THE SERVATOR

DISASTER SEARCH AND RESCUE DRONE PROJECT

TEAM MEMBER

BUI KHANH MINH
DO DUC LONG

A. GENERAL INFORMATION

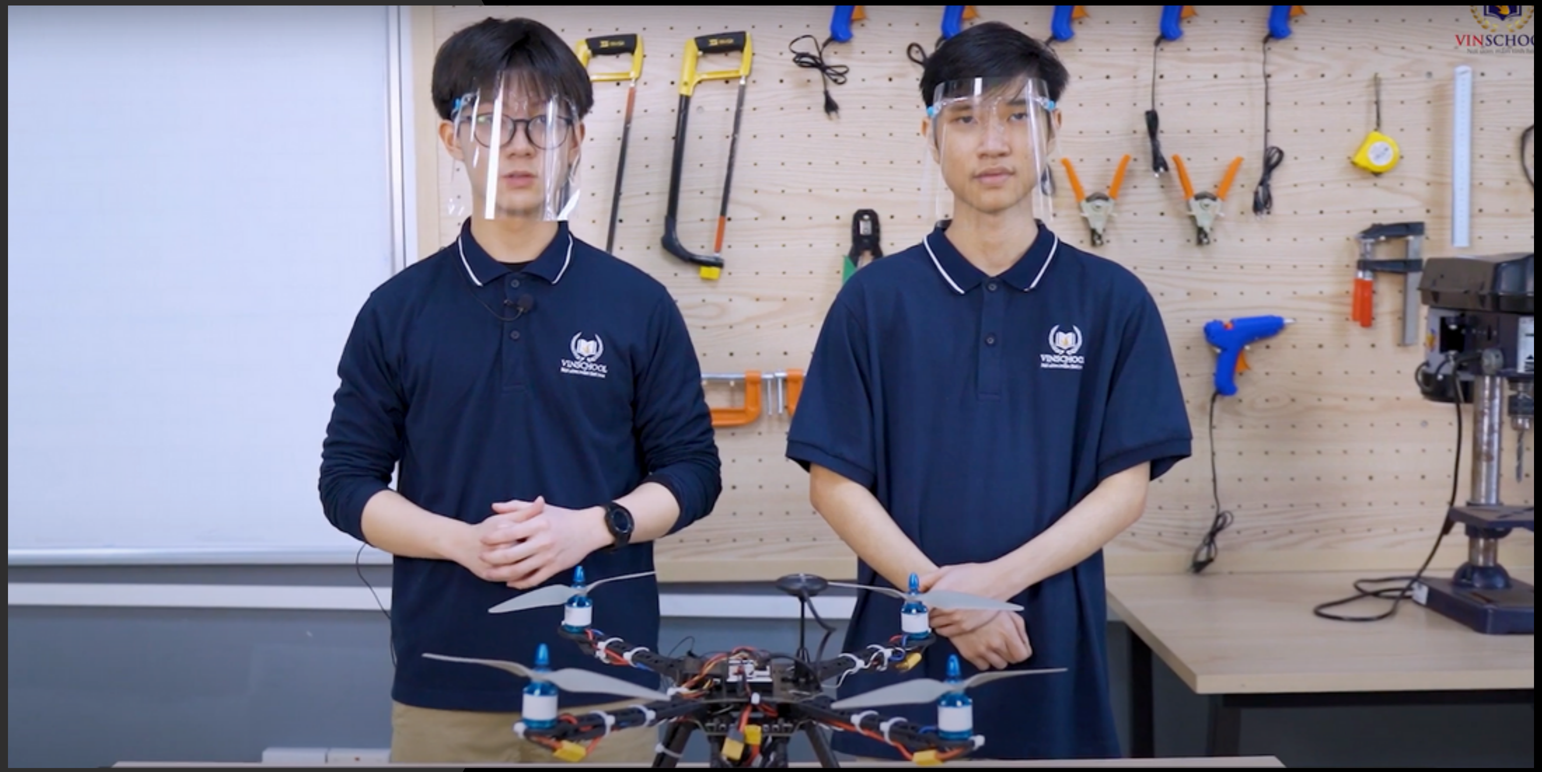


Fig.1: Project Members presenting the drone

PROJECT NAME

Disaster Search and Rescue UAV Project - The Servator

TIME

July 2021 - May 2022 (Expected)

PROJECT MEMBERS

Vinschool Education Sytem

Do Duc Long [Male] - 18 Years Old

Bui Khanh Minh [Male] - 15 Years Old

PROJECT MENTOR

Ph.D Pham Minh Trien

B. ABOUT THE PROJECT

I. Project Outcome

The main outcome is a drone built and equipped for the project's intended purpose: to detect natural disaster victims in flight.

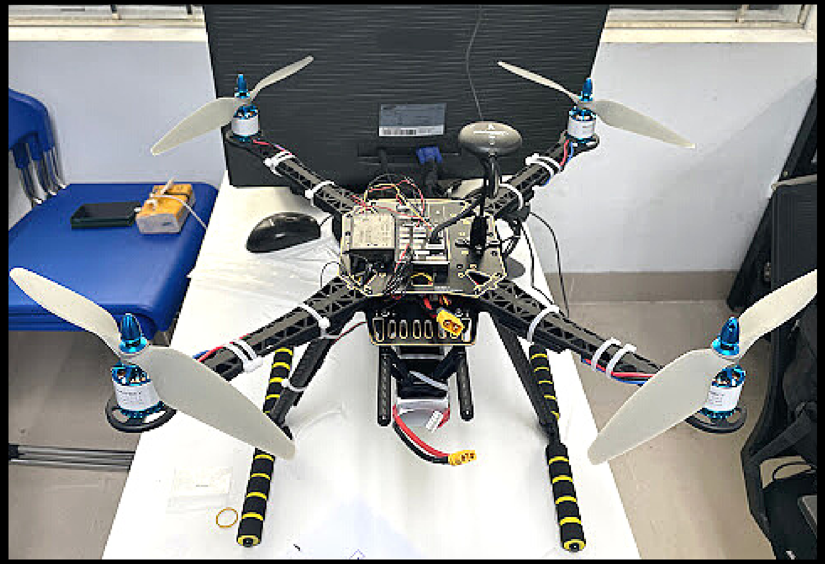


Fig.2: Drone fully built (Front view)

Mechanically it is a standard fully-functioning quadcopter, with the addition of internet connectivity, a GPS, a single-board computer (Raspberry Pi), and a camera (Pi Camera).

To detect victims, the drone utilizes machine learning in its software. Images are rapidly taken from the camera and sent to the single-board computer. This is where a machine learning model trained to recognize disaster victims will determine whether or not a human in need is present within the image. If a victim is detected, the image along with the coordinates where it was taken will be saved and sent to the administrator (local search and rescue forces).

