VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belagavi – 590 018

A

Project Report

on

"HUMAN DETECTION AND FOLLOWING DRONE"

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE AND ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the Project entitled **"HUMAN DETECTION AND FOLLOWING DRONE"** carried out by **BIPIN B P (4CI20CS006), DARSHAN B R (4CI20CS013), MANOJ N (4CI20CS032), PAREEKSHITH K V (4CI20CS040),** bonafide students of **Coorg Institute of Technology** in partial fulfillment for the award of **Bachelor of Engineering** in **Computer Science and Engineering** of the **Visvesvaraya Technological University**, **Belagavi** during the academic year 2023-2024. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of work prescribed for the said degree.

Prof. Yathiraj G R	**Prof. Daina K K**	**Dr. M Basavaraj**
Guide	HOD	Principal

EXTERNAL VIVA

Name of the Examiners: **Signature with Date:**

1.

2.

DECLARATION

We, **BIPIN B P (4CI20CS006), DARSHAN B R (4CI20CS013), MANOJ N (4CI20CS032) and PAREEKSHITH K V (4CI20CS040)** students of VIII semester, B.E degree in Computer Science and Engineering declare that this project titled "**HUMAN DETECTION AND FOLLOWING DRONE**" is original work carried out by us , after endorsement and authorization from **Coorg Institute of Technology, Ponnampet** in partial fulfillment of the curriculum requirements prescribed by Visvesvaraya Technological University, Belagavi in the 2018, B.E Degree Choice Based Credit System Scheme.

Date: 24/05/2024

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ABSTRACT

This project explores the development of an autonomous drone capable of detecting and following a human target. Leveraging advanced computer vision techniques, the drone employs real-time image processing to identify and track individuals within its camera feed. The system integrates machine learning algorithms to enhance the accuracy and reliability of human detection, even in dynamic environments with varying lighting conditions and backgrounds. Furthermore, the drone's navigation system is designed to adjust its flight path and speed autonomously to maintain a consistent distance from the target, ensuring smooth and uninterrupted following behavior. This technology has potential applications in search and rescue operations, personal security, and interactive entertainment. The effectiveness of the drone is evaluated through a series of tests, demonstrating its capability to perform robustly in real-world scenarios.

Keywords: *Human-following drones, Human-detecting drones, Computer vision, Machine learning, Sensor fusion, Human detection*

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CHAPTER 1

INTRODUCTION

A quad copter, also called a quadrotor helicopter or quad rotor is a multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers). Quad copters differ from conventional helicopters use rotors which are able to vary the pitch of their blades dynamically as they move around the rotor hub. In the early days of flight, quad copters (then referred to either as ‘quad rotors’ or ‘helicopters') were seen as possible solutions to some of the persistent problems in vertical flight; torque-induced control issues (as well as efficiency issues originating from the tail rotor, which generates no useful lift) can be eliminated by counter-rotation and the relatively short blades are much easier to construct. These vehicles were among the first successful heavier-than-air vertical take-off and landing (VTOL)vehicles.

A Drone or Quadcopter is a Vehicles have large potential for performing tasks that are dangerous or very costly for humans. Examples are the inspection of high structures, humanitarian purposes or search-and-rescue missions. One specific type of Drone is becoming increasingly more popular lately the quadcopter. When visiting large events or parties, professional quadcopters can be seen that are used to capture video for promotional or surveillance purposes.

A small remote-controlled quadcopter can be bought to fly around in your living room or garden. In these situations, the quadcopter is usually in free flight. There is no physical contact between the surroundings and the quad copter and no cooperation between the quadcopters If would have the capabilities to collaborate the number of possibilities grows even further. For example, a group of Drone would be able to efficiently and autonomously search a missing person in a large area by sharing data between. Or, the combined load capacity of a group of quad copters can be used to deliver medicine in remote areas.

This project focuses on the use of a commercially available quadcopter platform, the. Drone, to perform a task that requires physical collaboration and interaction: moving a mass. In this way a clear interaction between the quadcopters and their surroundings is present. As preliminary step towards the view of collaborating aerial robots the choice was made to perform this task in an indoor scenario where position feedback is present. Starting off with position control, additional controller logic can be implemented to counteract the forces imposed by a mass connected to the quadcopter. The choice is made for the Drone, a generalized approach is chosen where possible to encourage reuse of this research's outcome and deliverables.

A human-detecting and following drone harnesses the capabilities of a Raspberry Pi and an APM 2.8 flight controller to autonomously track and follow individuals. The Raspberry Pi, equipped with computer vision algorithms and a camera module, processes real-time video feeds to detect human presence using machine learning techniques. The APM 2.8, an advanced autopilot system, manages the drone's flight dynamics, ensuring smooth and responsive movements. By integrating these technologies, the drone can navigate complex environments, offering applications in surveillance, search and rescue, and personal assistance, thereby enhancing safety and operational efficiency in various scenarios.

Overall, Human-detecting and following drones represent a significant advancement in unmanned aerial vehicle (UAV) technology, merging sophisticated computer vision, sensor fusion, and autonomous navigation systems. These drones are equipped with advanced cameras and sensors capable of detecting human presence and tracking movements accurately in real-time. The integration of machine learning algorithms allows them to adapt to various environments and lighting conditions, ensuring robust performance even in complex scenarios.

The practical applications of such drones are vast and varied. In the realm of security and surveillance, these drones can enhance the capabilities of law enforcement agencies by providing real-time monitoring of large areas and tracking suspects or missing persons without putting human officers at risk. In disaster response, they can swiftly locate and follow individuals in need of rescue, significantly improving the efficiency and effectiveness of search and rescue operations.

Moreover, these drones have potential uses in personalized services, such as delivery systems that can follow a recipient to ensure precise delivery, or in sports and media, where they can provide dynamic and engaging coverage of events. However, the deployment of human-detecting and following drones also raises important ethical and privacy concerns. The ability to track individuals autonomously necessitates stringent regulations and safeguards to prevent misuse and ensure that such technology is employed responsibly. Addressing these concerns through comprehensive policies and transparent practices is crucial for gaining public trust and maximizing the societal benefits of this technology.

Human-detecting and following drones stand at the frontier of UAV innovation, promising enhanced capabilities across various sectors. Balancing technological advancement with ethical considerations will be key to harnessing their full potential while safeguarding individual privacy and security sectors.

1.1 PROBLEM STATEMENT

Designing a human-detecting and following drone using a Raspberry Pi and an APM 2.8 flight controller involves integrating advanced computer vision techniques with autonomous navigation systems. The primary objective of this project is to create an aerial vehicle capable of identifying a specific human target and maintaining a consistent distance from them while navigating autonomously. This technology holds significant potential for various applications, including search and rescue missions, personal photography, security surveillance, and elderly assistance. The core challenge lies in seamlessly combining the hardware and software components to achieve real-time human detection, accurate target tracking, and reliable drone flight control.

The Raspberry Pi serves as the computational brain of the system, running machine learning algorithms and image processing techniques to detect and track human subjects. Utilizing a camera module, the Raspberry Pi captures live video feeds, which are then analyzed using pre-trained neural networks, such as those based on the YOLO (You Only Look Once) or OpenCV frameworks, to identify and localize humans within the frame. Once a human is detected, the system calculates the target's position relative to the drone, converting image coordinates into real-world spatial data.

The APM 2.8 flight controller manages the drone's flight dynamics, translating high-level commands from the Raspberry Pi into precise motor controls. This controller is essential for stabilizing the drone and executing maneuvers required to follow the detected human. Communication between the Raspberry Pi and the APM 2.8 is facilitated through serial or I2C interfaces, enabling the exchange of navigation instructions and flight telemetry data.

A critical aspect of the system is ensuring real-time responsiveness and robustness in varying environmental conditions. The integration of ultrasonic sensors, GPS modules, and inertial measurement units (IMUs) enhances the drone's ability to maintain altitude, avoid obstacles, and ensure accurate following behavior. The algorithm must be optimized to handle dynamic changes in the target's movement and environmental factors like lighting and background variations.

Power management and efficient use of computational resources are also vital to extend the drone's operational duration and maintain performance. Furthermore, safety protocols must be implemented to prevent the drone from losing control or causing harm in case of system failures or unexpected obstacles.

In summary, developing a human-detecting and following drone using a Raspberry Pi and APM 2.8 involves a multidisciplinary approach, integrating computer vision, autonomous navigation, and real-time control systems. Success in this project could pave the way for innovative applications in various fields, leveraging the synergy between modern AI techniques and aerial robotics

.1.2 OBJECTIVES

The objective of developing a human-detecting and following drone using a Raspberry Pi and APM 2.8 is to create an autonomous system capable of identifying and tracking individuals in various environments. This project aims to leverage the Raspberry Pi's processing capabilities and the APM 2.8's flight control functionalities to build a versatile and efficient drone. The primary goal is to enable the drone to detect humans using computer vision algorithms implemented on the Raspberry Pi. This involves using cameras and potentially other sensors to recognize human shapes and movements accurately

Once a human is detected, the drone's flight control system, managed by the APM 2.8, will be tasked with maintaining a safe and consistent distance from the person, following their movements dynamically. This requires integrating advanced computer vision techniques with real-time flight adjustments to ensure smooth and reliable tracking. The project also aims to implement robust obstacle avoidance mechanisms to prevent collisions, enhancing the drone's safety and operational reliability in complex environments.

