SKYWATCH: ENHANCING MILITARY CAMP SURVEILLANCE WITH PC-BASED MONITORING USING DRONE CAMERA TECHNOLOGY AT FORT BONIFACIO

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ABSTRACT

Drones, or Unmanned Aerial Vehicles (UAVs), are widely used in various applications, most notably military surveillance. This abstract describes a PC-based drone system designed specifically for surveillance in camp areas. The system incorporates advanced features such as real-time video streaming and autonomous flight capabilities to improve security and situational awareness in military environments. The drone, a hexacopter equipped with high-resolution cameras, captures live video transmitted to a ground control station (GCS) running on a PC for immediate monitoring and analysis. This allows troops in charge of camp security to quickly access critical information. The PC-based drone's standout feature is its autonomous flight capability, enabling it to follow predetermined routes using GPS and navigation devices, or it can be remotely controlled via the PC-based ground station. The research demonstrated the drone's effectiveness in detecting and tracking objects, including vehicles and people, thereby enhancing security measures at military camps. However, limitations such as range, battery life, and potential interference were noted. Further research is necessary to optimize the system for specific surveillance scenarios. Overall, the study underscores the potential of PC-based drones for military surveillance and lays the groundwork for future advancements.

KEYWORDS

Autonomous Flight, Military Camp, PC-Based Drone, Real-Time Video Streaming, Security, Surveillance, Unmanned Aerial Vehicle (UAV)

INTRODUCTION

Drones, also known as unmanned aerial vehicles, or UAVs, are becoming more and more important instruments in security and military activities. These drones are equipped with cameras, which gives them vital capabilities for intelligence gathering, real-time surveillance, and reconnaissance in contemporary combat situations. Military operations have been completely transformed by their capacity to fly over dangerous or inaccessible regions, collect data from a safe distance, and send this data to a ground station for analysis. Though there are many different drone models available on the commercial drone market, not all of them are suitable for military and security purposes due to their differing features. Commercial drones frequently don't have the processing power, storage space, or robustness needed to perform well in challenging conditions or on extended missions.

This study suggests creating a PC-based drone system specifically designed for surveillance operations near Fort Bonifacio Army Military Camp as a solution to these problems. Because of their inherent coverage restrictions and set installation places, traditional CCTV systems might not be very practical. The planned computer-operated PC-based drone is intended to patrol the area, basically serving as an extension of the military personnel assigned to the area's surveillance. Considering the variety of scenarios that military security officers encounter, the researchers hope to develop a drone system that is tailored to the client's requirements and allows for effective patrolling using cutting-edge technology.

Drones are very useful for military surveillance since they can provide vital information about enemy positions, movements, and strategic targets. Drones have been used for a variety of inspection tasks outside of the military, such as mapping terrain, keeping an eye on construction projects, examining tall buildings, and spotting cracks and structural flaws. Significant issues arise from aging infrastructure, especially elevated roadways and bridges, where repairs account for the majority of maintenance expenses. The hardware and software elements of the suggested system, such as the drone, camera, PC, and pertinent software programs, will be thoroughly examined in this study. Additionally, it will assess variables related to system performance like power consumption, data transfer rate, and image quality. The results will be discussed in relation to a fictitious setting centered on Military Camp Fort Bonifacio.

Objectives of the Study

The primary objective of this study is to develop a PC-Based Drone Surveillance system for monitoring the vicinity of Military Camp Fort Bonifacio, with a focus on providing real-time monitoring and analysis of the designated area, thereby reducing the need for foot patrols around the Army Signal School.

To achieve this, the study aims to:

1. Design a drone equipped with a high-resolution camera capable of gathering information and securing the perimeter of the military camp.
2. Develop software using Pixhawk and PyCharm as the main programming platforms for controlling the drone.
3. Evaluate the functionality of the system, including its capability to record video and monitor the drone's camera feed in real-time.

