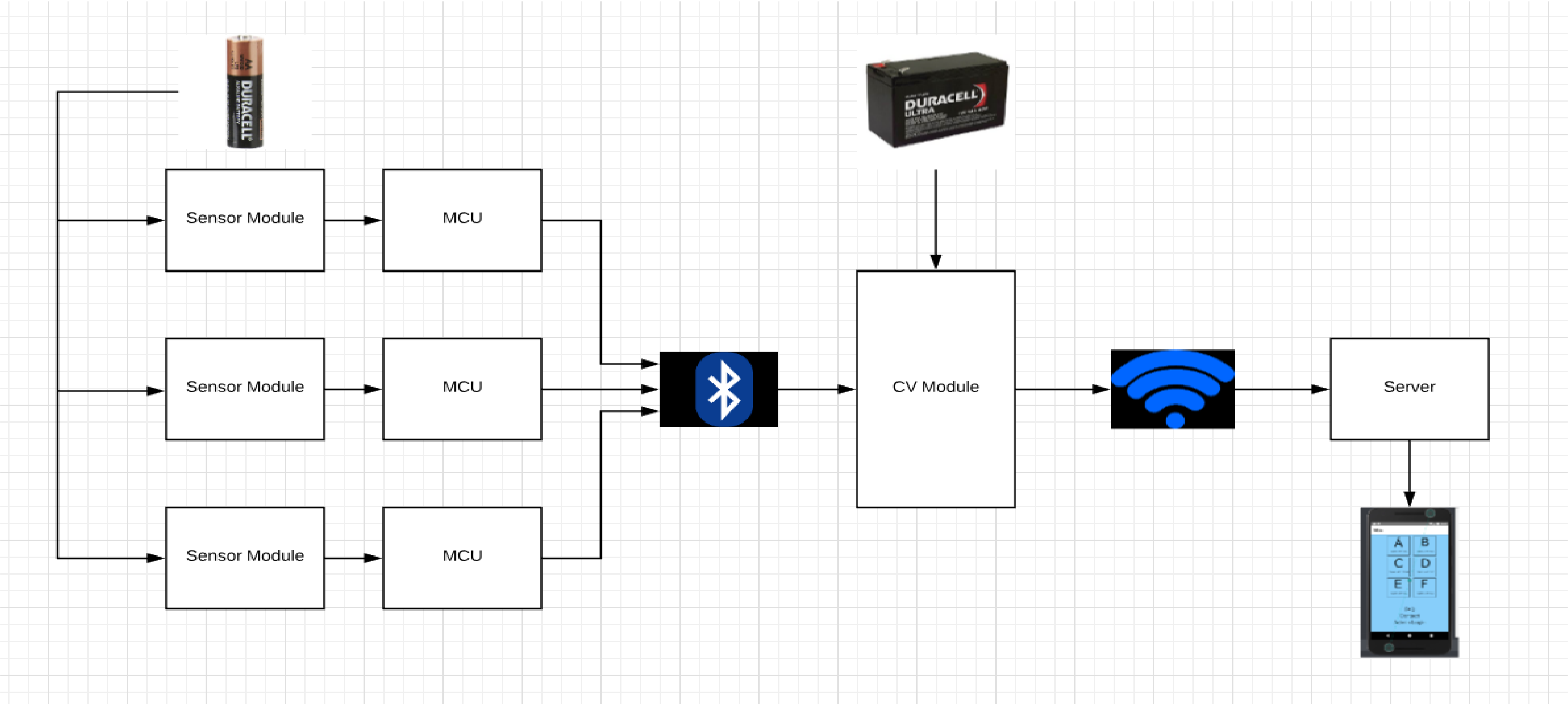
Specifications and Requirements (Computer Vision System)

Design Attribute	Goal
Small form factor	• Dimensions of product should not exceed 8.0 x 8.0 x 3.5 inches • Weight of product should not exceed 10 lbs
Low cost	• The production of a single vision system should not exceed $200 • No single component should exceed $100
Power	• This module shall pull no more than 300 mA • This device will be run off a small 12 V battery pack, and will require a recharge/change every 24 hours
Communication	• Be able to receive sensor reading wirelessly via Bluetooth • Transmit data to database over WiFi

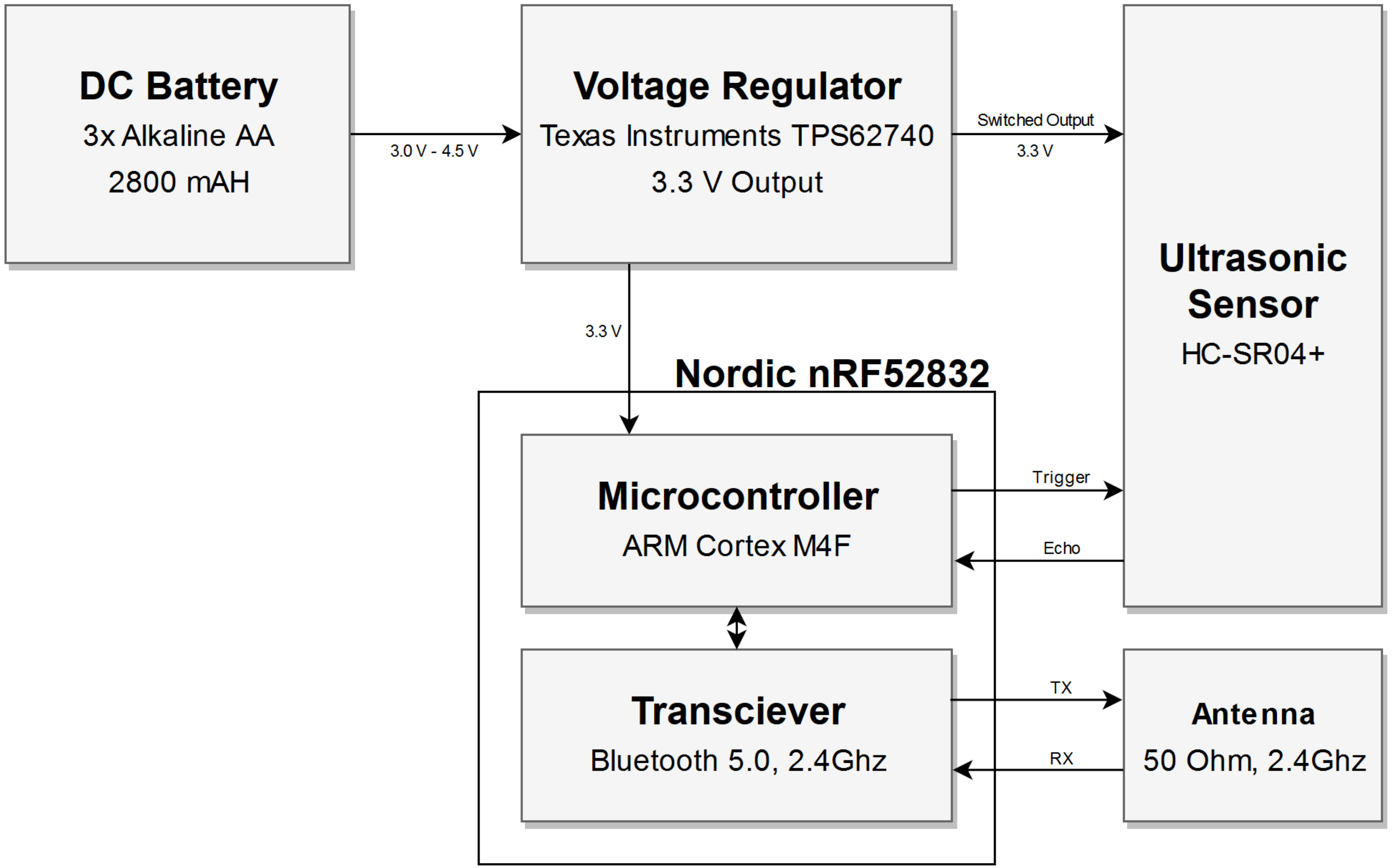
Specification and Requirements (Wireless Sensor System)

Design Attribute	Goal
Small form factor	• Dimensions of product should not exceed 4 x 3.7 x 3.1 inches • Weight of product should not exceed 3 lbs
Low cost	• The production of a single system should not exceed $50
Operating distance	• Unit should be able to detect vehicles at least 5 ft. from the wall or the ceiling
Power	• This module shall pull no more than 50 mA peak current • This device will run off a small battery pack • The device should enter a power saving mode in between taking sensor readings • Battery life of around 6 months
Communication	• Unit should be able to transmit data wirelessly via Bluetooth

Overall Block Diagram



Sensor Block Diagram



Microcontroller Selection

- Modern Bluetooth with integrated MCU allows lowest power draw and most processing power compared to separate old MCU such as MSP430
- Processing power not important for this application as it will sleep most of the time

Processor	ATmega328	MSP430FR400	nRF52832 (ARM Cortex M4)
Low Power Mode Current Draw	4.5 uA	1 uA	0.7 uA
Integrated Bluetooth	No	No	Yes, Bluetooth 5.0
Price	$1.95	$1.18	$3.51