Moreover, the system is designed to be flexible, allowing for various applications such as search and rescue operations, security surveillance, and personal assistant tasks. In search and rescue scenarios, the drone could autonomously locate and follow individuals in disaster-stricken areas, providing real-time updates to rescue teams. For security purposes, it could monitor and follow potential intruders in restricted zones. As a personal assistant, the drone could accompany individuals, carrying items or providing companionship.

A significant objective is to ensure the system's user-friendliness, enabling easy deployment and operation even for users without advanced technical knowledge. This includes developing an intuitive interface for controlling and configuring the drone's parameters. Additionally, optimizing the system for low power consumption and extended flight duration is crucial to maximize operational efficiency.

Another key goal is to foster a scalable design, allowing future enhancements and the integration of additional features such as advanced AI capabilities, improved sensors, and enhanced communication systems. By achieving these objectives, the project aims to create a practical and innovative tool that can significantly benefit various fields, showcasing the potential of combining Raspberry Pi and APM 2.8 technology in autonomous drone applications. This project not only demonstrates the feasibility of advanced human-detecting and following drones but also paves the way for future developments in autonomous systems and their applications in real-world scenarios.

1.3 SCOPE THE PROJECT

The project involves developing a human-detecting and following drone using a Raspberry Pi and an APM 2.8 flight controller. This innovative endeavour aims to leverage the power of modern technology to create an autonomous aerial system capable of identifying and trailing human subjects. The Raspberry Pi, a versatile and powerful microcomputer, will serve as the primary processing unit for image recognition tasks. Utilizing OpenCV, a highly efficient open-source computer vision library, the Raspberry Pi will be programmed to detect human figures in real-time through a camera module mounted on the drone.

The integration of the APM 2.8 flight controller is crucial for providing the drone with stable flight capabilities and precise manoeuvrability. The APM 2.8, known for its reliability and advanced features, will handle the core flight dynamics, including altitude control, stabilization, and navigation. By interfacing the Raspberry Pi with the APM 2.8, the project aims to achieve seamless communication between the image processing unit and the flight controller, enabling the drone to adjust its flight path based on the location of the detected human.

The scope of the project encompasses several key stages. Initially, the hardware components, including the Raspberry Pi, camera module, APM 2.8, and drone frame, will be assembled and configured. The next phase involves software development, where the focus will be on programming the Raspberry Pi for image processing tasks and integrating it with the drone's control system. The image processing algorithm will be designed to efficiently detect and track human subjects, even in varied lighting conditions and environments.

Subsequently, the project will involve extensive testing and calibration to ensure the drone can reliably follow a human subject without manual intervention. This includes fine-tuning the image recognition algorithms and the flight control parameters to achieve optimal performance. Safety features, such as obstacle detection and avoidance, will also be incorporated to prevent collisions and ensure smooth operation.

The final deliverable will be a fully functional prototype of a human-detecting and following drone, capable of autonomous operation. This project holds significant potential for various applications, including search and rescue missions, security and surveillance, and personal photography. By combining the computational capabilities of the Raspberry Pi with the robust flight control offered by the APM 2.8, this project aims to contribute to the growing field of autonomous aerial systems and push the boundaries of drone technology.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

The primary purpose of conducting a literature survey is to establish the context and significance of a research topic. By reviewing and analysing relevant literature, researchers can identify key concepts, theories, methodologies, and findings that have been explored by previous scholars. This process helps researchers build upon existing knowledge, avoid duplication of efforts, and ensure that their work contributes meaningfully to the academic discourse. Furthermore, literature surveys enable researchers to critically evaluate the strengths and weaknesses of existing studies, identify areas where further research is needed, and propose new research questions or hypotheses. By synthesizing diverse sources of information, researchers can gain insights into different perspectives on a topic, uncover conflicting findings, and develop a more nuanced understanding of complex issues. In essence, the purpose of a literature survey is not only to summarize existing knowledge but also to analyse, interpret, and synthesize information in a way that adds value to the research process.

By engaging with the existing literature in a systematic and rigorous manner, researchers can position their work within the broader scholarly conversation, demonstrate their familiarity with relevant theories and methodologies, and lay the groundwork for producing original contributions to their field.

In [1] the implementation Long-Term Person Tracking for Unmanned Aerial Vehicles (UAVs) Based on Human-Machine Collaboration is presented. This is a groundbreaking concept aimed at enhancing the capabilities of UAVs in tracking individuals over extended periods. This innovative approach leverages the strengths of both human operators and machine intelligence to achieve robust and reliable person tracking.

In this collaborative framework, human operators provide high-level guidance and supervision, while machine algorithms handle the intricacies of real-time tracking and navigation. Human operators can input objectives, such as tracking specific individuals or monitoring certain areas of interest, into the UAV's control system. The machine algorithms then process sensor data, including visual and positional information, to autonomously track the designated targets.

This human-machine collaboration ensures the UAV's ability to adapt to dynamic environments and evolving tracking requirements over long durations. Human operators can intervene when necessary, providing corrective actions or adjusting tracking parameters based on real-time feedback from the UAV's sensors.

The integration of machine learning algorithms enables the UAV to learn and improve its tracking performance over time, making it increasingly adept at handling complex scenarios and challenging conditions. By combining the cognitive abilities of humans with the computational power of machines, this collaborative approach achieves unparalleled efficiency and effectiveness in long-term person tracking tasks. Overall, Long-Term Person Tracking for UAVs based on human-machine collaboration represents a paradigm shift in aerial surveillance and monitoring capabilities, offering enhanced situational awareness and response capabilities for various applications, including security, search and rescue, and environmental monitoring.

Advantages:

- **Enhanced Surveillance Capabilities**: Long-term person tracking allows UAVs to monitor individuals over extended periods, providing continuous surveillance coverage in areas where human presence may be limited or impractical. This can be beneficial for security, search and rescue, and law enforcement operations.
- **Improved Search Efficiency**: By leveraging both human expertise and machine intelligence, UAVs can efficiently search large areas for specific individuals or targets. Human operators can provide context and guidance to UAVs, while machine algorithms enhance detection and tracking accuracy, leading to faster and more effective search missions.
- **Increased Safety**: Human-machine collaboration reduces the reliance on manual piloting of UAVs, mitigating the risk of human error and improving overall safety. Automated flight control systems can navigate UAVs through complex environments, while human operators oversee the mission and intervene when necessary to ensure safe operation.
- **Flexibility and Adaptability**: Combining human expertise with machine learning algorithms allows UAVs to adapt to dynamic environments and changing mission objectives. Human operators can provide real-time feedback and adjust mission

parameters, enabling UAVs to respond effectively to unexpected events or evolving situations.

Drawbacks:

- **Privacy Concerns**: Long-term person tracking raises privacy concerns, as it involves continuous monitoring of individuals' movements and activities. There may be ethical implications regarding the collection and use of personal data, necessitating clear guidelines and safeguards to protect individuals' privacy rights.
- **Limited Autonomy**: While human-machine collaboration enhances UAV capabilities, there may still be limitations in autonomy, particularly in complex or unpredictable environments. Human operators may need to intervene frequently to address navigation challenges or interpret ambiguous situations, reducing the efficiency of unmanned operations.
- **Technical Challenges**: Long-term person tracking requires advanced hardware and software technologies, including robust communication systems, high-resolution cameras, and sophisticated machine learning algorithms. Technical issues such as signal interference, sensor limitations, and algorithmic errors can impact the reliability and effectiveness of tracking systems.
- **Dependency on Human Operators**: Despite advancements in automation, UAVs still rely on human operators for mission planning, supervision, and decision-making. This dependency can introduce delays, inefficiencies, and potential communication errors, especially in high-stress or time-critical situations.

In [2] A study on person-following drones with LAN (Local Area Network) establishment is provided. It explores the integration of networking capabilities into autonomous aerial systems for enhanced tracking and following functionalities. By establishing a LAN connection between the drone and a ground control station, researchers aim to facilitate real-time communication and data exchange, enabling more precise and responsive person-following capabilities. This study involves the development of a custom communication protocol optimized for low-latency data transmission, ensuring seamless interaction between the drone and the ground control station. Additionally, the integration of LAN connectivity opens up possibilities for remote monitoring, control, and telemetry data retrieval, enhancing the overall versatility and usability of the system. The research focuses on optimizing network performance, minimizing communication delays, and ensuring robustness against environmental factors that may affect wireless connectivity. Moreover, the study evaluates the effectiveness of the person-following algorithm in dynamic environments, considering factors such as occlusions, varying speeds, and changes in trajectory.