Conceptual Framework

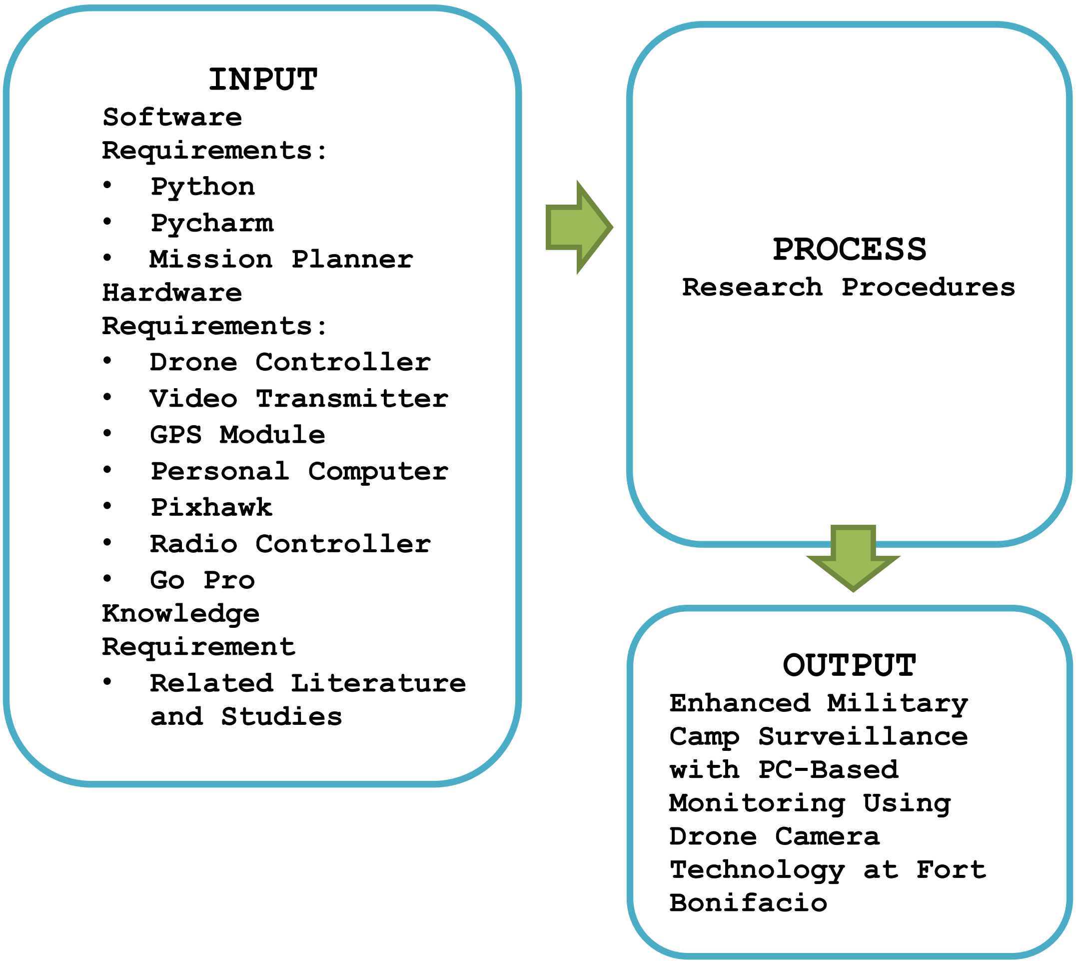


Figure 1. Conceptual Framework of the Study Using the IPO Model

Figure 1 illustrates the conceptual framework of this study, organized according to the Input-Process-Output (IPO) model. This framework guides the systematic approach to developing and analyzing the proposed PC-Based Drone Surveillance system.

- **Input Phase**: This initial phase involves identifying and detailing all necessary components required to develop the drone system. This includes hardware elements such as the drone, high-resolution camera, and computer, as well as the operational procedures needed to ensure effective functionality. Key software tools, including Pixhawk for drone control and PyCharm for programming, are also specified at this stage.
- **Process Phase**: The process phase encompasses the execution of various activities critical to the project's development. It begins with observing and collecting data relevant to the drone's operational environment. This is followed by the preparation of hardware and materials, along with the design and integration of the software required to operate the drone. The phase also includes rigorous testing to ensure that the drone can successfully connect to a computer, encrypt data, and display real-time images.
- **Output Phase**: In the final output phase, the result of the entire process is captured. This includes the successful operation of the drone for video surveillance, with

recorded footage serving as a tangible output of the study. The system's ability to perform real-time monitoring and secure data transmission is demonstrated, fulfilling the research objectives.

Review Of Related Literature

According to the International Civil Aviation Organization (ICAO, 2011), drones, also known as unmanned aerial vehicles (UAVs), are aircraft that fly without a human pilot. They are part of a larger system known as an unmanned aircraft system (UAS), which includes the drone itself, a ground-based controller, and a communication system that connects the two. Some studies refer to them as Remotely Piloted Aircraft Systems (RPAS), which include remotely piloted aircraft and remote pilot stations.

Drones are used in military applications for lethal surveillance and targeted killings, which saves money and reduces personnel dangers. Artificial intelligence (AI) is critical in military drones because it distinguishes between targets and civilians (Kindervater 2016). However, technological innovation encompasses more than just technical feasibility; it also includes changes in user practices, regulation, industrial networks, infrastructure, and symbolic meaning. The effectiveness of such innovations is partly dependent on business preparedness, which entails managing internal changes such as the implementation of new systems, technologies, or procedures (Tekfive, 2020).

