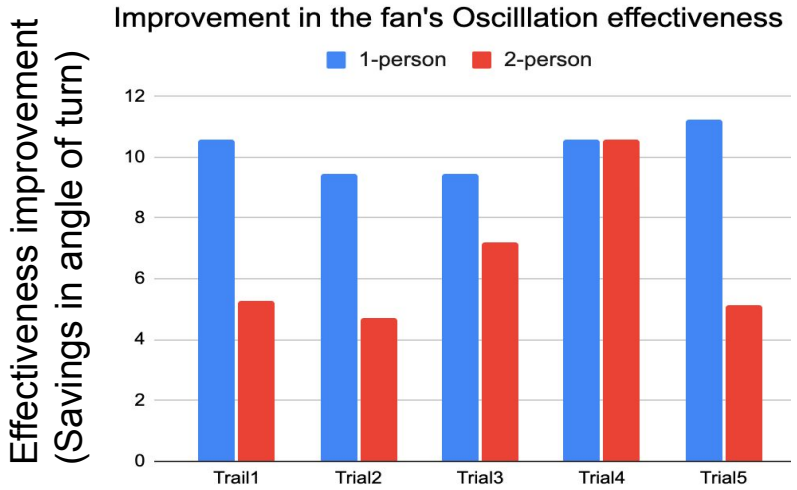
[MS-ROIM-119]

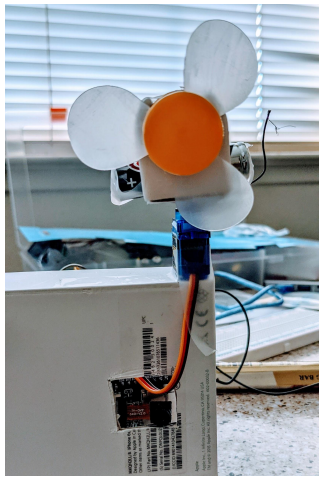
FAN OF THE FUTURE

Q1: Problem & Objectives

- Table fans or tower fans in the market are either set to a single direction or have a predetermined angle of oscillation. This causes a problem: either the fan will waste energy by blowing air towards nothing, or it will fail to cover everyone in the room.
- The energy wastage of an oscillating fan is also a problem because the extra electricity generated to power the fan contributes to global warming and climate change
- My goal is to create a relatively inexpensive fan which efficiently detects the faces of people and directs the air towards them effectively.
- Showcasing the use of artificial intelligence in everyday applications.