Sensor Comparison

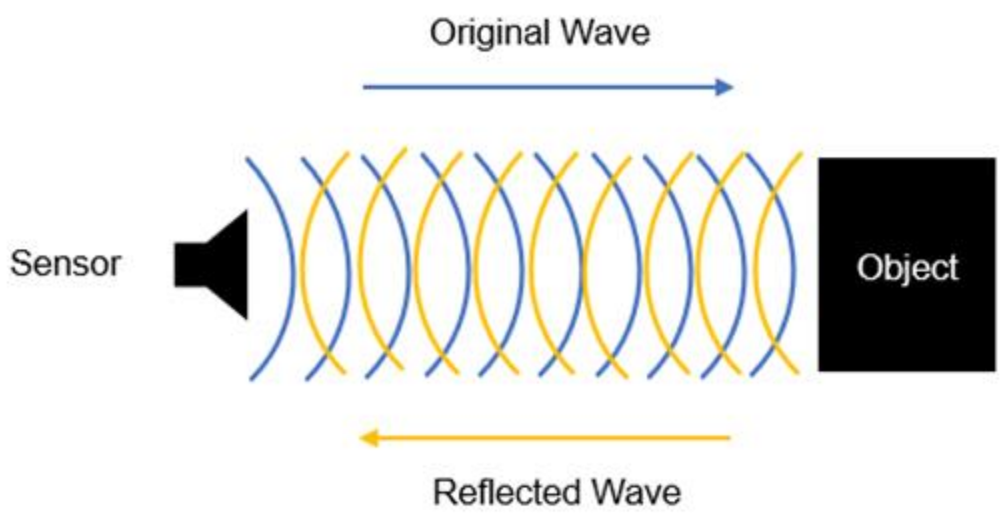
Specifications	Hall Effect	Ultrasonic	Infrared	Inductive
Max Sensing Distance	12 mT*	4 m	1.5 m	0.04 m
Supply Voltage	2.5 to 38V	4.5 to 5.5V	4.5 to 5.5V	10 to 30V
Operating Temperature	-40 to 125° C	-15 to 70° C	-10 to 60° C	-25 to 75° C
Cost	$0.83	$3.95	$14.95	$62

*Hall effect sensors are triggered by a change in the magnetic field. Instead of a sensing distance, its maximum operating point was written.

Ultrasonic sensor was chosen due to:

- Offers the highest sensing range
- Cost falls within budget
- Low power consumption

$$\text{Distance} = \frac{\text{Time Taken} \times \text{Speed of Sound}}{2}$$



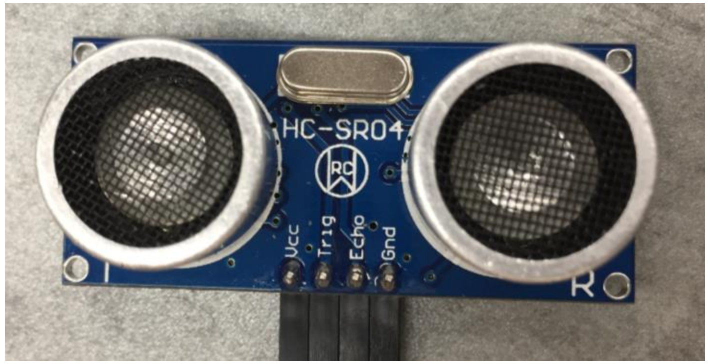
Ultrasonic Sensor

Advantages	Disadvantages
• Detection of objects by ultrasonic sensors is unaffected by its color, transparency, or light reflectivity	• Size, shape, and angle of an object can affect the accuracy of the ultrasonic sensor’s readings
• Certain environmental conditions such as dust, humidity, and dirt do not affect ultrasonic sensors	• Difficult to detect objects of low density, such as fabric or foam
• Can detect metallic objects without contact	• Sensitive to variation in temperature in terms of accuracy

Ultrasonic Sensors

Specification	HC-SR04	HC-SR04+
Operating Voltage	4.5 to 5.5 V	3.0 to 5.5 V
Operating Current	10 to 20 mA	10 to 20 mA
Quiescent Current	4 mA	3 mA
Price	$3.95	$1.44

HC-SR04



HC-SR04+

Wireless Communication

Wi-Fi

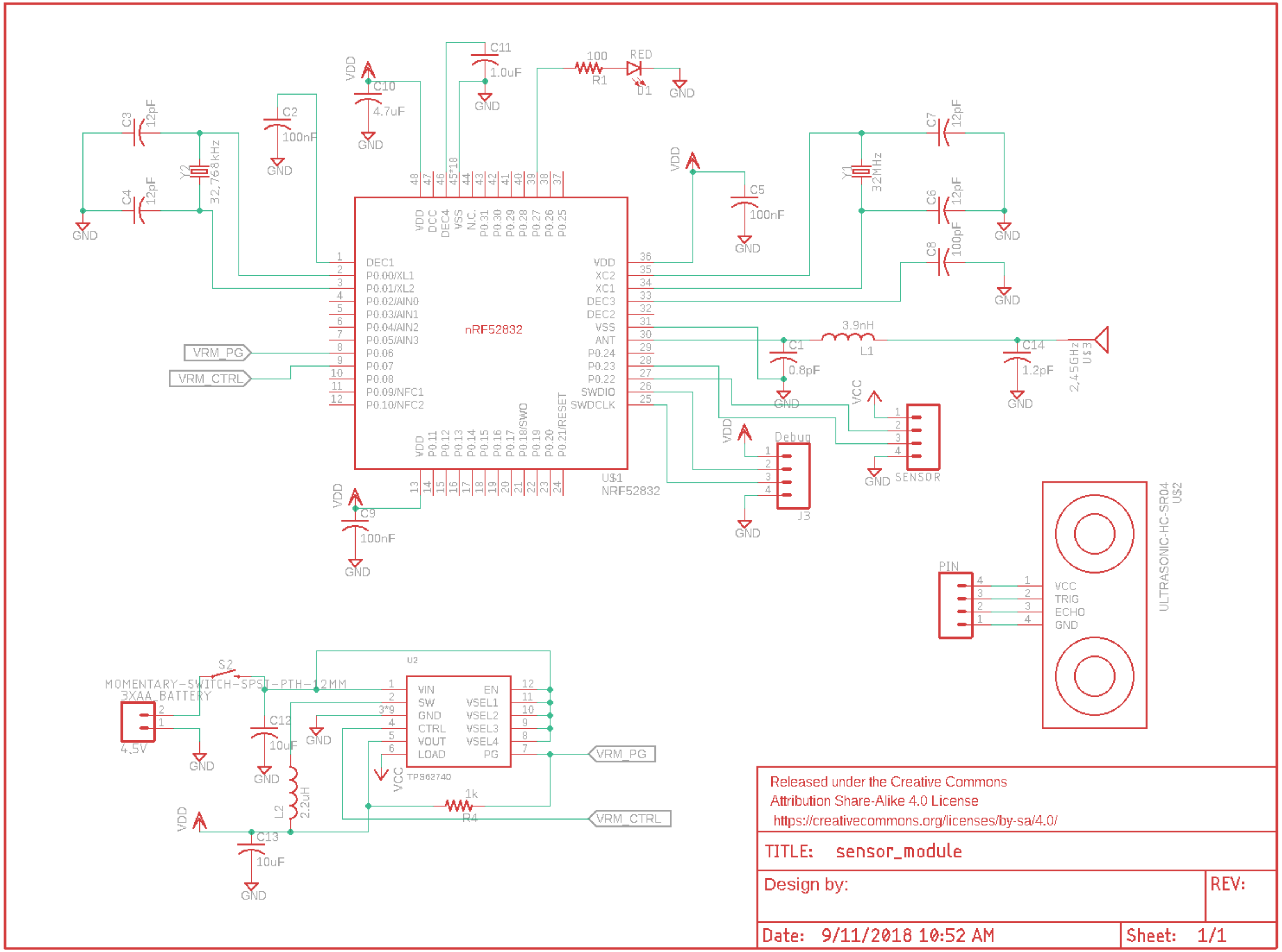
- Higher range
- Power requirement too high

Bluetooth

- Data bandwidth not important for this case
- Designed for low power
- Bluetooth 5 extends range and reduces power further
- Bluetooth 5 adds mesh network functionality

