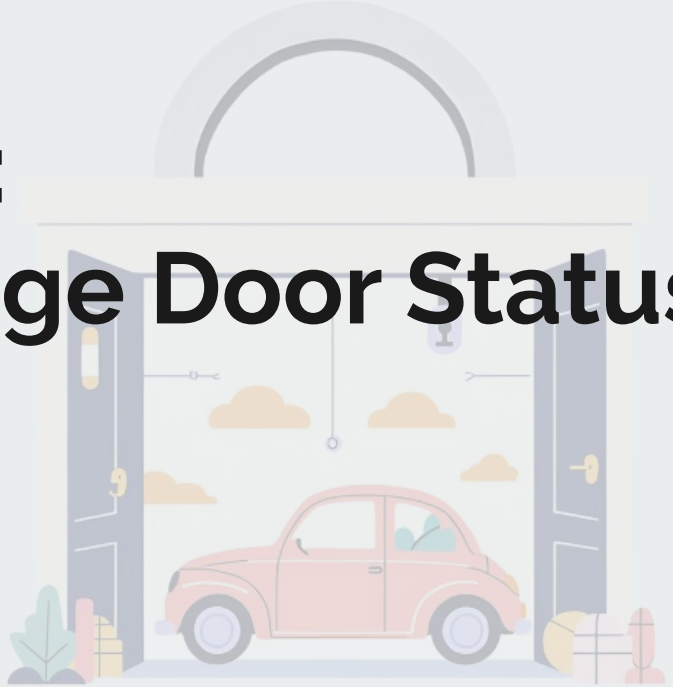
Door*Sure*:
The Garage Door Status Detector



Group 22
Senior Design

Meet The Team

Mina Ghandour

Electrical Engineering

Khang Nguyen

Electrical Engineering

Felix Liu

Computer Engineering

Andrea Rosa

Computer Engineering

Project Motivation

- Risks behind an open garage door
  - Major security risk: 2.5M burglaries in 2024, $3.4B in losses (
  - Weather and wandering animals can cause property damage
- Existing products are locked behind a company brand (ie. MyCha)
  - Universal solution
- Combine smart security innovation into a single device:
  - Real-time software and IoT integration
  - Remote status checks, alerts, and control
  - AI powered object identification
  - Camera monitoring

Goals and Objectives

Our project aims to expand on pre existing products and create a more cost-effective, user friendly, and universal solution to garage door monitoring.

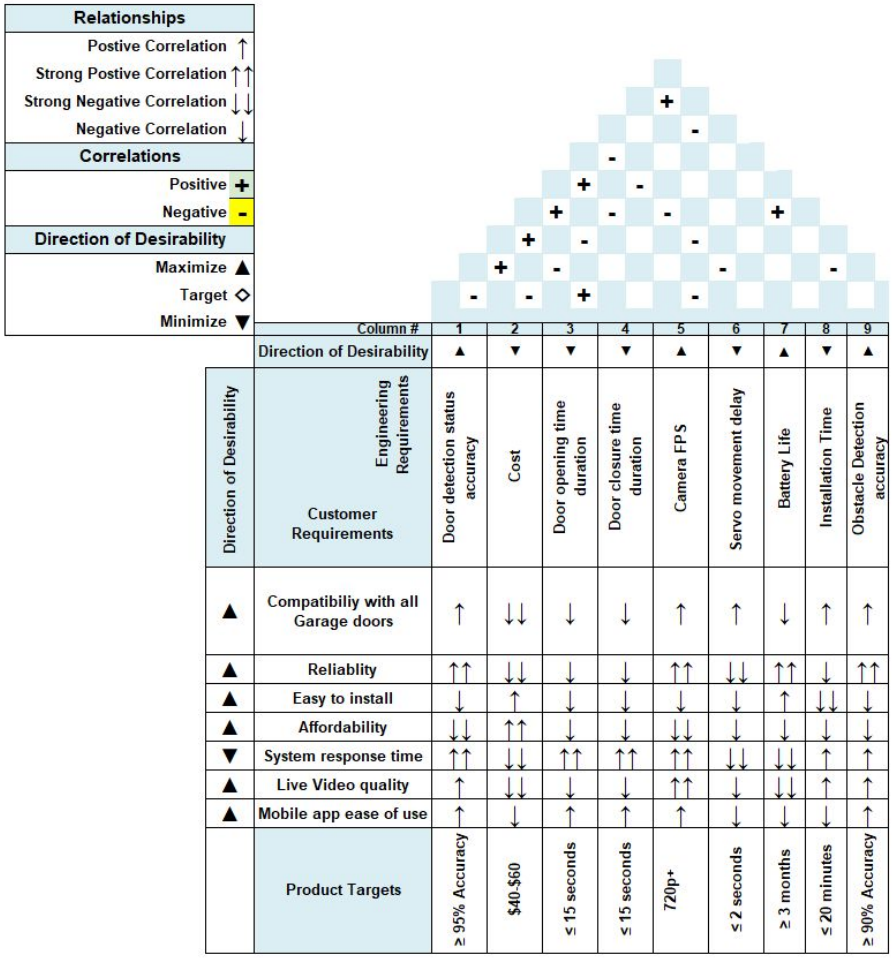
- Basic Goals
  - Constant and accurate access to their garage door's current status.
  - Will be able to alter the status of the garage door regardless of their location.
  - Receive notifications on garage door position changes
  - Not allow 'close' if there is an obstruction
- Advanced Goals
  - View live camera feed on accompanying software
- Stretch Goals
  - AI object recognition to identify object causing obstruction
  - Notification alerts based on user preference

Specifications

Parameters	Target Value
Garage Door Status Detection	≥ 95% Accuracy
Servo Movement Delay	≤ 2 seconds
Obstacle Detection accuracy	≥ 90%
Obstacle Object Identification accuracy	≥ 75% Accuracy
Battery Life	≥ 3 months
Operating Temperature	-20°C to 60°C
Operating Voltage	3.3V - 5V
Overall Power Consumption	~2W - 6W
Unit Cost	$40-$60