Q3: Data Analysis & Results





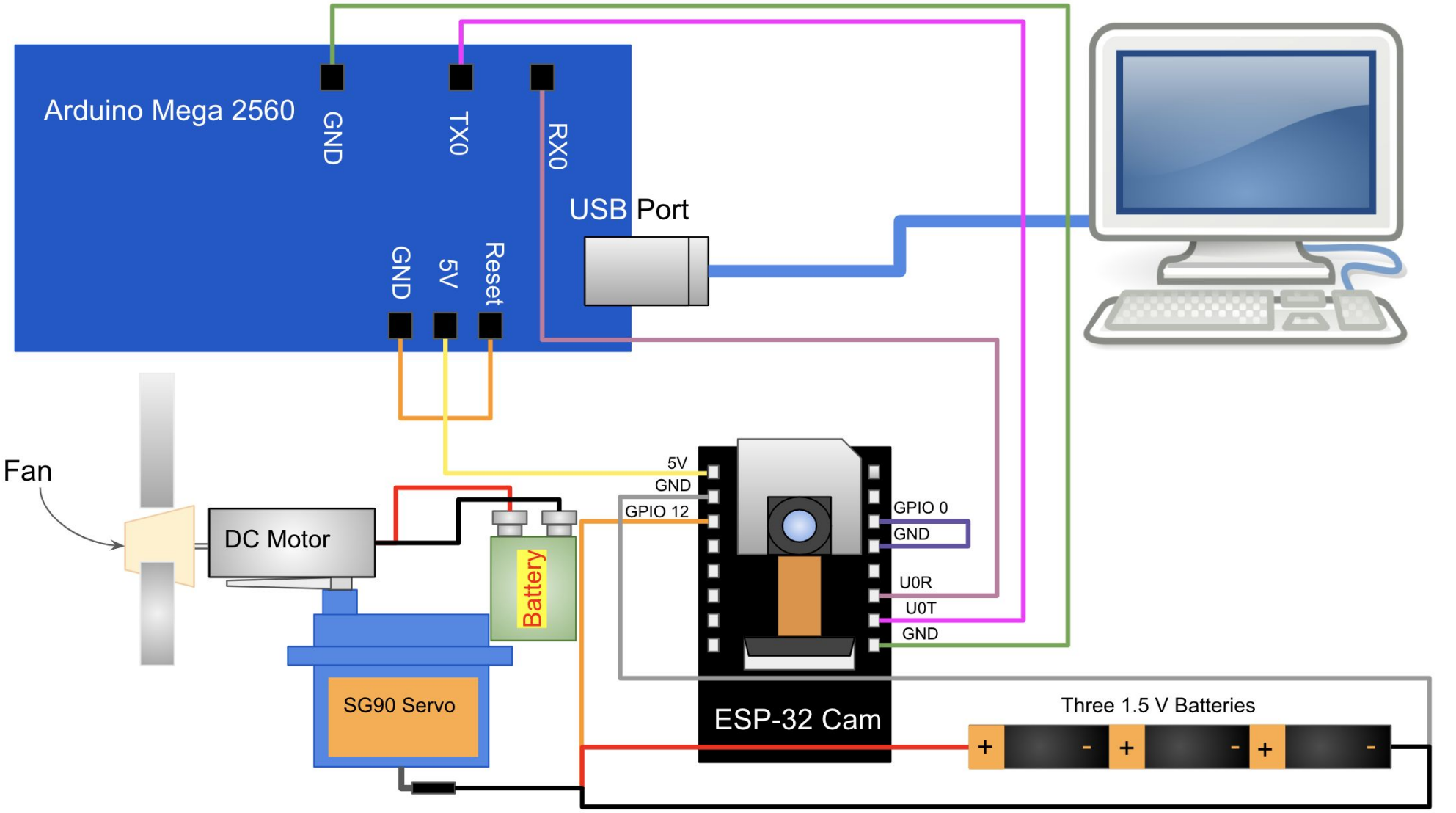
Q2: Project Design

- A DC motor with attached blades represents a fan; This sits on top of a servo motor capable of oscillates side to side.
- The servo is connected to an ESP32-CAM micro controller with a 2MP camera. Software is written using Arduino IDE and AI modules ESP-WHO controls the angle of oscillation of the servo motor.
- The software program captures the photo, recognizes the faces using the AI module, retrieves the coordinates of the faces, calculates the angle at which the person and people are sitting, then controls the oscillation angle of the servo motor to send the airflow toward the people.

Q4: Conclusions

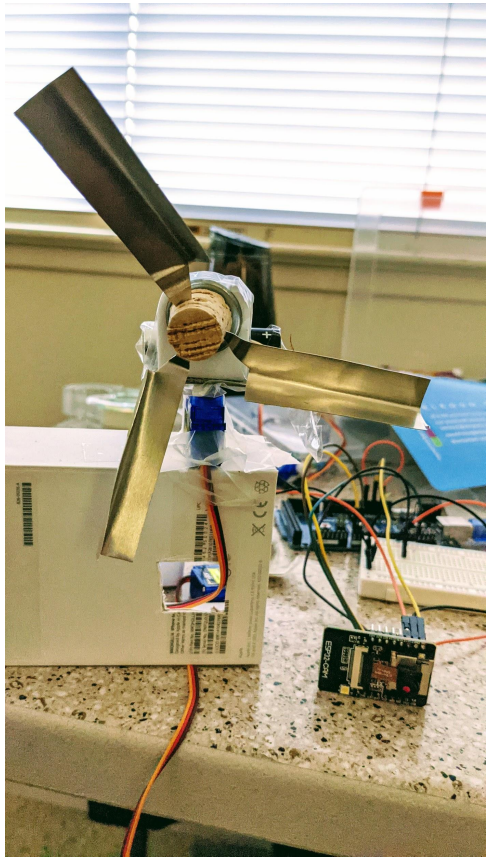
- The testing done shows that the first prototype of the project was successful
- The fan was able to detect the single face consistently. It needed software work around (multiple images scans) to recognize multiple faces.
- Artificial Intelligence (AI) helped improve everyday fan with ESP32-CAM microcontroller that costs about $10.
- This shows we can add AI improve common devices affordably.