UAVs have shown to be extremely useful military assets, particularly for intelligence and observation missions such as surveillance, target acquisition, and reconnaissance. They are critical in tracking and identifying dismounted soldiers in urban situations, particularly within Areas of Operation (AO), making them indispensable in the battle against militancy and terrorism.

Hardware composition

The hexacopter's overall weight distribution must be evaluated. This enables for component analysis, highlighting the importance of each part, and tracking its performance against prior and future versions of the multi-rotor designs. The battery is the heaviest component in all multirotor designs. To achieve a longer flight time, a bigger capacity battery may be selected. However, the greater weight of the larger battery pack has a direct impact on flying time. Because the implementation is done without LIDAR, a large amount of weight is saved. LIDARs also draw a significant amount of power from the battery. Table 1 shows the weight distribution of all the hexacopter's components.

Table 1. Weight Distribution of Hexacopter

No.	Item	Weight (gm)
1	F550 Hexa-Copter Frame	620
2	LiPo 8000mAh 3S 30C/60C	615
3	Jetson Nano	249
4	BLDC Motors EMAX RS2306	204
5	ESC Emax BLHeli	30A
6	Pixhawk	40
7	Optical Flow Sensor	30
8	Camera 8MP IMX219-170	22
9	Tri Blade Propellers	15
Total		1900

Structural and Stability Analysis

The structural analysis of the hexacopter drone is needed to be understand the weight of the other parts indicated above so the flight time of the drone will be longer and more stable.

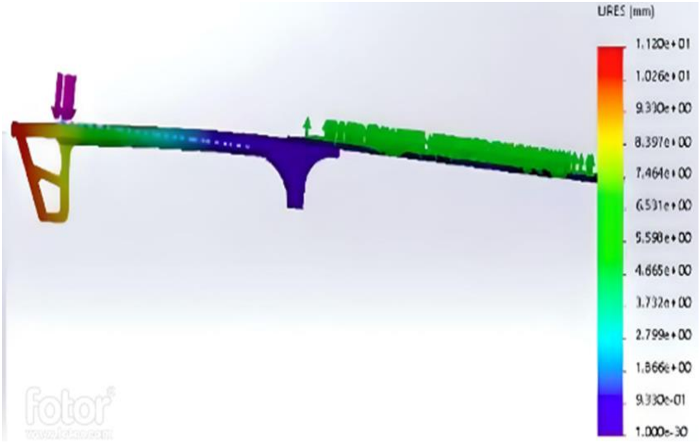


Figure 2. Drone Arm

Identifying the COM (Center of Mass) in drone is important to know because it affects the stability and balance of the drone during flight, control system performance, battery placement and flight duration, also payload and equipment. A drone's stability, maneuverability, control, flight time, and payload handling are all strongly affected by its center of mass. To ensure safe and effective operation, the COM must be properly considered during the design and operation of drones.

Figure 3. UAV for Surveillance

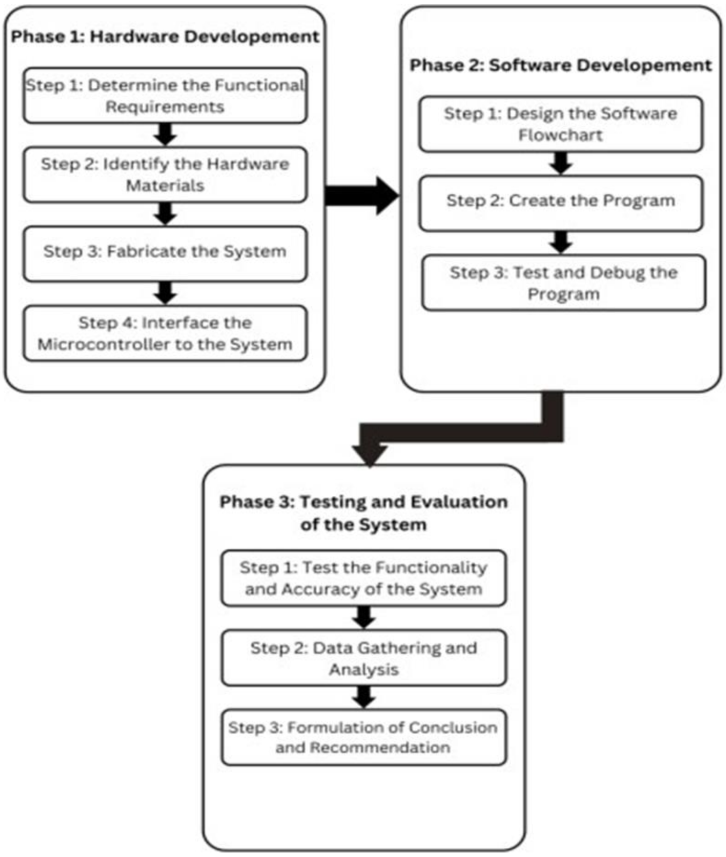
UAVs provide the ability to quickly and easily access areas that may be challenging or inaccessible for ground-based surveillance teams. They can cover large areas efficiently and change positions rapidly, aerial perspective offered by UAVs is one of their greatest advantages. This perspective enhances situational awareness and allows for effective surveillance and monitoring.