House of Quality

- Keep costs low
-



Hardware

Hardware Block Diagram

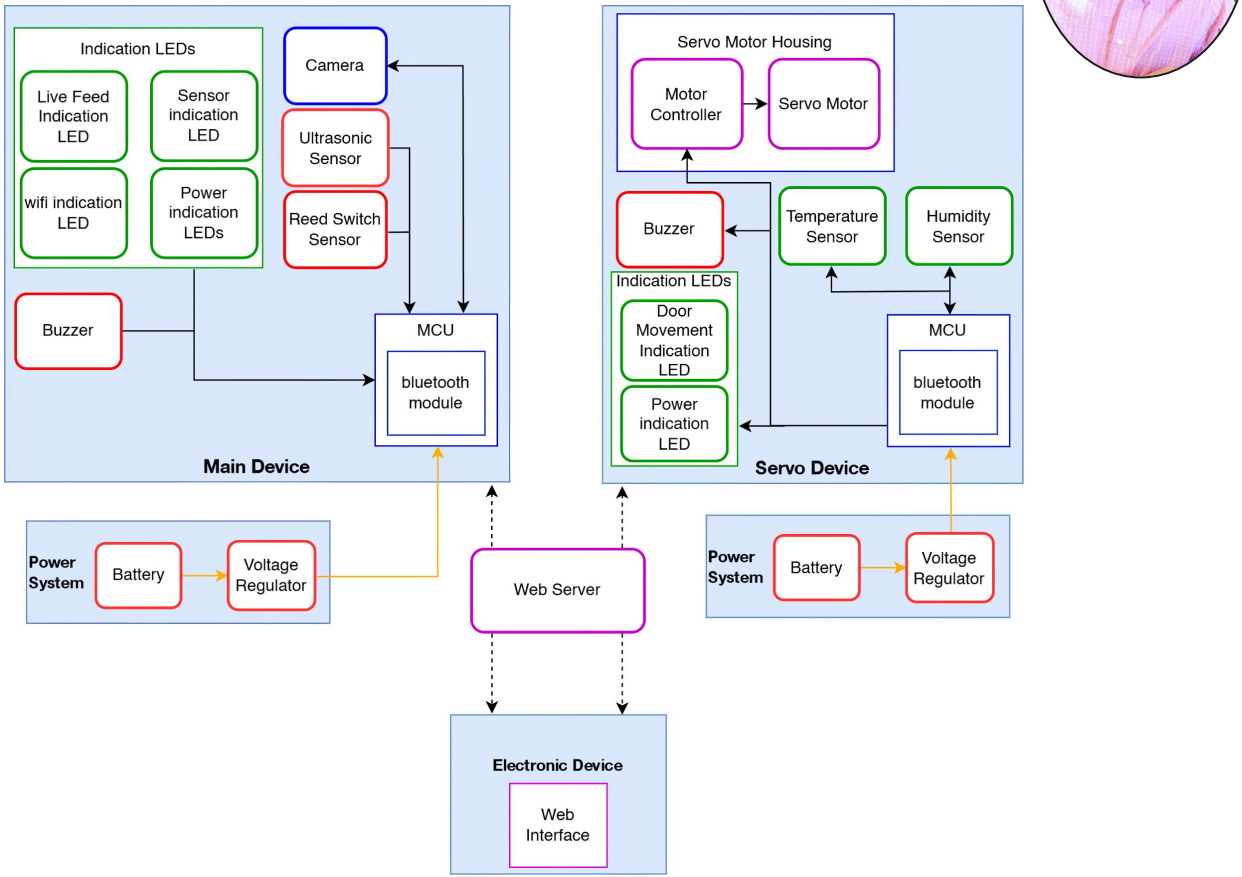
Legend

Wireless

Wired

Power

Mina Ghandour
Felix Liu
Khang Nguyen
Andrea Rosa



Microcontroller Technology Overview

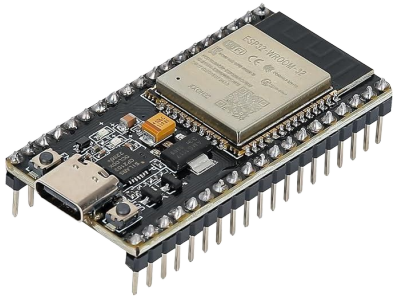
- Prioritized on MCU and development kits with wireless connectivity built in
- Which MCU provided the best specifications with reasonable and low cost?
- MCU of choice: ESP32

MCU and Devkit	ESP8266 (NodeMCU)	ESP32 (ESP32 WROOM)	BCM2835 (Raspberry Pi Zero W)	RP2040 (Raspberry Pi Pico W)	RP2350 (Raspberry Pi Pico 2 W)
Price	$8	$9	$15	$4	$5
Wi-Fi	Yes	Yes	Yes	Yes	Yes
Bluetooth	No	Yes	Yes	Yes	Yes
Clock Speed	160 MHz	240 MHz	1 GHz	133 MHz	150 MHz
Flash Memory	4 MB	4 MB	None	2 MB	4 MB
RAM	64 KB	520 KB	512 KB	264 KB	520 KB
Operating Voltage (V)	3.6V	3.6V	5V	5V	5V

Microcontroller Technology Selection

WHY ESP32-WROOM ?

- Low cost ($9)
- Wireless connectivity built in
- Easy integration
- Energy efficient
- Clock speed: 240 MHZ
- Memory(RAM) : 520 KB
- Flash Memory: 4 MB



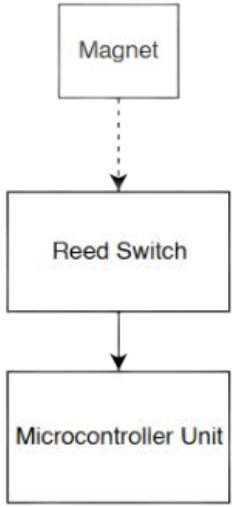
WHY ESP32-S3 ?