METHOD - Circuit Diagram

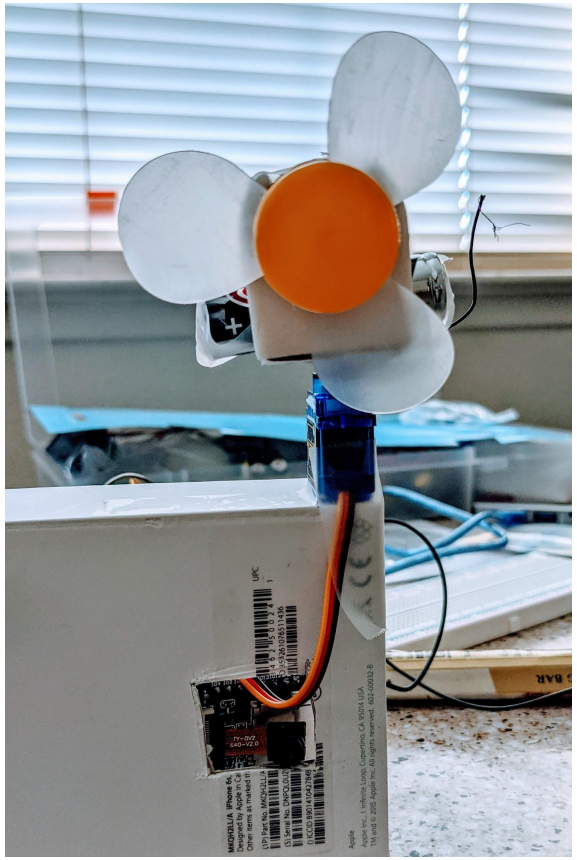


Method - CREATION

- Experimented with Arduino to create a DC-motor fan and control a servo motor angle
- Learnt about ESP32-CAM which had built-in camera. The company also provided ESP-WHO face detection AI modules
- Investigated into how face detection API works.
- Write the software to capture the photo, use the face detection, retrieve the coordinates for the rectangle around face detection.
- Converted the face coordinate to the angle for the servo motor.
- Designed the circuit to have ESP32-CAM, Servo motor, DC-Motor; This is connected to Arduino and a computer for loading the software.
- After the initial prototype worked, constrructed a prototype with a better fan blades.



Initial prototype



Final prototype

Method - Software Pseudocode

1. **Detect faces**.
    a. Take a picture with the ESP32-CAM.
    b. Attempt to detect a face in the picture.
    c. Repeat steps a-b nine more times to detect all the faces.
    d. If faces detected:
        i. Get the x-coordinates for all the faces and move on to step b.
    e. If no faces detected:
        i. Go back to step a.
2. **Calculate the angle between the leftmost and rightmost faces.**
    a. Convert the coordinates of the faces into angles.
    b. Make sure to test if the camera is flipped or not and adjust the algorithm accordingly.
3. Make the servo oscillate between the two angles 10 times.
4. Go back to step 1.

Method - Testing

1. Seat one person on a couch with no objects surrounding them.
2. Turn on the fan and let it oscillate.
3. Check the oscillation to see if it pointed at the person.
4. Seat at least two people on the couch with multiple inanimate objects(no paintings of people) around them.
5. Turn on the fan and let it oscillate.
6. Check the oscillation to see if it oscillated between the two outermost people without oscillating further.
7. Seat the two people in different positions and test the results.
8. Repeat step 6 three more times and record the results.
9. Use the program print messages to get the coordinates of the rectangle on the face and calculated angle each time.