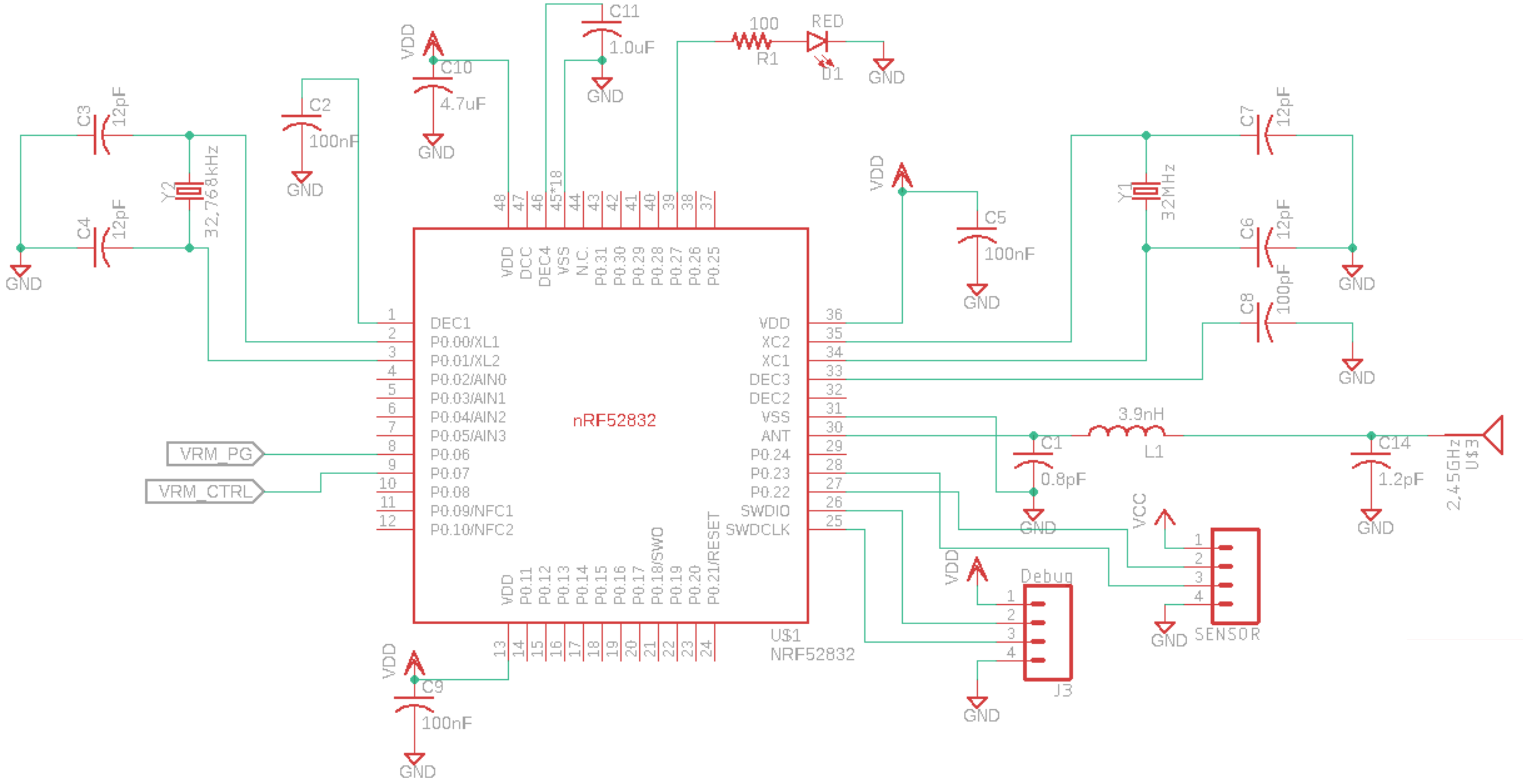
Schematic

- 2 main sections:
  - Power Supply
  - MCU
- Sensor is shown on the side
- Made on Eagle CAD



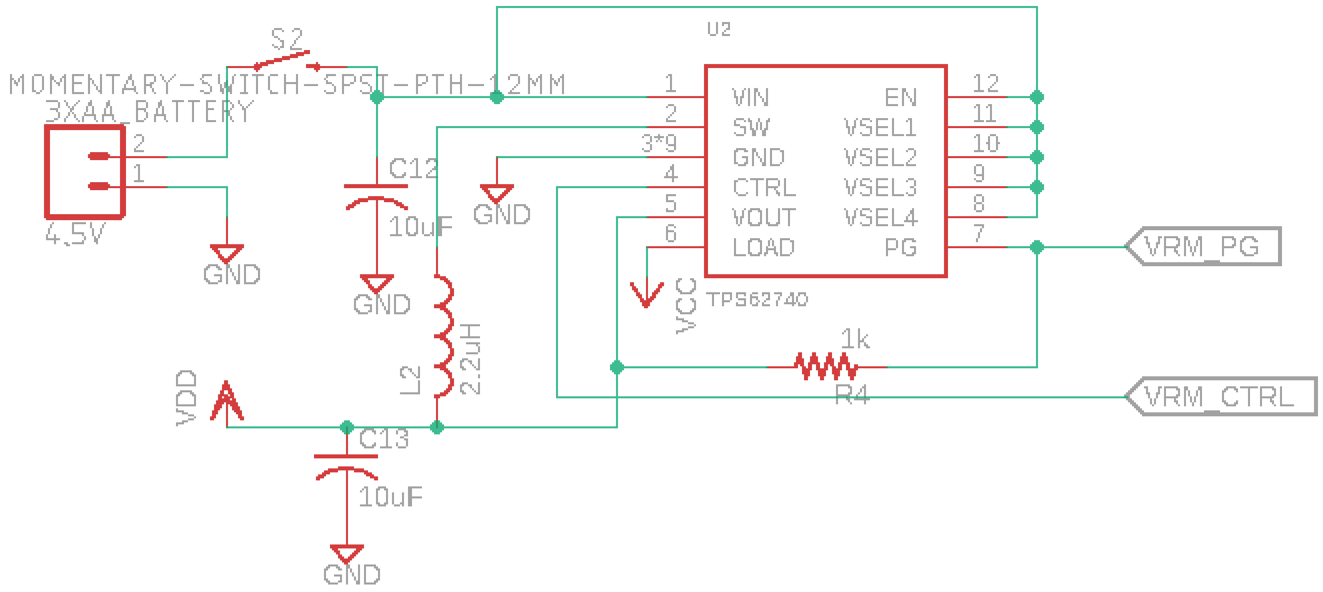
MCU Section

- Decoupling capacitors
  - Reduce noise
- Two crystals:
  - 32MHz
  - 32.768kHz
- Debug port



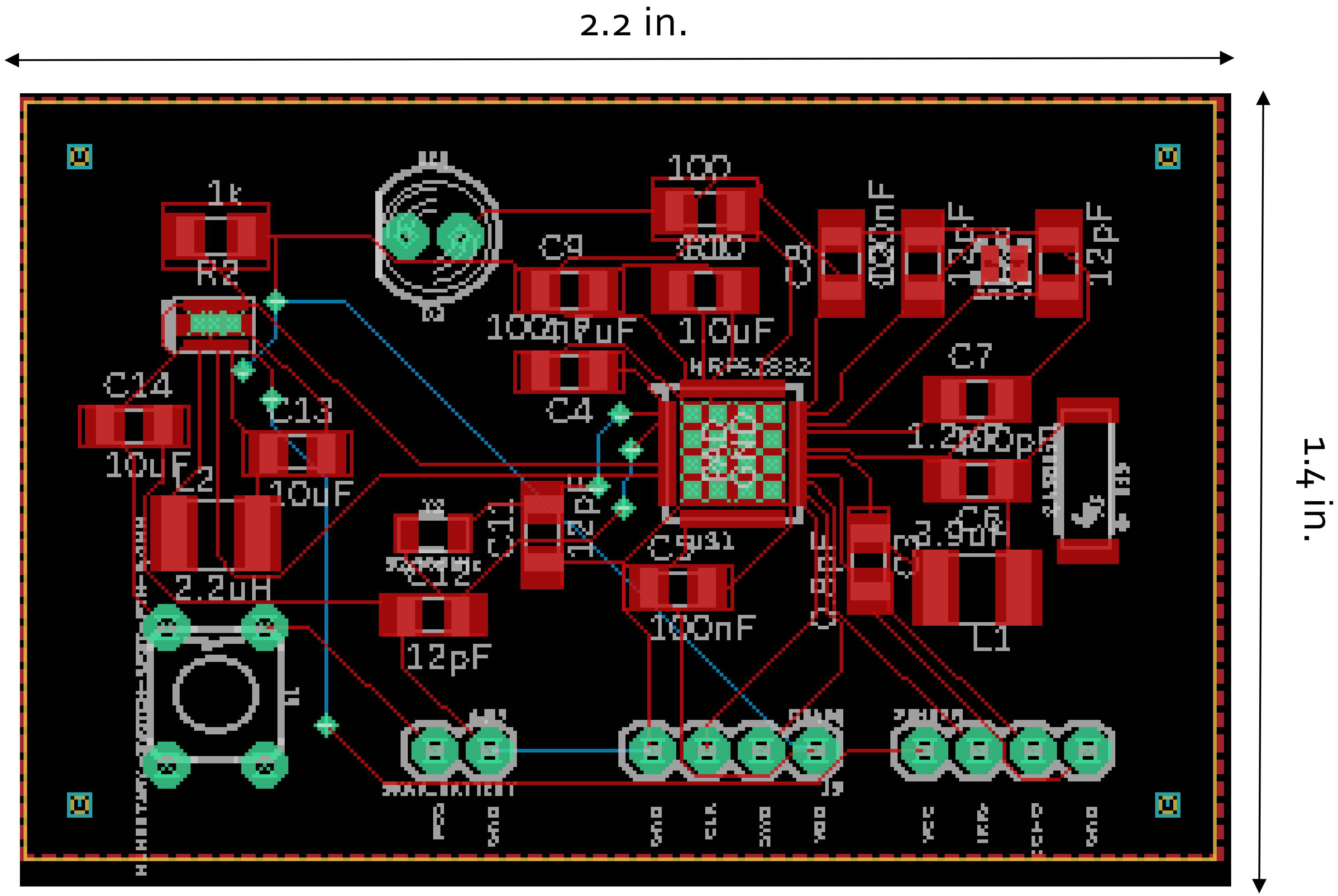
Power Section

- Voltage regulator
- 3xAA battery holder
- SPST switch



Printed Circuit Board

- Ground plane on both sides
  - Recommended for RF PCB
- Utilized SMD components
- Dimensions: 1.4 in. x 2.2 in.