Real-world testing scenarios are conducted to assess the system's performance and reliability under different conditions, providing valuable insights for further refinement and optimization. The results of this study contribute to the advancement of person-following drone technology, offering practical solutions for applications such as surveillance, search and rescue, and cinematography. By leveraging LAN establishment, researchers aim to overcome limitations associated with traditional communication methods and enhance the overall effectiveness and usability of person-following drones in various real-world scenarios. The findings of this study have implications for the development of future autonomous aerial systems, paving the way for more efficient and responsive person-following capabilities in dynamic environments.

Advantages:

- **Real-time Communication**: Establishing a Local Area Network (LAN) allows for real-time communication between the person-following drone and a ground control station or other connected devices. This enables seamless data exchange and command transmission, enhancing the drone's responsiveness and control.

- **Low Latency**: LAN-based communication typically offers low latency, ensuring minimal delay between command issuance and execution by the drone. This rapid response time is crucial for maintaining accurate tracking and following of the target person.

- **Security**: LAN communication can be more secure compared to wireless communication over the internet, as it operates within a localized network environment. This reduces the risk of unauthorized access or interference from external sources, enhancing data privacy and security.

- **Reliability**: LAN establishment provides a stable and reliable communication channel, particularly in environments with limited or unreliable internet connectivity. This ensures consistent and uninterrupted communication between the drone and ground control station, reducing the likelihood of signal loss or communication failures.

Drawbacks:

- **Limited Range**: LAN communication is typically limited to a specific geographical area, restricting the range of operation for the person-following drone. This limitation may hinder the drone's ability to track individuals over longer distances or in remote locations without LAN infrastructure.

- **Infrastructure Dependence**: LAN establishment relies on the availability of infrastructure such as routers, access points, and network cables. In areas where such infrastructure is lacking or inaccessible, setting up a LAN for drone communication may be challenging or impractical.

- **Interference**: LAN communication channels can be susceptible to interference from other devices operating on the same frequency or network congestion. This interference may degrade communication quality and impact the drone's performance, leading to potential disruptions in tracking and following operations.

- **Mobility Constraints**: LAN-based communication imposes mobility constraints on the person-following drone and ground control station, as they need to remain within the range of the LAN network. This limitation may restrict the flexibility and mobility of both the drone and operators, especially in dynamic or fast-paced environments.

In [3] the Visual detection and tracking with Unmanned Aerial Vehicles (UAVs) is implemented, especially for following a mobile object, is a rapidly advancing field that integrates computer vision, machine learning, and autonomous navigation technologies. UAVs equipped with high-resolution cameras and sophisticated onboard processing units can capture real-time video footage, which is then analyzed to detect and track objects of interest. This capability is crucial for applications ranging from surveillance and search and rescue to wildlife monitoring and personal photography.

The process begins with the UAV's camera capturing continuous video streams of the environment. These video feeds are processed using computer vision algorithms to detect the target object. Traditional methods, such as edge detection, Haar cascades, and background subtraction, have been used for object detection. However, recent advancements favor deep learning approaches, including Convolutional Neural Networks (CNNs) and models like YOLO (You Only Look Once) and SSD (Single Shot MultiBox Detector), which offer superior accuracy and speed in object detection tasks. These models can identify and classify objects within the video frames in real time, even in complex and dynamic environments.

Once the object is detected, tracking algorithms are employed to follow its movement. Algorithms such as the Kalman filter, Mean-Shift, and optical flow are traditionally used for tracking. However, more advanced methods like Deep Sort and Siamese networks have been developed to handle occlusions and rapid movements more effectively. These algorithms ensure that the UAV can maintain a lock on the moving object, continuously updating its position and adjusting its flight path accordingly.

The UAV's flight control system plays a critical role in maintaining the pursuit of the mobile object. Autonomous navigation systems, often using GPS, inertial measurement units (IMUs), and onboard flight controllers like APM or Pixhawk, allow the UAV to adjust its speed and direction in real time based on the object's location. Communication protocols such as MAVLink facilitate data exchange between the detection system and the flight controller, ensuring synchronized operations.

In summary, visual detection and tracking with UAVs involve a seamless integration of advanced computer vision techniques and autonomous navigation systems. This synergy enables UAVs to effectively follow mobile objects, offering significant benefits across various applications by enhancing situational awareness, operational efficiency, and overall capability in dynamic environments.

Advantages:

- **Enhanced Situational Awareness**: Visual detection and tracking with UAVs provide real-time monitoring and surveillance capabilities over large areas. This enables users to gain valuable insights into their surroundings, identify potential threats, and respond swiftly to changing situations.

- **Versatility and Flexibility**: UAVs equipped with visual detection and tracking systems can be deployed in diverse environments and scenarios, ranging from disaster response and search and rescue operations to wildlife monitoring and infrastructure inspection. Their agility and mobility allow them to access hard-to-reach or hazardous locations more easily than ground-based methods.

- **Rapid Deployment and Coverage**: UAVs offer rapid deployment and wide coverage capabilities, enabling them to quickly survey large areas and provide timely information to operators or decision-makers. This can be particularly beneficial in emergency situations where time is of the essence, such as natural disasters or security incidents.

- **Reduced Risk to Personnel**: By utilizing UAVs for visual detection and tracking tasks, organizations can minimize the risks to personnel involved in hazardous or dangerous missions. Instead of sending humans into potentially risky environments, UAVs can gather data from a safe distance, mitigating the likelihood of injuries or fatalities.

Drawbacks:

- **Limited Endurance and Range**: One of the primary drawbacks of UAVs is their limited endurance and range due to battery constraints. Most UAVs have relatively short flight times, which can restrict their ability to conduct prolonged surveillance missions or cover large areas without requiring frequent battery swaps or recharging.
- **Susceptibility to Environmental Factors**: UAVs are susceptible to environmental factors such as wind, rain, and temperature fluctuations, which can affect their flight performance and stability. Adverse weather conditions may limit the UAV's ability to maintain steady flight or capture clear imagery, reducing the effectiveness of visual detection and tracking operations.
- **Complexity of Operation**: Operating UAVs equipped with visual detection and tracking systems requires specialized skills and training. Pilots need to be proficient in both UAV flight operations and the use of software for image processing and analysis. This complexity can pose challenges for organizations lacking dedicated personnel or resources for UAV operations.
- **Privacy and Regulatory Concerns**: The use of UAVs for visual detection and tracking raises privacy concerns, particularly regarding the collection and storage of personal data. Additionally, regulatory restrictions and airspace regulations may limit where and how UAVs can be deployed for surveillance purposes, potentially hindering their utility in certain applications. Compliance with privacy laws and aviation regulations is essential to mitigate these concerns and ensure lawful and ethical UAV operations.

CHAPTER 3

SYSTEM REQUIREMENT SPECIFICATION

The System Requirement Specification (SRS) is a crucial document in the software development process that outlines the detailed requirements for a system or software product. It serves as a blueprint for the development team, guiding them throughout the entire software development lifecycle.

The primary purpose of the SRS is to clearly define the functional and non-functional requirements of the system, ensuring that all stakeholders have a shared understanding of what the software should accomplish and how it should behave. By documenting these requirements in a structured manner, the SRS helps minimize ambiguity, prevent misunderstandings, and facilitate effective communication among project stakeholders.

The SRS typically includes various sections, such as:

- **Introduction:** Provides an overview of the system, its purpose, and the scope of the document. It may also include background information, project objectives, and references to related documents.
- **Scope:** Defines the boundaries of the system, specifying what is included and excluded from the project. It outlines the functionalities, features, and constraints of the system to set clear expectations for both developers and users.
- **Functional Requirements:** Describes the specific functions or capabilities that the system must provide to meet the needs of its users. Functional requirements are typically described in detail, including input/output behavior, data processing, and system interactions.
- **Non-Functional Requirements:** Specifies the quality attributes or constraints that the system must adhere to, such as performance, reliability, security, usability, and scalability. Non-functional requirements ensure that the system meets the desired level of quality and usability.
- **External Interfaces:** Identifies the external systems, hardware devices, or software components that the system interacts with, specifying the nature and format of these interactions. This includes APIs, databases, user interfaces, and communication protocols.

- **System Features:** Provides a detailed description of the features or use cases that the system will support, along with any associated requirements, constraints, or dependencies.
- **Constraints:** Lists any limitations or restrictions that affect the design or implementation of the system, such as technical constraints, regulatory requirements, or budgetary constraints.
- **Assumptions and Dependencies:** Documents any assumptions made during the requirements elicitation process and identifies any external dependencies that may impact the project's success.

3.1 SYSTEM SPECIFICATION

The human-detecting and following drone is designed with a Raspberry Pi 4 and an APM 2.8 flight controller, integrating advanced hardware and software components to achieve autonomous functionality. The Raspberry Pi 4, equipped with a quad-core Cortex-A72 CPU running at 1.5GHz, 4GB of RAM, and a high-speed USB 3.0 interface, serves as the central processing unit. This microcomputer handles the computationally intensive tasks of image processing and human detection using OpenCV and deep learning models such as YOLO (You Only Look Once) or SSD (Single Shot MultiBox Detector). A Pi Camera Module v2, offering an 8-megapixel sensor and capable of capturing high-definition video, is mounted on the drone to provide real-time video feed for human detection algorithms.