RESEARCH METHOD

The research procedure for developing the PC-based drone surveillance system focused on both hardware and software development, followed by testing and assessment. The methodology was inspired by De Leon's 2022 study on hardware and software development.

Hardware Development

The hardware development involved selecting and assembling key drone components. These included:



- Pixhawk Flight Controller: Central unit for controlling drone operations.
- DJI Motors and Propellers: For drone propulsion.
- Drone Frame and Arms: Structure to hold all components.
- Electronic Speed Controllers (ESCs): Regulates the motors' speed.
- Video Transmitter and FPV Monitor: Transmits real-time video feeds to the ground station.
- Lipo Battery and Charger: Power source and charging unit for the drone.
- GPS Module: Provides location data for navigation.
- Gimbal: Stabilizes the camera for clear video capture.
- Telemetry Module: Sends drone status data back to the operator.
- GoPro Hero4: Camera for video recording.
- Personal Computer (PC): Central control unit to operate and monitor the drone.

Design Prototype

The design prototype involved creating a DIY Hexacopter, with detailed diagrams showcasing the top view, bottom board components, and front view.

Figure 4. DIY HEXACOPTER Drone TOP VIEW

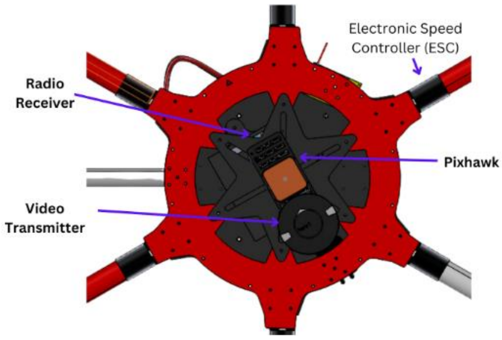


Figure 5. HEXACOPTER Bottom Board Components

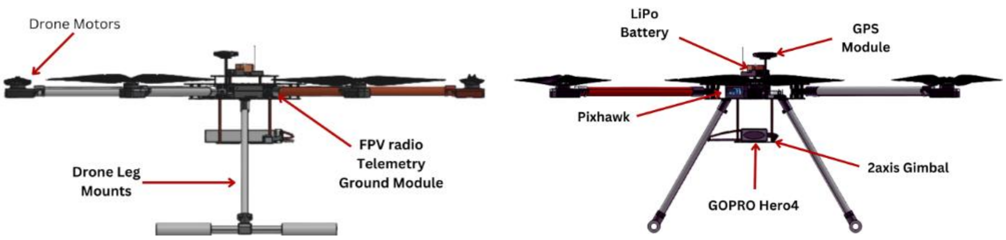


Figure 6. HEXACOPTER FRONT VIEW

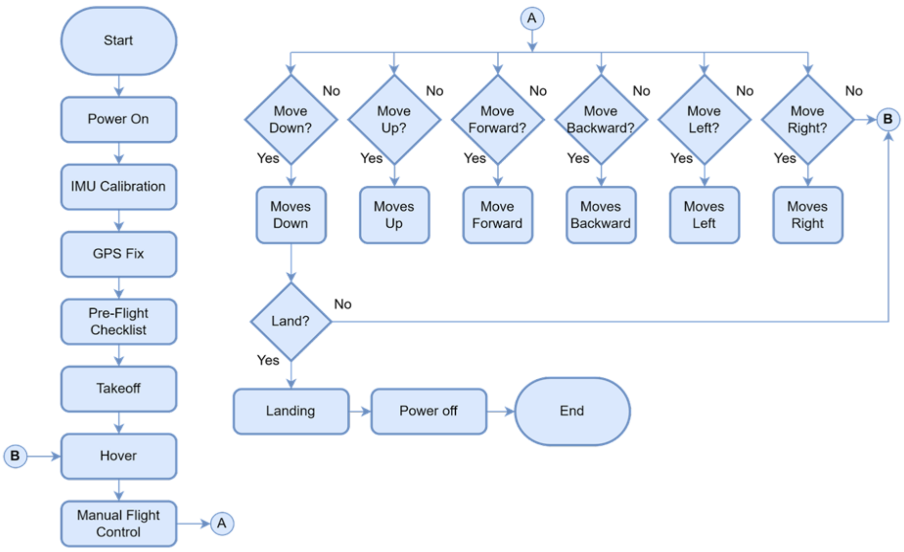


Figure 8. Flowchart of the process of controlling a PC-based drone system

In figure 8, illustrates the process of controlling a PC-based drone system, from receiving user commands to translating them into flight instructions, executing the instructions on the drone, collecting and processing sensory data, and presenting the results to the user.

