Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

Ember Bot:

A Fire Fighting Robotic Vehicle

ECEN403 Final Presentation

Team 30:
Jonathan Chen, Kevin Rivera,
Nancy Ramirez Castillo, Yuwen Zheng
Sponsor: Zian Wang

Project Overview

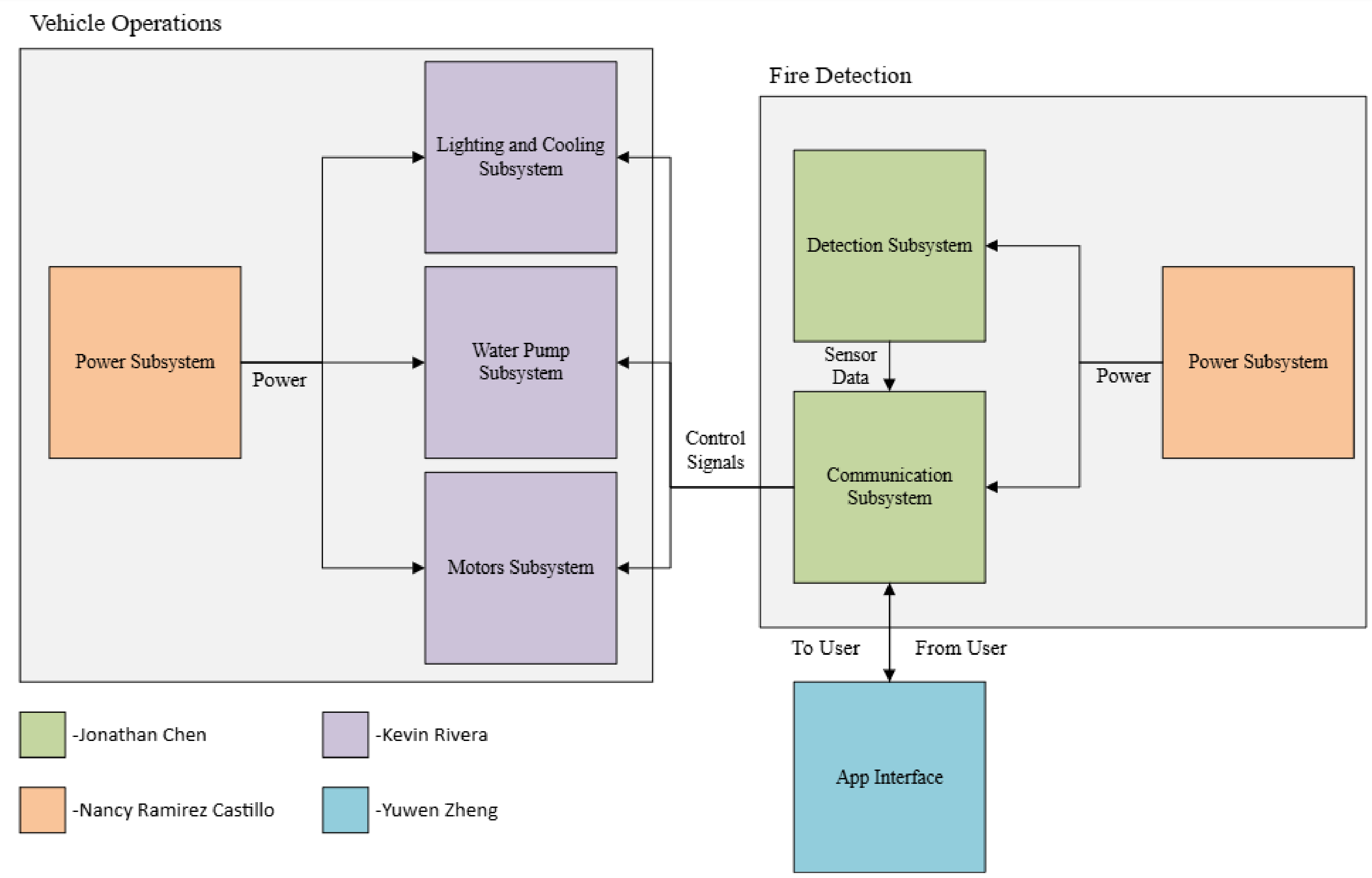
Problem Statement:

Traditional firefighting methods rely on human intervention, exposing personnel to extreme hazards such as heat, toxic smoke, and structural collapse. These settings can pose safety risks and potential response delays, especially in hard-to-reach areas.

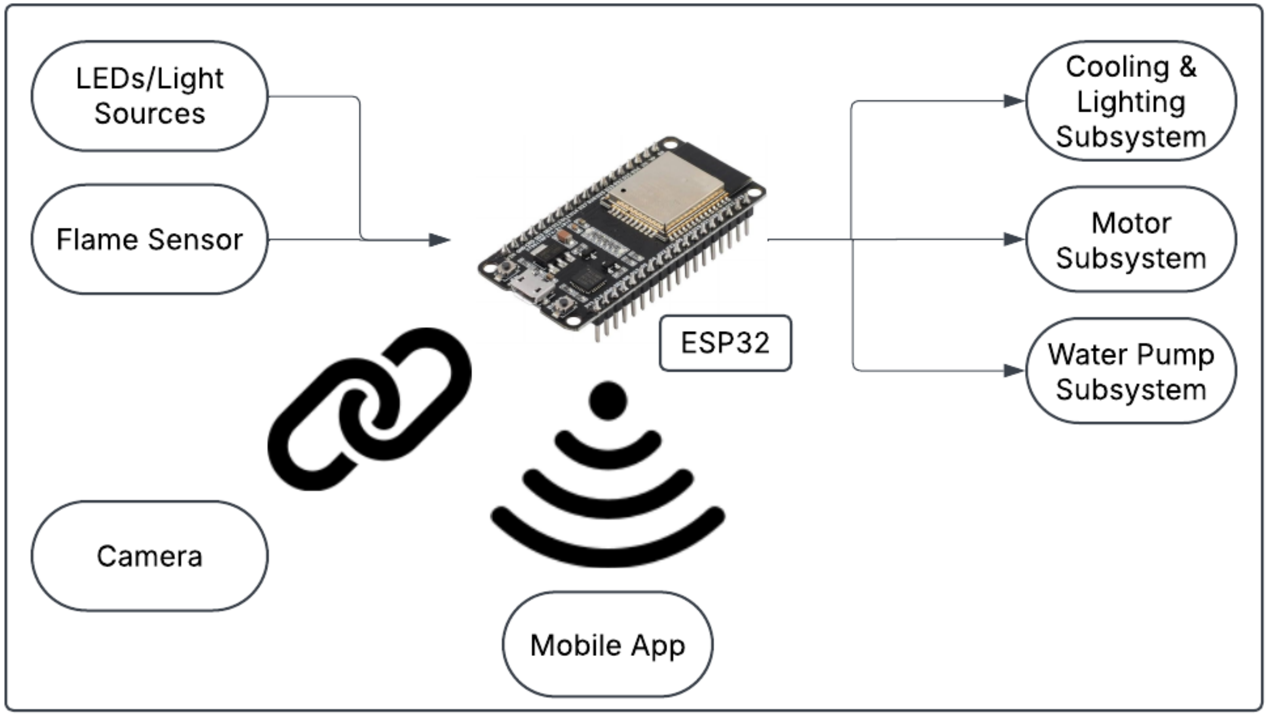
Solution proposal:

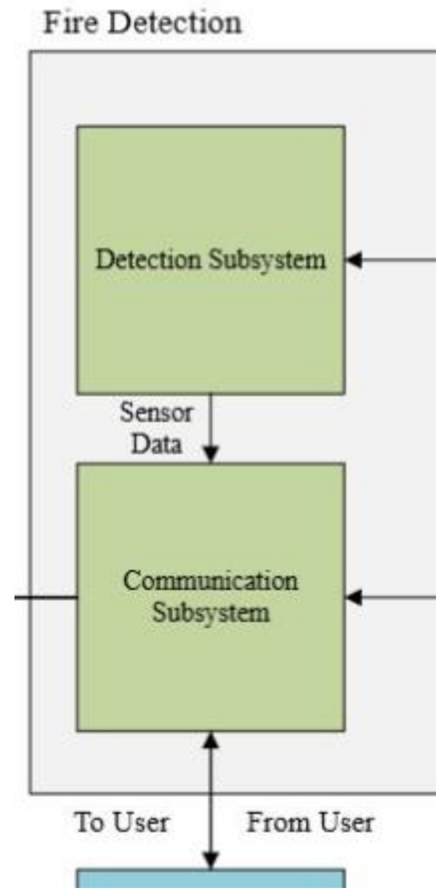
Ember Bot is a fire-fighting robotic vehicle designed to detect and extinguish small fires in high-risk areas through a mobile app. Equipped with IR sensors and a camera, firefighters will be able to control Ember Bot in areas deemed unsafe for humans.

System Overview



Microcontroller Subsystem





ECEN403 Subsystem Deliverables:

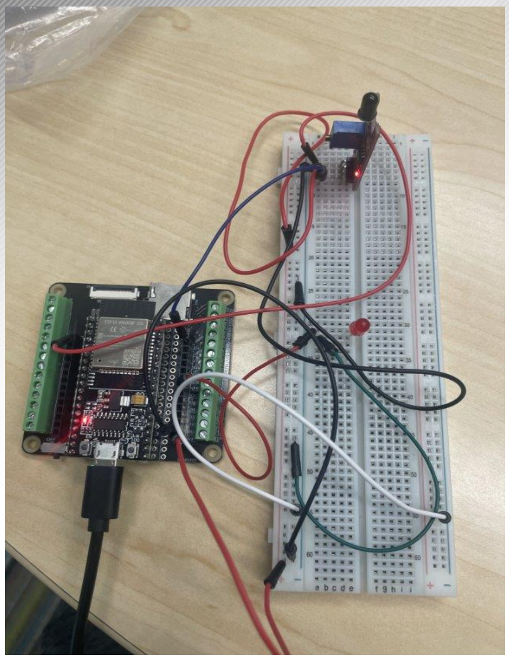
- Fire Detection
- Camera Live Streaming
- Light Source
- ESP32 Wi-Fi Access Point

KY-026

ESP32-CAM

Microcontroller Subsystem

Jonathan Chen



```
Setting AP (Access Point)…AP IP address: 192.168.4.1
KY-026 Flame Detection:
Analog Voltage Value: 14.3939 V;        Digital Threshold Value: Flame Not Detected
-----------------------------------------------------------------
Analog Voltage Value: 14.3597 V;        Digital Threshold Value: Flame Not Detected
-----------------------------------------------------------------
Analog Voltage Value: 14.2278 V;        Digital Threshold Value: Flame Not Detected
```

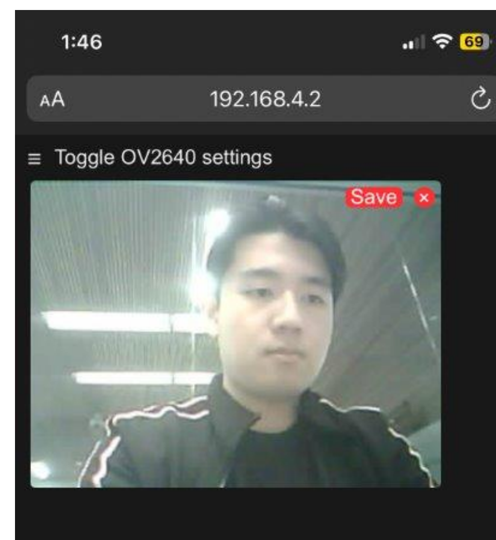
```
-----------------------------------------------------------------
Analog Voltage Value: 14.2229 V;        Digital Threshold Value: Flame Not Detected
-----------------------------------------------------------------
Analog Voltage Value: 14.2473 V;        Digital Threshold Value: Flame Not Detected
-----------------------------------------------------------------
Analog Voltage Value: 6.6276 V;         Digital Threshold Value: Flame Detected
-----------------------------------------------------------------
Analog Voltage Value: 5.6403 V;         Digital Threshold Value: Flame Detected
-----------------------------------------------------------------
```