- Flash ram of ESP32-WROOM was insufficient for necessary camera functions
- More pins exposed for the camera
- Clock speed: 240 MHZ
- Flash memory: 8 MB
- PSRAM: 8MB (Needed for the camera)
- More expensive ($15)

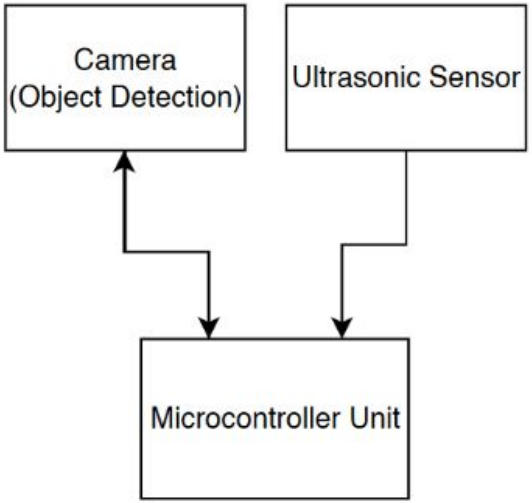
Door Position Detection Sensor Technology

Reed Switch MC-38

Sensor Type	Description	Pros	Cons
Reed Switch	Use a magnet to detect open/closed states	-Low cost -Low power draw -Reliable	-Need precise alignment -Only detect open/close
Hall Effect Sensor	Detects magnetic field changes	-No wear and tear -More precise	- High power draw -Requires calibration
Limit Switch	Mechanical switch that detects physical contact	-Simple and reliable -Low cost	-Wear over time



Object Detection Technology



Sensor Type	Description	Pros	Cons
Ultrasonic Sensor	Measuring distance using sound waves	-Good accuracy -Works in many lighting conditions	-Affected by environmental noise -Power consuming
Infrared Sensor	Detects based on infrared reflection	-Low cost -Simple to implement	-Poor performance in bright light -Short range
Lidar Sensor	Laser to measure the distance	-High accuracy -Works in all lighting conditions	-Cost –Higher power consumption
Camera with AI	Processes images to detect object	-Versatile -More visual information	-Processing power -Privacy concerns

Camera Technology Selection

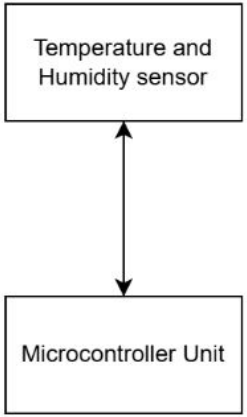
- Used for both object detection and live feed
- Originally used OV2640 due to low cost and good image quality output
- Switched to OV5640 due to limited amount of OV2640 breakout boards

Camera Module	Resolution (MP)	Lens size	Library support	Power requirement	Cost
OV2640	2	¼”	High (Most used and supported)	Moderate	$8.99
OV3640	3	¼”	Moderate	Moderate-High	$13.63
OV5640	5	¼”	Moderate	High	$30.09
OV7670	0.3	⅙”	Low	Low	$2.10
OV7725	0.3	¼”	Moderate	Low	$4.72
NT99141	1	¼”	Low	Moderate	$21.58

Temperature and Humidity Technology

- Due to its low cost and fair amount of accuracy and deviation, we chose the DHT11 for our temperature and humidity sensor.

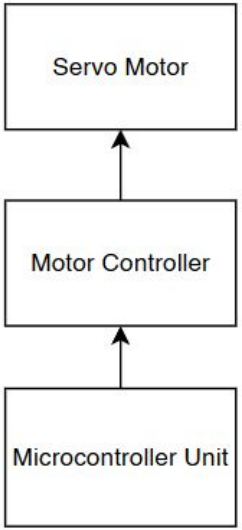
Sensor	DHT11	DHT22	SHT7
Temperature range (°C)	-20 - 60	-40 - 80	-40 - 123.8
Temperature Deviation (°C)	+-5	+-0.5	+-0.5
Humidity Range (RH)	5-95	0-100	0-100
Humidity Deviation (RH)	+-5%	+-2%	+-3%
Power Requirement (V)	Min 3.3V, Max 5V	5V	Min 2.4V, Max 5V
Cost	$5	$6.25	$30



Motor Technology

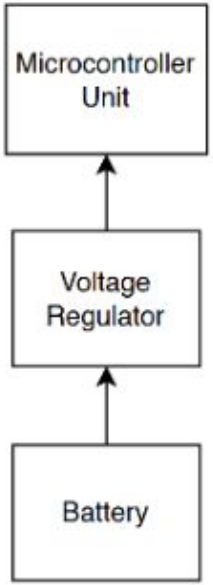
- Servos chosen for their high accuracy through PWM (pulse width modulation)
- MG90 servo was chosen for their all metal build quality

	SG90	MG90s	MG90D	MG996R	RDS3225
Stall Torque (kg/cm)	1.4 at 4.8V 1.9 at 6.0V	1.8 at 4.8V 2.2 at 6.0V	2.1 at 4.8V 2.4 at 6.0V	9.4 at 4.8V 11 at 6.0V	24 at 5.0V 28 at 6.8V
Speed (seconds/60 degrees)	0.11 at 4.8V 0.08 at 6.0V	0.10 at 4.8V 0.08 at 6.0V	0.10 at 4.8V 0.08 at 6.0V	0.17 at 4.8V 0.14 at 6.0V	0.19 at 5V 0.14 at 6.8V
Gear Material	Plastic	Metal	Metal	Metal	Full metal
Weight (g)	9	13.4	13.5	55	60
Dimensions (mm)	22.2 x 11.8 x 31	22.4 x 12.1 x 28.5	22.8 x 12.2 x 28.5	40.7 x 19.7 x 42.9	40 x 20 x 40.5