Method - Troubleshooting

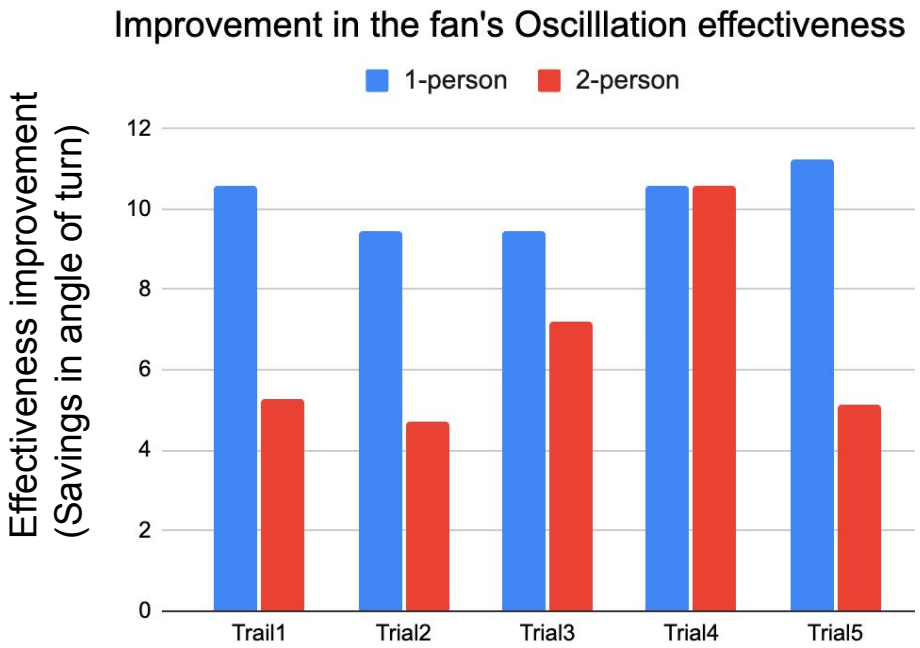
1. Single photo scan detected just one face. Added loop to scan the image multiple times to detect multiple faces.

RESULTS

- The device was able to take multiple images and recognize one and two faces using the software developed.
- Once the software detects the faces, it calculates the coordinates of the imaginary rectangular box around the face. The new oscillation angles (start angle and end angle) are calculated

DATA ANALYSIS

- The prototype was able to recognize single face consistently and change the direction of the fan correctly at the direction of the face.
- With the software change to capture and analyse multiple images, it was able to consistently recognize two faces.



DATA FOR SINGLE FACE DETECTION

	Start Angle	End Angle	Improvement against 180° oscillating fan	Difference against 180° oscillating fan
Trial 1	81	98	10.588 times effective	163 degrees less
Trial 2	80	99	9.473 times effective	161 degrees less
Trial 3	83	102	9.473 times effective	161 degrees less
Trial 4	82	99	10.588 times effective	163 degrees less
Trial 5	80	96	11.25 times effective	164 degrees less
Average	81.2	98.8	10.22 times effective	162.4 degrees less

DATA FOR TWO-FACE DETECTION

	Start Angle	End Angle	Improvement against 180° oscillating fan	Difference against 180° oscillating fan
Trial 1	69	103	5.294more effective	146 degrees less
Trial 2	66	104	4.737more effective	142 degrees less
Trial 3	66	91	7.2more effective	155 degrees less
Trial 4	68	85	10.588more effective	163 degrees less
Trial 5	68	103	5.143more effective	145 degrees less
Average	67.4	97.2	6.592more effective	150.2 degrees less

Discussion

- The project required a lot of research and learning: DC Motor, Servo motor, Arduino, ESP32-CAM, Arduino-IDE, C++ and ESP-WHO.
- The project was developed step by step with multiple failures in between
  - Had to understand of oscillation of a tower fan
  - Had to learn to control the servo motor
  - Initial thinking was to use a Arduino, but learnt that wasn't powerful enough to run an AI program.
  - Learned about the ESP32-CAM microcontroller and its the ESP32-CAM camera.
    - Learned about ESP-WHO and ESP-FACE AI modules for facial recognition.
  - Had to learn C++ programming.
  - Had to get both servo motor and ESP32-CAM to work together
    - Sometimes the failures can occur in reading the image. So, the retry mechanism was introduced.
- LIMITATIONS
  - Detecting multiple faces takes time.
  - The fan's power supply is independent of the ESP32-CAM circuit. With a better design, the fan can be turned on/off when the faces are recognized.