Flame Detection & Wi-Fi Access Point

```
Camera Initialized Successfully!
WiFi connecting....
WiFi connected
Camera Ready! Use 'http://192.168.4.2' to connect
```

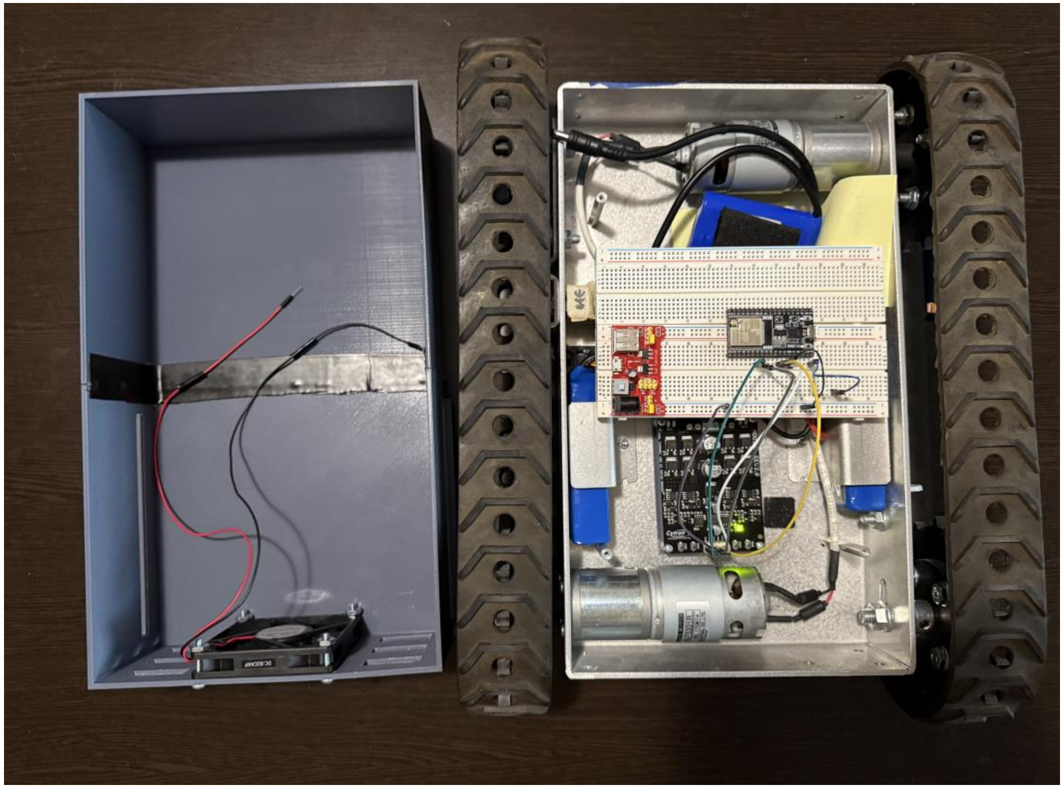
Live Camera Streaming

Test	Validation
Flame Detection	✓
Wi-Fi Access Point + Camera	✓



Vehicle Operations

Kevin Rivera

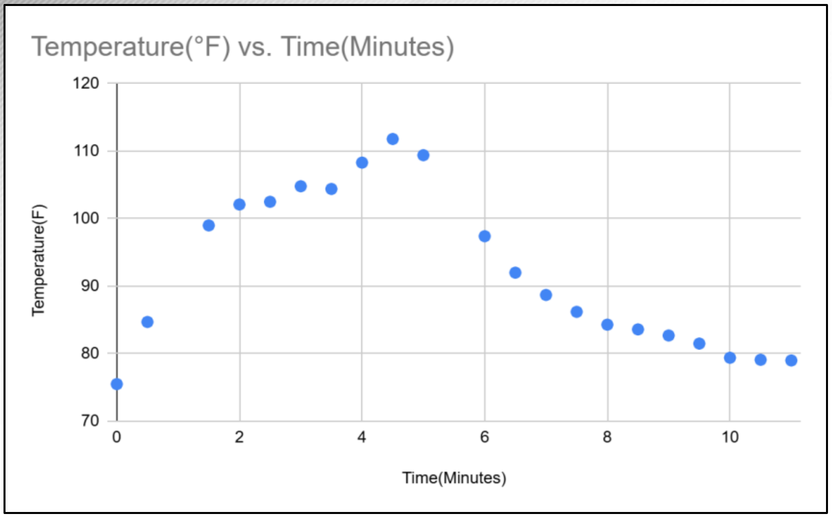


Test	Validation
Independent bidirectional motor control	✓
Frame to protect electronics from water	✓