Final Circuit Board

- 3 boards created
- Manufactured from OSH Park
- Assembled using solder paste and hot plate
- Utilized a stencil
  - Had to resolder MCUs by hand due to bridging with solder paste + hot plate method

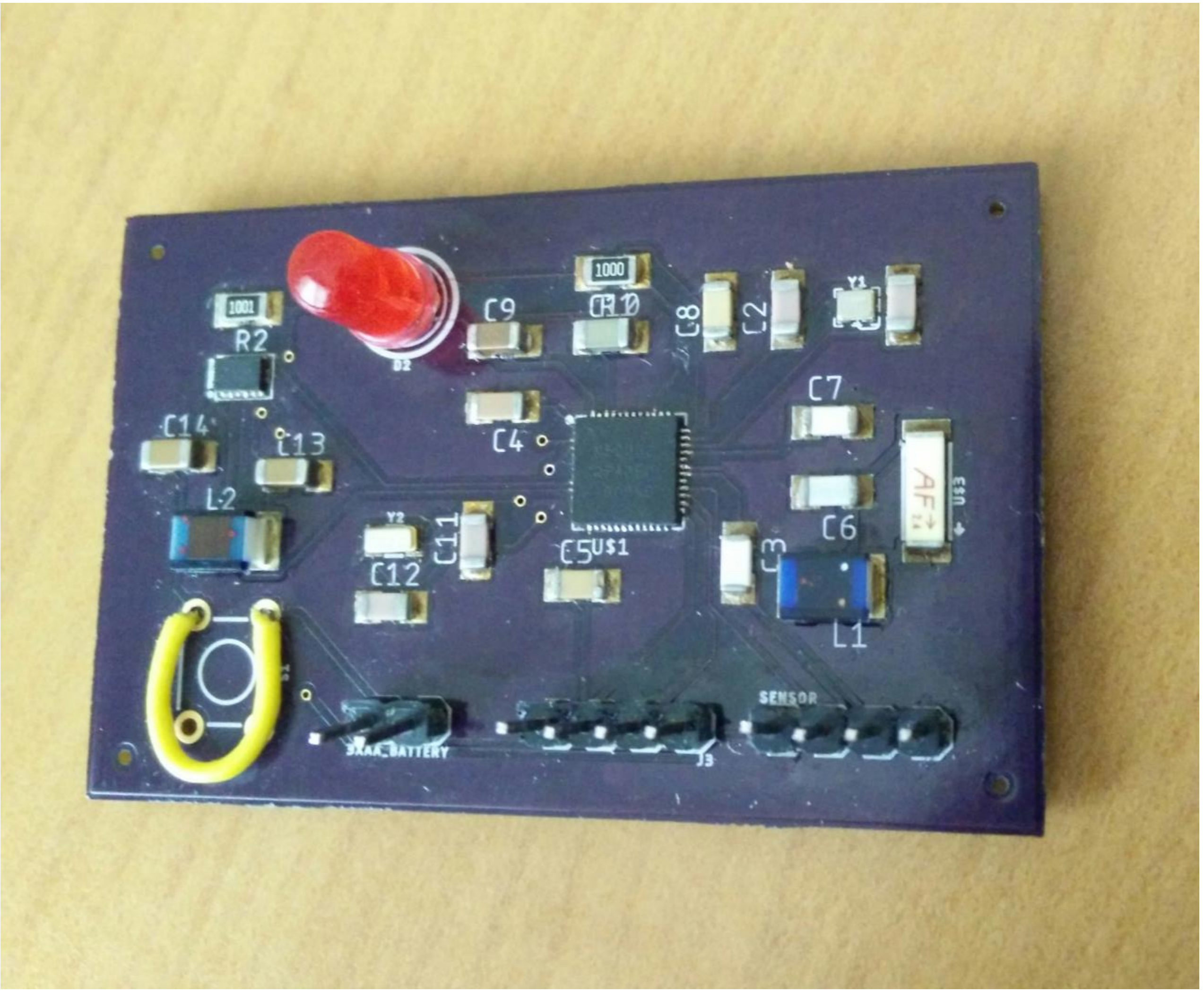
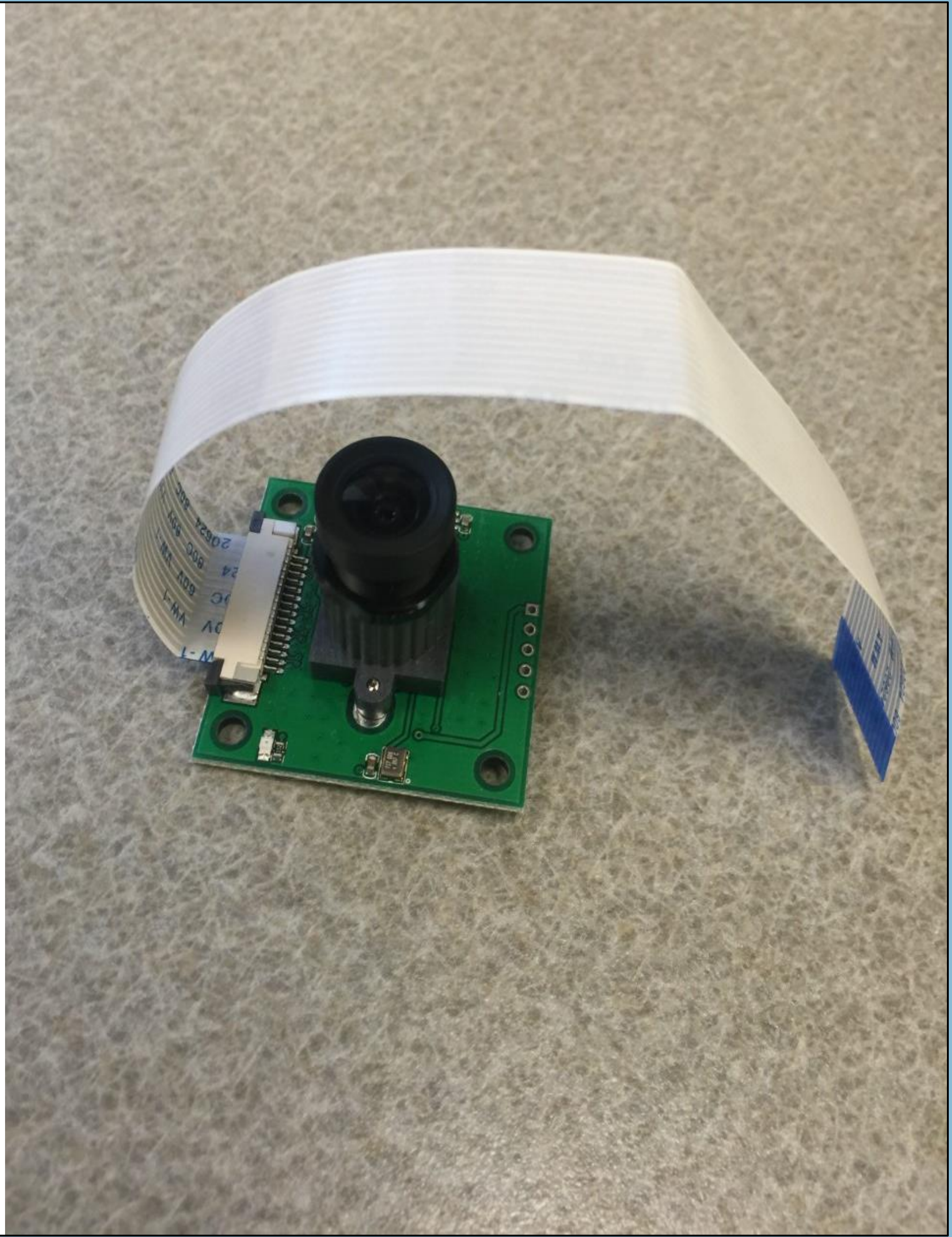


Table of Components

Item	Quantity (Per PCB)	Cost
Nordic NRF52832	1	$3.51
TPS62740 Voltage Regulator	1	$1.98
HC-R04+ Ultrasonic Sensor	1	$1.44
2.4GHz Chip Antenna	1	$2.95
Red LED	1	$0.06
Pin Head Connector	3	$0.08
32 MHz Crystal	1	$0.75
32.768 kHz Crystal	1	$0.50
SMD Resistors	2	$0.04
SMD Capacitors	14	$1.50
SMD Inductors	2	$1.48
3xAA Battery Holder	1	$2.64
PCB Board	1	$5.10
Total Cost	30	**$21.73**

Camera Selection

- Pixy Cam
  - Price : $69.00
  - Outdated
  - Limiting
- Arducam 5 MP OV5647
  - Price : $13.49
  - Freedom



Computer Vision

- You Only Look Once (YOLO) Algorithm
- Applies a single neural network to the full image and predicts bounding boxes and probabilities for each region
- Supports real-time detection*
- YOLO vs Tiny YOLO

Using a pure Open-CV implementation of YOLO with Python

Computer Vision – Issues

- Defining detection area / Overlapping cameras
  - Panorama sitching with SIFT
  - Manually crop image to look at desired spots after camera installation