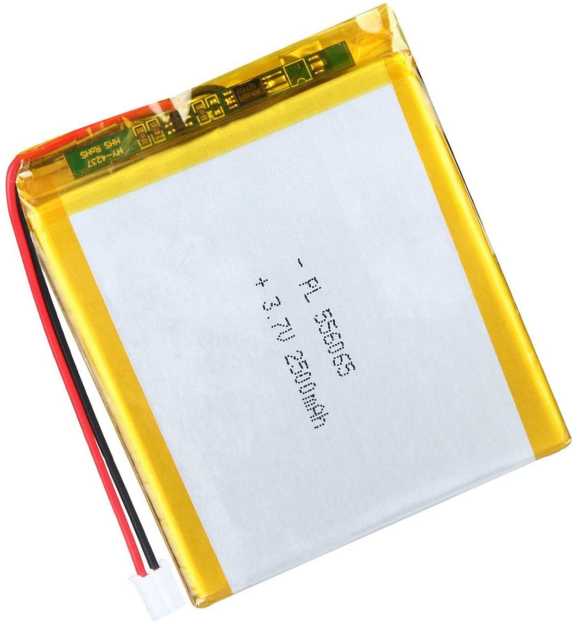
Power - Battery Technology

Battery Type	Description	Pros	Cons
Alkaline (AA/AAA)	Common disposable batteries	-Low cost -Availability	-Lower capacity -Less lifespan
Lithium	Primary Batteries	-Long lifespan	-higher cost
Carbon-Zinc	Primary Batteries	-good for low drain systems	-Low shelf life -Less capacity
Lithium-ion	High energy density	-Longer lifespan -Lightweight -rechargable	-Higher cost



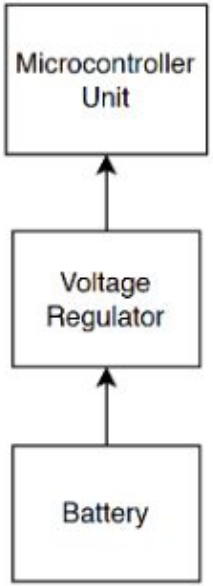
Battery Selection

- Current choice: 556065 Li-Po battery
- Originally considered CR123 battery due to convenience but had low power output compared to our current choice



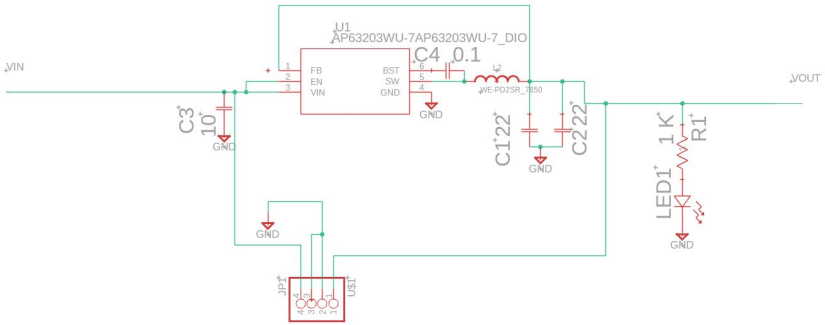
Power - Voltage Regulator Technology

	Linear	Switching
Efficiency	Low	High
Heat Loss	Large	Minimal
Voltage Conversion	Step-Down	Step-Up, Step-Down
Design	Simple	Complex
Cost	Cheap	Expensive