Conclusions

- The goal of this project was to develop a relatively inexpensive oscillating fan which detects people's faces and adjusts the angle of oscillation accordingly. The testing done shows that the first prototype of the project was successful; however, more testing must be done to understand the level of success and limits of this fan.
- Increasing the number of photos taken helped increase the accuracy of the AI, but the time taken for the AI to go over each photo made the wait long. Still, the fan was able to take pictures, detect faces, and adjust the angle of oscillation accordingly, and it did its job well. However, adjustment must be made in order for the project to truly achieve its stated purpose.
- The face recognition integrated into a small and affordable (less than $10) microcontroller and camera plows the way for adding intelligence into many of our appliances.
    - Safety camera in the kitchen to recognize kids and alarm when the oven or stove is on.
    - Customized home temperature control based on face recognition.
    - Explore applications in the hospitals and elder care.

References

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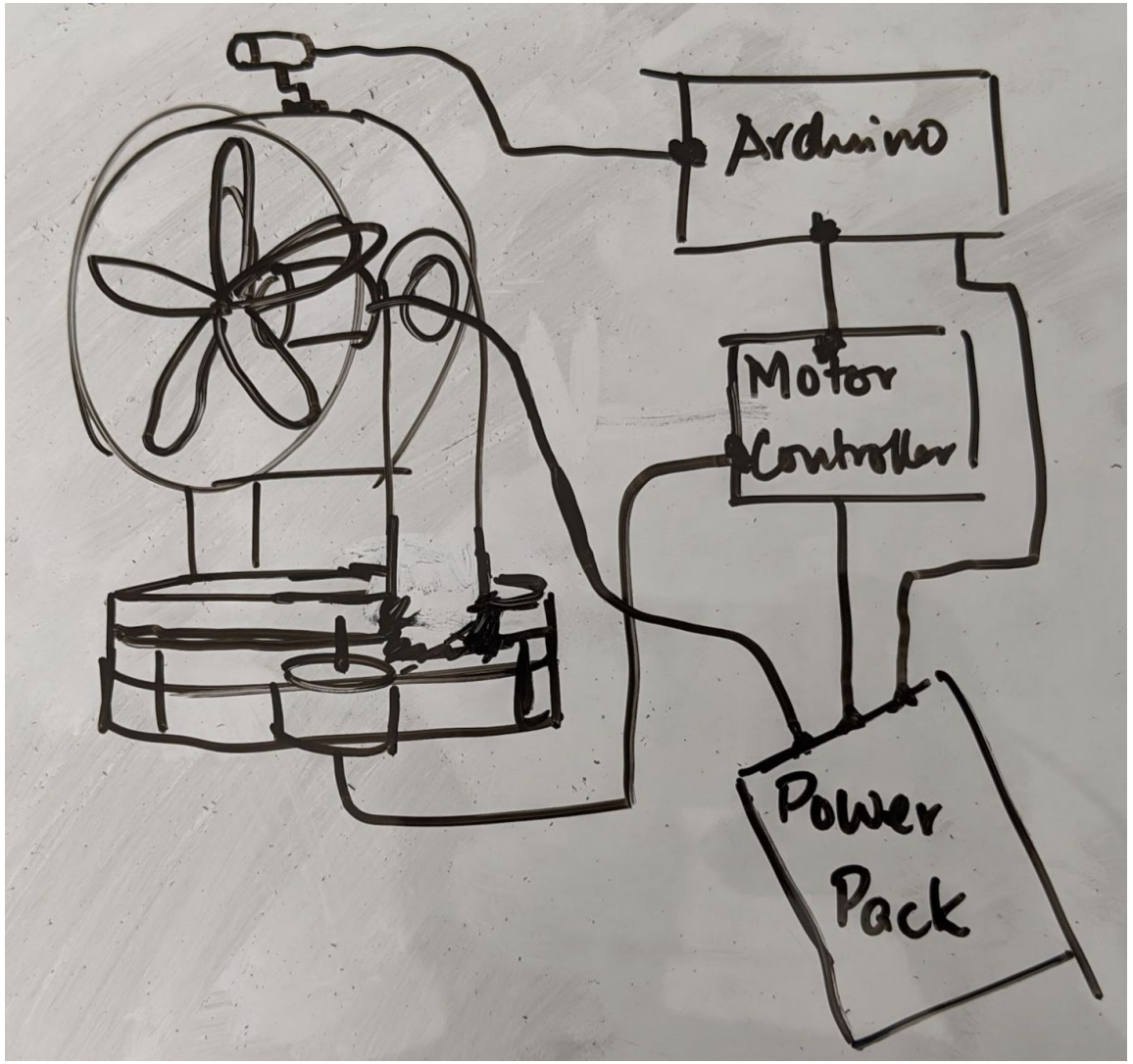
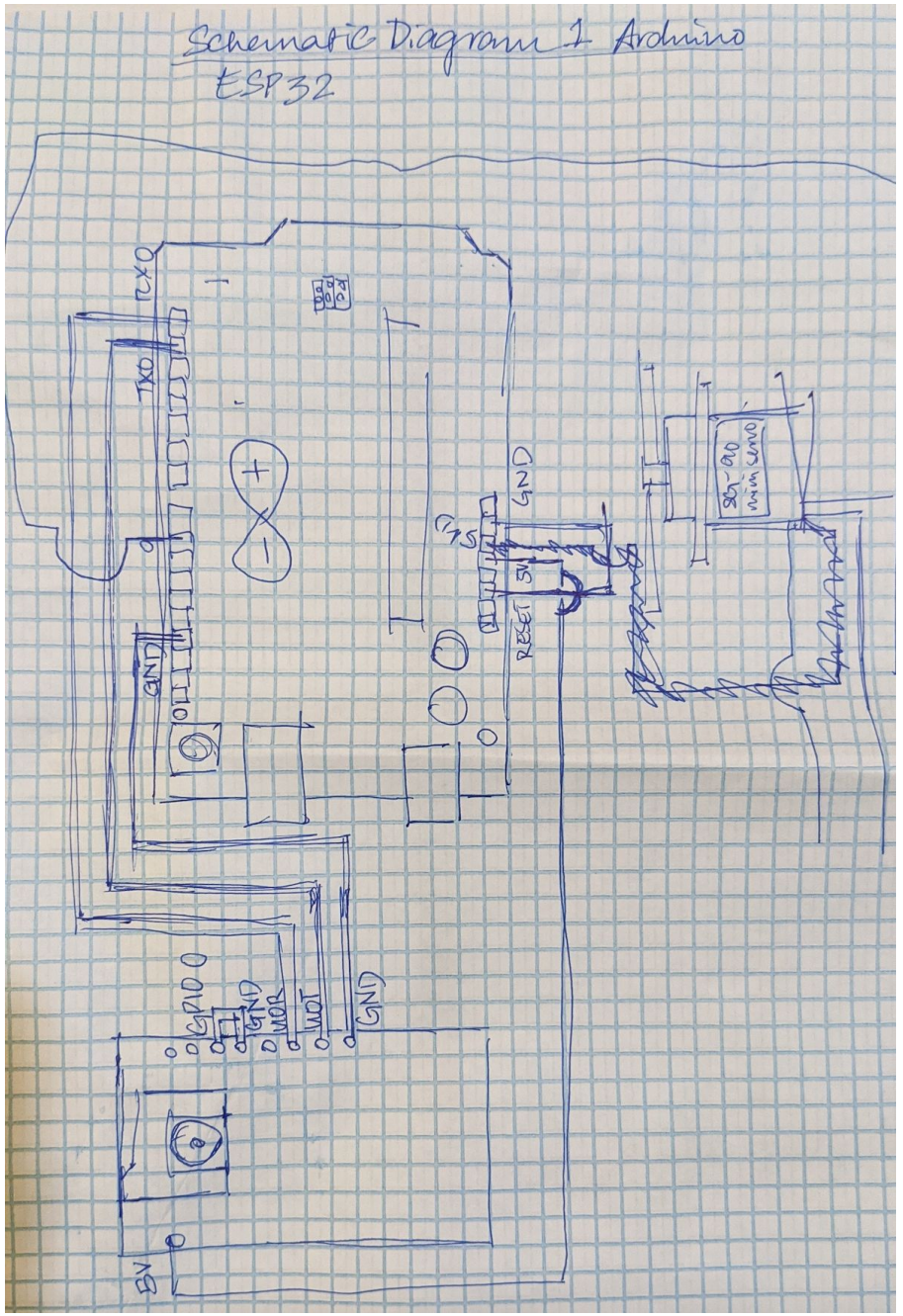
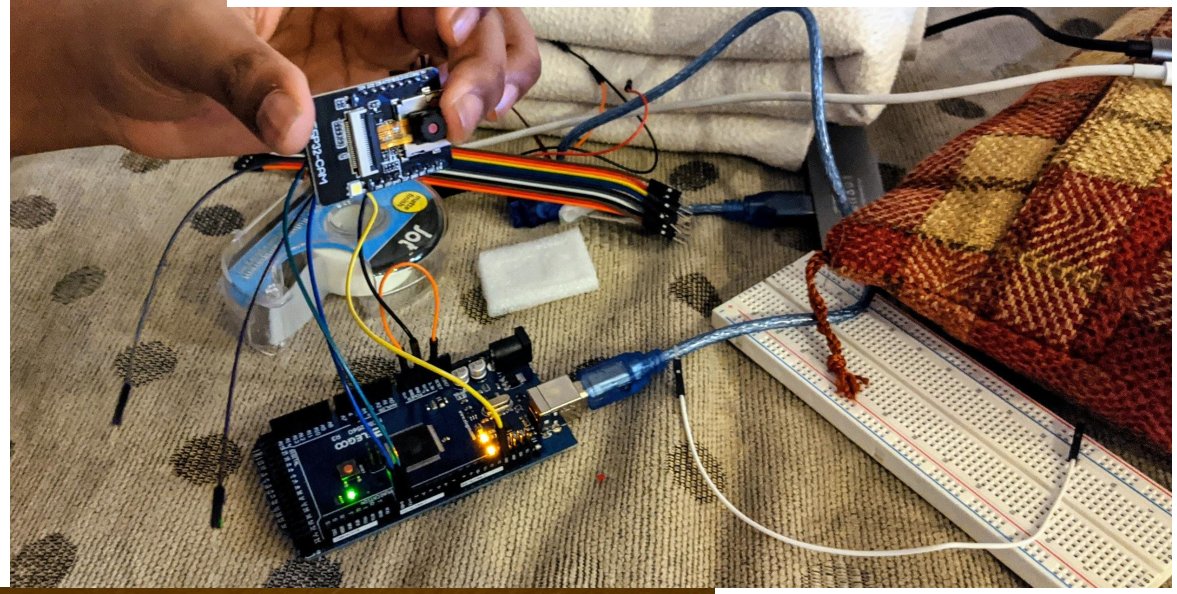
Virtual Lab Notebook Excerpt 1