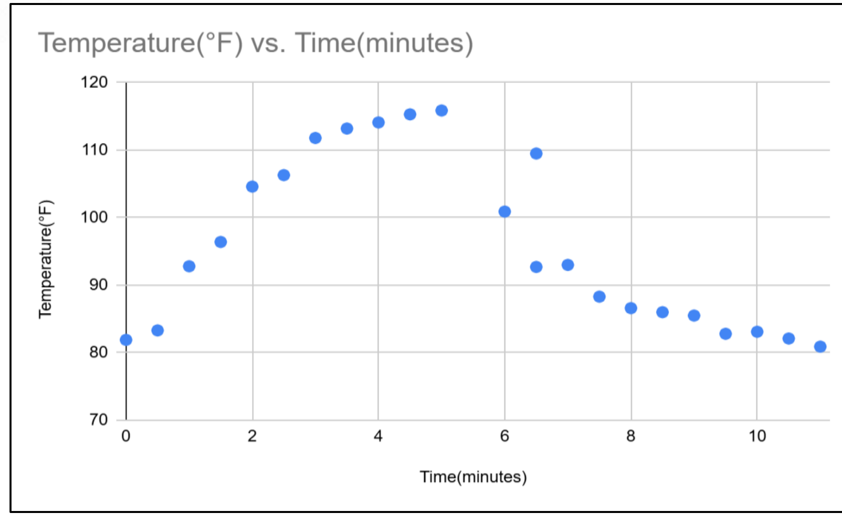
Vehicle Operations

Kevin Rivera

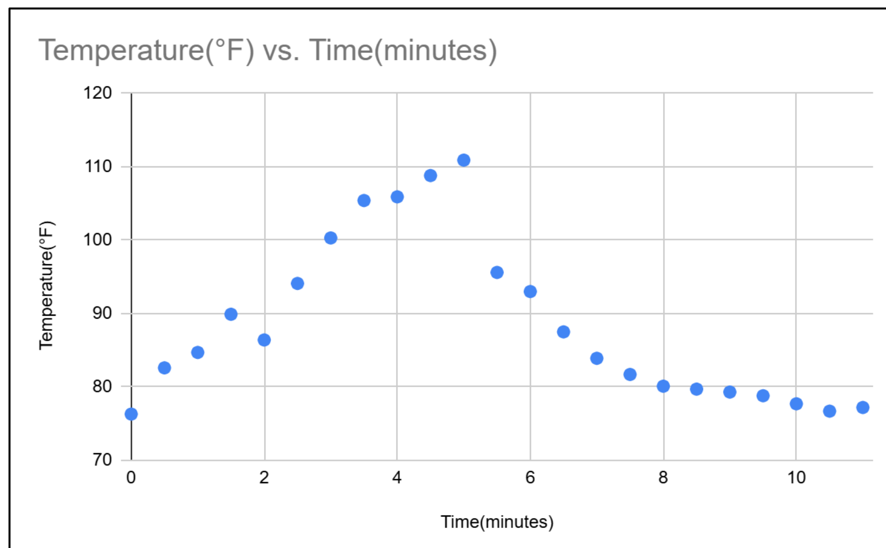
No frame placed. Avg temperature = 92.21



Frame placed. Avg temperature = 95.96



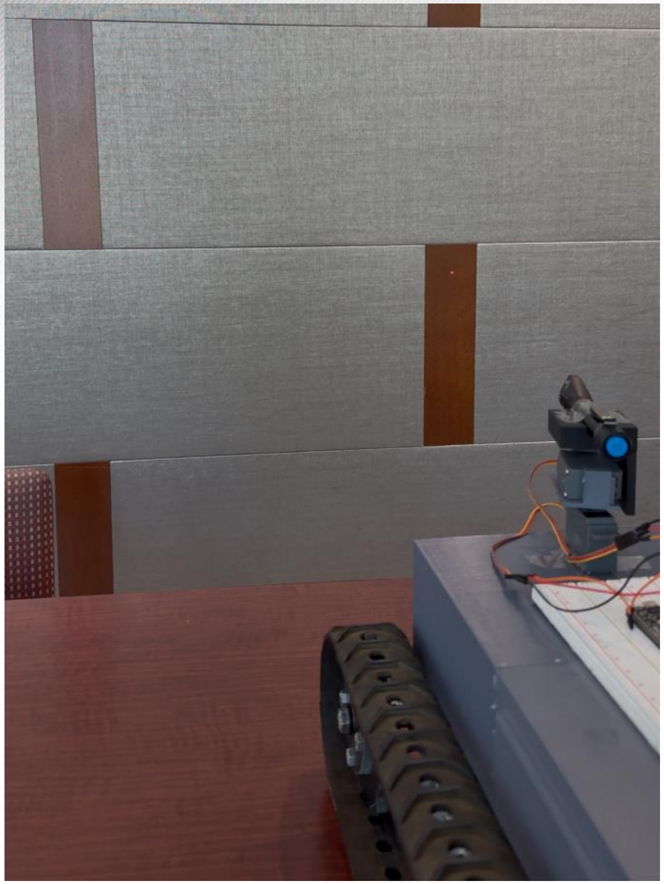
Frame placed and fan on 5V. Avg temperature = 88.54