Fig.3: Drone fully built (Angled view)

Fig.4: Drone taking off

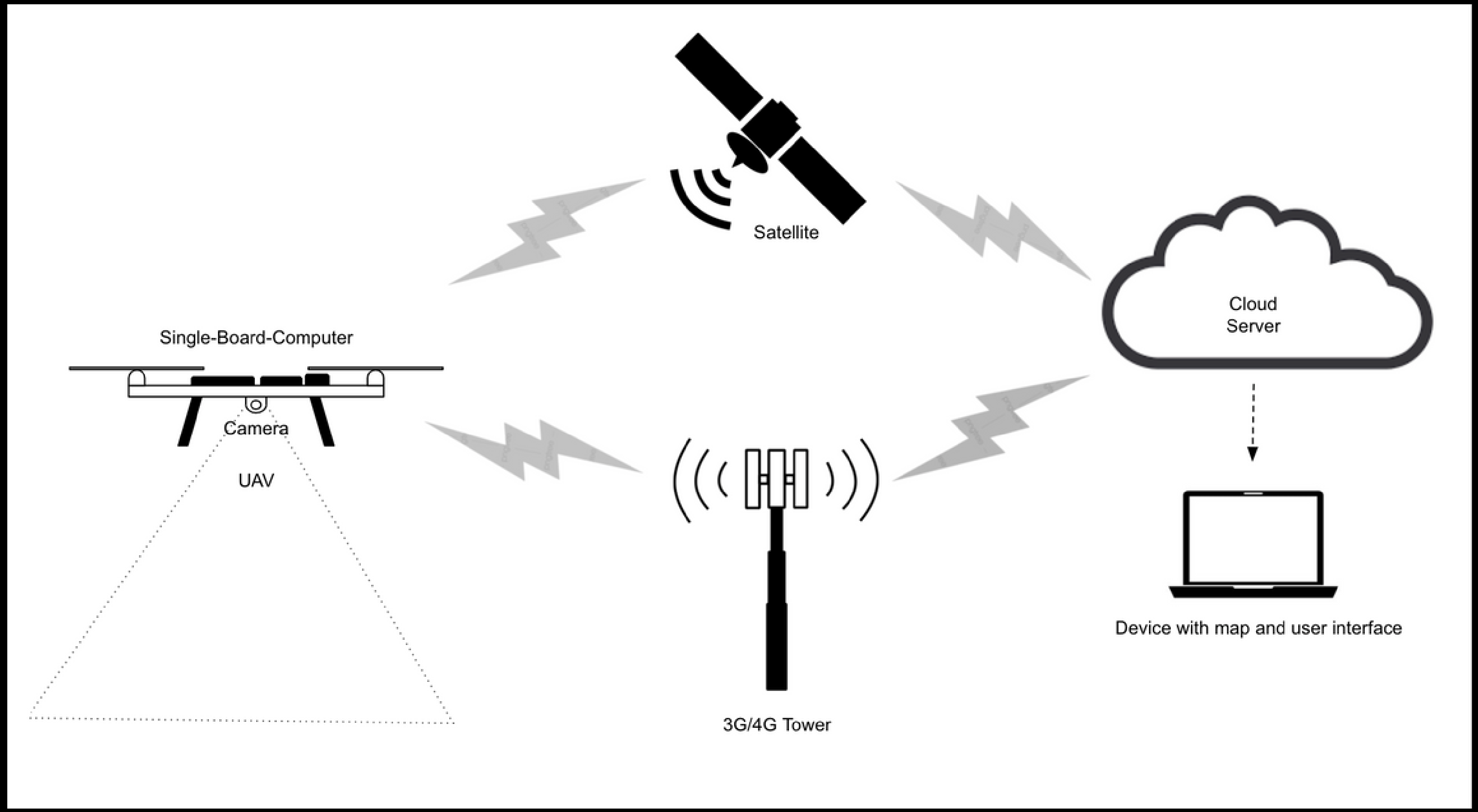
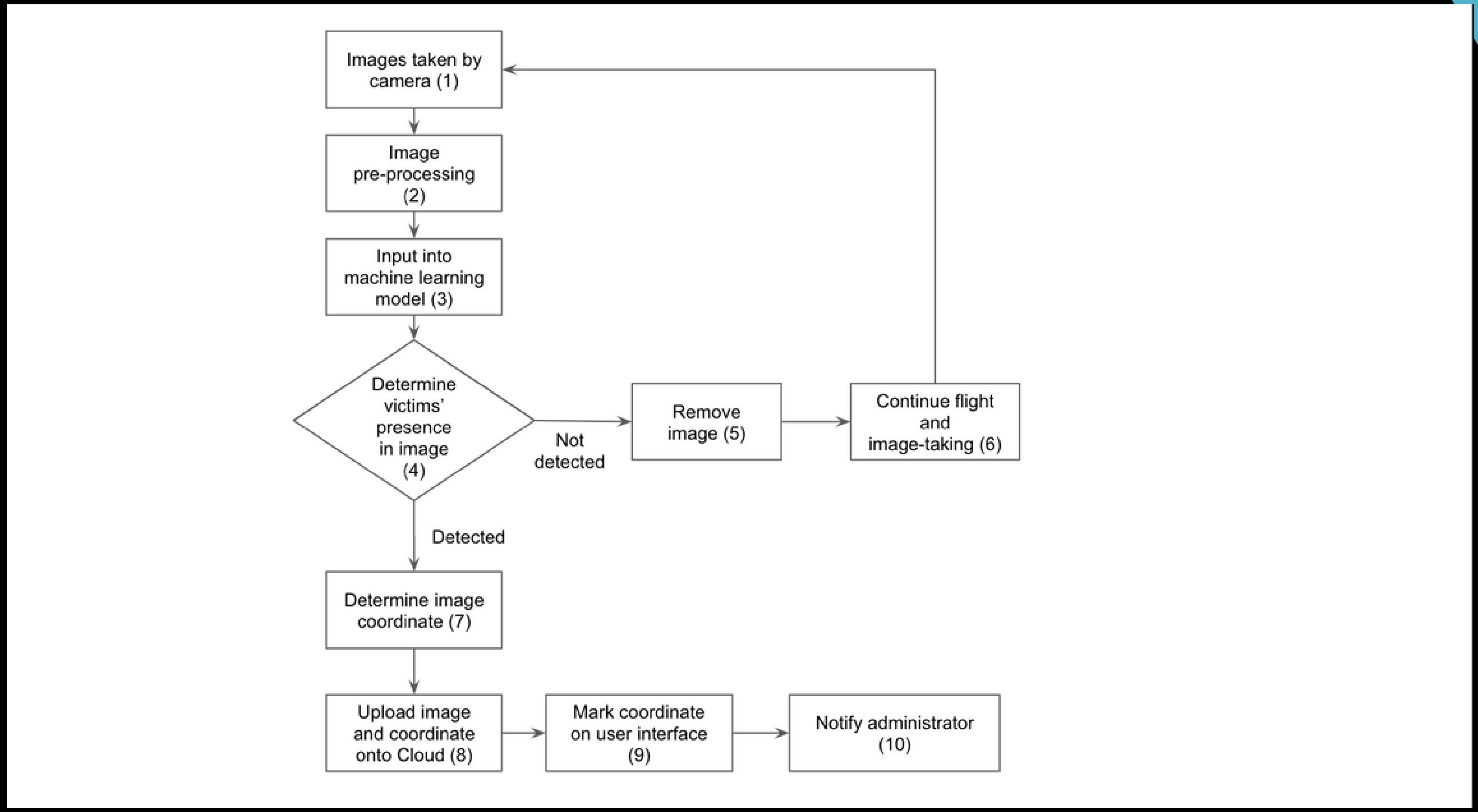