The flight control system is managed by the APM 2.8, a versatile and reliable flight controller equipped with an ATMega2560 microcontroller. It includes a range of sensors, such as a 3-axis gyroscope, accelerometer, magnetometer, and barometer, to ensure stable flight and accurate navigation. The APM 2.8 interfaces with the Raspberry Pi 4 via a serial communication link, enabling the exchange of flight commands and telemetry data. This setup allows the Raspberry Pi to instruct the APM 2.8 to adjust the drone's flight path based on the detected human's position.

Powering the system is a LiPo battery, typically a 3S or 4S configuration, providing sufficient voltage and capacity to sustain both the flight controller and the Raspberry Pi 4 for extended operation periods. The drone frame is constructed from lightweight yet durable materials, such as carbon fiber, to support the payload while ensuring agility and stability during flight. For communication and control, the drone is equipped with a telemetry radio module, enabling remote monitoring and control via a ground control station (GCS). Additional features include GPS for precise positioning, ultrasonic sensors or LiDAR for obstacle detection and avoidance, and electronic speed controllers (ESCs) to manage the brushless motors, ensuring smooth and responsive flight dynamics.

Overall, this system specification highlights a sophisticated integration of components, leveraging the computational power of the Raspberry Pi 4 and the flight stability of the APM 2.8 to create a capable and autonomous human-detecting and following drone.

3.1.1 HARDWARE REQUIREMENT

Th The hardware requirements for a human-detecting and following drone using a Raspberry Pi 4 and APM 2.8 include a Raspberry Pi 4 for processing image recognition tasks, a compatible camera module (such as the Pi Camera), and an APM 2.8 flight controller for stable flight and navigation. Additional components include a drone frame, motors, Electronic Speed Controllers (ESCs), propellers, a GPS module for location tracking, a power distribution board, a battery (typically LiPo), and various sensors (e.g., ultrasonic or LiDAR) for obstacle detection. Essential peripherals include an SD card for storage and a power module for consistent power supply.

1. Raspberry Pi 4:

The Raspberry Pi is a small, circuit board-sized computer. It consists of a Broadcom system-on-a-chip, which includes a 700MHz ARM processor and graphics processor, as well as 512MB of RAM. It also has an HDMI port, Ethernet port, USB ports, a 3.5mm audio jack, and a microSD card slot for storage.

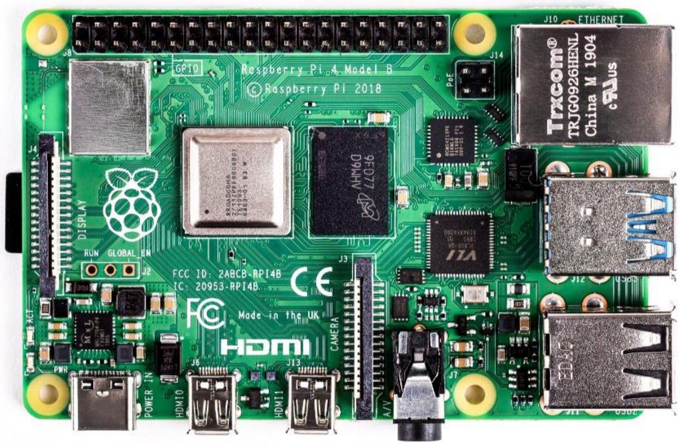

Figure 3.1: Raspberry Pi 4

The above Figure 3.1 represents Raspberry pi 4. The Raspberry Pi 4 boasts several notable features that make it a versatile and powerful single-board computer:

- **Quad-core Processor:** It is equipped with a Broadcom BCM2711 quad-core Cortex-A72 (ARM v8) 64-bit processor, providing significant performance improvements over previous models.
- **Increased RAM Options:** The Raspberry Pi 4 offers multiple RAM options, including 2GB, 4GB, and 8GB LPDDR4 SDRAM, catering to a variety of computing needs.
- **Enhanced Connectivity:** It features dual-band 802.11ac wireless LAN, Gigabit Ethernet, Bluetooth 5.0, and USB 3.0 ports, enabling faster data transfer and seamless connectivity.
- **4K Video Support:** With support for dual micro-HDMI ports, the Raspberry Pi 4 can drive two displays simultaneously at resolutions up to 4K.
- Improved Graphics Performance: The VideoCore VI graphics processor delivers improved multimedia performance, making it suitable for applications such as gaming, media centres, and digital signage.
- **GPIO Pins:** Like previous models, the Raspberry Pi 4 retains the 40-pin GPIO header, allowing for interfacing with a wide range of external devices and sensors.
- USB-C Power Port: It features a USB-C power port for improved power delivery, replacing the micro-USB port found in earlier models.
- **Heat Management:** The Raspberry Pi 4 incorporates heat spreaders and improved thermal management, addressing concerns about overheating during intensive computing tasks.
- **Compatibility:** While offering significant improvements, the Raspberry Pi 4 maintains compatibility with previous Raspberry Pi accessories, software, and operating systems, ensuring a smooth transition for existing users.
- **Versatility:** Its small form factor, low cost, and extensive community support make the Raspberry Pi 4 suitable for a wide range of applications, including education, IoT projects, home automation, and hobbyist electronics.

2. APM 2.8

The APM 2.8 is a popular open-source autopilot system designed for unmanned aerial vehicles (UAVs) and drones. It features advanced flight control capabilities, including stabilization, navigation, and autonomous mission planning. With its versatile and customizable platform, the APM 2.8 is widely used in both hobbyist and professional drone applications.

Figure 3.2: APM 2.8

The above Figure 3.2 represents APM 2.8 and here are some key features of the APM 2.8:

- **Autonomous Flight:** APM 2.8 supports autonomous flight modes, enabling drones to fly predetermined missions without manual control.
- **GPS Integration:** It incorporates GPS functionality, allowing precise positioning, navigation, and waypoint-based flight.
- **Stability and Control:** APM 2.8 offers advanced stabilization algorithms, ensuring stable flight even in challenging conditions.
- **Telemetry:** It supports telemetry systems, providing real-time data transmission between the drone and ground control station.
- **Sensor Compatibility:** APM 2.8 is compatible with various sensors, including accelerometers, gyroscopes, and magnetometers, for accurate flight dynamics measurement.
- **Flight Modes:** It offers multiple flight modes such as stabilize, loiter, altitude hold, and return to home, catering to different mission requirements.
- **Open-Source Firmware:** APM 2.8 firmware is open-source, allowing customization and community-driven development.
- **Reliability:** Known for its robustness, APM 2.8 ensures reliable performance in diverse applications, from hobbyist drones to commercial-grade UAVs.
- **Integration:** It seamlessly integrates with ground control software like Mission Planner and QGroundControl for mission planning, parameter tuning, and flight monitoring.

3. ESC

An Electronic Speed Controller (ESC) is a device that regulates the speed and direction of a drone's brushless motors. It converts the battery's direct current (DC) into alternating current (AC) and adjusts motor speed based on control signals from the flight controller, ensuring stable and responsive flight.

Figure 3.3: ESC

The above Figure 3.3 represents Electronic Speed Controller. ESCs are crucial components in the operation of drones, providing several key features that ensure efficient and precise control of the motors. Here are the primary features of ESCs:

- **Throttle Control:** ESCs manage the speed of the drone's motors by regulating the power supplied based on the throttle input from the flight controller. This allows for smooth acceleration and deceleration.
- **Programmability:** Many ESCs are programmable, enabling customization of various parameters such as timing, brake settings, and motor direction. This allows for optimization based on specific motor and flight characteristics.
- **Battery Compatibility:** ESCs are designed to work with different types of batteries, most commonly LiPo (Lithium Polymer) batteries. They often include voltage monitoring to ensure proper operation and prevent damage from low voltage.
- **Safety Features:** ESCs typically incorporate safety features like overcurrent protection, thermal protection, and low voltage cutoff. These features protect both the ESC and the motor from damage due to excessive current, overheating, or low battery voltage.

- **Signal Processing:** ESCs convert the Pulse Width Modulation (PWM) signals from the flight controller into motor power levels. Advanced ESCs may also support other protocols such as OneShot, MultiShot, DShot, or ProShot for faster and more precise signal processing.
- **BEC (Battery Eliminator Circuit):** Some ESCs include a BEC that provides a stable voltage output to power the flight controller and other onboard electronics, eliminating the need for a separate power source.
- **Firmware Updates:** Modern ESCs often support firmware updates, allowing users to benefit from improvements and new features introduced by the manufacturer.
- **Telemetry:** Some advanced ESCs provide telemetry data such as current draw, RPM, and temperature, which can be sent back to the flight controller or ground station for monitoring and analysis.

4. Brushless motors

A brushless motor is an electric motor that operates without brushes, using an electronic controller to switch the current in the motor windings. It offers higher efficiency, reliability, and longevity compared to brushed motors, making it ideal for applications like drones, electric vehicles, and various industrial tools.