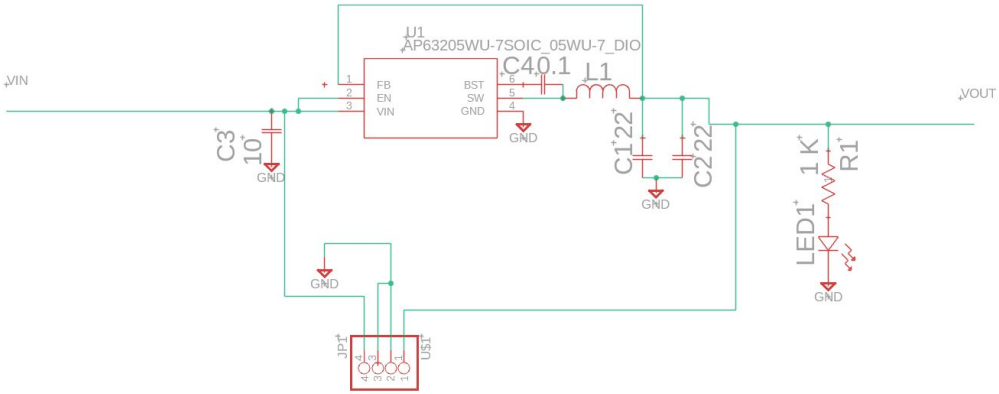


Schematic Designs

3.3v buck regulator; AP63203

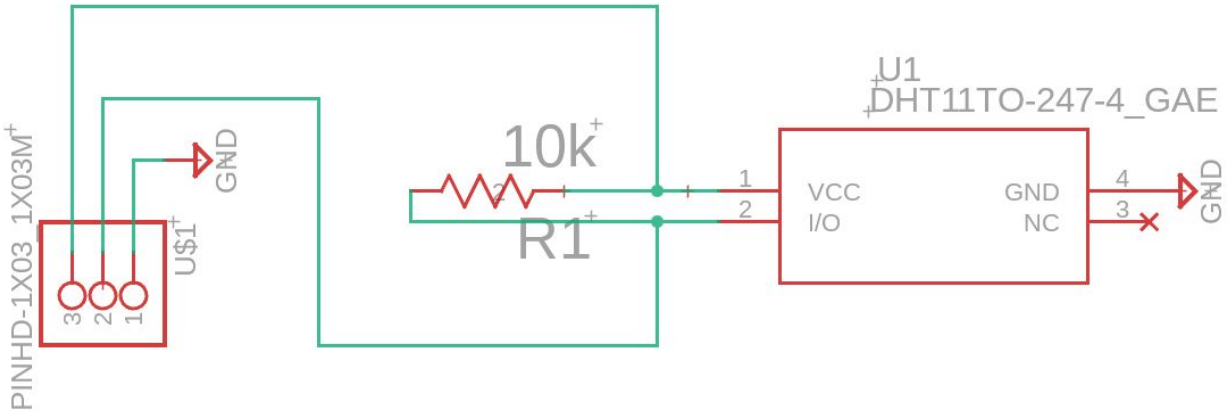


5v buck regulator; AP63205



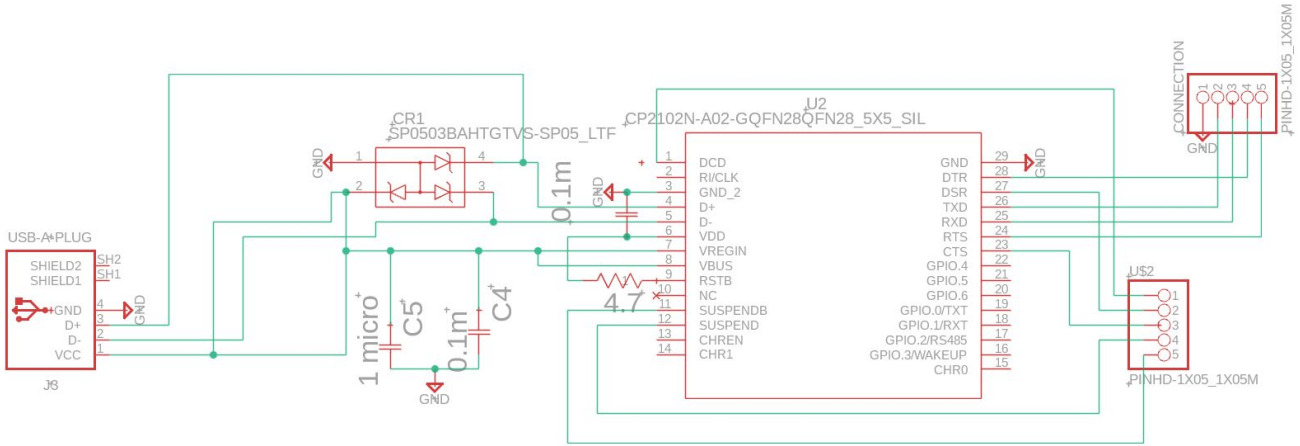
Schematic Designs

DHT11

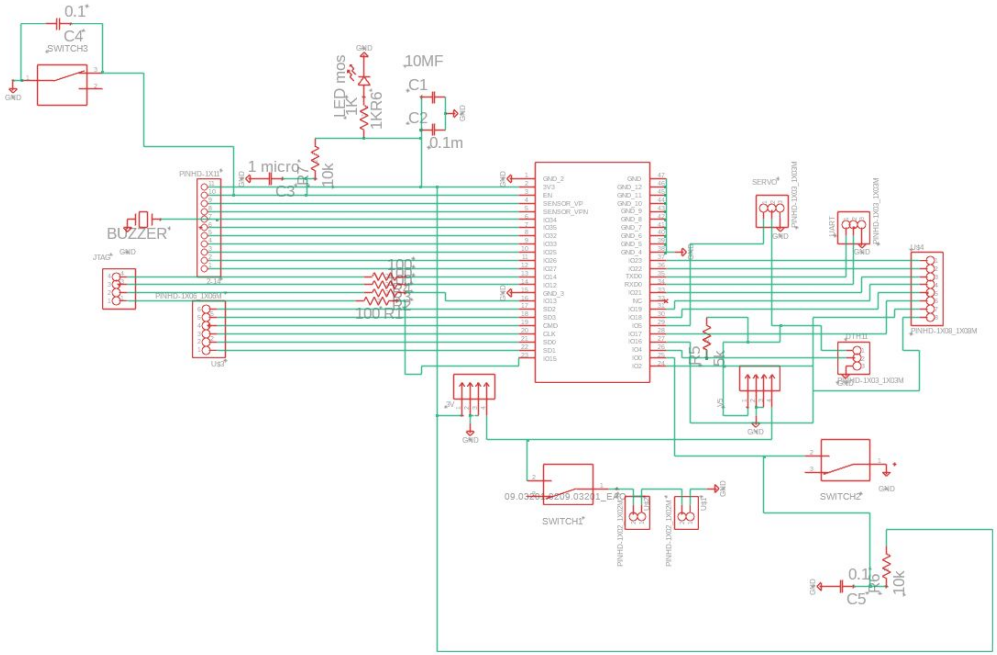


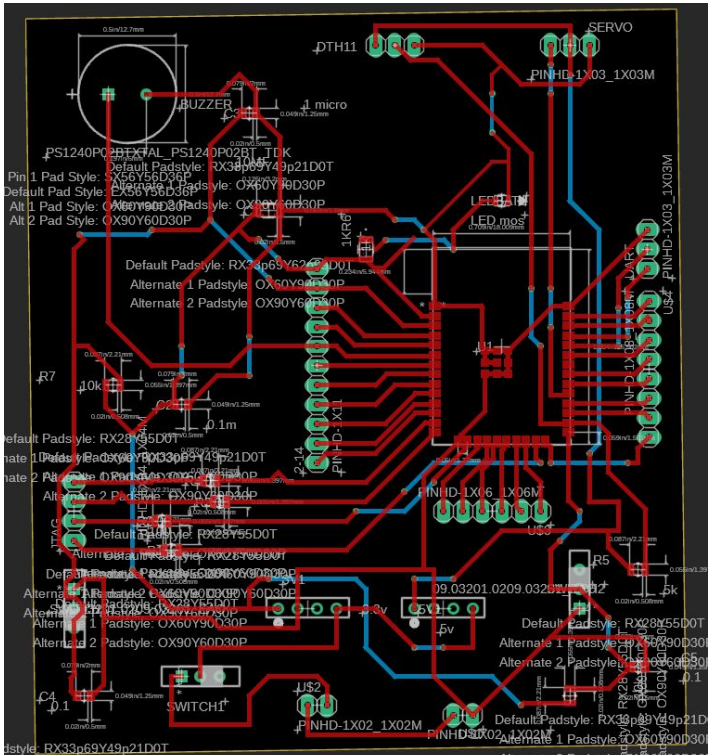
Schematic Designs

USB to UART

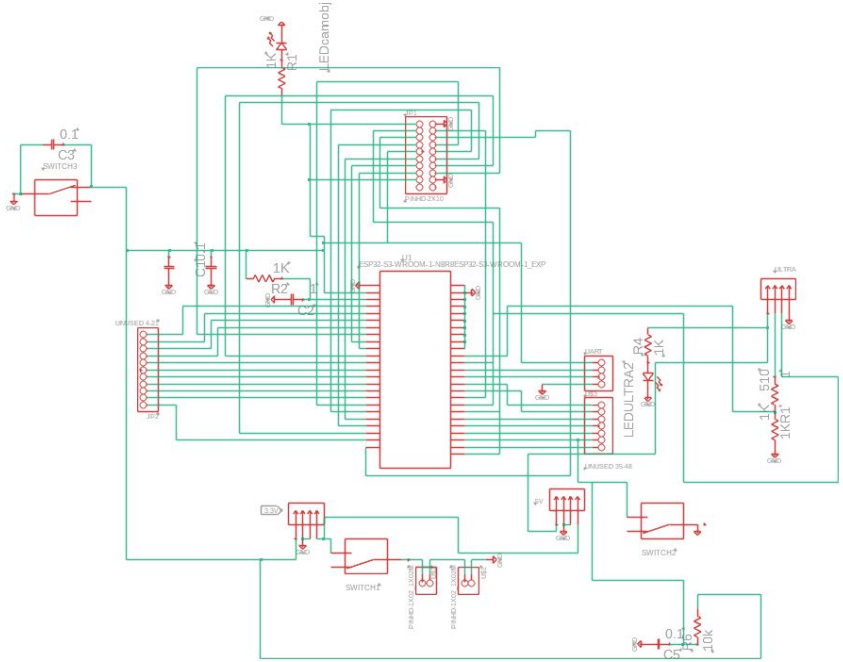


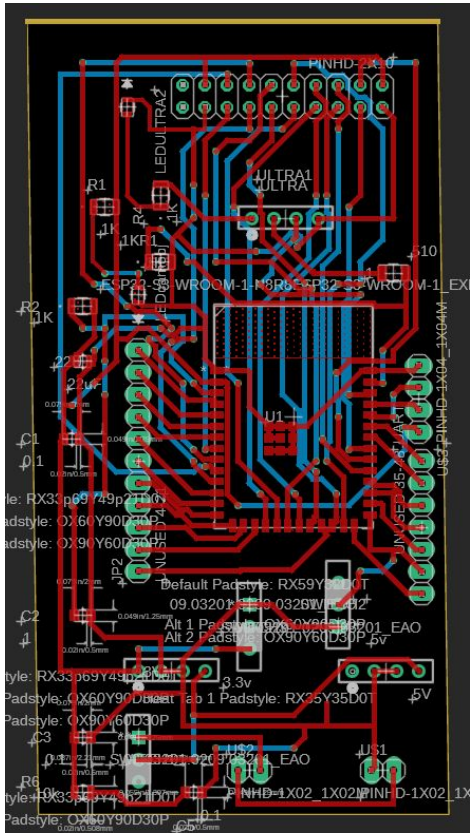
Servo Board Schematic and PCB Design





Main Board Schematic and PCB Design





Software

Platform Technology

Web Based Application

- low development and publishing costs
- No app store restrictions
- High cross-platform compatibility: maximizes universal user availability

	iOS	Android	Web-Based
Development Cost	High, requires Mac, Xcode, fees	Lower	Lowest