Fig.5: Diagram of the intended communication system

Fig.6: Flowchart of the victim detection process



II.Main phases

Fig.7: Project Members preparing the drone for flight

Phase	Time	Description	Progress
1 - Formation of Idea	31/7/2021 - 14/8/2021	The team brainstormed ideas with the goal of utilizing drones in a meaningful manner and solving an existing issue.	Completed
2 - Study of drone hardware and software	21/8/2021 - 8/1/2022	The team studied and researched specific aspects of drone technology and machine learning that are relevant to the project. The goal was to gain sufficient knowledge to successfully carry out the project.	Completed
3 - Assembly of hardware. System connection test	15/1/2022 - 22/1/2022	The team built and joined all hardware components of the project. The connection between the drone's onboard components (including the single-board computer) and ground equipment was also carried out.	Completed
4 - Implementation of image processing and machine learning	22/1/2022 - Present	The team trained the machine learning model and carried out the coding process for the program (including pre-processing steps and post-processing actions)	In Progress (90%)
5 - Test and adjustments to final system	3/2022 - 5/2022	The team integrates the individual products of the previous steps into the complete project. Tests and subsequent adjustments to the system will be made to ensure the project's functionality and reliability.	Not started

C. PROJECT DIARY

Phase 1: Formation of Ideas

1.1 Summary

Through narrowing processes, we refined our idea from the general and multi-faceted issue of natural disasters, to the specific question that the project aims to solve - "How do we save more people in a shorter time frame, while saving the most amount of resources?"

Fig.8: The flag of Vietnam

On day one of the project, the team discussed the wide topics that we could work towards. Throughout the discussion, we wanted the final product to hold relevance to Vietnam (our country), so that we can understand and approach the problem more effectively.

After the discussion, two potential topics stood out:

1. Solar energy: proposed by Duc Long
2. Natural disaster: proposed by Khanh Minh

The team separated (accordingly to who proposed each idea) to further develop our respective topics.

Fig.9: A solar panel

Fig.10: Flooding in Vietnam

After roughly a week, we came back with our ideas, now slightly more refined:

1. Drone to monitor and maintain large-scale solar power fields
2. Drone to deliver survival necessities to victims of natural disasters

Fig.11: A solar power field

Fig.12: A home damaged by flooding

Once again, we entered a thorough discussion on aspects such as feasibility, relevance, and importance of the ideas. After which the necessities delivery drone was chosen, due to its urgency, potential impact, and ability to utilize the advantages of drone technology.

Fig.13: The Amazon delivery drone

However, upon further talking, we realized the various obstacles with this idea, namely the high payload capacity, adverse weather conditions, and limited battery life. While extremely advanced solutions to them exist, it is not within our reach due to budget constraints and our range of accessible technologies. Thus we had to find an alternative path to aid the victims of natural disasters, with the inputs of both members, we came up with the idea of having a drone automatically detect these victims, in order to speed up their rescue process. After more deliberation, it was ultimately chosen as our project.

Phase 2: Study of drone hardware and software

2.1 Summary

Upon selecting our project idea, we reinforced our understanding and obtained technical knowledge specifically relevant to our project, which would be crucial to the completion of this project. This process was done with the help of instructors working at the VNU University of Engineering and Technology. The entirety of this stage was done through online means of communication due to the local COVID situation worsening.

2.2 Diary

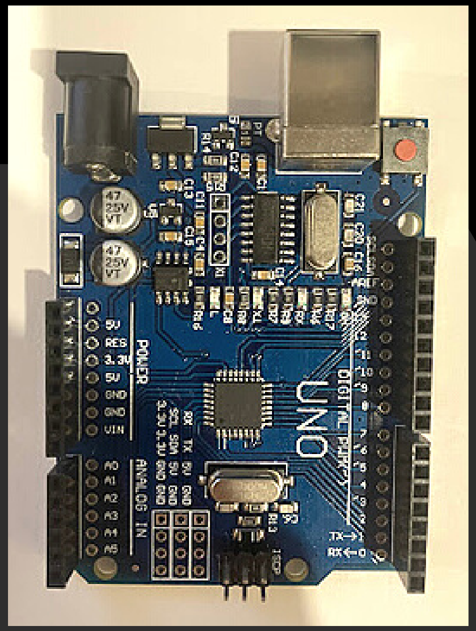


Fig.14: An Arduino UNO

The team started out with re-learning the basics, such as electricity flow, motor workings, and wiring. Most notably we got used to the Arduino UNO microcontroller and performed basic tasks with it.

We then moved on to learning how to use the Raspberry Pi. The initial steps included installing an operating system, which gave us some difficulties. We switched back and forth between the Ubuntu and Debian operating systems, due to various problems not allowing a successful installation process and sporadic issues arising afterward, even when the installation was successful.

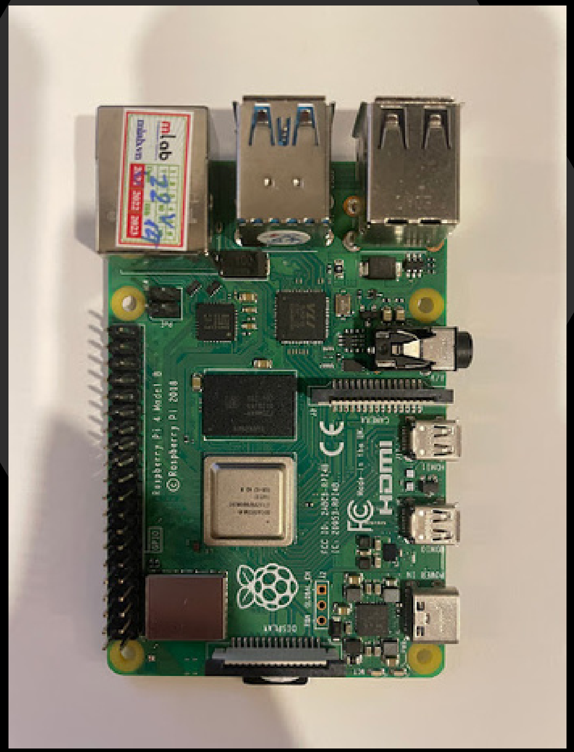


Fig.15: A Raspberry Pi

The whole installation process, from downloading the operating system on a laptop, transferring to a micro SD card, and finally uploading it on the Raspberry Pi took up to hours each time. It became troublesome every time we had to switch systems.

Eventually, we settled on Ubuntu 18.04 (an older version but yielded more stable performance) temporarily, and managed to get it installed. After this, we started coding directly on the Raspberry Pi.

Using the OpenCV library, we coded basic Computer Vision programs, allowing the Pi to recognize and point out the facial features of a human (nose, eyes, mouth, etc...), this was initially done by following online guides, then gradually modify it to debug and adjust the program to our likings.

