ISEF 2023 -Research Plan

Reconnaissance and Medical Drone

By: Nathan Aruna & Christos Velmachos

Rationale:

As machines and computer software develop, we can begin to replace dangerous or expensive tasks. We designed a drone from start to finish with the use of computer software and hardware. Our focus was to solve these pressing issues with our drone. Which in return avails paramedics, ski patrollers, military/government operations and search and rescue teams. One of our focuses has been on the issue of fatalities stemming from the delayed arrival of paramedic teams during emergency situations. To mitigate this challenge, our drone can be used to identify the location of incapacitated individuals and relay this information to medical professionals in a timely and efficient manner. This technology is designed to enhance emergency response times and ultimately, to save lives in critical situations. Secondly, we have identified a problem pertaining to the access of vital supplies in rural areas. To tackle this challenge, our drone is equipped to transport and deliver crucial supplies, including medical provisions, to remote locations during times of crisis. This cutting-edge technology is meant to enhance emergency response capabilities and ultimately, to safeguard the lives of individuals living in such areas. This can all be done with advanced python modules and drone technology. Our project is heavily inspired by the utilization of drones in the current ongoing conflict in Ukraine. Drones like the DJI Mavic Pro are great but for the most part they are single use. The open-source software that we use allows us to identify terrain details, humans, and animals with the use of AI. Additionally, cargo can be attached and automatically dropped when a certain waypoint is reached. For more reliable cargo drop off we have enabled remote release via the ground computer. The drone operator can write custom python scripts for more specific applications. Our drone can be utilized in multiple situations, 1: a controlled environment like a ski resort with a good understanding of the terrain and property limits. An environment like this is where our drone can operate most efficiently. Not only because the search area is well defined, but the drone operator can set automated paths over less populated areas, reducing the need for human presence.

Our drone is equipped with a wide array of sensors that provide almost perfect precision. Among the features on board are a global navigation satellite system (GNSS) receiver, dual inertial measurement units (IMU's), and a high-resolution barometer. The IMU's, which are equipped with accelerometers, allow for the measurement of a moving objects acceleration on each axis. Additionally, the IMU's incorporate gyroscopes, which enable the determination of the drones (pitch, roll, and yaw). To enhance the accuracy of the data, advanced techniques such as a Kalman filter are utilized, which combine data from various sources, including GPS and IMU data, to estimate the drones positioning. While a full understanding of Kalman filters may not currently be necessary, it's advantageous to have a basic knowledge of them when conducting testing and debugging our drone. Many issues were faced during the research and the production of our project. Issues like satellite connection, radio communication, water damage, and even shipping time delayed our progress. However, we managed to overcome any challenge we faced.

Materials:

A Raspberry Pi 3 is at the heart of our drone and makes all the logical processes. This is then paired with the Navio 2 sensor shield. Other critical materials like 4 935kV brushless motors, 4 electric speed controllers, 1 (5100 mAh 11.1V 20c lipo), 2 (100mW, 915 Mhz Telemetry Radio), Raspberry Pi camera, and a drone frame needed to be purchased. Less important components like zip ties, electrical tape, solder, m3 bolts and nuts, and a roll of PLA filament, all proved to be useful in the construction of our project. Components like propellers, GPS antenna, and the power distribution board came together with other purchases.

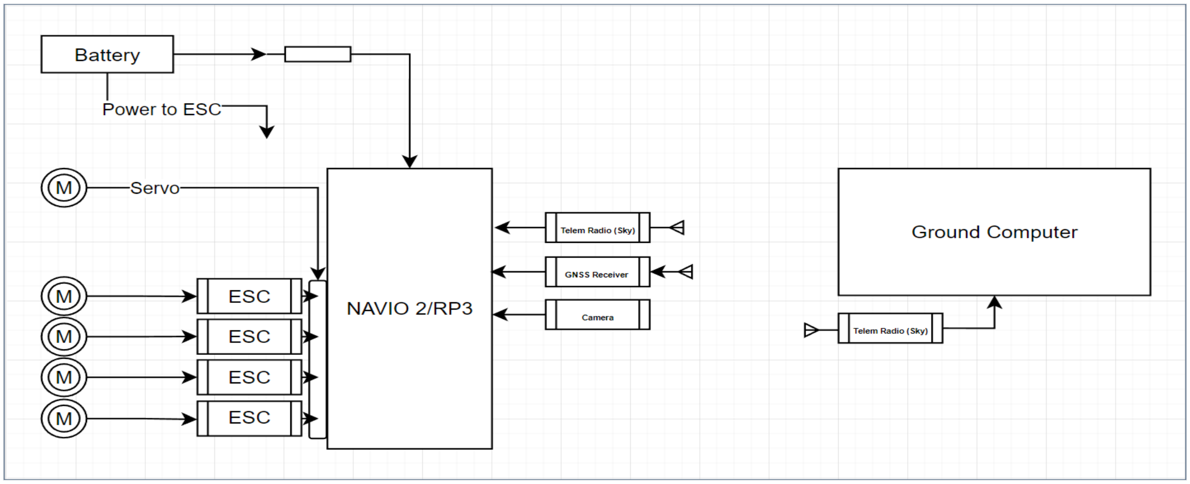
Procedure:

Making use of rigid injection molded plastic, we put together a drone frame to house all our components. To create some distance between the drone and the ground, legs are 3D printed and installed to the drone's frame. Two m3 bolts are used to secure each leg.

