PART A: PROBLEM DEFINITION

A.1 Problem statement and project aims

Aim:

The aim of this project is to develop a remote-control drone used on campus to improve its security. Such drones can patrol the campus autonomously and perform aerial filming and photography, which serves as surveillance. The data will be sent back to the central server to identify if there are any unusual events using machine learning mechanisms. When an event occurs, it will assess the severity of the event and take appropriate action (send a message back to the office, contact the police, etc.) to minimise the damage.

Objectives:

A1.1 - To consider using materials durable enough to withstand damage such as strong winds and heavy rain, avoiding accidents caused by falling off the campus.

A1.2 - To select a set of cameras that can take high-quality images and thermographic imagery and turn on the infrared LED light for auxiliary light when there is no insufficient light source.

A1.3 - Set an appropriate drone patrol schedule and regularly dispatch drones to ensure campus security issues.

A1.4 - Set appropriate drone patrol routes to maximise the coverage of all critical areas while ensuring the feasibility of ways and considering the availability of resources.

A1.5 - To determine when power is low and go back to charge, then call the next drone

A1.6 - To select both lightweight and durable batteries to maximise drone flight time.

A1.7 - To build a flawless wireless network on campus so the data can be returned to the server without any loss or delay.

A1.8 - To create a mechanism to maintain an extensive database to store each student and teacher's face and basic information, suspects, and criminals.

A1.9 - To develop an image processing algorithm to determine the type and severity of security events using the images taken by drones and use the database in A.1.8 to determine the intruder and victims (if any)

A1.10 - To develop a mechanism to take immediate action on different events (notify security guard immediately when an outsider invades, contact police when a crime occurs, ring fire brigade when fire, etc.)

A2. Feasibility Study and issues on Ethics and Sustainability

Marketing segment:

According to precedence research, the global commercial drone market size is expected to be worth around USD 504.5 billion by 2030 and is poised to grow at a CAGR of 46.04% over the forecast period 2022 to 2030. Consumer drones are becoming increasingly popular among people that want to earn a second income, explore ariel photography, and use drones in safety and airdrop supply programs. In addition, they are also becoming popular with traditional flight enthusiasts and hobbyists. Customers are increasingly exploring the benefits of drones in enriching leisure activities and interests, resulting in a significant increase in global consumer drone sales. Furthermore, the recent initiatives by the federal aviation authority (FAA) and additional governmental spending on advanced drones are anticipated to drive industry growth in the US. The impact of COVID-19 on the UAV drone market (pre-pandemic) saw global demand for drones rise rapidly owing to their diverse application portfolio across a wide range of industries. However, as the COVID-19 epidemic hit, industrial activity around the world slowed down, resulting in a decline in demand for drones. Despite the tepid short-term prospects, increased investments in technology are expected to fuel long-term market growth.

Therefore, the demand for drones, especially when wanted to be used in safety programs, is very high, meaning our project is very feasible and will fully meet these demands.

Technical segment:

A drone is an automated, unmanned and mechanized vehicle that is mobile in nature and can be used to perform varied tasks as opposed to a robot which performs the same task repeatedly. A drone system relies on a combination of hardware and software components to achieve successful take-off, flight and landing. For a drone used in a safety program, the drone must be able to survey the property in the correct amount of time and efficiently. The drone must have rotors or fixed wings, sensors, navigation systems and gyroscopes for stability. Another requirement with regard to the drone safety program is land surveying. As the use of drones for public safety continues to expand, so does their usefulness in emergency situations. By providing responders with a wide range of ariel reconnaissance and mapping capabilities, drones have revolutionized public safety operations in ways that were never possible before.