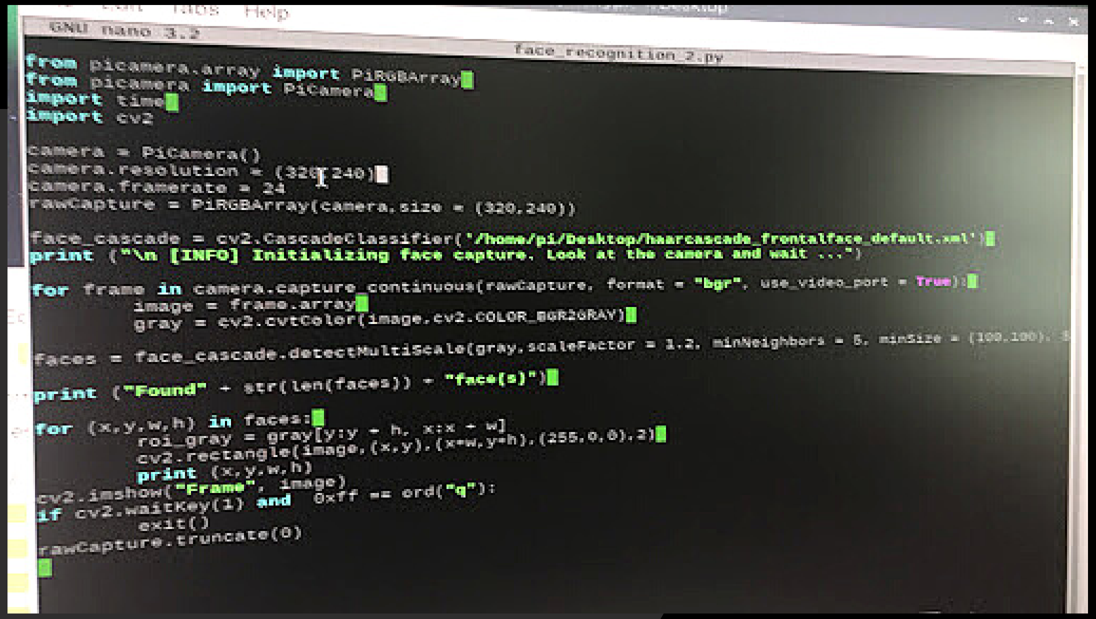


Fig.16: Computer Vision program to identify facial features of any pictures

Speaking of debugging, the majority of our time coding was spent figuring out and resolving these issues. A program that took 30 minutes to write would take upwards of 2 hours to completely debug. We frequently visited coding forums to look for solutions, as well as talked with our instructors. Though online learning certainly limited the effectiveness of communication.

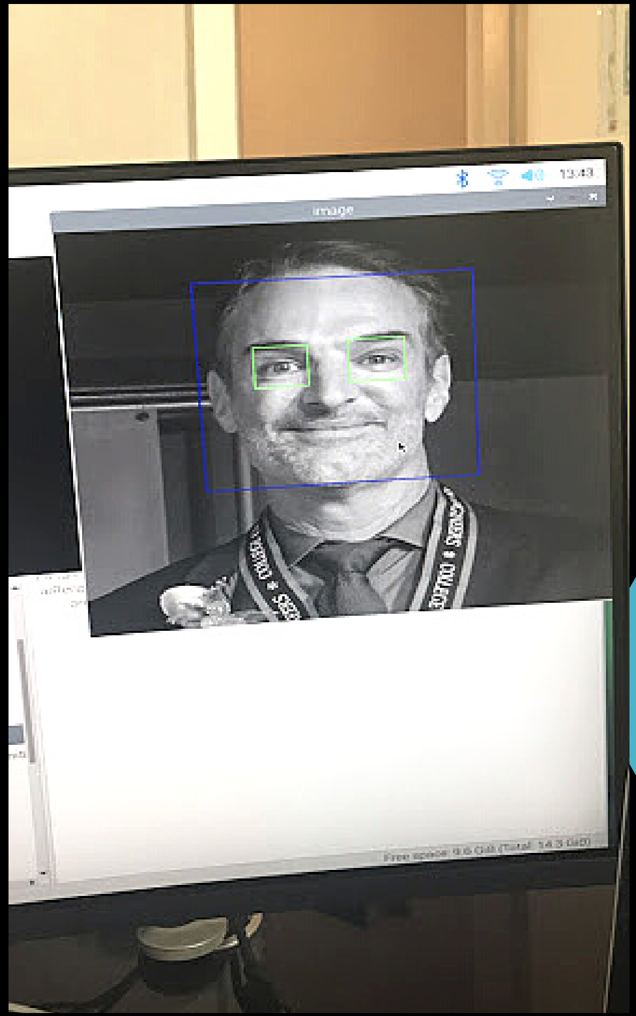


Fig.17: Results of the program on a picture of Tom Mueller

After that, we went further and coded Machine Learning programs, with our pictures inputted beforehand, it had the ability to recognize our face and link the image with our name. This was done under the guidance of our instructors, as neither member of the team had interacted with Machine Learning before.

We also familiarized ourselves with the PX4 Autopilot system, as it would be responsible for the basic flight functions of the drone.