Block Diagram

The block diagram provided a general framework of the PC-based drone system. It highlighted the interactions between the PC, drone platform, communication module, and user interface, ensuring effective surveillance operations.

This methodology outlines the comprehensive steps taken to develop and test the PC-based drone surveillance system for Fort Bonifacio.

Hardware Connection Diagram

This section provided a detailed connection diagram of the drone's hardware, including the flight controller, power module, GPS, radio receiver, ESCs, motors, and FPV transmitter.

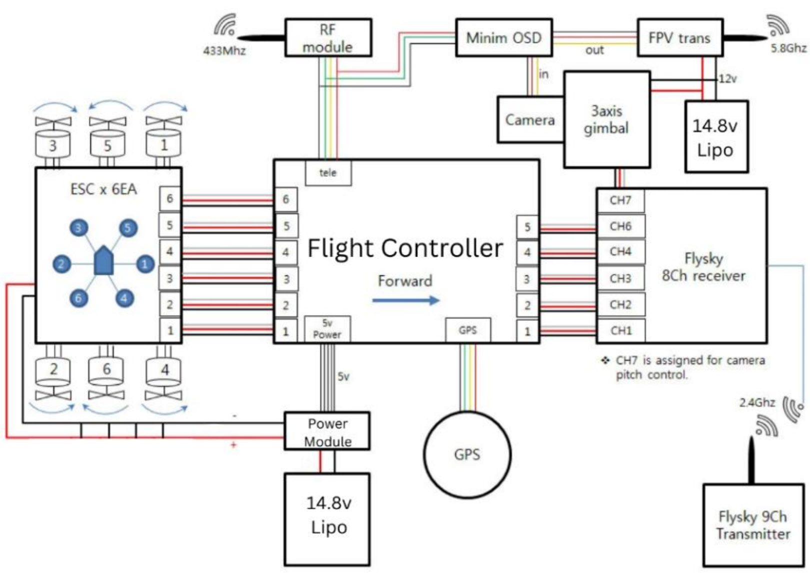


Figure 9: Drone Components

Figure 9 depicts the detailed connection between the Flight controller, Battery, Power Module, GPS, Radio Receiver, ESC, Motors and FPV Transmitter. The hardware connection diagram of a hexacopter for a PC-based drone system used for surveillance in the vicinity of a military camp Fort Bonifacio involves several essential components and their interconnections.

The description serves as a general overview of the main hardware components and their connections in a PC-based hexacopter drone system for surveillance.

Software Tools

In the field of surveillance in the vicinity of military camps Fort Bonifacio, the integration of advanced software tools is crucial to ensure efficient and effective operations.

The flowchart outlines the sequence of steps involved in operating a PC-based drone system. The system starts by initializing the connection between the PC and the drone through wireless communication, such as Wi-Fi. Once the connection is established, the system is ready to receive user commands.