Four 935kv brushless motors are securely bolted to the frame. Zip ties came in useful to secure the ESC’s and tidy up the wires. An anti-vibration plate was purchased online to dampen the vibrations created by the motors. Four m3 bolts secure the anti-vibration plate to the drone frame. A pole was 3D printed for our GNSS receiver and mounted on one of the drone arms to give a clear and unobstructed view of the sky. The drone registration number, camera, and cargo release mechanism are all mounted on the belly of the drone. Double sided tape was used to accomplish this. The last step hardware-wise was to wire everything up and ensure proper solder connections. Tools like helping hands help keep our wire still while we soldered. All the ESC’s, servos, GNSS receiver, and telemetry radio interface with our flight computer.

We used secure shell or SSH to remotely connect and access the flight computer. This form of connection to the drone is imperative to upload programs that we need to run. This is only required for the initial setup as we use a telemetry radio later. Data such as airspeed, altitude, sensor data, latitude/longitude, and compass data, are transmitted over this radio channel.

Electrical Schematic:



Risk and Safety:

Safety and regulation were a big concern during the early phase of our project. Things like radio frequency and drone registration via transport Canada were all taken into consideration. Our registration number can be found on the belly of our drone (C-2227001494). More safety precautions systems have been implemented to repudiate takeoff whenever the drone's batter is below a certain threshold, or when there is no solid satellite connection.

Data Analysis:

Battery used during testing – (5100 mAh, 3 cell – 11.1v, 20c, lithium polymer battery)

Motor specifications – (935 KV, Max Current 12 Amps, 900 grams of thrust)

Telemetry radio specifications – (100mW, 915 Mhz, connection to Raspberry Pi via UART port)

- 80% load ≈ 23 min 32 sec of flight time * calculation-based estimation.
- 3600g (motor thrust) – 2500g (drone weight) ≈ 1000 g absolute max carrying capacity.
- Telemetry radio range ≈ 300 meters.

Discussion:

Search and rescue efforts can be considerably improved by the use of this autonomous drone, which can surveil a specific region and reduce the time necessary to save people. This remarkable technology has the potential to save many more lives while also lowering the cost and amount of physical effort required for missions. Unlike many existing drones, the possibilities are limitless because of its extremely versatile design. However, it may take some time for the operator to grasp the functions and capabilities. To use its AI feature, you must be familiar with computer programming, notably Python (a high-level programming language). Lines of code can be written and uploaded to the drone via our ground computer. A truly limitless system because of Python's thousands of opens source libraries. Probably the most important library for this application is "OpenCV". "OpenCV" allows Python to analyze individual frames for detection of objects, humans, terrain, etc. Rather than just surveilling locations, you may instruct it to drop medical supplies utilizing the cargo release mechanism. The autonomous drone functions entirely on its own, you simply have to input waypoints into the ground computer. After determining the course, it will fly autonomously utilizing the on-board flight computer. Whenever something interferes with the drone, such as a strong gust of wind, it will rectify itself, making it even more reliable. This drone is unique in that it is open source, which allows you to tailor it to your specific demands and needs, making it an even more versatile tool for whatever application you might have. You can alter it to capture various types of data, such as locations of enemies or civilians. An understanding of CAD, computer programming, and soldering is needed to replicate this design. Furthermore, this drone is relatively inexpensive to manufacture; for around $800 and a little handywork, our drone can be mass produced. Making an army capable of much larger deliveries or cover a much more vast and unoccupied area. Although we must ensure that each drone can communicate with one another may entail a more complicated system. Using an electric drone instead of a large gas helicopter is far more ecologically friendly. A drone simply needs one operator, in contrast to a helicopter that needs at least two skilled pilots. In addition, depending on the circumstance, a drone's stealth may be a significant benefit.

Conclusion:

To recapitulate, it was designed with the purpose of appealing to a range of applications such as search and rescue teams, paramedics, and public safety. Months of continuous testing and issues occasionally lead nowhere. Our problems included satellite connection, radio communication, and power distribution. There are some limitations, like with most inventions. There is a weight limit, as it cannot lift more than ≈500g, however we can upgrade the drone in the future to carry more weight. Thermal imaging could be used to improve efficiency in low-light conditions. One significant issue with our concept is that live footage from the drone cannot be obtained. This means that any entities spotted by our drone can only be examined after it has landed. It also cannot avoid objects in flight because it requires several cameras or an object detection system to do so. Future improvements may include installing an object detection system, adding thermal imaging for even greater accuracy, making the drone more powerful to carry more weight, radio range, live transmission of feed to ground computer, and a longer lasting battery. We have learned many skills in the process of this year's science fair project. These skills include proficiency in Autodesk inventor, proper soldering techniques, and mathematical algorithms more specifically the Kalman Filter.

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