Figure 3.4: Brushless Motor

The above Figure 3.4 represents Brushless motors. Brushless motors, commonly used in drones, offer several distinct features that make them ideal for various applications, including human-detecting and following drones. Here are the key features:

- **High Efficiency:** Brushless motors are more efficient than brushed motors because they lack brushes that cause friction and energy loss. This efficiency translates to longer flight times for drones.

- **Durability and Longevity:** The absence of brushes reduces wear and tear, making brushless motors more durable and increasing their lifespan significantly.
- **Higher Power-to-Weight Ratio:** These motors provide more power relative to their weight, which is crucial for drones to achieve better performance and agility.
- **Low Maintenance:** Brushless motors require less maintenance compared to their brushed counterparts, as there are no brushes that need periodic replacement.
- **5 Better Speed Control:** They offer precise control over speed and torque, essential for the accurate manoeuvres required in human-following drones.
- **Quieter Operation:** With fewer moving parts that create friction, brushless motors operate more quietly, which is beneficial for applications requiring low noise levels.
- **Thermal Management:** They have better thermal efficiency and can dissipate heat more effectively, preventing overheating during prolonged operations.
- **Higher RPM and Torque:** Brushless motors can achieve higher revolutions per minute (RPM) and deliver greater torque, enhancing the drone's lift and responsiveness.
- **Precision and Stability:** The precise electronic control allows for smoother and more stable operation, which is essential for maintaining a steady flight path while following a human subject.

5. Power Distribution Board

A drone power distribution board (PDB) distributes power from the main battery to various components of the drone, such as motors, ESCs (Electronic Speed Controllers), and flight controllers. It ensures efficient and organized power management, enabling stable and reliable operation of the drone's electrical systems.

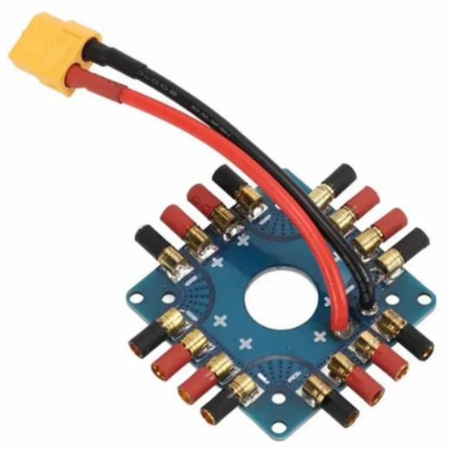

Figure 3.5: Power Distribution Board

The above Figure 3.5 represents Power Distribution board and here are some key features and characteristics of Power Distribution board:

- **Power Distribution:** The primary function of the PDB is to evenly distribute power from the main battery to the ESCs, which then supply the motors. This ensures consistent power delivery to all motors, crucial for stable flight.
- **Integrated Voltage Regulators:** Many PDBs come with built-in voltage regulators (BECs) that step down the main battery voltage to a lower level (e.g., 5V or 12V) suitable for powering other onboard electronics like the flight controller, camera, and telemetry systems.
- **Current Sensing:** Some advanced PDBs include current sensors that monitor the power draw of the drone. This data can be fed to the flight controller to help manage battery usage and provide real-time feedback on power consumption.
- **Compact Design:** A well-designed PDB reduces the need for multiple power wires running throughout the drone, minimizing weight and improving the overall tidiness of the build. This compact design helps in efficient space management within the drone frame.
- **Solder Pads and Connectors:** PDBs typically feature multiple solder pads and connectors, making it easier to connect the ESCs, battery, and other components securely and reliably.
- **Filtering and Noise Reduction:** Some PDBs include capacitors or other filtering components to reduce electrical noise, which can interfere with the flight controller and other sensitive electronics, enhancing the stability and performance of the drone.
- **Heat Dissipation:** High-quality PDBs are designed to handle the heat generated by high current loads, with materials and designs that help dissipate heat effectively, preventing overheating during flight.

6. Raspberry Pi Camera Module

The Raspberry Pi Camera Module offers up to 12MP resolution, full HD 1080p video recording, and infrared capabilities with the NoIR variant. Its compact size, interchangeable lenses, and seamless integration with the Raspberry Pi via the CSI port make it ideal for versatile applications, including computer vision and robotics.

Figure 3.6: Raspberry Pi Camera

The above Figure 3.6 represents Raspberry Pi camera and here are some key features and characteristics of Raspberry pi camera:

- **High Resolution:** It offers up to 12 megapixels resolution for capturing detailed images and videos.
- **Video Capabilities:** It supports full HD 1080p video recording at 30 frames per second (fps), 720p at 60 fps, and 480p at 90 fps.
- **Compact Size:** The small and lightweight design makes it ideal for integration into drones and other portable devices.
- **Interchangeable Lenses:** Some models, like the Camera Module 3, allow for interchangeable lenses, providing flexibility in field of view and focus.
- **Infrared (IR) Versions:** The NoIR Camera Module variant is equipped for low-light and night vision capabilities, useful for applications requiring infrared imaging.
- **Compatibility:** It connects directly to the Raspberry Pi via a CSI (Camera Serial Interface) port, ensuring easy integration and setup.
- **Wide Range of Applications:** Suitable for still photography, time-lapse, slow-motion, and live streaming.
- **High Quality:** Provides clear and sharp images, suitable for computer vision tasks like object and human detection.

7.GPS Module

A GPS module for a drone provides precise location tracking and navigation capabilities. It enables the drone to determine its exact position, maintain stable flight paths, and execute autonomous functions such as waypoint navigation and return-to-home features. Essential for enhancing flight accuracy and safety in various applications.

Figure 3.7: GPS Module

8. Propellers

Drone propellers are critical for generating lift and thrust. Made from materials like plastic or carbon fiber, they come in various sizes and designs to match specific drone requirements. Proper selection ensures efficient flight performance, stability, and maneuverability, directly affecting the drone’s speed, agility, and energy consumption.

Figure 3.8: Propellers

9. Drone Battery

A LiPo (Lithium Polymer) battery for drones is a lightweight, high-capacity power source known for its high discharge rates and efficient energy storage. It provides the necessary power for motors and electronics, ensuring longer flight times and stable performance, crucial for autonomous and high-performance drone operations. 5200 mAh LiPo Battery is used to power the drone in our project.

The features of a 5200 mAh LiPo Battery are:

LiPo (Lithium Polymer) batteries are widely used in drones due to their high energy density, lightweight nature, and ability to deliver high current outputs. Key features of LiPo batteries for drones include:

- High Energy Density: LiPo batteries can store a significant amount of energy in a compact size, which is crucial for maximizing flight time without adding excessive weight to the drone.
- Lightweight: Compared to other battery types, LiPo batteries are relatively light, helping to keep the drone's weight down and improve its manoeuvrability and efficiency.
- High Discharge Rates: They can deliver high bursts of power, necessary for the rapid acceleration and climbing capabilities of drones.
- Variety of Sizes and Capacities: LiPo batteries come in various shapes, sizes, and capacities, allowing users to select the optimal battery for their specific drone model and requirements.
- Voltage Configurations: They are available in different cell configurations (e.g., 2S, 3S, 4S), providing different voltage levels to match the power needs of various drone motors and electronic components.
- Balanced Charging: Most LiPo batteries come with balance connectors to ensure each cell is charged equally, preventing overcharging and increasing the battery's lifespan.

Figure 3.9: LiPo Drone Battery

10. Frame

A drone frame made from plastic pipe is lightweight, cost-effective, and easy to assemble. It offers flexibility in design and durability for hobbyist projects. While not as strong as carbon fiber, plastic pipe frames are suitable for low-cost, DIY drones, providing adequate support for components and basic flight stability.

3.1.2 SOFTWARE REQUIREMENT

The software requirements of the Project represent the digital soul of this groundbreaking assistive device. From real-time data processing algorithms to intuitive user interfaces, each software component plays a vital role in translating sensor inputs into actionable insights and user feedback. With a keen focus on accessibility, usability, and reliability, developers strive to create software solutions that not only meet the functional needs of users but also enhance their overall experience and independence. As we delve into the intricacies of software requirements, it becomes evident that the success of the Multi-Purpose Blind Stick Project hinges on a multidimensional approach to software development. Beyond mere functionality, developers must consider factors such as responsiveness, adaptability, and compatibility with existing assistive technologies. By leveraging cutting-edge software engineering principles and user-centred design methodologies, developers can craft a software ecosystem that empowers visually impaired individuals to navigate the world with confidence and ease.

1. Raspberry Pi Imager

Raspberry Pi Imager is a versatile and user-friendly tool designed to simplify the process of installing operating systems on Raspberry Pi devices. Developed by the Raspberry Pi Foundation, this software is compatible with Windows, macOS, and Linux, making it accessible to a broad range of users. The primary function of Raspberry Pi Imager is to write image files directly to SD cards or USB drives, which can then be used to boot Raspberry Pi computers.

To use Raspberry Pi Imager, users simply download and install the application on their computer. The interface is straightforward, guiding users through a few easy steps: selecting the desired operating system, choosing the storage device to write to, and initiating the writing process. Raspberry Pi Imager supports a variety of operating systems, including the official Raspberry Pi OS, Ubuntu, and other third-party distributions. It also offers direct downloads from within the application, ensuring users always have access to the latest versions.