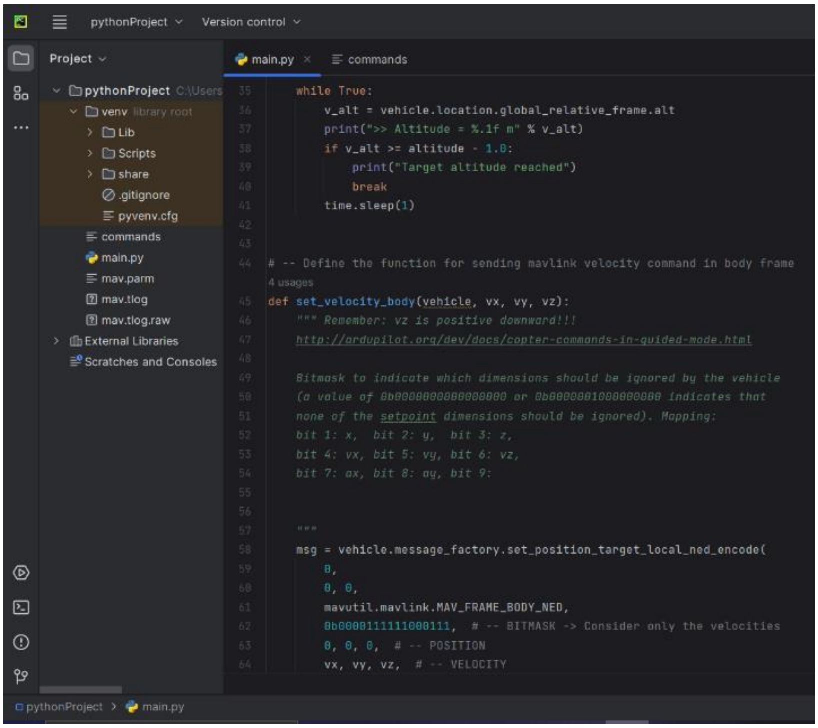


Figure 10: Used Code in PhyCharm

Mission Planner serves as a comprehensive mission control tool, while PyCharm acts as an integrated development environment (IDE) tailored for Python programming. Together, these tools optimize the surveillance workflow, from mission planning and execution to data analysis and code development.