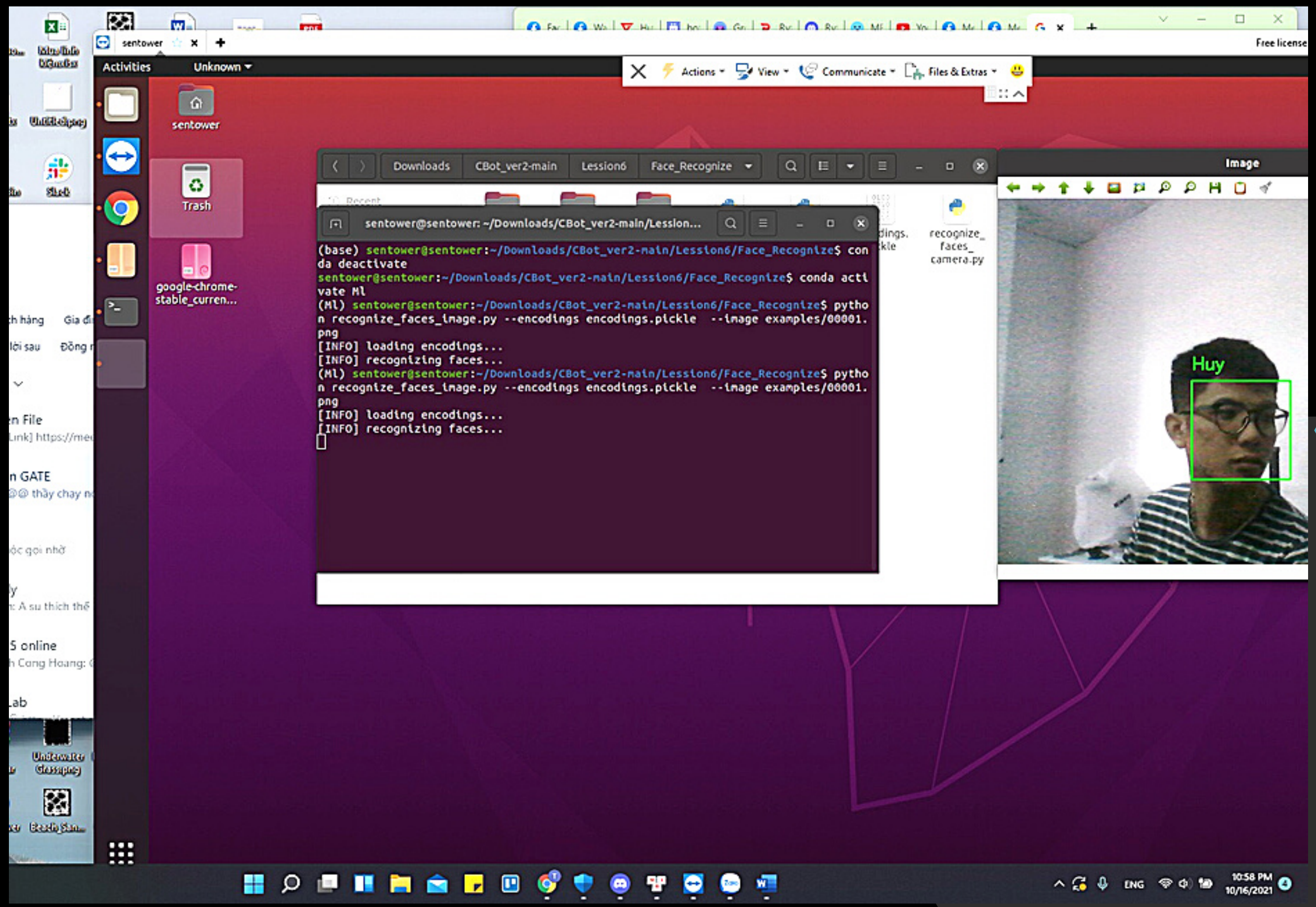


Fig.18: Machine Learning program recognizing a face

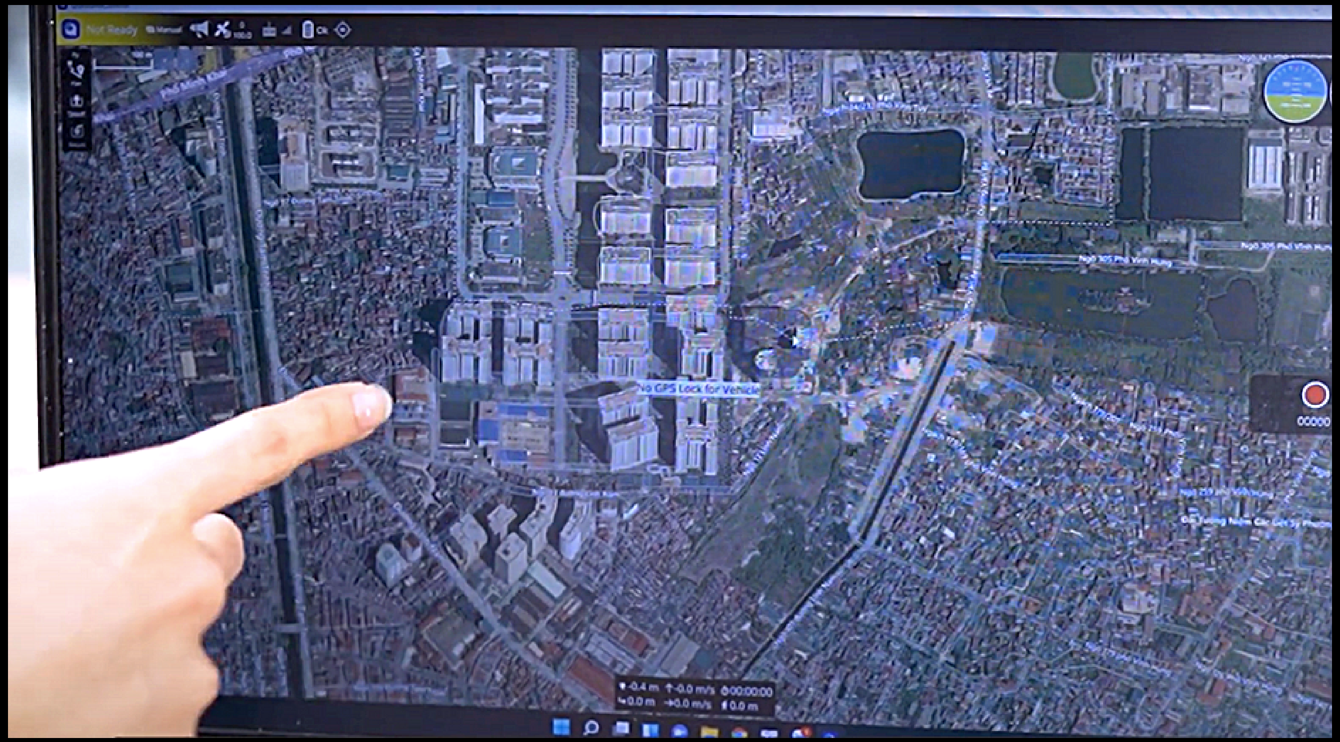


Fig.19: Mission control interface of the PX4 Autopilot system (1)

Phase 3: Assembly of hardware and testing connections

3.1 Summary

With the team and instructors fully vaccinated, as well as COVID restrictions lifted, we were able to meet up and start the mechanical assembly + basic testing of the system, specifically the drone.

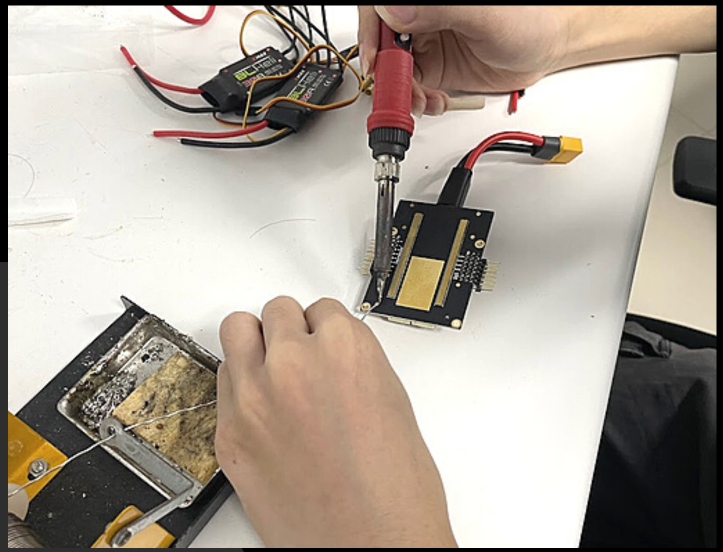


Fig.21: Soldering wires to the power distribution board

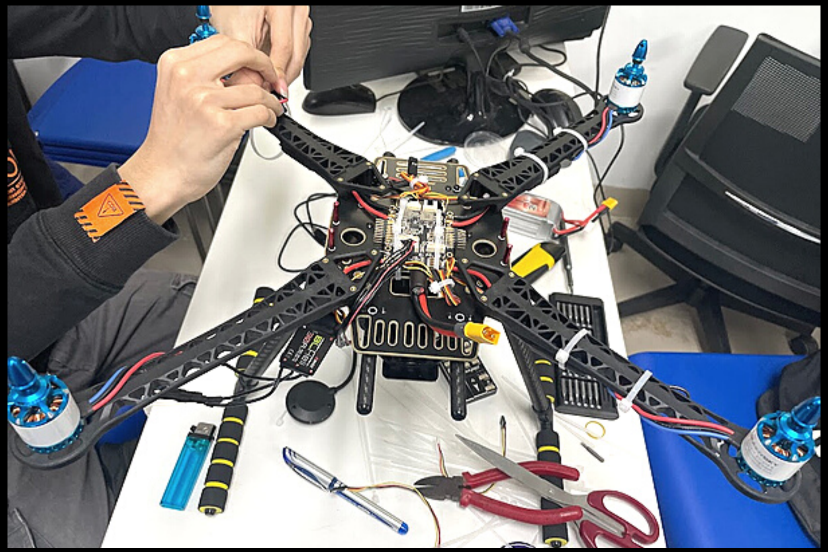


Fig.22: Attaching components and connecting wires on the frame

3.2 Diary

Firstly was the construction of the bare drone frame, with the materials from a bought kit. The process was surprisingly lengthy due to the large number of screws and bolts needed.

Fig.20: The drone's bare frame

Next was the connection of various electrical components. We soldered the ESC to the power distribution board, did the same to motor and ESC wires, securing them to brass connectors so that we can easily remove/connect them if necessary. We then attached the flight controller, battery, Raspberry Pi, and camera. We connected all these components and managed the cables neatly on the drone. This initial process took 2 afternoons and 1 morning to complete. We then uploaded the PX4 firmware from our laptop, checked the GPS connection, and performed calibration tests.