Overall, Raspberry Pi Imager is an essential tool for anyone working with Raspberry Pi devices, offering a seamless and efficient way to prepare and manage operating systems for various projects.

2. Raspberry Pi OS

Raspberry Pi OS, formerly known as Raspbian, is the official operating system for the Raspberry Pi hardware. It is a Debian-based Linux distribution optimized for the performance and capabilities of the Raspberry Pi's ARM architecture. Raspberry Pi OS comes in three main versions: Raspberry Pi OS Lite, a minimal CLI-only version; Raspberry Pi OS with Desktop, which includes a lightweight desktop environment; and Raspberry Pi OS with Desktop and Recommended Software, which bundles various educational tools, development environments, and media software.

The OS is designed to be user-friendly and versatile, catering to a wide range of users, from beginners in programming and electronics to advanced developers and hobbyists. Its default desktop environment is PIXEL (Pi Improved X-Window Environment, Lightweight), providing an intuitive graphical interface while remaining efficient. Raspberry Pi OS supports a vast array of software available from the Debian repositories, ensuring users have access to a broad spectrum of applications.

Key features include built-in support for Python, Scratch, and other educational programming tools, making it an excellent platform for learning coding and computer science. The OS also supports GPIO pins natively, allowing users to interact with physical hardware components easily. Regular updates and a strong community ensure that Raspberry Pi OS remains secure, stable, and continuously improved, making it an ideal choice for a wide variety of projects and educational purposes.

3. ArduPilot Mission Planner

ArduPilot Mission Planner is a powerful ground control station software designed for configuring, planning, and monitoring autonomous flights of vehicles equipped with ArduPilot autopilot systems. With an intuitive user interface, it offers a comprehensive suite of features for both beginner and advanced users.

The software enables users to upload firmware, configure vehicle parameters, and calibrate sensors with ease. Its mission planning capabilities allow users to create complex flight paths using waypoints, geofences, and commands, ensuring precise navigation and execution of autonomous missions.

Additionally, the software offers advanced features such as geotagging images, logging flight data for analysis, and integrating with external ground control systems for expanded functionality.

Overall, ArduPilot Mission Planner is a versatile and user-friendly tool for managing ArduPilot-based vehicles, offering a seamless experience for mission planning, execution, and monitoring in various applications, including drones, ground vehicles, and unmanned aerial vehicles (UAVs).

4. MAVProxy and DroneKit

MAVProxy (MAVLink Proxy) and DroneKit are two essential tools in the realm of drone development and operation, offering powerful capabilities for interfacing with unmanned aerial vehicles (UAVs) and controlling them programmatically.

MAVProxy serves as a versatile ground control station software, facilitating communication between a ground-based computer and the UAV through MAVLink, a lightweight messaging protocol. It enables users to monitor telemetry data, send commands, and even modify parameters in real-time. MAVProxy's modular architecture allows for customization and integration with various hardware and software components, making it a popular choice among drone enthusiasts, researchers, and developers.

DroneKit, on the other hand, is a high-level SDK (Software Development Kit) that simplifies the process of drone programming. Built on top of MAVLink, DroneKit provides a Python API for creating autonomous missions, implementing flight control algorithms, and interacting with onboard sensors and peripherals. With DroneKit, developers can write scripts to automate complex tasks, such as waypoint navigation, geofencing, and camera control, empowering drones to execute predefined missions with precision and reliability.

Together, MAVProxy and DroneKit form a powerful ecosystem for drone development, enabling seamless communication, control, and automation of unmanned aerial systems. Whether for hobbyist experimentation, academic research, or commercial applications, these tools play a crucial role in advancing the capabilities and versatility of drones in various domains.

CHAPTER 4

SYSTEM ANALYSIS

4.1 INTRODUCTION

System analysis in the context of human detection and following drones involves examining the entire system's components, interactions, and functionalities to ensure efficient and effective performance. It includes evaluating hardware components such as cameras, sensors, and flight controllers, as well as software algorithms for human detection, tracking, and flight control.

System analysis identifies potential bottlenecks, limitations, and areas for improvement, guiding the design and optimization process. It also considers factors such as environmental conditions, user requirements, and safety considerations to develop a comprehensive understanding of the system's capabilities and limitations in real-world applications.

4.2 EXISTING SYSTEM

The existing and older systems of human detection and following drones typically relied on simpler hardware and software solutions compared to modern counterparts. These systems were often characterized by basic components and algorithms, limited autonomy, and reduced reliability. Here's an overview of the key aspects of older human detection and following drone systems:

- **Microcontrollers**: Instead of powerful single-board computers like the Raspberry Pi, older systems often used microcontrollers with limited processing capabilities, such as Arduino boards. These microcontrollers were sufficient for basic control tasks but lacked the computational power for advanced image processing.

- **Low-Resolution Cameras**: Older drones typically employed low-resolution cameras with limited image processing capabilities. These cameras provided basic visual feedback but struggled to accurately detect and track human subjects, especially in challenging lighting conditions or cluttered environments.

- **Basic Flight Controllers**: Flight controllers used in older systems were often simpler and less feature-rich compared to modern counterparts like the APM 2.8 or Pixhawk. They provided basic stabilization and control functions but lacked advanced navigation and autonomy features.

- **Traditional Computer Vision Techniques**: Instead of sophisticated deep learning algorithms used in modern systems, older drones relied on traditional computer vision techniques such as color segmentation, edge detection, or template matching. These techniques were less accurate and reliable, leading to reduced performance in human detection and tracking tasks.

- **Manual Control Strategies**: Exsisting systems typically used manual control strategies where operators manually piloted the drone to follow a human subject. This manual control approach limited the drone's autonomy and responsiveness, making it less suitable for autonomous operation.

- **Single Sensor Systems**: Older drones often used single sensor systems, such as monocular cameras or ultrasonic sensors, for perception and obstacle detection. These single sensor systems had limited capabilities and struggled to provide robust situational awareness in complex environments.

- **Limited Autonomy**: Due to the simplicity of hardware and software components, older drones had limited autonomy and were heavily reliant on human operators for control and decision-making. They lacked the ability to navigate autonomously or adapt to changing environmental conditions.

4.2.1 DISADVANTAGES OF EXISTING SYSTEM

The older existing systems of human following and detection drones, while innovative for their time, were associated with several disadvantages that limited their effectiveness and reliability:

1. **Limited Computing Power**: Older drones often relied on basic microcontrollers or processors with limited computational capabilities. This restricted their ability to

perform complex image processing tasks, leading to slower detection and tracking algorithms and reduced overall performance.

2. **Low-Resolution Cameras**: The cameras used in older systems typically had lower resolutions and less advanced imaging capabilities compared to modern counterparts. This resulted in reduced image quality and detection accuracy, especially in challenging lighting conditions or when tracking fast-moving objects.

3. **Manual Control and Navigation**: Early human following and detection drones often required manual control and navigation by operators. This reliance on manual input made them less autonomous and responsive, increasing the risk of accidents or collisions, particularly in dynamic environments.

4. **Limited Autonomy and Features**: Older systems lacked advanced autonomy features such as obstacle avoidance, autonomous navigation, and adaptive flight control algorithms. This limited their ability to operate effectively in complex or cluttered environments, restricting their utility for real-world applications.

5. **Hardware Constraints**: The hardware components used in older drones, including sensors, processors, and communication systems, were often less sophisticated and reliable compared to modern equivalents. This resulted in reduced system robustness, increased susceptibility to hardware failures, and shorter operational lifespans.

6. **Inadequate Object Tracking**: Early tracking algorithms used in older systems were less accurate and robust, making it challenging to maintain a consistent lock on moving objects, especially in crowded or dynamic environments. This led to frequent tracking errors and loss of target acquisition, compromising the overall effectiveness of the system.

7. **Limited Battery Life**: Older drones typically had shorter battery life and limited endurance, limiting their operational range and duration. This restricted their ability to conduct prolonged surveillance missions or cover large areas without requiring frequent recharging or battery swaps.

Overall, the disadvantages of older existing systems of human following and detection drones highlight the technological limitations and challenges faced during the early stages of development in this field. However, these limitations have spurred ongoing research and innovation, leading to the development of more advanced and capable systems in recent years.

4.3 PROPOSED SYSTEM

The proposed system of a human detection and following drone utilizing Raspberry Pi and APM 2.8 represents a significant advancement over older existing systems. By leveraging the computational power of Raspberry Pi for real-time image processing and decision-making, coupled with the precise flight control capabilities of the APM 2.8, the proposed system offers enhanced accuracy, reliability, and autonomy. Compared to older systems, this solution benefits from more advanced hardware components, sophisticated algorithms, and seamless integration, resulting in improved detection accuracy, smoother flight trajectories, and increased operational efficiency. Overall, the proposed system sets a new standard for human-following drones, offering superior performance and functionality.