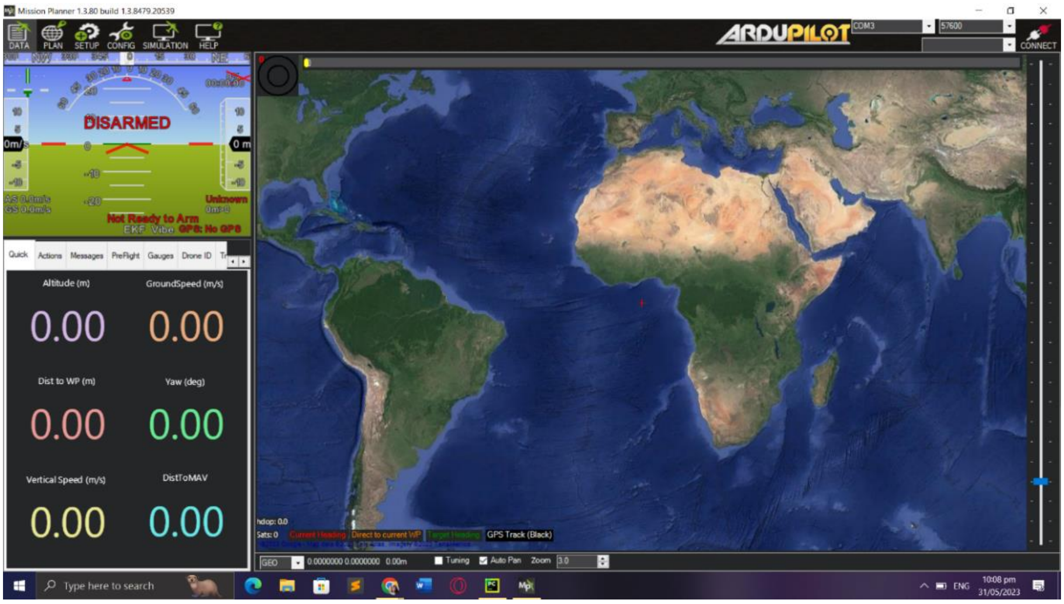


Figure 11: Mission Planner

Block Diagram

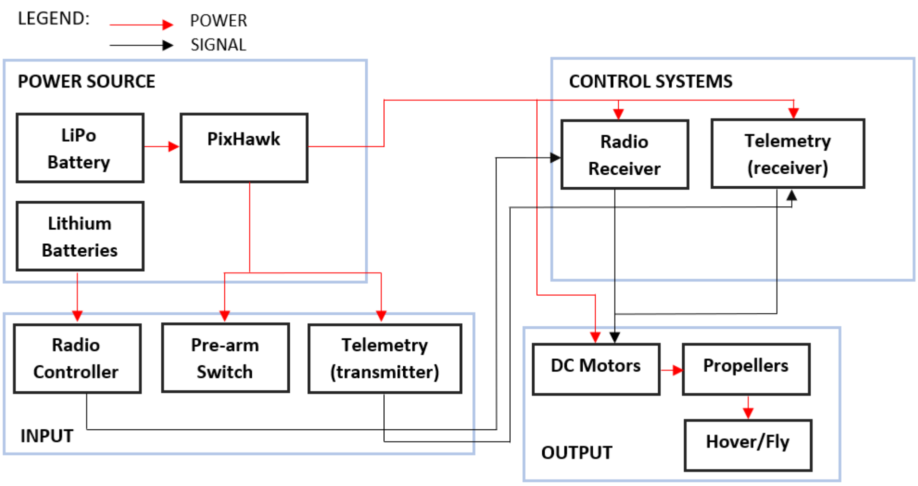


Figure 12: Block Diagram

Figure 12: Illustrate the block diagram of a PC-based drone for surveillance in the vicinity of a military camp in Fort Bonifacio.This typically consists of several key components that work together to enable the drone's surveillance capabilities. PC-Based serves as the central control unit for the drone's operation. It runs sophisticated software algorithms and provides a user interface for controlling the drone, receiving and processing data, and analyzing surveillance information. The drone platform itself includes the physical structure, propulsion system, flight controller, and other hardware components necessary for flight. It may also include capturing surveillance data. The communication module allows the drone to establish a connection with the PC for data transfer and control signals. This module can utilize wireless communication technologies, such as Wi-Fi or radio frequency (RF) links, to facilitate real-time communication between the drone and the PC. The PC provides a user interface, typically in the form of a graphical user interface (GUI), to enable the operator to control the drone and monitor the surveillance operation. The interface may display real-time video feeds, processed information, mission status, and other relevant data to aid the operator in making informed decisions. A PC generates control signals based on the operator's commands through the user interface. These signals are transmitted to the drone via the communication module, allowing the operator to control the drone's flight path, altitude, speed, and other parameters necessary for effective surveillance. It's important to note that the specific configuration and components may vary depending on the drone's design, intended use, and technological advancements. The block diagram provided here serves as a general framework for understanding the key components involved in a PC-based drone system for surveillance in the vicinity of a military camp.

RESULT AND DISCUSSION

Metrics for Evaluation

The evaluation of the PC-based drone system for surveillance at Fort Bonifacio was conducted using a series of performance metrics that are critical for assessing the effectiveness and reliability of the drone. These metrics include flight time, which measures the duration the drone can stay airborne on a single battery charge. A longer flight time is particularly advantageous as it allows the drone to cover more area and gather more data without the need for frequent recharging.

Another important metric is the range, which assesses the maximum distance the drone can travel from the operator before losing communication or becoming unresponsive. A greater range is desirable as it enables the drone to survey larger areas, making it more effective for extensive surveillance operations. Additionally, payload capacity was evaluated, which refers to the maximum weight the drone can carry while maintaining stable flight. A higher payload capacity allows the drone to carry additional sensors or equipment, enhancing its versatility for various surveillance tasks.

The altitude range of the drone, which measures the maximum height it can reach during flight, was also considered. A greater altitude range provides a broader perspective, allowing for more comprehensive aerial surveys. Accuracy was another critical metric, assessing how precisely the drone can perform specific tasks such as mapping, surveying, or inspection. Accuracy is quantified using methods like Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and standard deviation, which are essential for ensuring the reliability of the collected data.

The quality of the images and videos captured by the drone's camera(s) was also evaluated, as high-quality imagery is crucial for accurate analysis and decision-making, particularly in surveillance and reconnaissance missions. Finally, the stability of the drone during flight and under various conditions, including different weather scenarios, was assessed. A stable drone is less prone to crashes or control loss, ensuring both safety and the reliability of data collection.

The researchers conducted comprehensive tests based on these metrics to evaluate the performance of the PC-based drone. The results of these tests were compared against the project's objectives and problem statements to determine the overall effectiveness of the system. This evaluation is critical for understanding the drone's operational capabilities and identifying potential areas for further improvement.

The table below shows the different testing that the researchers have achieved based on the given objectives and problem’s statement.

Table 3: Test Plan for Accuracy of the Drone

TEST PLAN			
Test Type	**Description**	**Test Step**	**Target Output**
Payload Capacity	This measures the maximum weight the drone can carry while still maintaining stable flight. Higher payload capacities are desirable as they allow the drone to carry more sensors or equipment.	• Choose the payload • Determine the weight of the drone • Measure the weight of the payload • Calculate the total weight • Conduct flight testing	1.9 Kilogram
Flight Time / Battery Life	This measures the amount of time the drone can fly on a single battery charge. Longer flight times are generally desirable as they allow the drone to cover more ground and collect more data.	• Identify the drone's battery specifications • Determine the weight of the drone and payload • Calculate the power consumption • Calculate the estimated flight time • Conduct flight testing	5 minutes
Drone Range	This measures the maximum distance the drone can fly from the operator before losing communication or becoming unresponsive. Greater range is	• Identify the drone's communication system (telemetry) • Determine the maximum transmission distance of the	300 meters back and forth