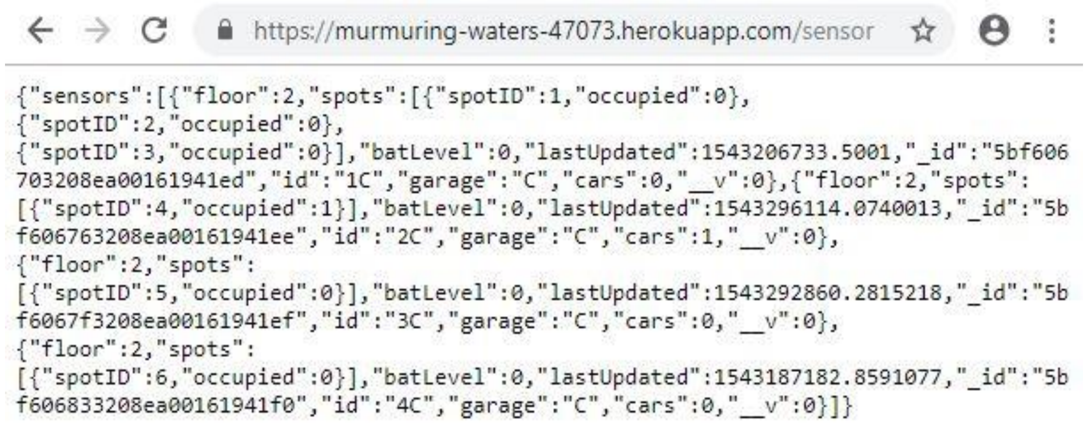
- Individual Spot Detection
  - Detecting parking spots with Hough Line Tranform
  - Manually define bounds

Mobile Application / Website

- React/React Native
- JavaScript (Since we are using React Native for the mobile application we are going to be using JavaScript)
- MERN
  - MongoDB (Database)
  - Express (Framework to help with node)
  - ReactJs
  - NodeJs

Park Shark API

- **Node JS**
- **MongoDB Database**
- **Hosted on Heroku**
  - Both the app and website make calls to the API to retrieve data and display the information
  - Can be used by other developers who want UCF parking information for projects
  - All GET requests return JSON object with Sensor and Garage model information



User Interface

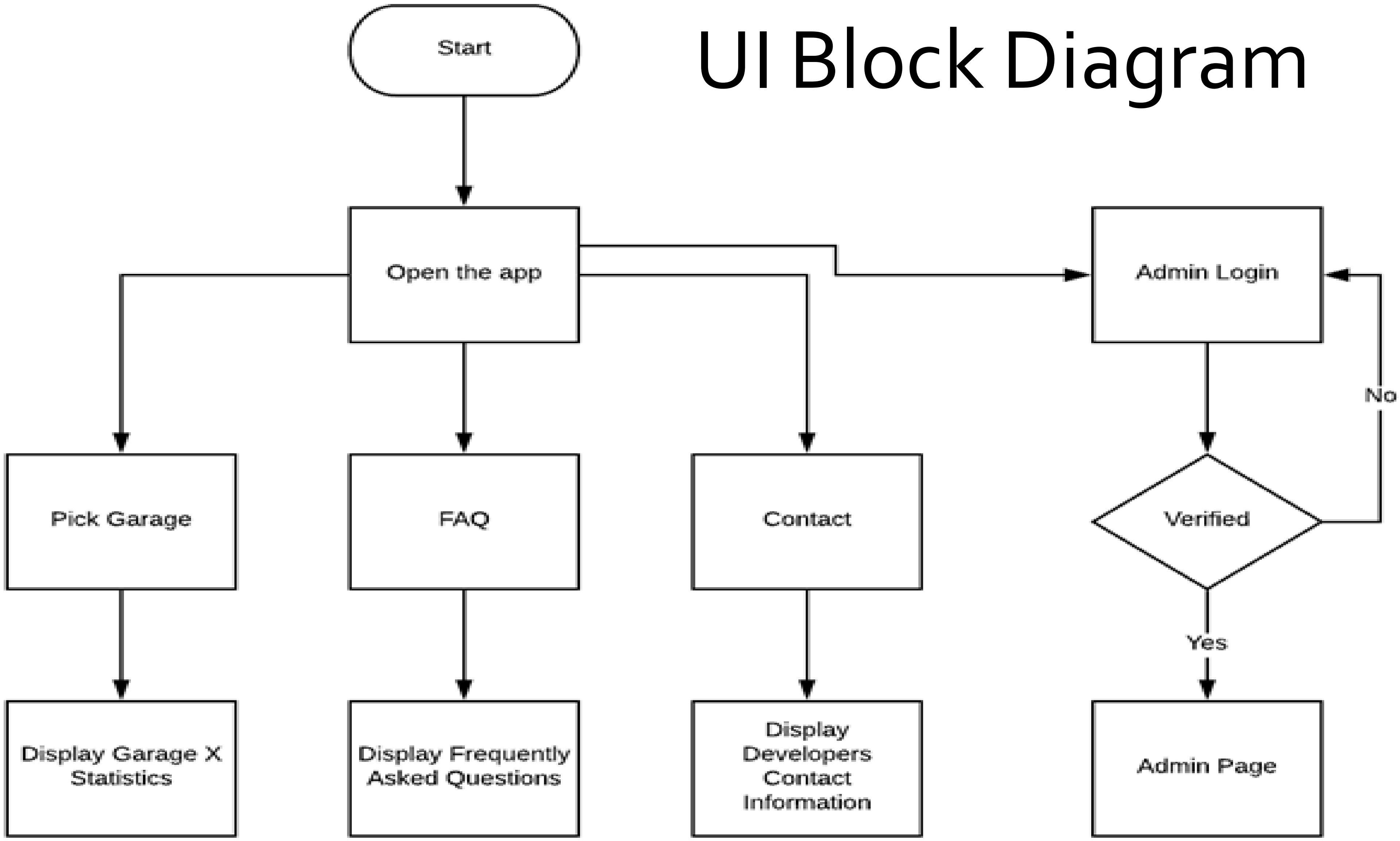
Administrator (Mobile Only)

- This user will be able to register and login (More details in later slides)

Standard User (Website and Mobile)

- This is for all other users. (Anyone just looking for info on the UCF garages)
- Ability to select between all available garages.
- FAQ
- Contact

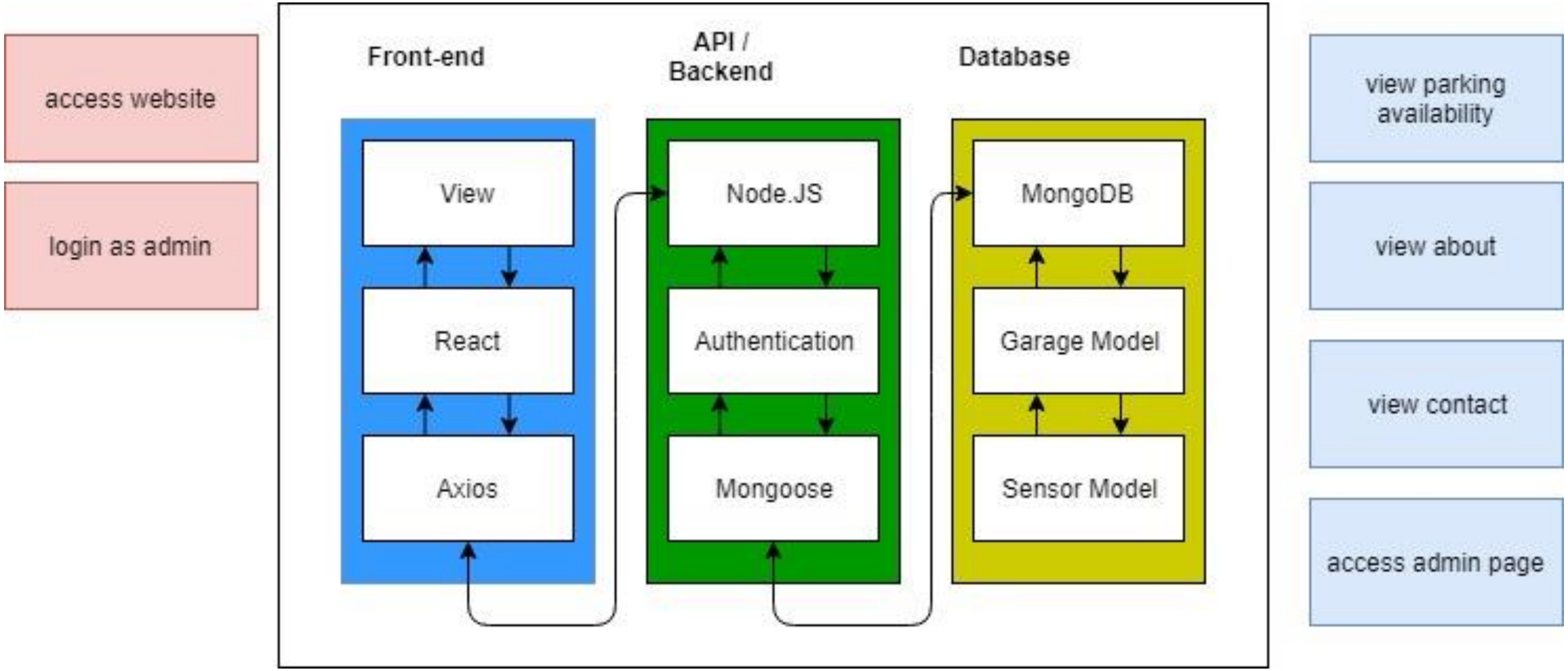
UI Block Diagram



Development Tools

Tool/Software	Description
Git	Git will be used for all software version control
Heroku	Cloud hosting platform
Postman	Postman will be used to simulate calls to the database and will assist greatly in the design and testing phase of the website
React	Will be used to create the front-end of the application
Axios	HTTP Request Library used to retrieve data from the API
Node.js	Will be used to create the back-end of the application
MongoDB	Will be used to create the database for this application
Mongoose	Will be used in tandem with MongoDB and Node.js to help communicate between the two
React Native	Will be used to implement the mobile application
Android Studio	Android Studio will be used to implement react native tools, as well as using an emulator to simulate a phone and debugging.