Publishing Cost	$99/year	$25 flat fee	No app store distribution
Cloud Server Integration	Seamless with Apple only	Easy integration with third-party cloud services	Fully dependent on cloud-based interactions
App Store Restrictions	Strict and time-consuming	Faster approvals, less restrictive	N/A
Cross-Platform Compatibility	Limited	Limited	High

Database Technology

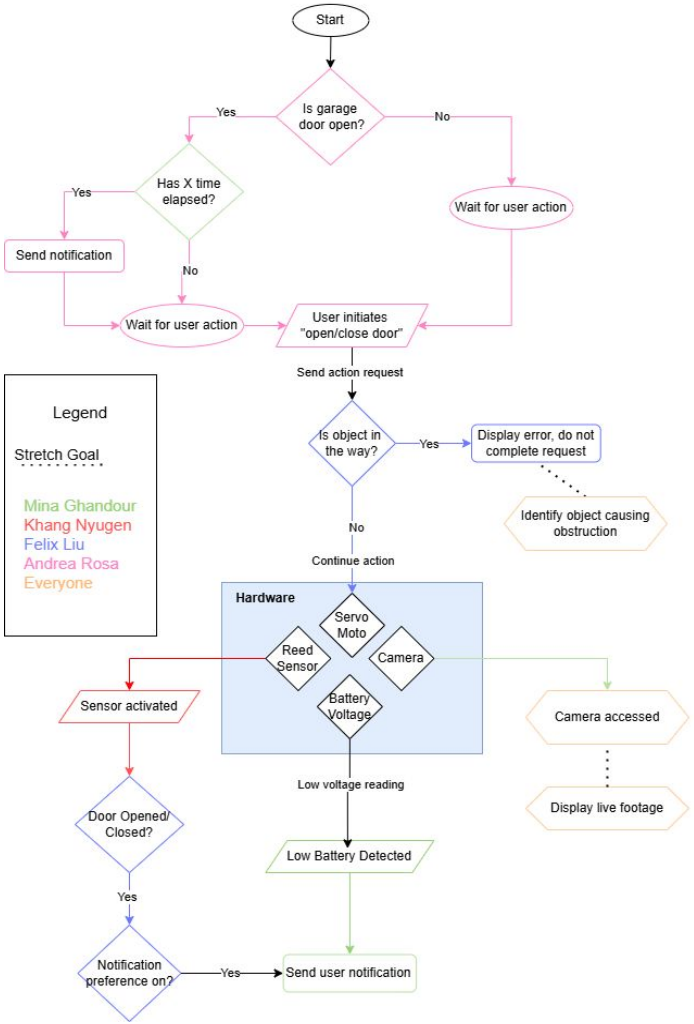
	Cloud Bigtable	Cloud Datastore	Firestore	Firebase RTDB
Data Synchronization	No real time	No real time	Real-time	Real-time
Offline Support	None	Limited	Stronger, automatic syncing	Basic
Data Structure	Key-value Wide column	Entities and Properties	Documents and collections	JSON tree
Query	Single-row	Simple, indexing	Advanced, indexing	Simple filters