	desirable as it allows the drone to cover larger areas.	communication system (telemetry • Conduct flight testing • Consider battery life	
Drone Altitude Range	This measures the maximum altitude the drone can fly to. Greater altitude ranges are desirable as they allow the drone to collect data from a wider area.	• Conduct flight testing • Optimize the drone's performance • Identify the drone's maximum altitude limit	50 meters back and forth
Drone Accuracy	This measures the precision with which the drone can perform specific tasks such as mapping, surveying, or inspection. The accuracy can be measured using various methods such as Root Mean Square Error (RMSE), mean absolute error (MAE), and standard deviation.	• Identify the drone's GPS • Conduct flight testing • Analyze the results • Make adjustments • Repeat the testing.	60% Accuracy
Drone Stability	This measures the stability of the drone during flight and in different weather conditions. A stable drone is less likely to crash or lose control which is essential for safety and accurate data collection. These metrics can be used to evaluate the performance of a PC-based drone and compare it with other drones or industry standards.	• Conduct a pre-flight check • Check the drone's center of gravity • Conduct hover testing • Conduct flight testing • Make adjustments	70% Stable
Image/Video Quality	This measures the quality of the images and videos captured by the drone's camera(s). Higher image and video quality is desirable as it allows for more accurate and detailed analysis of the collected data.	• Identify the camera and its specifications • Define the desired image and video quality • Evaluate the footage and images • Make adjustments • Repeat the testing	2.7K video at 60 frames per second and 720p video at up to 240 frames per second

Table 4: Test Result for Accuracy of the Drone

TEST RESULT				
Test Count	**Test 1**	**Test 2**	**Test 3**	**Final Testing**
Flight Time (in min)	1	2	3	3.5
Drone Altitude Range (in meters)	7.14	14.2	21.42	24.99
Drone Range	42.9	86.8	129.7	151.15
Drone Accuracy (in %)	80	75	73	70
Payload Capacity(in kg)	2.4	2.4	2.4	2.4
Stability (in %)	90	80	75	72

Table 5: The Assessment Process of the Project

Components	**Definition**	**Working**
Flight Controller "Pixhawk"	A device that will serve as the mind of the drone and to connect all the things needed so that the drone will function well.	✓
Motors and Propellers	These two devices are connected to each other to help the drone fly.	✓
Battery	Provides power to the drone.	✓
Electronic Speed Controllers (ESCs)	An electronic device built to control the speed of the motors.	✓

Radio Receiver	A receiver is a device that accepts signals, audio, video from the camera to the drone.	✓
Frame	The frame holds all the parts of the drone together and provides stability and support.	✓
Safety Features	Make sure it is functioning well before flying the drone.	✓

In table 5, shows the Assessment Process of the Project. This process exhibits how the project works successfully according to the plan that the researchers made. The accomplished assessment processes are shown in the table below.

The researchers created and tested a PC-based drone system meant for surveillance in the vicinity of military facilities. The system included a hexacopter drone with a high-resolution camera and a ground control station (GCS) that ran on a personal computer (PC). The study's goal was to investigate the ability of this drone technology to improve security measures by offering real-time surveillance capabilities.

The researchers flew the drone several times, obtaining significant video footage of the surroundings. This film was then examined for object detection and tracking, with the goal of identifying potential threats or unusual activity near military camps.

The results showed that the PC-based drone was effective in detecting and tracking objects of interest, such as vehicles and people. The system's ability to monitor the area in real time enabled the early detection of possible security risks, which could subsequently be dealt more effectively.

The study found that the PC-based drone developed in this study has great potential to improve the security and surveillance capabilities of military camps. The high-resolution video footage given by the drone can help military personnel identify possible threats and respond more promptly and efficiently. Despite these hopeful findings, the study revealed a number of limitations and obstacles that must be addressed.

For example, the drone's operational range and battery life were found to be limiting factors, and the system may be susceptible to interference. Addressing these issues through further research and development is crucial to optimizing the system for specific surveillance scenarios.

CONCLUSION

The study's conclusion focused on the possible benefits of a PC-based drone camera system for military surveillance. The technique is more efficient and dependable than traditional monitoring methods like human patrols and fixed cameras. The system's architecture and components were meticulously planned, and the software and hardware requirements were recognized and met. Testing revealed that the device could successfully deliver real-time video footage while covering a broader area than traditional approaches.

One of the primary benefits of the proposed system is its capacity to respond swiftly to security concerns, hence improving the entire security infrastructure of military bases. Furthermore, the system is versatile and can be customized to fit the unique needs and requirements of various military environments. This versatility makes it an effective solution for improving the safety and security of military personnel and equipment. The project makes a substantial contribution to current efforts to strengthen military security. The researchers dedicated a significant amount of time and effort to researching and developing the PC-based drone system, setting the framework for its possible use in a variety of military environments.

Although more work needs to be done before the system can be widely implemented, the study's findings lay a solid foundation for future research and development in this field.

Overall, the PC-based drone camera system for military camp surveillance is a promising concept worth considering for implementation. With additional developments and uses, this technology could play a critical role in boosting military security and protecting both soldiers and equipment.

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