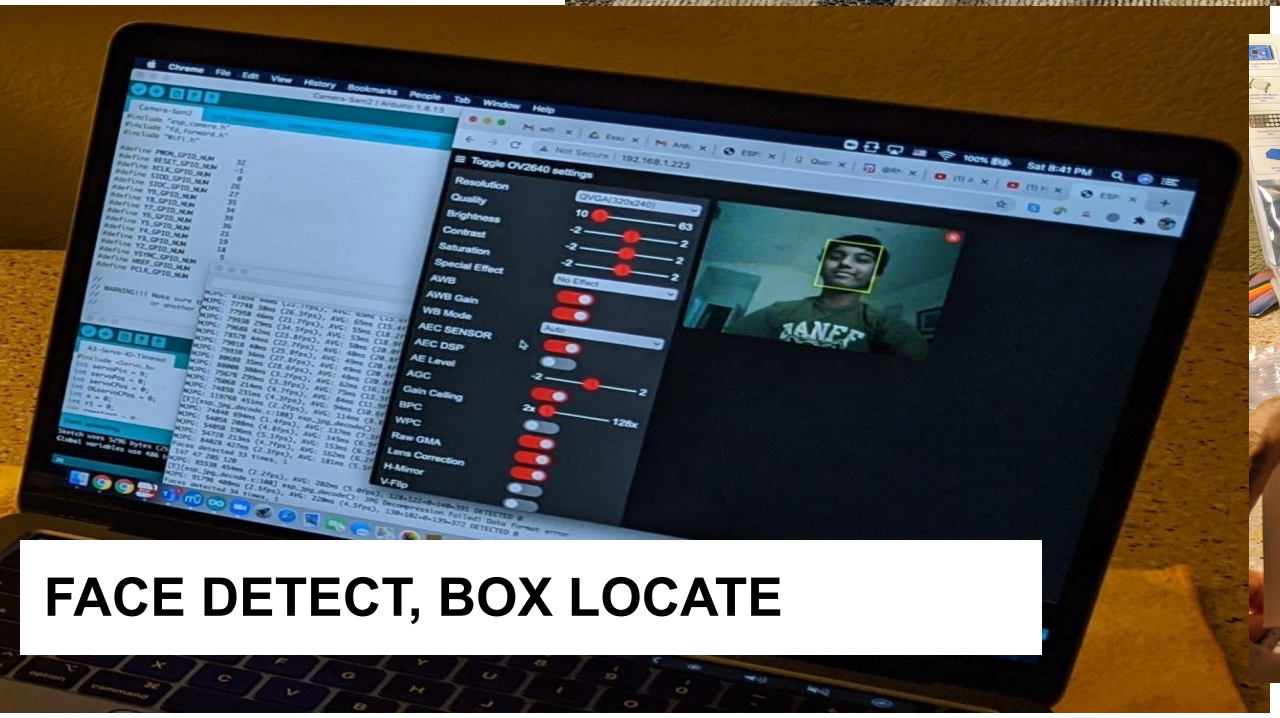




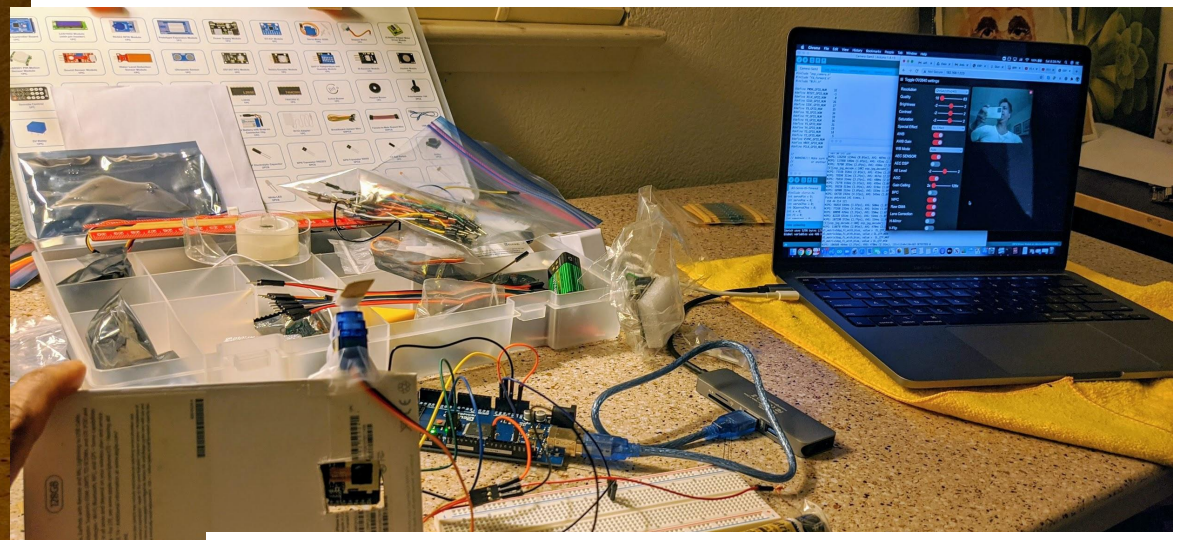
Background

ESP-32, ARDUINO, & CAMERA





FACE DETECT, BOX LOCATE



FACE DETECT, FAN ROTATE