Gallery of the drone construction process

1

Fig.20: The drone's bare frame

2

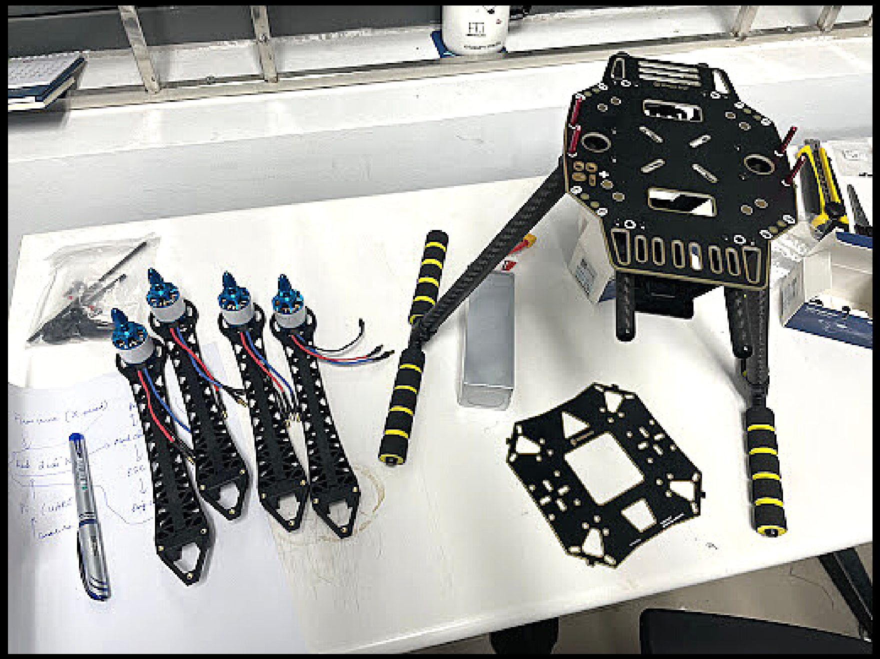


Fig.23: The drone frame detached arms with motors

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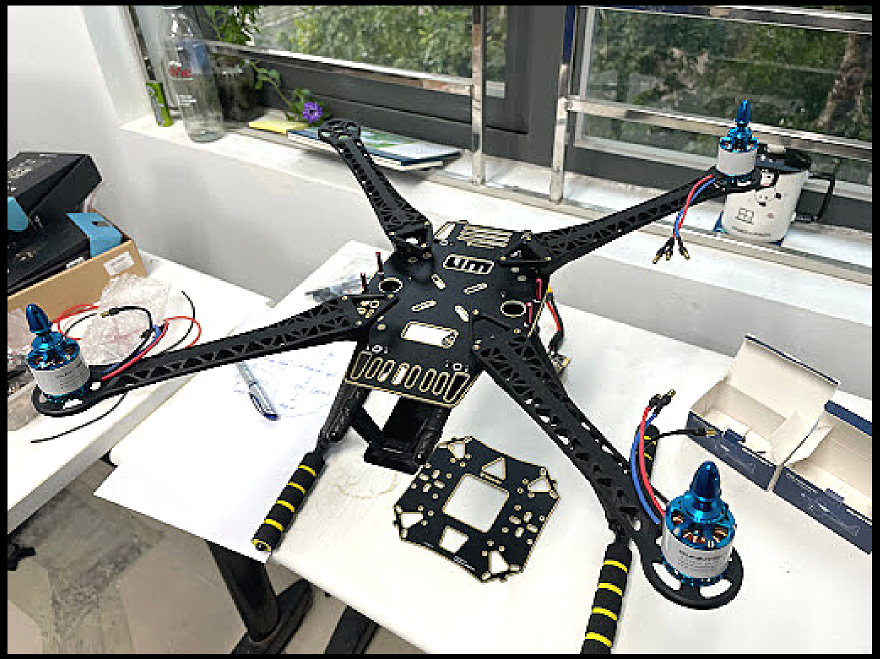

Fig.24: The drone with motors mounted

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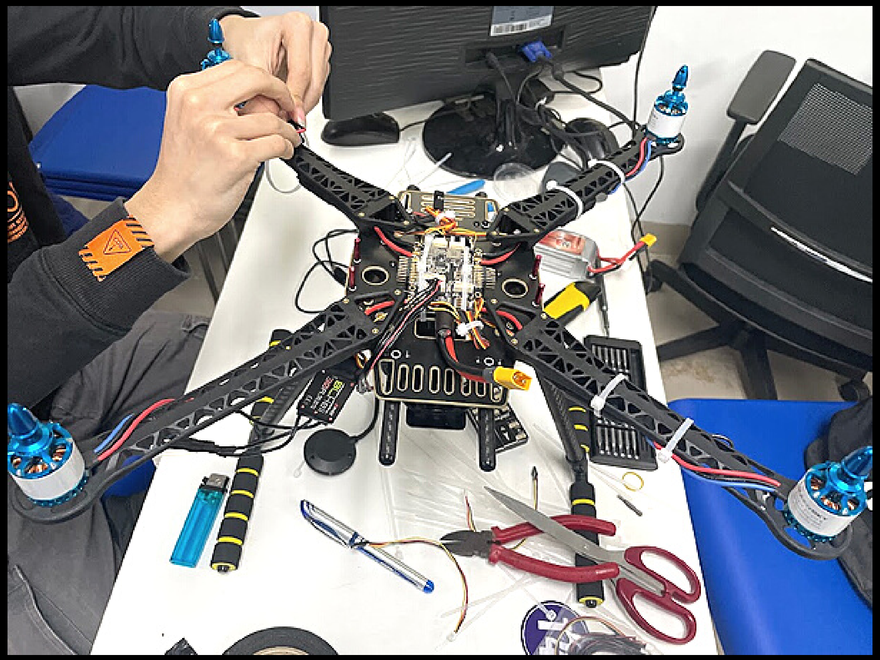

Fig.22: Attaching components and connecting wires on the frame

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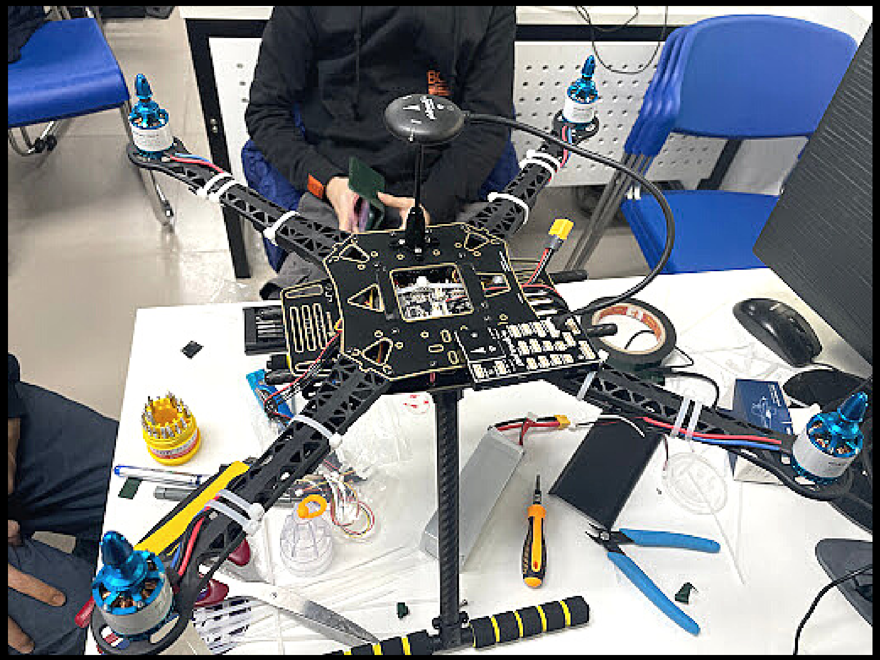