A component of the drone is its sensors for safety. An HD visible camera with high zoom capabilities and a high precision thermal camera. The camera must have the ability to capture high-quality and high-resolution images. The drone camera must also have the ability to shoot 4K videos. It should also have different features: capture photos and videos in 4K and heat/thermal camera detection. The camera should also be able to synchronize any video/photo captured to any external device. Cameras must have high performance, zoom and gimbal steady Cam to zoom into faces and emergency situations, and tilt capabilities (Cast, 2022)

More drone features include artificial intelligence (AI) that enables drones to follow objects. Augmented reality features superimpose virtual objects on the drone’s camera feed. They can also be equipped with sensors, including ultrasonic, laser or lidar distance sensors, time-of-flight sensors, chemical sensors and stabilization and orientation sensors. The drone will also have aerodynamic development, a propulsion system th at has been upgraded, which would result in more weather resistance which is vital when flying the drone to perform ariel filming and photography efficiently (Nichols, 2022)

All the features of our drone are extremely important for its purpose: using a drone to improve security on campus. The most significant factor in surveillance and security patrol is the safety of students on campus. This means that the drone must be as efficient and as renovated as possible. The latest technology and innovations attached to our drone make it easier to do its job. It will have more flight batteries and chargers for maximum flight endurance. The drone will also have non-magnetic navigation meaning that the navigation is more robust and subject to less magnetic interference, which is significant as the drone will be able to capture the right footage at the right time without being diverted.

In conclusion, our project is very feasible regarding the market and technology. Despite the advantages, it is said that constructing and deploying this drone onto campus could require help from business angels and perhaps a loan from the bank. Yet, this would allow the safety of students to be as high as possible, and the technology could therefore be adopted by multiple campuses across the country.

A.3 User Requirements

A3.1 - Used to improve campus public safety：

According to the 2020 Public Safety Drone Report by the Center for Drone Research at Butte College, drones have been used in the United States to find prisoners and maintain public safety (GETTINGER, 2020). It is feasible to apply drones to maintain campus safety. We can use on-campus applications to locate missing persons, evaluate traffic accidents, film crime scenes, and draw evacuation routes to assist fire and police evacuation.

A3.2 - Details on how drones are keeping students safe.

Pushstart has proposed a new autonomous drone system capable of accompanying students and staff to their destinations on campus. Once the drone is called, it will accompany the user to the destination. The colleague drone can also wait for the bus with the students in a circular form to protect the rotor and prevent accidents. This system can illuminate the road for students and start an emergency alarm service under the user's manipulation (Pushstart Creative, 2017).

A3.3 - Drones can be used in campus maintenance.

According to research from Stanford University, the current drone technology has been developed to capture specific objects or filter image details (Han et al., 2022). Therefore, the campus can describe drones as external wall maintenance or looking for mechanical parts under the current technology. In this way, it can ensure that the campus facilities will not be deliberately damaged when students are using them, resulting in accidents that endanger the safety of students.

A3.4 - The connection method of the drone and the covered area.

The current primary connection method of drones is through radio or a network, so when we use drones on campus, we need to provide a stable Wi-Fi signal (Vatelmacher, 2020). And the signal needs to cover the entire campus to achieve the purpose of using drones.

A3.5 - Weight and power control of UAV.

Lighter drones will fly longer than heavier drones, and having suitable batteries and providing charging stations can extend the drone's operating time (UniEnergy Technologies, 2022). Therefore, the application of drones on campus requires supporting measures such as building drone charging stations and controlling the weight of purchased drones.

A3.6 - Establish drone access permissions.

At present, the access control of Class A buildings in the United States uses a drone identification system, which is used to identify whether a visitor has registered and then determine whether the visitor is eligible to enter the building (Shamy, 2016). Schools can refer to the system and change to users must provide a student ID or license being used for emergency rescue. This ensures that campus drones are used wisely to save school resources.

A3.7 - Drones need to be able to detect.

The drones used on campus need to have radar to detect nearby drones and change their flight paths. At the same time, the detection system needs to provide secure position data and a central system to allow users to know the location of drones. This function can give users better information when the drone rescues or finds objects.

A3.8 - Drones need to have a remote control system.

In addition to the automatic navigation function, the campus drone also needs a manual operating system. The system needs to allow the user to move the drone, for example, east, west, east, west. This can add a layer of protection for the use of drones under particular circumstances.

A.4 Constraints

Cost constraints – The process of manufacturing drones and implementing advanced technology into them remains an expensive one. The demand for drones has risen dramatically over the last couple of years, which is why they remain expensive. However, the usefulness of drones outweighs the cost constraints associated with them. If drones can guarantee safety and security surveillance, the cost of producing them or the price of purchasing one shouldn’t be a problem.