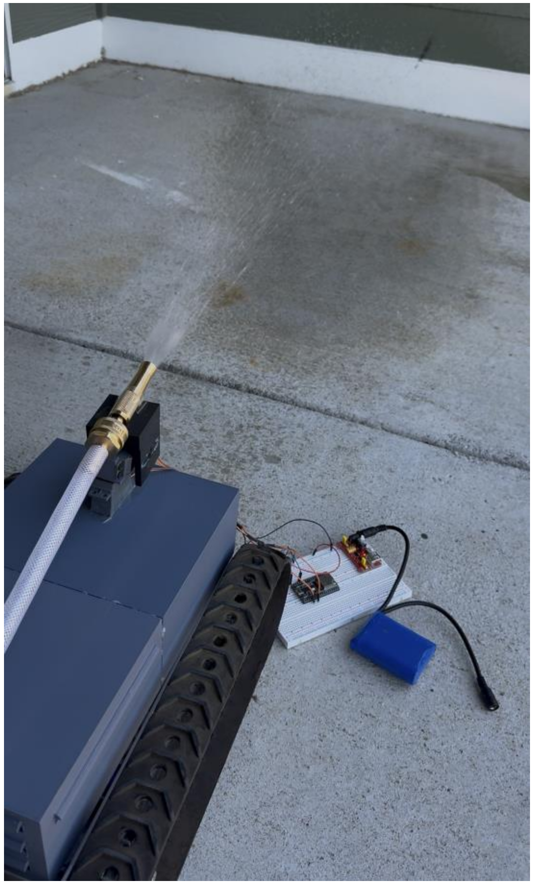


Test	Validation
Cooling Fan Implementation	✓

Water Pump System

Kevin Rivera

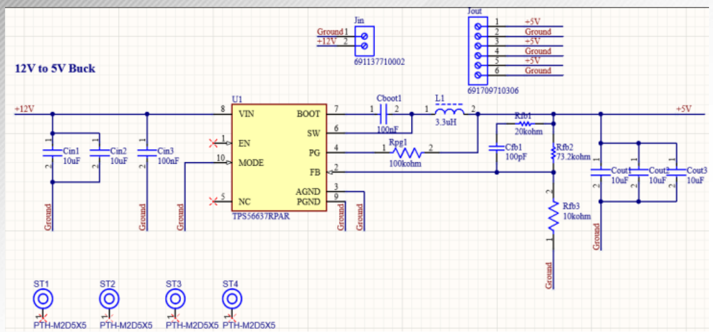


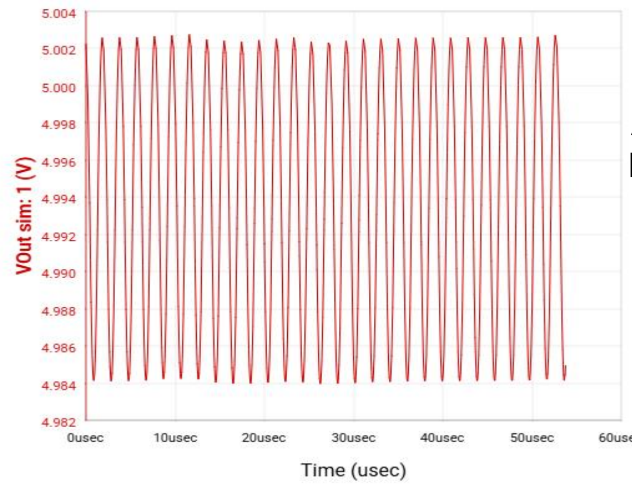


Test	Validation
Servo Movements	✓
Maximum Water Range	✓

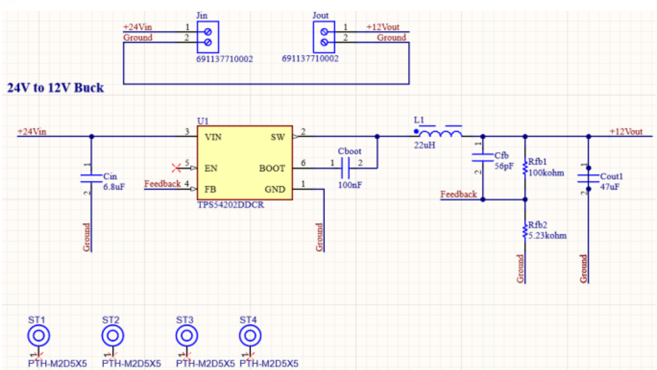
Power Subsystem

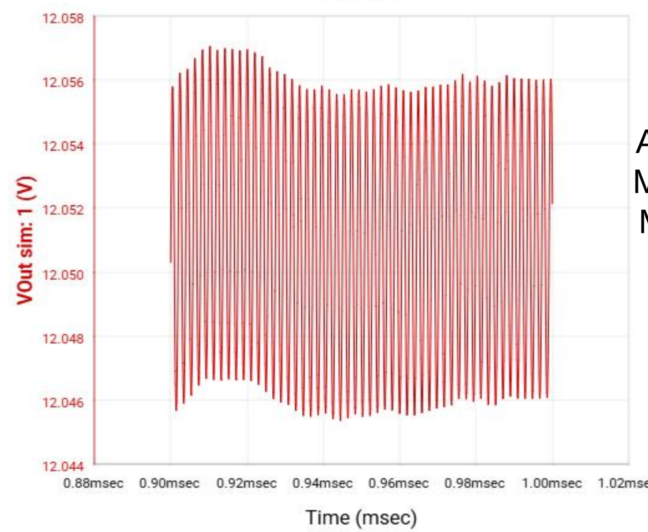
Nancy Ramirez Castillo





Avg. Vout = 5.01 V
Max. Vout = 5.07 V
Min. Vout = 4.90 V



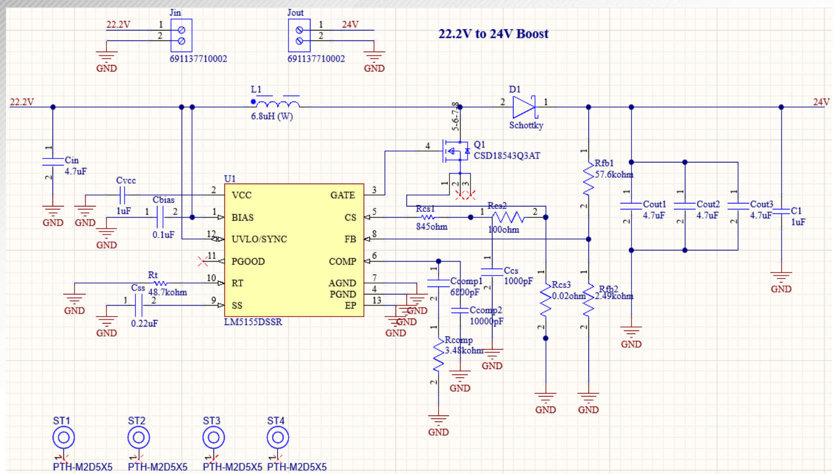


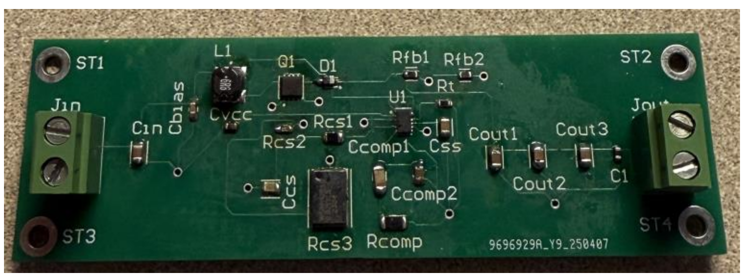
Avg. Vout = 12.05 V
Max. Vout = 12.55 V
Min. Vout = 11.52 V