AI-Based Detection Technology

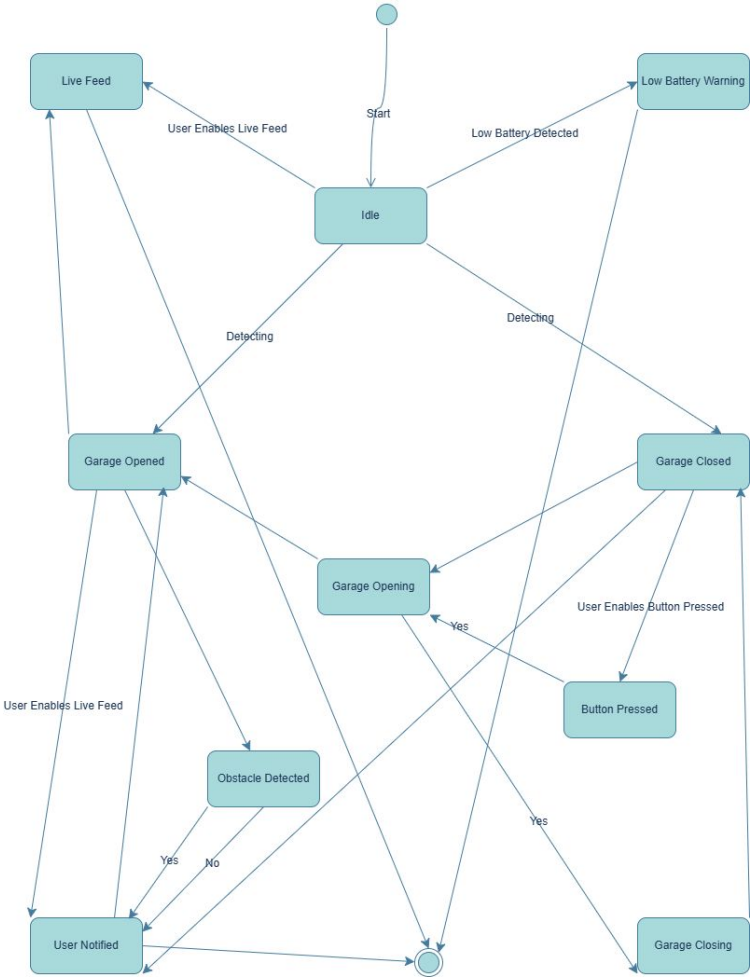
- Initial selection: Edge Impulse
- After testing, running locally with the ESP32-WROOM had low detection results
- Implemented Google Gemini for faster and more accurate identifications

Feature	TensorFlow Lite	OpenCV	Edge Impulse
ESP32-CAM Compatibility	Limited (TELite Micro too constrained for object detection)	Not compatible (requires more RAM/OS than ESP32-CAM has)	Designed for microcontrollers like ESP32-CAM
Offline Inference	Yes (for simple models)	No (requires external processing)	Yes (after training)
Model Complexity Support	Only very simple classification models	Not on ESP32-CAM	Automatically optimized for microcontrollers
Ease of Use / Setup	Requires many tools and technical knowledge	Complex setup and external hardware needed	User-friendly web interface; minimal ML knowledge needed
Training Requirements	Requires external tools and expertise	External training required	Online training via browser
Cost & Resource Overhead	Yes	No	Yes

System Flowchart

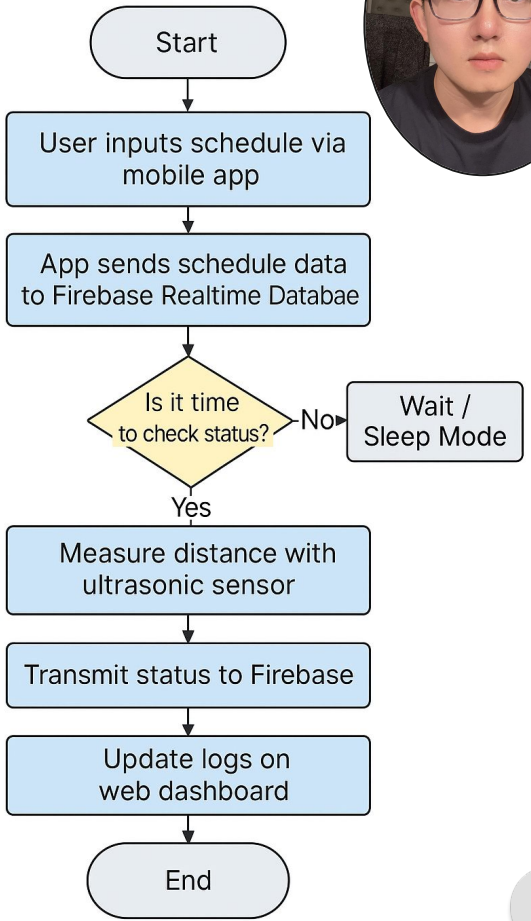


State Diagram

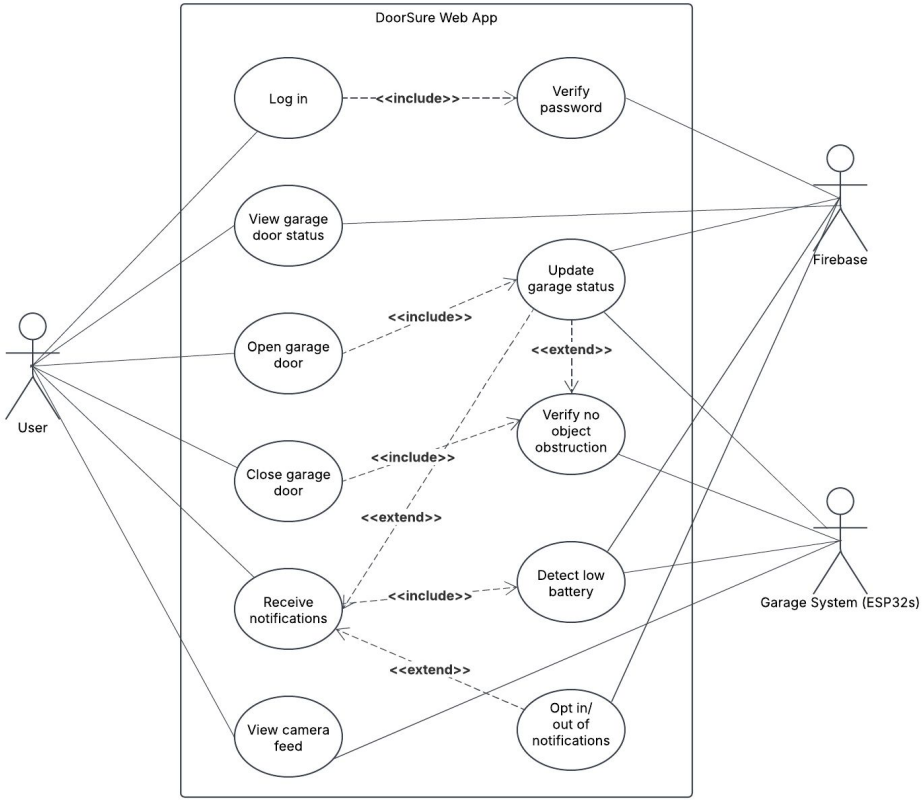


Project Activity Diagram

- User interacts with DoorSure system via web app.
- System checks current garage door status.
- User can request to change door position.
- System verifies for obstructions before changing door.
- Notifications sent to user on status updates.