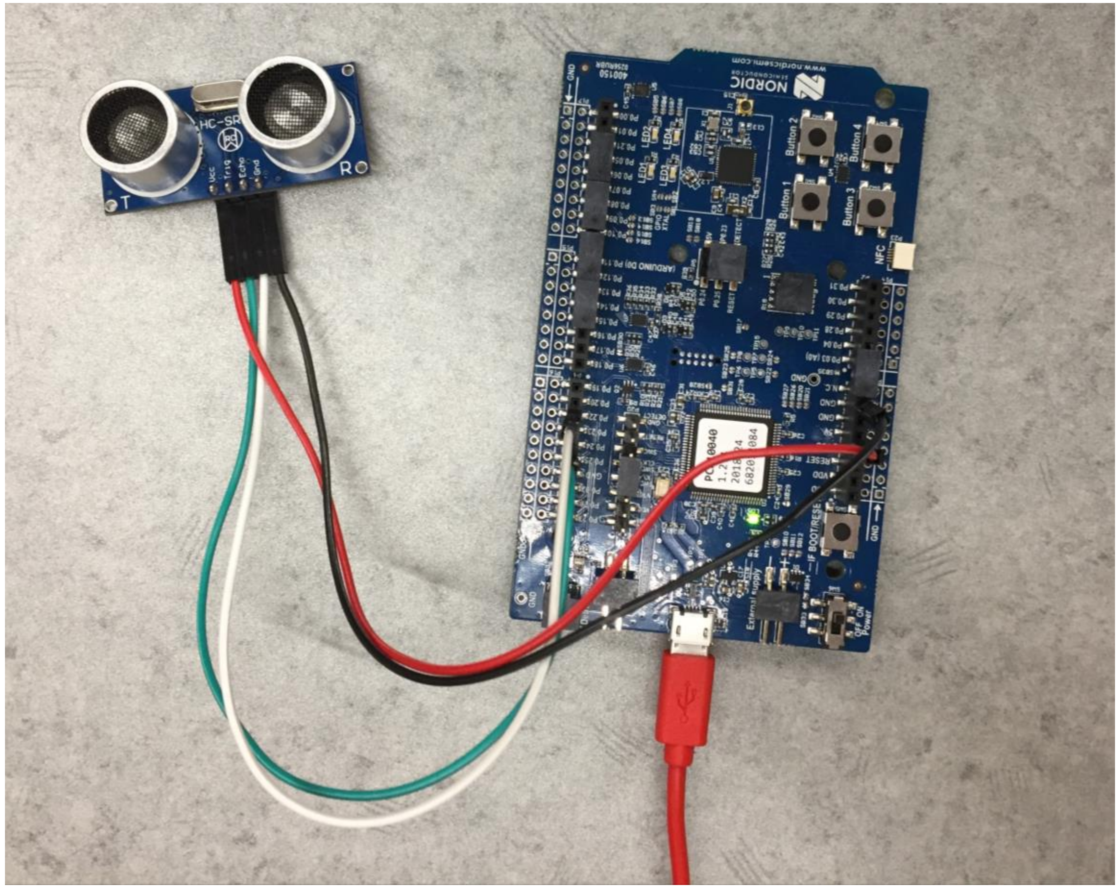
Overall Website / App Structure



Computer Vision Prototype

- Raspberry Pi 3 Model B+
- Arducam 5 Megapixel
- DROK LM2596 Voltage Converter 12V to 5V
- 12 V Battery Pack

Sensor Prototype – Dev Kit

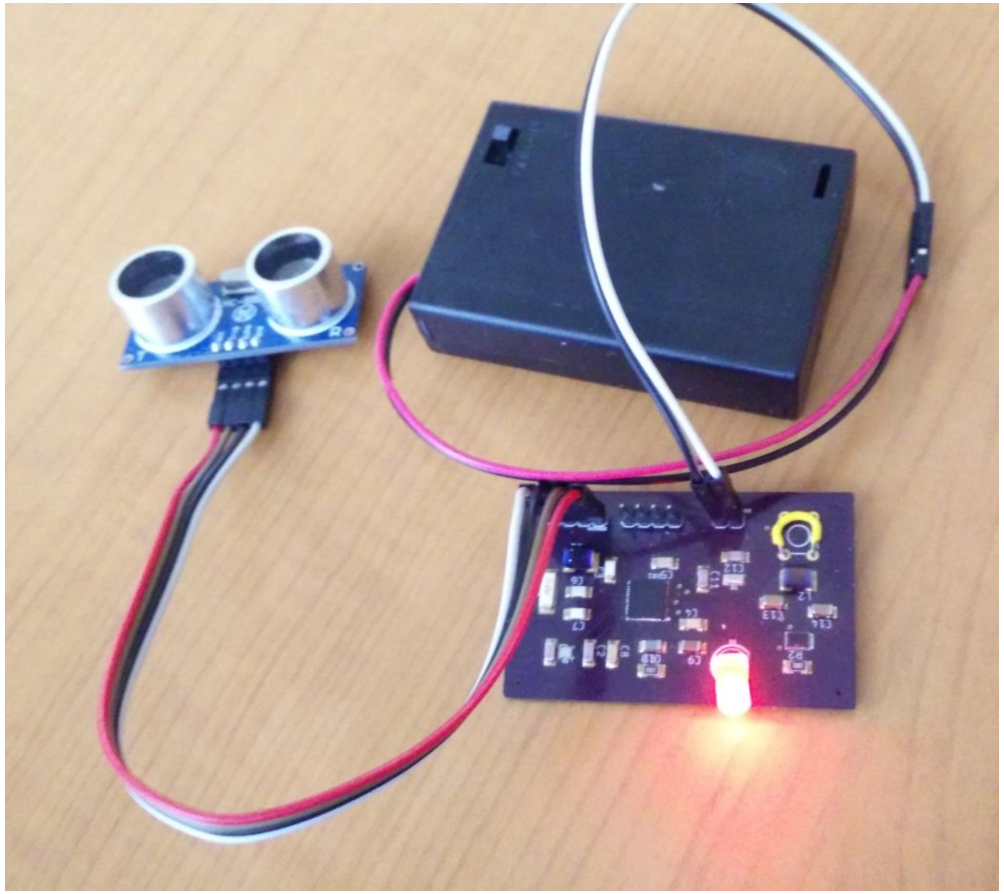


Debug Terminal

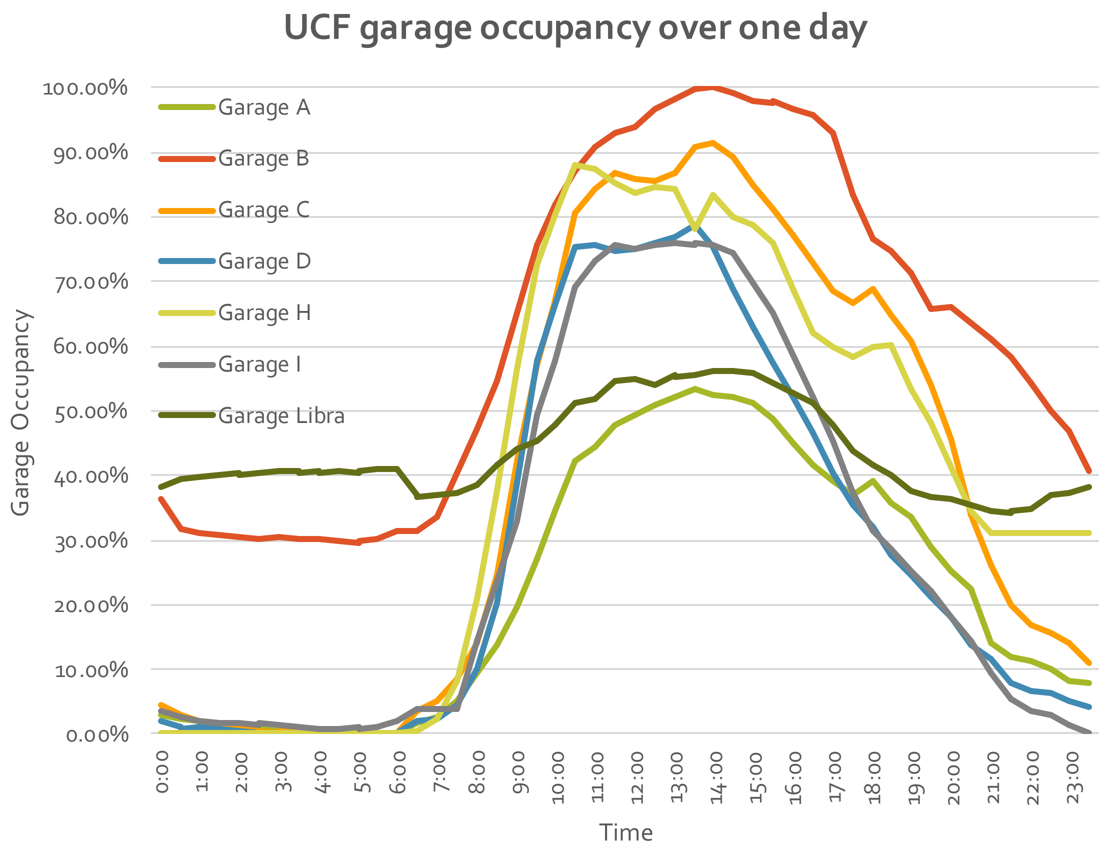
```
Distance: 0.00 meters
Distance: 0.07 meters
Distance: 0.10 meters
Distance: 0.15 meters
Distance: 0.19 meters
Distance: 0.24 meters
Distance: 0.28 meters
Distance: 0.23 meters
Distance: 0.19 meters
Distance: 0.37 meters
Distance: 0.21 meters
Distance: 0.21 meters
```