Test	Validation
Simulation Verification	✓

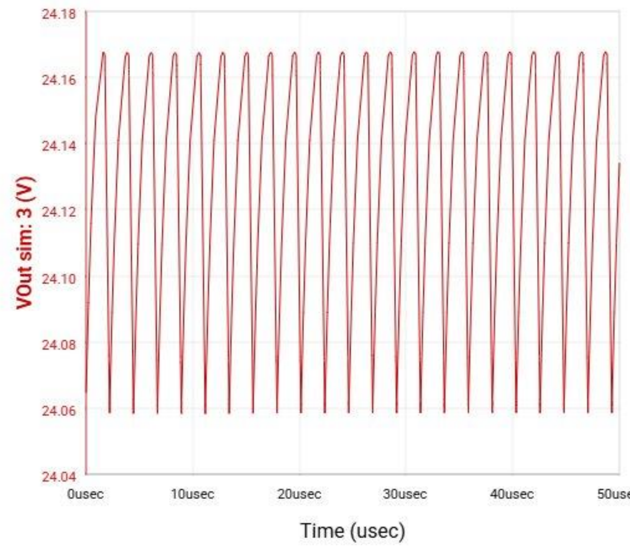
Power Subsystem

Nancy Ramirez Castillo

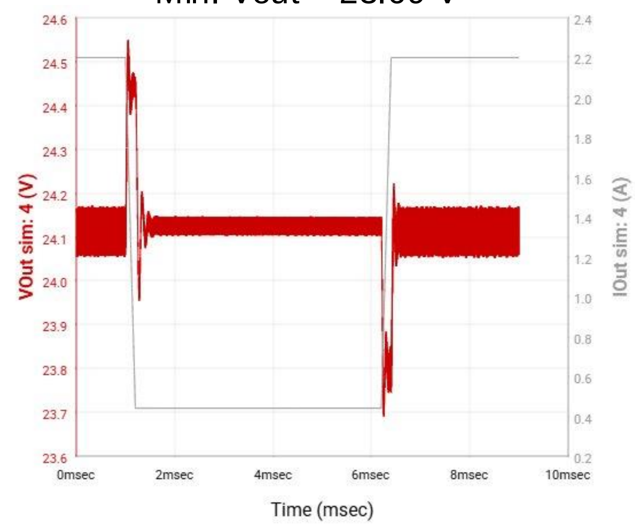




Test	Validation
Simulation Verification	✓



Avg. Vout = 24.13 V
Max. Vout = 24.55 V
Min. Vout = 23.69 V

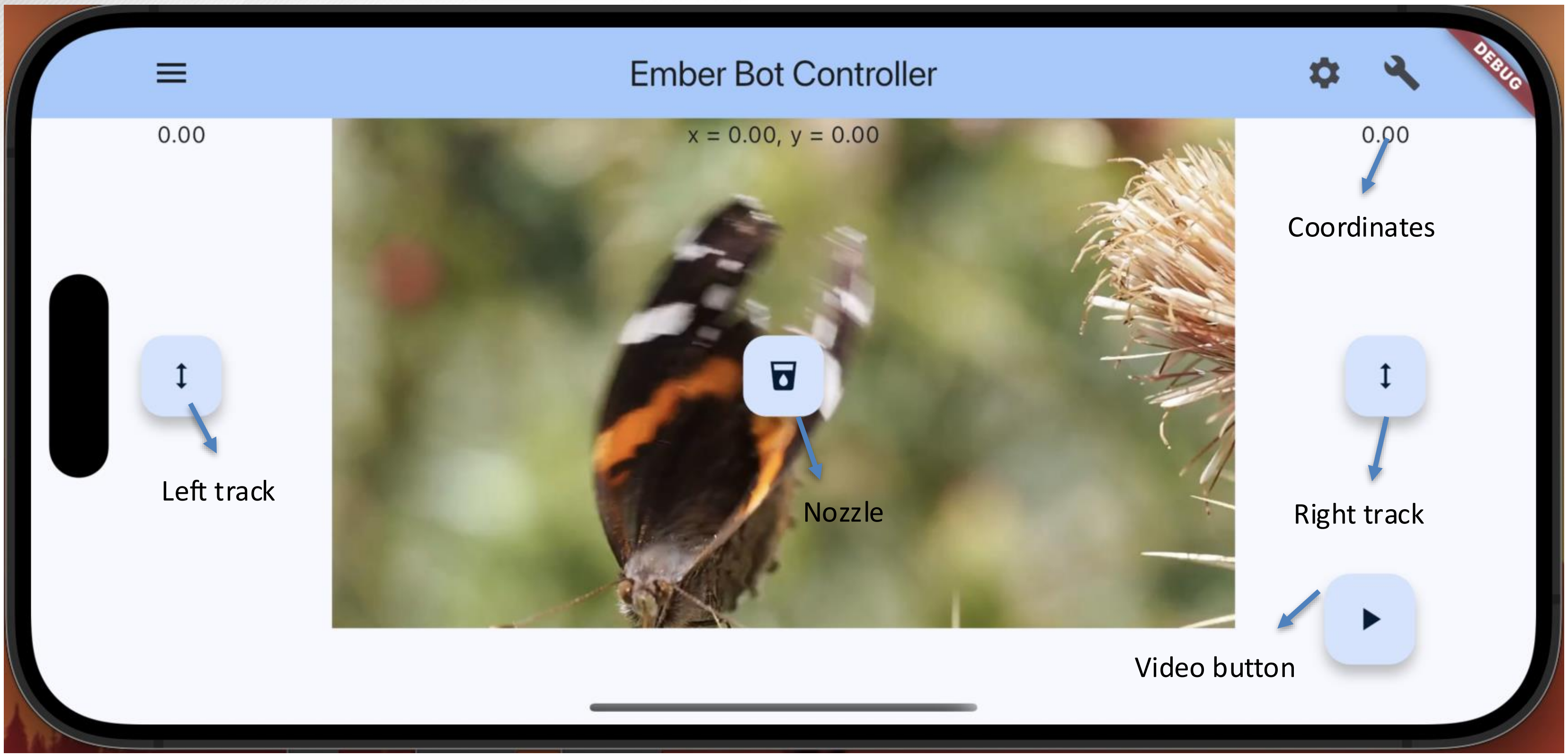


App Design

- Designed and built a mobile app as controller for Ember Bot
- Can be used on iOS & Android
- Communicate with Ember Bot via Wi-Fi
- Including live video streaming functionality
- User experience considered