System constraints – On May 12, a drone flew illegally over Orange county. The drone crashed into a swamp causing 3,000 nesting terns to fly away out of fear of an attack. 2,000 eggs were left behind, ultimately wiping out a future generation of terns. Huntington beach is now littered with eggshells. Some types of drones also emit chemicals that can harm agriculture, and studies have also illustrated that certain types of drones can release up to 3,400 grams of CO_2 per 24 hours (Rosenberg, 2021).

Privacy constraints – A primary concern associated with drones is privacy. Drones can be manipulated and hijacked. They can also trespass into authorized areas such as airports and military zones. While convenient surveillance is an advantageous use of drones, it can become a disadvantage with severe consequences when done by third parties. Despite this, measures have been taken. Such as geofencing to restrict the movement of UAVs into authorized zones. There is still more to be done to secure public security and individuals’ privacy (Husain, 2022).

PART B: SYSTEM REQUIREMENTS

B1 inputs and outputs

B1.1 - Powerful embedded I/O interface

The I/O interface can be built into the computer system or as a pluggable module. These processor boards and single board computers (SBCs) are based on standard form factors such as PCI/104e or COM Express. They can contain a variety of ports and interfaces for standard connectors such as USB, micro D-Sub, or military circular connectors per MIL-DTL-38999 (Simpson, 2022).

B1.2 - Analog and digital input and output signal
The I/O interface can communicate via analogue or digital signals. Analogue inputs may come fro m sensors that measure environmental factors such as temperature or pressure. Analogue outputs may need to communicate with devices such as flight surface control actuators, antenna platform c ontrols, or fluid or hydraulic systems. Because computers process digital signals, analogue I/O inte rfaces and modules require onboard analogue-to-digital and digital-to-analogue converters (ADCs and DACs) (Simpson, 2022).

Digital I/O systems can communicate using a variety of protocols. Serial protocols include RS-23 2, RS-422, and RS-485, which vary in the number of command and listening devices per port and the maximum length a signal can carry. Other standard protocols include PWM (Pulse Width Mod ulation), UART, I2C, USB, and CANbus (Simpson, 2022).

B1.3 - hardware in the loop system
During drone and looping system design testing, the I/O interface can connect to hardware-in-the-l oop (HIL) systems. These systems allow real-time simulations using accurate signals and simulate the signals used during operation (Simpson, 2022).

B1.4 - The FLC algorithm is implemented in AR.Drone 2.0 Elite Edition by LabVIEW software. F urthermore, the algorithm was tested on different trajectories, such as B. Straight lines, straight lin es with vertical curves, rectangular trajectories, and curved trajectories. The results show that AR. The drone can follow the course well under different initial positions and orientations (Prayitno et al., 20 14).

B1.5 - Two cameras are installed on the bottom of the drone, and a thermal imaging camera next t o it outputs image files of type JPEG based on user input from conventional cameras. Air traffic c ontrollers take pictures.

B1.6 - It is required to have radar detection and automatically transmit the detected data to the central system. The data can be the drone's location or the location of other drones and their flight history.

B1.7 - Campus drones need to fly automatically and monitor designated areas, and they also need to fly autonomously to charging stations. All non-manual actions require the support of the program, so the campus drone must have a memory to store the program.

B2 Operation requirements

B2.1 - The drone will have 6 operational modes: manual mode, automatic mode/autopilot mode, p osition mode, trace mode, surveillance & accident mode and storage.

B2.2 - Manual Mode - this mode allows the user to control the drone with the highest manoeuvrab ility manually and can be used for free flying. In this mode, all other flight assistance functions are disabled. (Stapleton, n.d.) The user has complete control of the drone. (Singh, 2022)

B2.3 - Autopilot Mode - the drone operates without needing remote control and is active when ma nual mode (B2.2) is inactive. "The autopilot has 2 significant modes: first with the use of GPS to fly pre-programmed missions and second with tracing a target" (RM, n.d.). Autopilot is activated when the drone is low in the battery (below 25%) or when there is a connection interrupt (WIFI si gnal and/or connection interrupt) to return to its base to charge. (Editor, 2022)

B2.4 - Position - in this mode, the drone holds its position in the air. All drone sensors are active i n this mode, allowing robust GPS and WIFI signals. The drone operates more stably in the locatio n mode with a strong signal. This mode can be used for surveillance to take images/videos of the s urroundings and store the environment around the drone (Posea, 2022) and then put it into the dro ne's database.