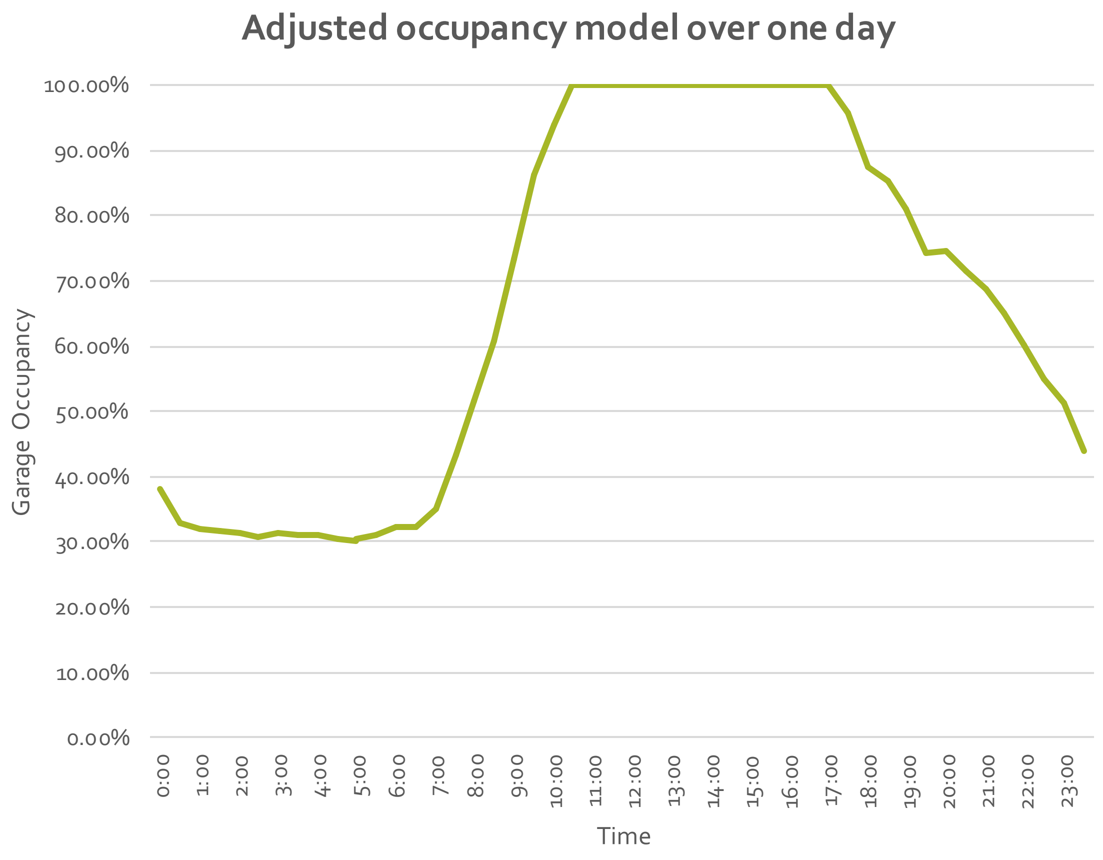
Sensor Prototype – Printed Board

- Now running on battery power instead of USB
- LED only for demonstration or debug purpose
  - In practice would be disabled as it draws more current than rest of circuit



Power Conservation





Power Conservation

- Can adjust sensor polling rate depending on garage occupancy to save power
- Frequent updates not needed during nighttime
- Frequent updates desired at high occupancy

Interval Level	Occupancy >	Occupancy <=	Interval Length	Checks Per Hour
1	95%	100%	30 seconds	120
2	85%	95%	1 minute	60
3	70%	85%	5 minutes	12
4	0%	70%	10 minutes	6

Power Draw

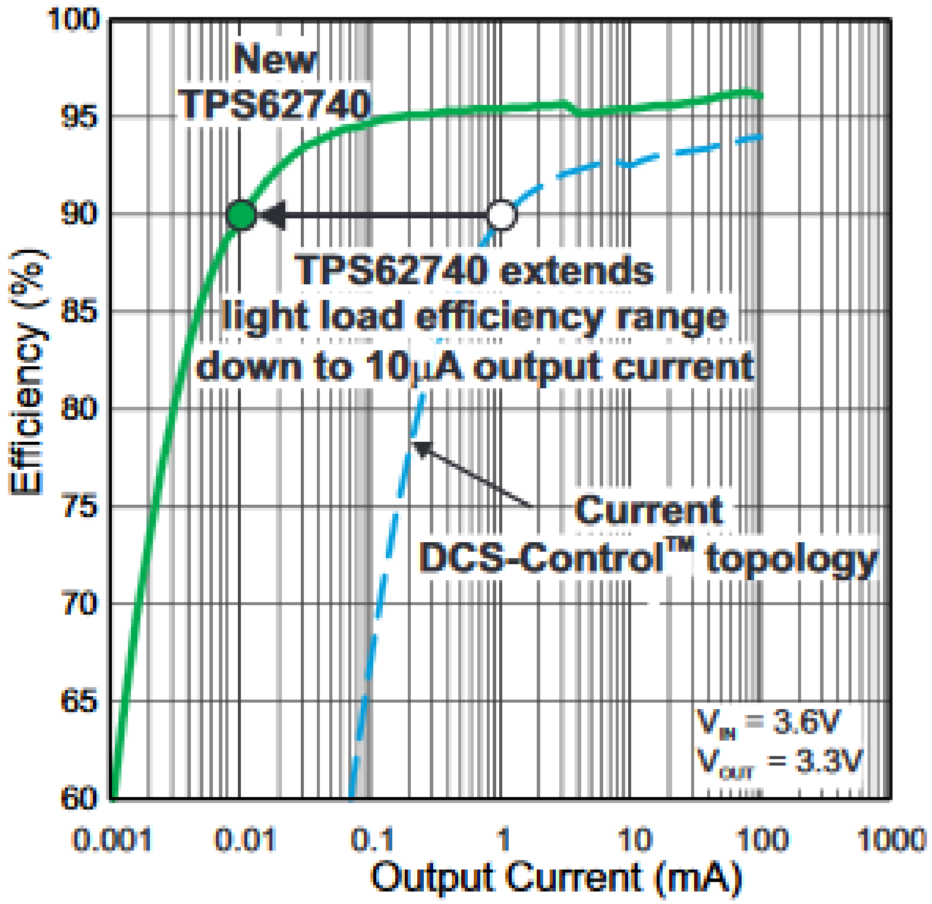
Stage	Description	Time (ms)	Length (us)	Avg. current (mA)	Peak current (mA)
pre	Pre-processing	0.0	61	3.4	
ramp	Standby + HFXO ramp	0.1	430	1.5	
stdby	Standby	0.5	1014	0.4	
start	Radio startup + CPU	1.5	133	2.8	
RX	Radio RX	1.6	261	5.7	6.2
switch	Radio switch	1.9	102	5.7	
TX	Radio TX	2.0	323	7.6	8.2
post	Post-processing	2.3	205	3.1	
	System On IDLE	2.5	3997.5 ms	2.0 uA	
Total			**4000.0 ms**	**3.7 uA**	

- Ultrasonic current draw is 4 mA
- Bluetooth/MCU current draw is negligible compared to Ultrasonic Sensor
- Therefore, keep MCU running and only schedule Ultrasonic pulses to minimize power draw
  - Need voltage regulator that can switch off one output while keeping MCU powered

Voltage Regulator

Texas Instruments TPS62740

Feature	Specification
Efficiency	90% at 10 uA output
Max Current Output	300 mA
Voltage Input Range	2.2 V – 5.5 V
Voltage Output Range	1.8 V – 3.3 V
Number of Outputs	2 (1 toggleable)
Cost	$1.76 at Mouser



Battery Selection

- Estimated current drawn by sensor module after activation scheduling is 50μA
- Desired battery life is a year or 8760 hours
- Necessary battery capacity is **438 mAh**
- Chose AA batteries due to:
  - Small size
  - Easy attainability
  - Low cost
- 3 AA batteries will be used
  - Nominal voltage of an alkaline cell is 1.5 V
  - 3 x 1.5 = 4.5 V