Fig.25: Mounting the drone's top panel

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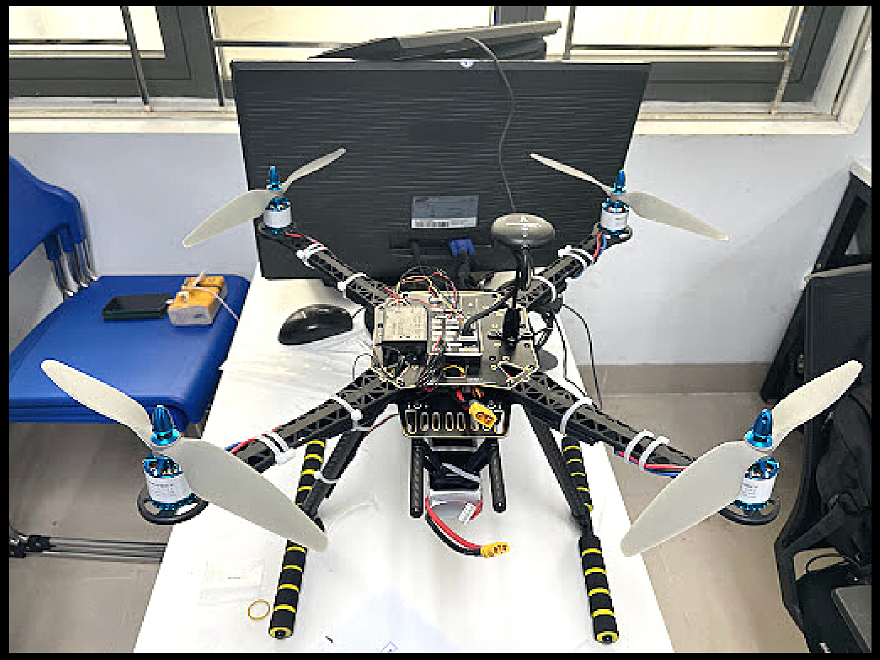


Fig.26: Drone fully built (Front view)

The first flight test failed, as 2 of the motors failed to rotate smoothly, making the drone unable to takeoff. One of the motors was also noticeably heated compared to the rest. Troubleshooting efforts started with switching the motors around (motor 1 to the position of motor 2, motor 2 to the position of 3, and so on) to find the failure point. We suspected either the motor or ESC was faulty.

After switching motors, the problem still occurred in the original spot, confirming that the ESC was the issue. An oversight in our component purchasing process resulted in us lacking any spare ESC, leading to us having to borrow the ESC of an old drone belonging to the VNU University of Engineering and Technology's lab.

Although not the exact ESC model, the specifications were the same, allowing a drop-in replacement with the addition of some re-soldering. The following day, the drone successfully completed a brief test flight.

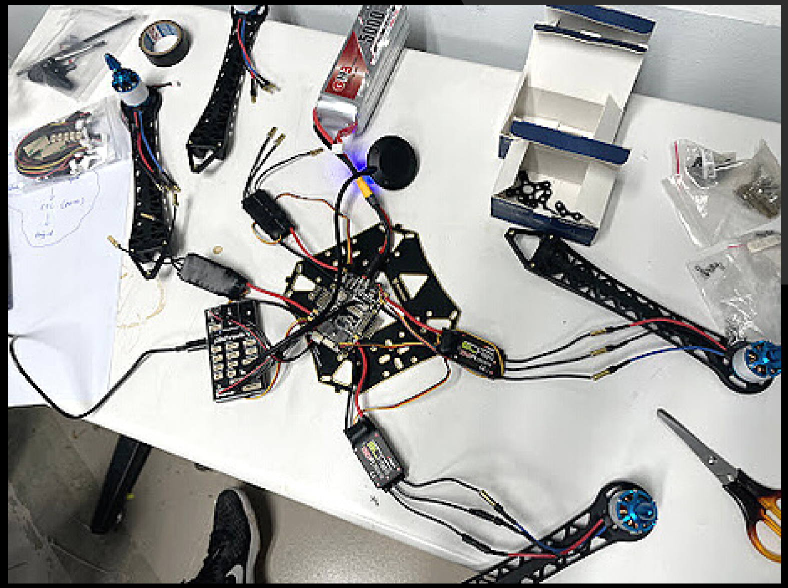


Fig.27: Drone disassembled for troubleshooting

Fig.29: The drone gaining altitude

Fig.28: Duc Long preparing the drone for a test flight

2 days later we brought it to its next test flight. The drone crashed, breaking one of its landing legs and propeller. It was due to the navigating system unexpectedly disconnecting from our laptop. We replaced its propeller, cut the 2 landing legs so that they were the same length, and put it up in the air once again. Unfortunately, after around 10 seconds airborne, one of its motors shut down and it plunged into the ground, breaking one of its arms, and damaging the landing legs beyond repair.

The motor that suddenly stopped was found to be more heated compared to the rest. We suspected that the issues in the first test, coupled with the previous crash, had damaged the motor and led to this failure. Once again, we did not have the spare parts immediately available, leading to a waiting period of purchasing and waiting for the delivery of additional components.

This was certainly a valuable lesson for having contingencies and backup plans/equipment in place for these projects.

Eventually, the needed parts arrived, and we replaced all the failed/broken components with new ones. After calibration, we conducted another flight test. This time it successfully flew for 10 minutes straight.

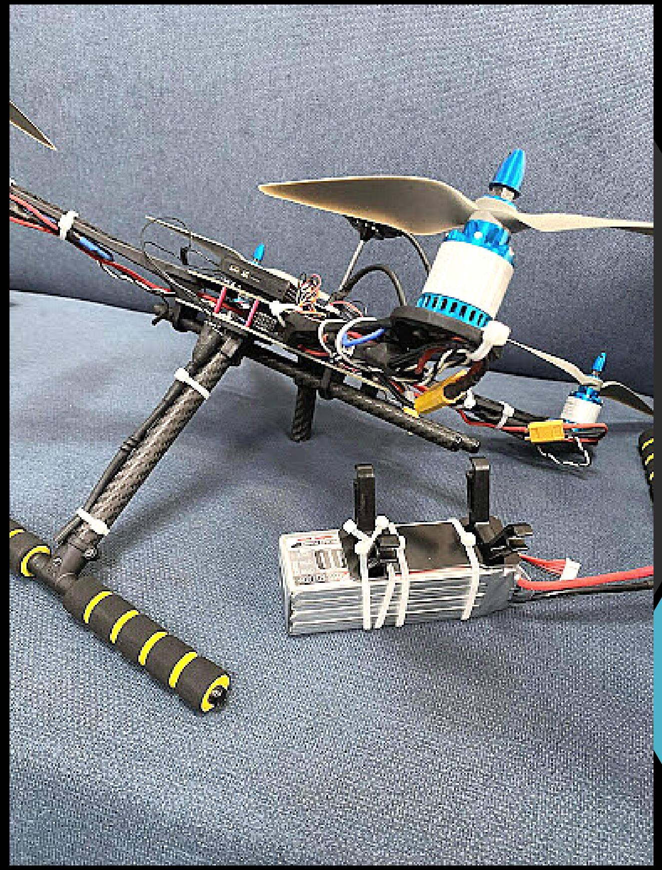


Fig.30: The damaged drone after failed flights

Fig.31: Project Members performing preflight checks

It landed and we did brief checks on the drone and found no issues, most notably the motor's temperature are all in the expected range. We sent it up to the air, where it completed another 10 minutes of flight. Upon recharging the drone’s battery to its full capacity, it safely flew for roughly 17 minutes, which is nearing the maximum flight time for the battery and drone setup we were using. While we understood more testing would have to be done, it was a preliminary success.