B2.5 - Trace Mode - the drone traces the vestiges. The target is identified by image processing. Th e information used for image processing is taken from the user to teach the machine and help it ide ntify surrounding objects and people. The data taken is then put into the database of the drone for f urther use. The trace mode follows the thing in the move while keeping an appropriate distance fro m the thing. (Heid, 2017)

B2.6 - Surveillance & Accident Mode - helps receive real-time information via live streaming. It al lows the control of the site, detection, and protection of objects and individuals. The user is inform ed if there is a victim found. (Lutkevich & Earls, 2021) The surveillance taken can be used to iden tify the victims and attackers/perpetrators. Accident mode allows viewing the incident from differe nt angles to secure evidence. (Security Drone, 2022) This and the information from the database h elp identify the severity of the situation and, if needed, contact the authorities. (Surveillance drone: What solutions are available?, 2022)

B2.7 - Storage - every surveillance, image, and video taken by the drone is sent to a database to be processed by the machine learning algorithm to improve response to the situation, minimise respon se time, and improve the quality use of the drone.

B3 Functional requirements

B3.1 - Durable battery: Only a battery with muscular endurance can run the drone patrol stably.

B3.2 - Camera and infrared fill-in light control: The drone needs to automatically fill in the light when the light is insufficient and then use the machine to judge people who may be dangerous.(Ariw oola, 2016)

B3.3 - Event detection system: The drone must be able to faithfully relay the situation and immedi ately use recognition algorithms to judge possible victim detection.

B3.4 - Automatic alarm system: When the drone detects danger (such as a fire), it can immediately call the corresponding processing personnel.

B3.5 - Automatic positioning system: There must be an accurate positioning system which can ide ally locate the exact place of the event when danger occurs.(Shin et al., 2020)

B3.6 - Campus 3D model drawing algorithm: Drones must be able to transmit images in real time to the mechanism. With an automatic positioning system, the processed images should be able to d etect the cause of the hazard and immediately start the automated alarm system.

B4 Non functional

B4.1 - In the case of network interruption, the data stored in the drone's disk will be stored till it is uploaded to the system (till the connection comes back). When the data is uploaded to the central s ystem, data stored in the drone will be deleted.

B4.2 - The drone returns to base when: its battery is lower than 15%, there is a connection interrup t, and there are issues with hardware (sensors, cameras, coating).

B4.3 - The hardware for the drone parts should be in access (the supplier should provide spare part s) and be easy to replace with the instructions provided.

B4.4 - Drone parts should be disposed of as indicated on the labels.

PART C: KEY DESIGN CHALLENGES

C1 - Handle complex programs:

We want to design an autonomous drone system and apply this system to campus drones. This drone can receive the user's call and automatically arrive at the user's location from the charging station (Pushstart Creative, 2017). It involves many programs, so campus drones need an effective processor and memory to store the programs in the system and process them quickly.

C2 - Identify direction and position:

For the drone to reach the destination from the starting point, it must have a positioning system. The difficulty of this positioning system is that it needs to use the network and satellites to achieve accurate positioning (Pushstart Creative, 2017). Therefore, to achieve autonomous drones to maintain campus security, we need to provide a stable network and have an accurate positioning system.

C3 - Lighting system and camera function:

Current drone technology can be equipped with lighting systems and cameras. Take DJL Mavic drones as an example(Tundra Drone, 2022). This drone is equipped with four anti-collision lights and can reach 10,000 lumens. This technology can be applied to campus drones to perform the functions of escorting or monitoring at night. In addition, it seems that the UAV has the patented technology of Automoving(Tundra Drone, 2022). This technology can automatically follow the camera. We can improve based on this technology and make the drone follow the user's mobile phone to achieve accompanying lighting effects. Or follow the ambulance crew to carry out rescue operations at night.