The proposed system utilizes Raspberry Pi and APM 2.8 offers several advantages over older existing systems, making it a superior solution in terms of performance, reliability, and versatility. Here's why:

- **Enhanced Processing Power**: The Raspberry Pi 4 provides significantly more computational power compared to the microcontrollers or processors used in older systems. This allows for real-time image processing and advanced computer vision algorithms, resulting in faster and more accurate human detection and tracking.

- **High-Resolution Camera Support**: The Raspberry Pi can support high-resolution cameras with advanced imaging capabilities, improving detection accuracy and image quality. This enables the drone to capture clearer and more detailed video footage, even in challenging lighting conditions.

- **Autonomous Navigation Capabilities**: The integration of the APM 2.8 flight controller enables autonomous navigation and precise flight control, reducing the reliance on manual input and improving overall system autonomy. This allows the drone to follow human subjects smoothly and accurately without constant operator intervention.

- **Advanced Control Algorithms**: The APM 2.8 flight controller supports advanced control algorithms, such as model predictive control (MPC) or reinforcement learning (RL), for optimized flight performance and adaptive navigation. These algorithms enable the drone to adjust its flight path dynamically based on detected human positions, enhancing tracking accuracy and responsiveness.

- **Integration of Telemetry and Communication**: The communication protocols, such as MAVLink, facilitate seamless data exchange between the Raspberry Pi and APM 2.8, ensuring synchronized operations and real-time feedback. This integration enhances system reliability and responsiveness, enabling efficient command execution and telemetry data transmission.
- **Scalability and Customization**: The modular design of the proposed system allows for scalability and customization to meet specific requirements and applications. Additional sensors, such as LiDAR or thermal cameras, can be integrated to enhance detection capabilities, while software algorithms can be tailored to adapt to different environments and scenarios.
- **Improved Battery Management**: The Raspberry Pi's efficient power management capabilities, combined with the APM 2.8's support for battery monitoring and management, help optimize battery usage and extend flight times. This enhances operational efficiency and enables longer surveillance missions without frequent recharging.

Overall, the proposed system of human detection and following drone using Raspberry Pi and APM 2.8 represents a significant improvement over older existing systems, offering enhanced performance, reliability, and versatility for various applications in surveillance, search and rescue, and beyond.

CHAPTER 5

SYSTEM DESIGN

System design is the process of defining the architecture, components, modules, interfaces, and data for a system or software application to meet specific requirements. This process involves converting the requirements gathered during the system analysis phase into a detailed plan that specifies how the system or application will function.

The system design phase is critical in determining the feasibility of the project and identifying any technical constraints or risks that need to be addressed. The design phase involves several sub-phases, including architectural design, interface design, database design, and component design. Once the design is complete, it serves as the blueprint for the system or application's development and guides the coding and testing processes. The system design process is critical in ensuring that the final product meets the requirements of the stakeholders and operates efficiently, reliably, and securely.

5.1 METHODOLOGY

The methodology for developing a human detection and following drone using Raspberry Pi and APM 2.8 involves several key steps. Initially, the hardware components, including the Raspberry Pi, camera module, APM 2.8 flight controller, and drone frame, are assembled and configured. The Raspberry Pi is then programmed to process real-time video feeds from the camera module using computer vision algorithms, such as Haar cascades or deep learning-based approaches, to detect human subjects.

Once a human is detected, the Raspberry Pi calculates the target's position relative to the drone's current location. This information is sent to the APM 2.8 flight controller, which adjusts the drone's flight path to maintain a safe distance and follow the detected human. Integration between the Raspberry Pi and APM 2.8 is crucial, requiring communication protocols such as MAVLink to exchange data seamlessly. Throughout the development process, iterative testing and refinement of both hardware and software components are conducted to optimize performance, accuracy, and reliability. This methodology ensures the successful creation of an autonomous aerial system capable of detecting and following human subjects in real-world environments.

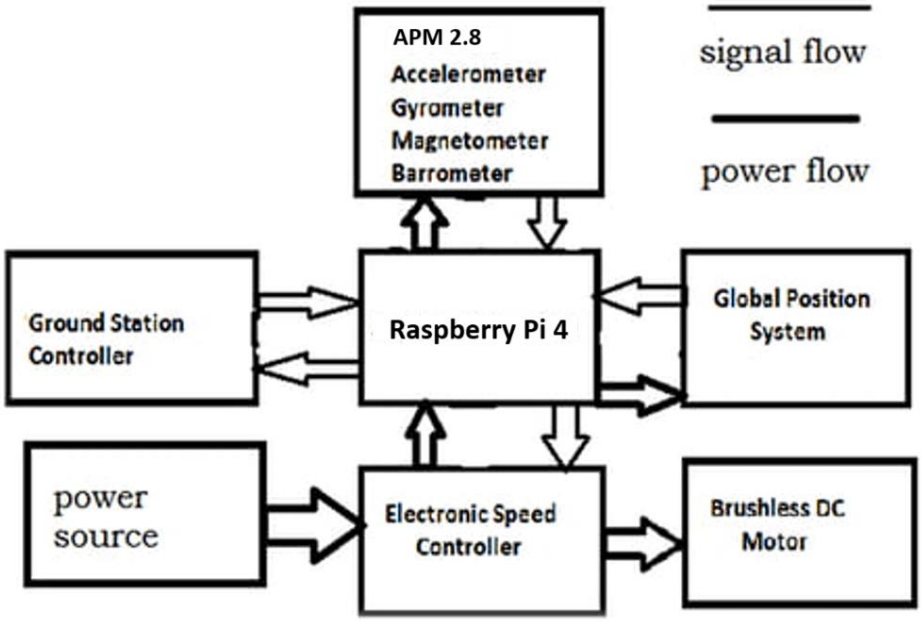

Figure 5.1: Block Diagram of the Drone

The block diagram shows a Raspberry Pi 4 based drone system. Here's a breakdown of the components:

- **Sensors:**
    - Accelerometer: Measures the drone's acceleration in all directions.
    - Gyroscope: Measures the rate at which the drone is rotating around its X, Y, and Z axes.
    - Magnetometer: Measures the strength and direction of Earth's magnetic field.
    - Barometer: Measures atmospheric pressure, which can be used to estimate the drone's altitude.
- **Flight controller:** APM 2.8 - is the brain of the drone. It collects data from the sensors, processes it, and sends signals to the Electronic Speed Controllers (ESCs) to control the speed of the motors.
- **Electronic Speed Controllers (ESCs):** control the speed and direction of the brushless DC motors.
- **Brushless DC motor:** brushless electric motors that are known for their high efficiency and power.
- **Power Source:** The battery provides power to the entire system.

- **Ground Station (optional):** A ground station is a computer program that allows a user to control the drone and monitor its flight path. You can connect the Raspberry Pi to a ground station software using a telemetry radio.

Here's how the data flows in the system:

1. The sensors (accelerometer, gyroscope, magnetometer, barometer) continuously send data to the Flight Controller (APM 2.8).
2. The Flight Controller processes the sensor data and calculates the drone's attitude (position, orientation) and flight dynamics.
3. Based on this data and the user's input (from the remote control or ground station), the Flight Controller sends control signals to the Electronic Speed Controllers (ESCs).
4. The ESCs then vary the speed and direction of the brushless DC motors accordingly.

This feedback loop allows the Flight Controller to maintain the drone's position and orientation in flight.

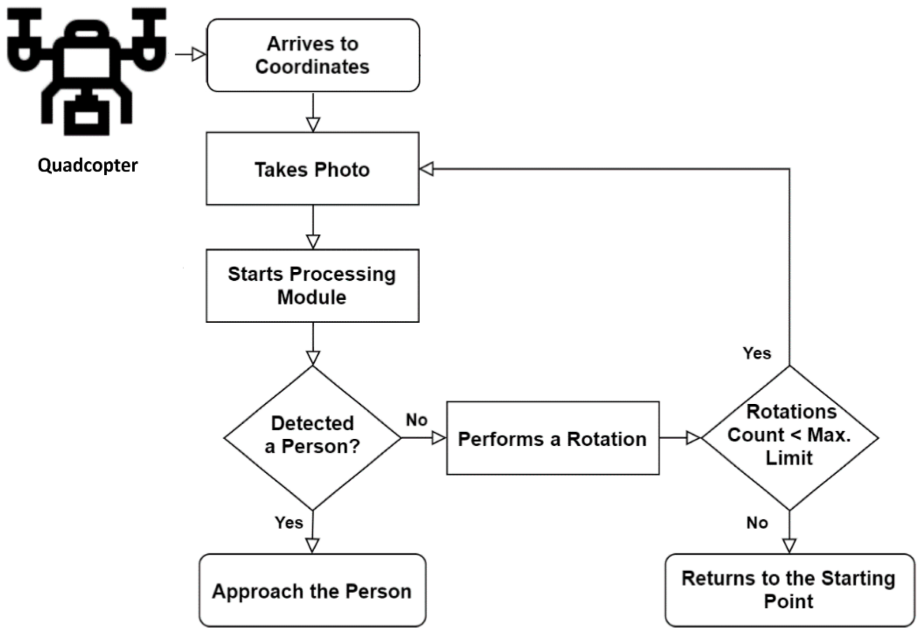

Figure 5.2: Block Diagram of Quadcopter following a person

The diagram above diagram is a flowchart outlining a decision-making process for a quadcopter, or drone, equipped with a camera. The flowchart suggests the drone's purpose is to take a photo of a person.