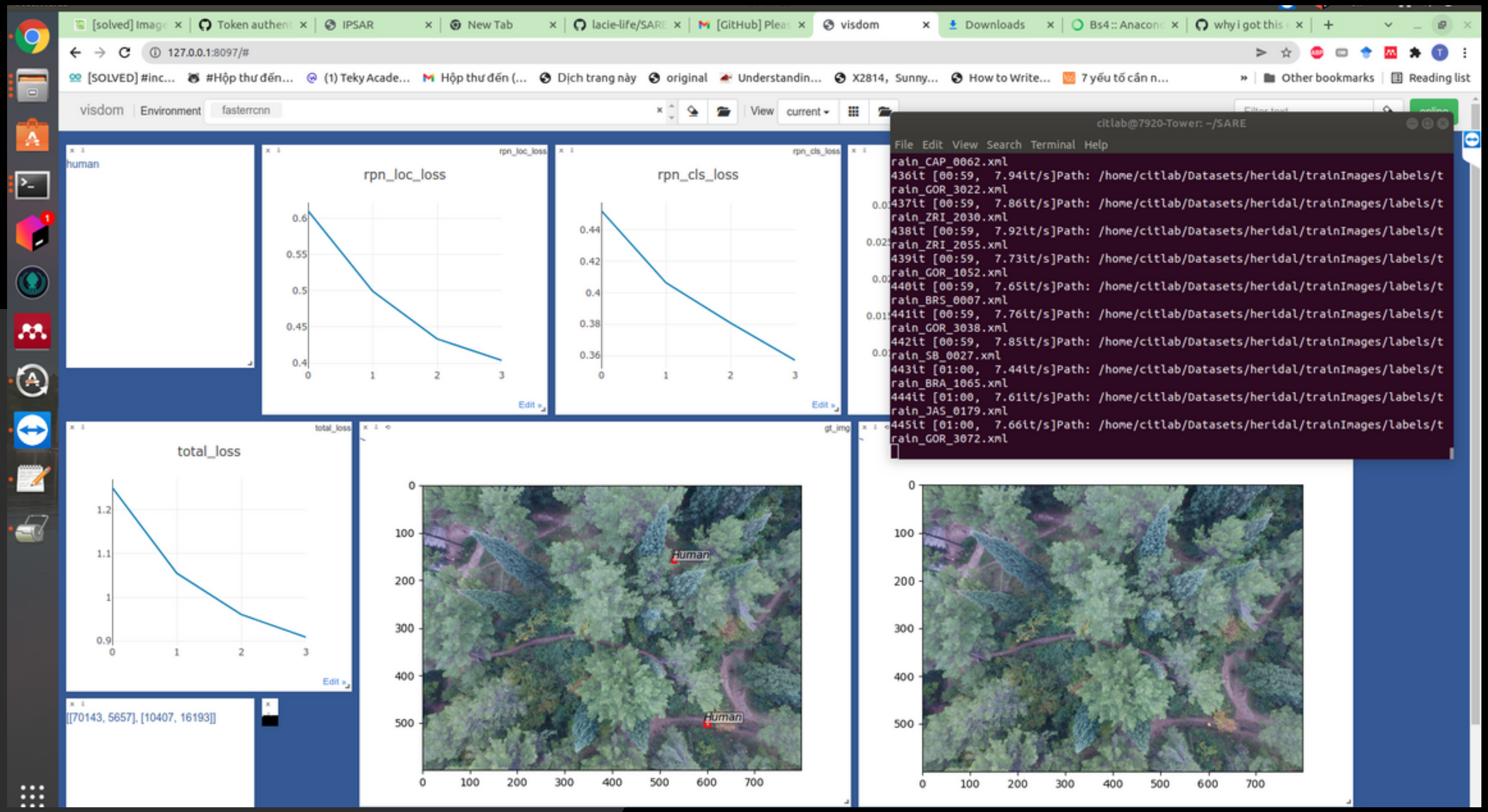
Fig.32: The drone successfully completing a test flight

Fig.33: Khanh Minh examining the drone after flights

Phase 4: Implementation of image processing and machine learning

4.1 Summary

Once the hardware portion of the project was completed, we forged onwards to finish the software portion, which involves image processing and Machine Learning algorithms. The whole process was done directly on the Raspberry Pi.



4.2 Diary

The first step was obtaining necessary prerequisites. We installed the Anaconda coding environment on our Raspberry Pi, allowing coding in the Python programming language. Then was the download process for various libraries and tools, most notably Tensorflow and Keras, which enabled us to use Machine Learning. The Accenture AIR solution also served as our detection and data training framework, albeit requiring a substantial amount of modification due to bugs. Essentially, we have all the necessary components in place, the remaining objective for our code was to link all these pieces for it to function together, bringing us the desired results.

Fig.34: The program carrying out data training

And we did just that, writing the program for all these resources to collaborate in the drone's flight, as well as tweaking codes to fit with our usage and hardware. Some additional steps, such as image preprocessing, were also needed to make everything function as a whole.

Once again, the debugging process as we coded portion to portion was lengthy, but with online forums and instructors' guidance, we were able to complete it eventually. Some preliminary tests were conducted to test the accuracy and reliability of the program's detection, the results of which were encouraging. At the moment, the program is able to detect individuals from the drone's flying height.

The final piece is to enable the Raspberry Pi to request coordinates from the GPS module and send this, along with the taken pictures to our ground equipment. Unfortunately, due to the COVID predicament taking a turn for the worse in Hanoi, our progress was once again hampered. As such, this portion of the code is in progress, though it is still expected to be completed soon if all goes to plan.

Fig.35: Machine Learning detecting person from flying height

Phase 5: Tests and adjustments of the system

5.1 Summary

This is the planned final step to refine the project to the best of our ability, ensuring the maximum level of functionality and reliability. Due to obstacles of the COVID pandemic, the team have not moved onto this final phase.

If the system fails to meet these criteria, troubleshooting and subsequent adjustments will be made until it does. Essential components, such as the GPS module, motors, and the camera will be checked for anomalies after every flight.

5.2 Diary

Once our final portion of the code is completed, we will move on to conduct final assessments on the drone. The planned tests and criteria include:

- A minimum of 15 successful full-time (15 - 20 minutes), full-altitude (10 meters) flights.
- A minimum accuracy of 98% in human detection (in all of the flight tests mentioned in criteria 1).
- A minimum success rate of 98% in transferring the accurate coordinates and pictures to ground equipment upon victim detection (within all the flight tests mentioned in criteria 1).

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