Battery Size	Battery Capacity (mAh)
9V	570
AAA	1150
AA	2870
C	7800
D	17000

$$\frac{\text{Battery Capacity (mAh)}}{\text{Current Draw (mA)}} = \text{Battery Life (hours)}$$

Battery Testing

- Measured average current draw from sensor module: **0.2-0.3 mA**
  - **0.1 mA current draw between sensor reads, spikes of up to 3.0mA when polling sensor**
  - As predicted, average power draw lowered from 3mA by using longer intervals for polling
- Using this value and the battery capacity value for AA batteries,
  - Estimated battery life: **about a year**
  - 2870 mAh / 0.3 mA = 9,266 hours = **386 days**
- Both values meet the requirements set for the sensor module
- Cannot verify a year-long battery life within project timespan, but all sensors still on original sets of batteries since assembly

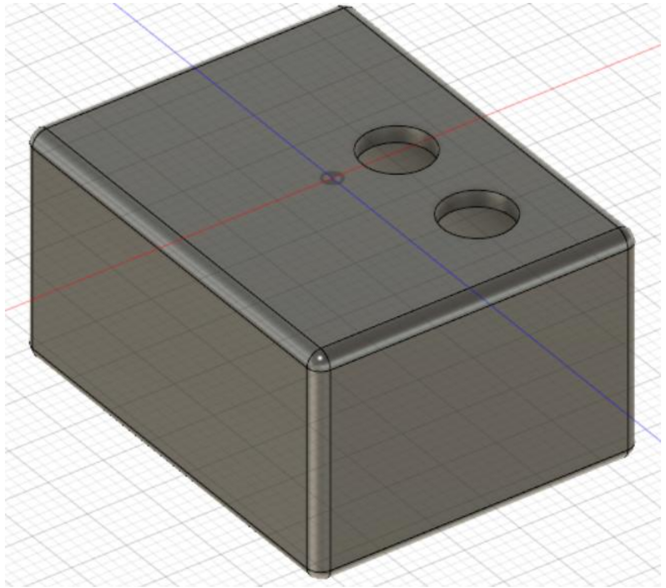
System Housing Requirements

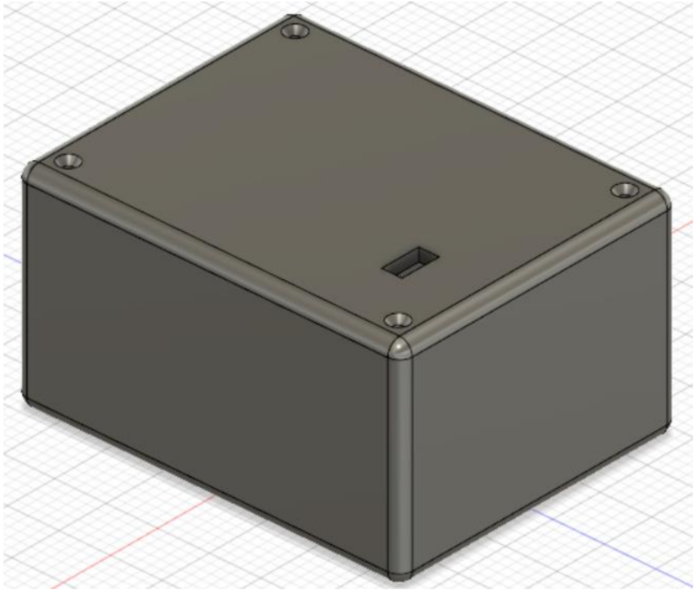
Parameters:

- Sensor measuring angle: 15 degrees
- Sensor dimension: 1.78" x 0.79" x 0.59"
- PCB dimension: 1.4" x 2.2"
- Battery holder dimension: 2.7" x 1.91" x 0.73"
- Placement of components

System Housing for Sensor Module

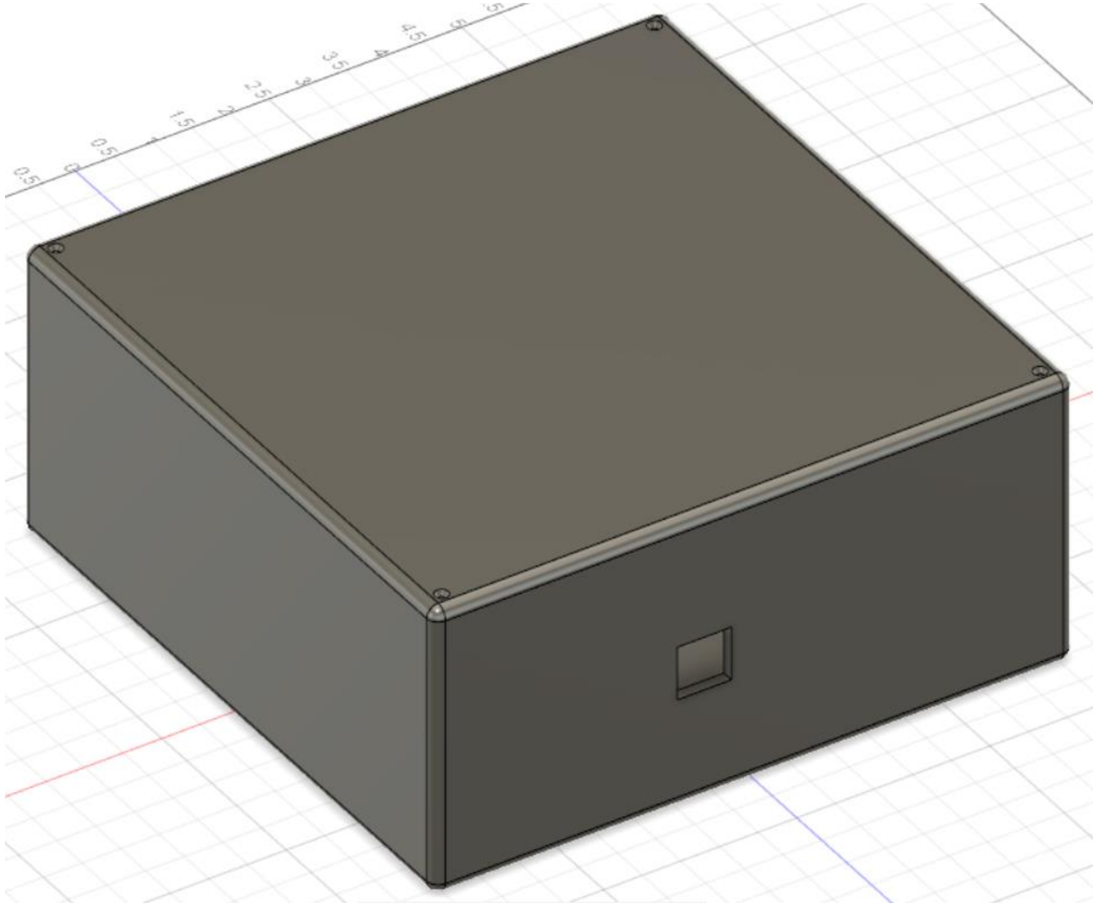
- 3D Print in TI Innovation Lab
  - ABS plastic
- Modeled in Fusion 360
- Dimensions:
  - Box: 2.7 x 3.5 x 1.8 in.





System Housing for CV Unit

- 3D Print in TI Innovation Lab
  - ABS plastic
- Modeled in Fusion 360
- Dimensions:
  - Box: 8.15 x 8.15 x 3.65 in.



Work Distribution

Team Member	Sensor Hardware	Sensor Software	Computer Vision	Parking API	Mobile App	Website	Power Supply	System Housing
Keegan			P	P	S	S		
Marcelino			S	S	P	P		
Beatriz	P	S					S	P
Travis	S	P					P	S

<u>Legend</u>
P: Primary
S: Secondary

Development Budget

Item	Component Cost	Quantity	Total Cost
Arducam 5 MP OV5647	$14.99	1	$14.99
Pixy Cam	$69.00	1	$69.00
Raspberry Pi 3 Model B+	$35.00	1	$35.00
DROK Voltage Converter	$12.16	1	$12.16
12V Battery Pack	$4.00	2	$8.00
16 GB Micro USB	$8.45	1	$8.45
48 x AA Alkaline Battery	$18.98	1	$18.98
Nordic Dev Board	$39.00	1	$39.00
PCB	$21.73	3	$65.19
Module Housing	FREE	FREE	FREE
Total Cost			**$270.77**

Ultrasonic Unit Cost

Item	Unit Cost
3 x AA Alkaline Battery	$1.19
PCB	$21.73
Module Housing	FREE
Total Cost	**$22.92**

CV Unit Cost

Item	Unit Cost
Arducam 5 MP OV5647	$14.99
Raspberry Pi 3 Model B+	$35.00
DROK Voltage Converter	$12.16
12V Battery Pack	$4.00
16 GB Micro USB	$8.45
8x AA Alkaline Battery	$4.75
Module Housing	FREE
Total Cost	**$79.35**

Future Improvments

- Computer Vision Improvements
  - User friendly tool for system installer to define spots
  - Don't use computer vision
    - Cost
    - Complicated software trying to replace simple hardware
- Ultrasonic Sensing Unit Improvements
  - Could use improved manual mesh networking algorithm
  - Bluetooth Mesh not feasible – high power draw
  - High power draw when scanning for multiple devices
    - But, sensors may be able to connect to 1 other sensor in a chain formation with minimal power increase

QUESTIONS?