App Interface

Yuwen Zheng

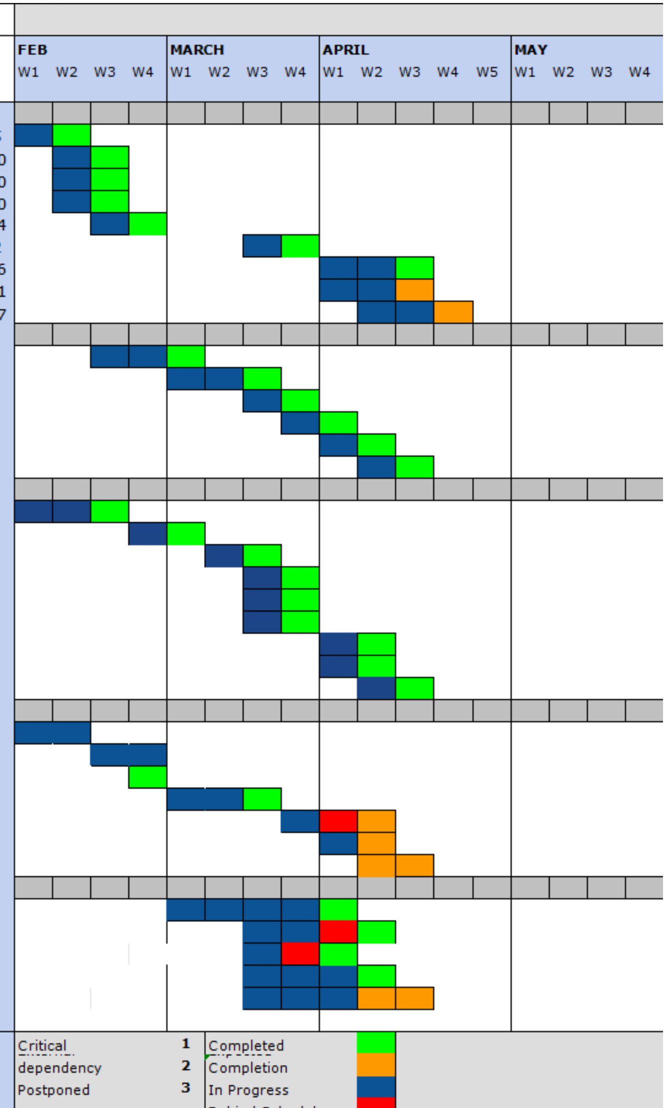


Execution Plan

Ember Bot Project Schedule

Deliverable/Task	Owner	n	Note
Overall Deliverables			
ConOps	All	2w	Due 2/5
FSR + ICD	All	2w	Due 2/20
Validation Plan	All	2w	Due 2/20
Milestone Plane	All	2w	Due 2/20
Midterm Presentation	All	2w	Due 2/24
Status Update Presentation	All	2w	Due 4/2
Final Presentation	All	3w	Due 4/16
Final Demo	All	3w	Due 4/21
Final Report	All	3w	Due 4/27
Microcontroller & Fire Detection			
ESP32 Installation + Start-Up	Jonathan	3w	
ESP32 Framework	Jonathan	3w	
Camera Module	Jonathan	2w	
IR Sensor Detector	Jonathan	2w	
Light Source	Jonathan	2w	
Microcontroller Connection w/ Systems	Jonathan	2w	
App Development			
Create wireframe and overall structure	Yuwen	3w	
Create clickable prototype	Yuwen	2w	
Create User Interface Design	Yuwen	2w	
Test the app with basic functionality	Yuwen	2w	
Create User Mannual within app	Yuwen	2w	
Create User Help page within app	Yuwen	2w	
Add Wifi Functionality	Yuwen	2w	
Add video streaming	Yuwen	2w	
Finalize App Design	Yuwen	2w	
Power System			
Design circuit schematic	Nancy	2w	
Breadboard Assemble and Testing	Nancy	2w	
Power Efficiency and Load Testing	Nancy	1w	
PCB Design	Nancy	2w	
PCB Testing	Nancy	3w	
Thermal and Safety Analysis	Nancy	2w	
Validate Recharging	Nancy	2w	
Pump System + Car			
Verify Vehicle Movement	Kevin	2w	
Set up Lighting and Cooling	Kevin	2w	
Servo System	Kevin	2w	
Water Pump System	Kevin	3w	
Creating Vehicle Frame	Kevin	2w	

Annotations:



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Validation Plan

Test Name	Success Criteria	Methodology	Status	Engineer(s) Responsible
Fire Detection	Flame Sensor delivers correct output resulting from Flame/IR	Measure Sensor Output with IR Source at Varying Distances	TESTED	Jonathan Chen
Camera Streaming	Steady Visual Output from Camera Stream	Set up ESP32-CAM to transmit live video. Evaulate frame rate, transmission stability, and stream quality	TESTED	Jonathan Chen
ESP32 WiFi Access Point	System connects with Microcontroller Remotely	ESP32-CAM and Cellular Device are able to connect to ESP32 via WiFi. Measure functionality at Distance	TESTED	Jonathan Chen
LED Output	LED functions as directed	Light Source tested at OFF/ON State	TESTED	Jonathan Chen
Communication Range	All subsystem components can be remotely accessed across the room	System Communication Test is tested across the FEDC room, performed at 5 Feet Intervals till no response	TESTED	Jonathan Chen
Vehicle Movement	Both motors can be controlled independetly via the motor driver	Input control signals can control each motor independetly to go forward, backwards, turn left, turn right, and turn 180 degrees.	TESTED	Kevin Rivera
Electonics Isolation	There is no risk of water damaging the PCB, motors, and other electronics in the bottom layer of the robot	Seal and connect the two pieces of the bottom frame and pour 1 gallon of water over it for a short time and once done check below the frame to see if water leaked	TESTED	Kevin Rivera
Vehicle Chassis	Vehicle frames can hold all electronics and water tank safely	Place the bottom level of the frame with the water tank atattched on top to ensure even weight distribution while moving	UNTESTED	Kevin Rivera
Servo Movements	Servos can successfuly move and point to a certain point	Attatch a laser on the end of the servo configuration to point to a x-y grid. Input x and y coordinates and verify that the laser is pointing to the correct point	TESTED	Kevin Rivera
Maximum Water Range	Check the maximum range of the water pump system	Turn on the water pump with the nozzle on and measure the distance in which the flow of water goes before beginning to drop	TESTED	Kevin Rivera
Water Nozzle Movement	Water pump system successfully attatched to the servo system	Connect the servos with the water nozzle and verify that the range fits with the coordinate system verified in the servos movement test	UNTESTED	Kevin Rivera
Cooling Fan Implimentation	Cooling fan can turn on and cool the system	Attach the fan onto the fan vents and turn it on while running the motors. Measure the difference in temperature when the fan is on and off.	TESTED	Kevin Rivera
App Launch on emulator	The app can run and tested on emulator	The app can obtain all the function designed on emulator	TESTED	Yuwen Zheng
App Launch on mobile device	The app can be installed on mobile device and can be opened	The app is able to function on both emulator and a physical mobile device	UNTESTED	Yuwen Zheng
Left/Right wheel button	Both button can be dragged vertically, show the axis position on screen	Drag each button on screen and drag both button at the same time	TESTED	Yuwen Zheng
Nozzle Button	The button can be dragged both vertically & Horizontally	drag nozzle button on screen	TESTED	Yuwen Zheng
User Manual Page Button	The button can direct the user to a new page with user manual	click on the button and check if the user is direct to a new page with user manual	TESTED	Yuwen Zheng
Help page Button	The button can direct the user to a new page with help guide on Ember Bot	click on the button and check if the user is direct to a new page with help page	TESTED	Yuwen Zheng
Wifi Functionality	The app is able to establish communication with ESP32 through wifi connection	Write a test application running on a laptop that listens for incoming packets, let the app send control signals to laptop's IP	TESTED	Yuwen Zheng
Video Streaming	The app is able to receive and display video signal in the mobile app	Test if the video can be received and displayed on the screen of the mobile device	UNTESTED	Yuwen Zheng
1.1 Buck (24V-12V) Simulation	Steady state waveform and outputing a max of 12.6V	Using LTSpice/Altium to select components and verify power rail. Using a higher voltage to compensate for real world applications which will decrease the output voltage	TESTED	Nancy Ramirez Castillo
1.2 Buck (24V-12V)	Keeps operating under high temperature and running time	Use the DC Power Supply to provide 24V and measure the output voltage using the Oscilloscope ensuring it runs smoothly for 15 minute without overheating	UNTESTED	Nancy Ramirez Castillo
1.3 Buck (24V-12V)	Smooth step-down voltage from boost converter	Test the flow of power, voltage, and current with the boost and buck converter connected. Outputs at both converters should be minimal compared to when running alone	UNTESTED	Nancy Ramirez Castillo
2.1 Buck (12V-5V) Simulation	Steady state waveform and outputing a max of 5.5V	Using LTSpice/Altium to select components and verify power rail. Using a higher voltage to compensate for real world applications which will decrease the output voltage	TESTED	Nancy Ramirez Castillo
2.2 Buck (12V-5V)	Low voltage output and current of min. 1.5A	Use the DC Power Supply to provide 12V and measure the output with Oscilliscope ensuring minimal ripple and runs for 15 minutes without overheating	UNTESTED	Nancy Ramirez Castillo
2.3 Buck (12V-5V)	Smooth step-down voltage from first buck converter	Test the flow of power, voltage, and current with both buck converters connected. Outputs at both converters should be minimal compared to when running alone	UNTESTED	Nancy Ramirez Castillo
3.1 Boost (22.2V-24V)	Outputs 23.5V-24.5V and 2.2A current with minimal voltage ripple	Use the DC Power Supply to provide the 22.2V that will be provided by the Li-Po batteries and measure the ouput voltage using the Oscilloscope ensuring it runs smoothly for 5 mins	UNTESTED	Nancy Ramirez Castillo
4.1 AC/DC Charger Simulation	Simulation shows use of all 120VAC to output 12.6VDC	Using LTSpice/Altium to select components and verify power rail. Using a full-wave rectifier to use all alternative power to help cut down recharging time	TESTED	Nancy Ramirez Castillo
4.2 AC/DC Charger	Steady DC output from wall outlet	Keeps a steady 12.6V/2.2Ah to charge one Li-Po battery and indicating when battery is full with LED lights	UNTESTED	Nancy Ramirez Castillo
Full System Load	No overheating under max. load conditions	Power the entire system and let it run under full operation for 15 minutes. Monitor every converter's output with a load connected to simulate next semester integration	UNTESTED	Nancy Ramirez Castillo

Remaining Tasks & 404 Goals

Subsystem	Remaining Tasks	404 Goals
Microcontroller Subsystem	• Prepare for Demo with Independent Power	• Subsystem Integration with Communication • Integrate Data Readings into Mobile App • Help Design PCB for Microcontroller
Vehicle Operations & Water Pump System	• Attach frame onto the body • Design water tank • Translate co-ordinates to servo positions	• Placing PCBs and sensors inside the robot • Attach water pump system to the frame
Power Subsystem	• Test soldered PCB designs • Complete thermal testing with max load conditions	• Minimize wiring, new PCB design for microcontroller paths
Mobile App	• Test video stream from camera • Finalize app design	• Integrate app buttons with other subsystems • Optimize user experience