C4 - Tradeoff between size, weight and power:

There is an apparent trade off between the components of drones. For example, a good sensor may be heavy and introduce aerodynamic drag to the drones. A bulky sensor can also shift the centre of gravity location, which can cause imbalance and impact flight stability negatively. High resolution cameras/sensors will also reduce the duration of flight considerably due to their heavy use of batteries. Moreover, the weight of drones is directly related to flight time. The metallic structure of drones needs to be lightweight to reduce their weight of drones. However, if the drones are too light, it may cause problems in flight stability, especially under bad weather conditions. (Romeo, 2016)

C5 - Batteries:

The battery life should belong enough for campus patrol, which may take hours. It can be challenging because such batteries are mostly heavy or cost ineffective. Battery packs that are too heavy are not suitable for drones. The battery life and sustainability of patrol drones are also crucial as they are for daily use. If the battery life is short, it needs to be replaced with a new battery from time to time, which is very inconvenient and costly. If the battery malfunctions during flying, it will crash and burn, damaging drones. The mainstream choices in drone battery systems have several main types: fuel cells, lithium-ion, nickel-cadmium, and lithium polymer (LiPo). They are all viable choices, but it still needs to be tested and verified to see which one is best to fit our requirement. In addition, to ensure battery safety, we need to implant health-check modules in drones to monitor battery health. It should keep evaluating the condition of the batteries. When the batteries have problems, they can send alerts or go back to the base automatically.(Romeo, 2016)

C6 - Camera complexity:

Our drone will have multiple types of cameras, all with different purposes. Firstly, an FPV camera should be implemented into our drone. An FPV camera is a small camera which is light in weight and can be implemented at a low cost to producers. The FPV camera will be mounted onto the drone and will be able to send real time video down to ground level through a video transmitting source. This will allow the user to see where the drone is flying and the point of view of the drone directly. (Corrigan, 2020) There are also two types of other cameras our drone will be equipped with: DJI Zenmuse H20T and Flir Vue TZ20. These two cameras will have resolutions of 640x512 pixels. This will result in high quality images and videos with a wide field of view being the most significant. This will be extremely useful, especially when patrolling the campus and being able to view the campus from a reflex angle. Other cameras in the drone will print out heat maps where danger is present. However, despite the advantages, multiple cameras can cause an overload to our drones' systems. An overloaded CPU can cause the speed to decrease. To overcome this problem, a solid-state drive could be installed into the drone, allowing processes to run quicker with multiple cameras.

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ROLES TAKEN ON IN LAB ACTIVITIES:

Member	Lab 5	Lab 6	Lab 7	Lab 8
Chun Yi Ng	Manager	Questioner	Manager	Questioner
Chia Yi Chou	Questioner	Manager	Manager	Scribe
Melike Yigit	Manager	Questioner	Scribe	Manager
Hassan Nouri	Scribe	Manager	Questioner	Scribe

TEAM CONTRIBUTION STATEMENT

For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1 to 4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column.

Evaluation criteria	Chun Yi Ng	Chia Yi Chou	Melike Yigit	Hassan Nouri
Attends group meetings regularly and arrives on time.	4	4	4	4
Contributes meaningfully to group discussions.	4	4	4	4
Completes group assignments on time.	4	4	4	4
Prepares work in a quality manner.	4	4	4	4
Demonstrates a cooperative and supportive attitude.	4	4	4	4
Contributes significantly to the success of the project.	4	4	4	4
TOTAL	24	24	24	24

Feedback on team dynamics:

How effectively did your group work? - We assigned roles to each team member based on the requirements of the task. - Everyone participated, every suggestion was discussed, and decisions were made as a group. - With the meetings we had, we were able to carry out the project.
Were the behaviors of any of the team members particularly valuable or detrimental to the tea m? Please explain. - We switched around the roles that each team member played during lab sessions so we were abl e to hear what everyone had to say and discuss it.
What did you learn about working in a group from this project that you will carry into your next group experience? - Task management - Teamwork - Communication skills - Compliancy - Diversity in perspectives - Time management - Problem-solving