Use Case Diagram



Administrative Content

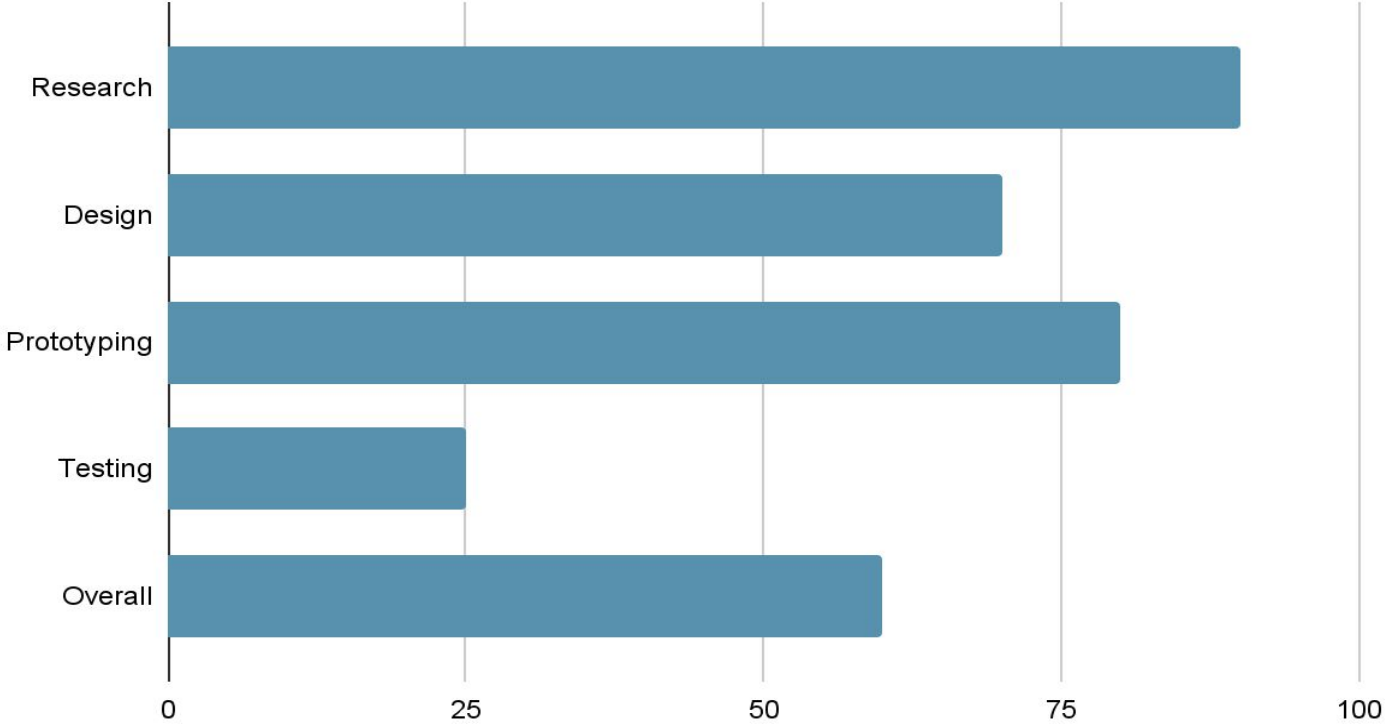
Budget

Components	Details	Vendor	Quantity	Unit price	Total price
Microcontroller	ESP 32s wroom 2.4 GHZ dual mode WIFI + bluetooth dual-core microcontroller integrated with antenna RF AMP filter	Amazon	3	$8.99	$26.96
Microcontroller	ESP32 S3 Development Board N8R8	Amazon	2	$7.59	$15.19
Ultrasonic Sensor	HC-SRO4 Ultrasonic Sensor module	Amazon	1	$6.99	$6.99
Camera	Waveshare OV5640 Camera Board	Amazon	1	$24.99	$24.99
Reed switch	4 pcs door sensor magnetic switch	Amazon	1	$7.99	$7.99
Servo motor	MG90 180-degree servo motor 4PK	Amazon	1	$13.99	$13.99
Temperature and Humidity Sensor	DHT11 Sensors	Amazon	1	$9.99	$9.99
Replaceable batteries	556065 3.7V Lipo battery 2500 mAh	Amazon	2	$11.49	$22.98
Battery charger	3.7V Lipo Battery Charger	Amazon	1	$5.99	$5.99
Colored LEDs	100PK of LEDs for prototyping	Amazon	1	$4.99	$4.99
PCBs	Printed circuit boards	JLCPCB	1	$195	$195
Other Components	Resistors, capacitors, inductors and regulators	Digikey	1	$200	200
Total:					$535

Work Distribution

Andrea Rosa	Khang Nguyen
• Web App development • UI design • Servo motors	• PCB assembly • 3D design • Mini demo garage build
Felix Liu	**Mina Ghandour**
• Mini demo garage build • Camera integration • AI-Thinker	• PCB design • PCB assembly • UI design

Progress



Remaining Items and Plan for Completion

- Finish assembling PCB boards
- Test PCB boards and ensure hardware is working as expected
- Continue testing to ensure system specifications are met
- Add a login system to web application for additional security
- Refine web application UI for user-friendliness and intuitive navigation
- Build mini garage for live demo

Questions?