Here’s a breakdown of the decision process:

1. **Arrives at Coordinates:** The flowchart begins with the drone arriving at its designated coordinates.

2. **Takes Photo:** The drone takes a photo.

3. **Starts Processing Module:** The flowchart suggests the drone has a built-in processing module which presumably analyzes the photo that was just taken.

4. **Detected a Person?:** The processing module then determines if a person was detected in the photograph.

   - If a person was detected (Yes): The flowchart moves on to step 8.

   - If no person was detected (No): The flowchart indicates the drone performs a rotation, possibly to take another photo at a slightly different angle. There’s a limit to how many rotations the drone will perform searching for a person (Max Rotations Limit).

5. **Rotations Count < Max Rotations Limit:** The flowchart checks if the number of rotations the drone has performed is less than the maximum number of rotations allowed.

   - If the number of rotations is less than the maximum (Yes), the flowchart loops back to step 2 where the drone takes another photo.

   - If the number of rotations is equal to or greater than the maximum (No), the flowchart moves on to step 7.

6. **Returns to Starting Point:** After reaching its maximum number of rotations without finding a person, the flowchart indicates the drone returns to its starting point.

7. **End:** This concludes the flowchart.

Overall, this flowchart outlines a decision-making process for a drone programmed to take a photo of a person. The drone takes a photo, analyses it to find a person, and if it doesn’t find one within a certain number of attempts, it returns to its starting point.

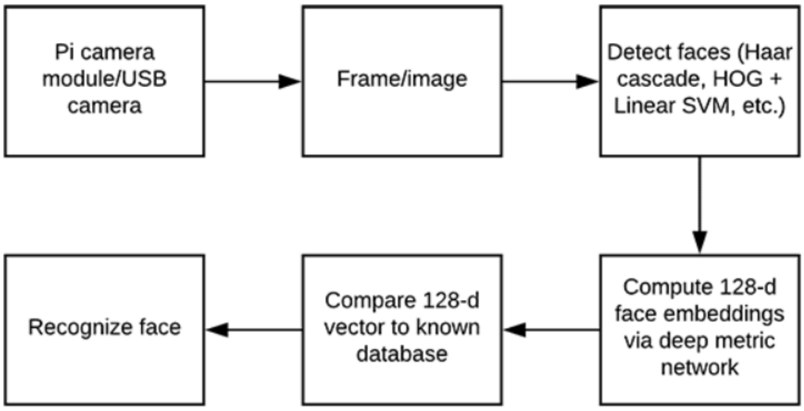

Figure 5.3 Block Diagram of face recognition in RPi

The Figure 5.3 depicts a facial recognition system. It outlines the steps involved in recognizing a face using a camera and a database. Here's a breakdown of the process:

1. **Capture Image:** The first step involves capturing an image of a person's face using either a regular camera or a Pi camera.
2. **Detect Faces:** The system then employs various methods to detect faces within the captured image. Some of the techniques mentioned in the diagram include Haar cascade classifiers, Histogram of Oriented Gradients (HOG) with linear SVM, and other unspecified methods.
3. **Extract Facial Features:** Once a face is detected, the system extracts a 128-dimensional vector containing facial features from the image. This essentially creates a mathematical representation of the face that can be compared to other faces.
4. **Compare to Database:** The system then compares the 128-dimensional vector to a database of known facial features, also represented as 128-dimensional vectors. This comparison is done using a deep metric network, a type of artificial neural network used for face recognition.
5. **Recognize Face:** Finally, based on the comparison with the database, the system determines whether a match is found. If there's a match, the system recognizes the face.

In essence, this flowchart outlines the process by which a facial recognition system captures an image, detects faces, extracts facial features, compares them to a database and makes a recognition decision.

5.2 CIRCUIT DIAGRAM

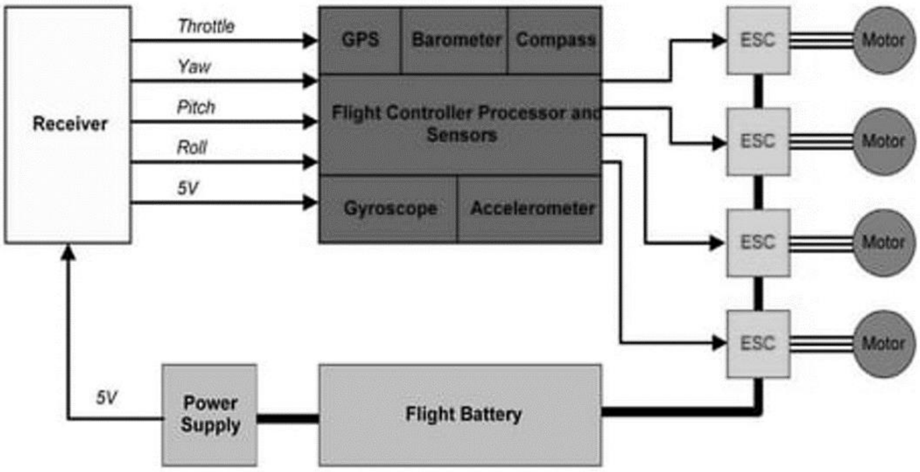

Figure 5.4: Circuit Diagram of Drone

The circuit diagram you sent shows the flow of power and signals in a drone flight control system. Here's a breakdown of the connections without explaining the specific components:

- The battery supplies power to the entire system.
- The power supply connects to the flight controller.
- The flight controller sends signals to the Electronic Speed Controllers (ESCs).
- The ESCs control the motors.
- The receiver receives signals from the remote control.
- The flight controller also receives signals from the receiver.
- The barometer, gyroscope and accelerometer all feed into the flight controller.

The flight controller interprets the data it receives from the receiver, barometer, gyroscope and accelerometer and sends signals to the ESCs to control the motors accordingly. This allows the pilot to control the drone's movement and the flight controller to maintain its stability.

CHAPTER 6

IMPLEMENTATION

6.1 MODULES

The implementation of a human detection and following drone using Raspberry Pi 4 and APM 2.8 involves several key modules. Each module plays a crucial role in ensuring the drone operates effectively and reliably. Here are the main implementation modules:

1. **Image Processing Module**:
    - **Components**: Raspberry Pi 4, camera module, OpenCV library.
    - **Tasks**: Capture video feed from the camera, implement human detection algorithms using OpenCV (e.g., Haar cascades, deep learning models), and identify human targets in real-time.
    - **Outputs**: Coordinates of detected humans in the video frame.

    Snippet code for Image processing Module:

```
import cv2

import time

from dronekit import connect, VehicleMode, LocationGlobalRelative

# Connect to the vehicle

vehicle = connect('/dev/ttyAMA0', baud=57600, wait_ready=True)

# Load the pre-trained model for human detection

net = cv2.dnn.readNetFromCaffe('deploy.prototxt', 'mobilenet_iter_73000.caffemodel')

# Function to send velocity commands to the drone

def send_ned_velocity(vehicle, vx, vy, vz):

    msg = vehicle.message_factory.set_position_target_local_ned_encode(

        0, 0, 0, mavutil.mavlink.MAV_FRAME_LOCAL_NED, 0b0000111111000111,
```

```
        0, 0, 0, vx, vy, vz, 0, 0, 0, 0, 0)
    vehicle.send_mavlink(msg)
    vehicle.flush()
# Function to process the frame and detect humans
def process_frame(frame):
    (h, w) = frame.shape[:2]
    blob = cv2.dnn.blobFromImage(cv2.resize(frame, (300, 300)), 0.007843,
(300, 300), 127.5)
    net.setInput(blob)
    detections = net.forward()
    for i in range(detections.shape[2]):
        confidence = detections[0, 0, i, 2]
        if confidence > 0.2:  # Confidence threshold
            idx = int(detections[0, 0, i, 1])
            if idx == 15:  # Class label for 'person' is 15 in COCO dataset
                box = detections[0, 0, i, 3:7] * np.array([w, h, w, h])
                (startX, startY, endX, endY) = box.astype("int")
                return (startX + endX) // 2, (startY + endY) // 2  # Return the center
of the detected person
    return None
# Initialize camera
cap = cv2.VideoCapture(0)
while True:
    ret, frame = cap.read()
    if not ret:
```

```
            break
        center = process_frame(frame)
        if center is not None:
            frame_center = (frame.shape[1] // 2, frame.shape[0] // 2)
            error_x = center[0] - frame_center[0]
            error_y = center[1] - frame_center[1]
            # Simple proportional control
            vx = -error_y * 0.01  # Control forward/backward
            vy = error_x * 0.01   # Control left/right
            send_ned_velocity(vehicle, vx, vy, 0)
        cv2.imshow("Frame", frame)
        key = cv2.waitKey(1) & 0xFF
        if key == ord("q"):
            break
    cap.release()
    cv2.destroyAllWindows()
```

2. **Flight Control Module**:

    - **Components**: APM 2.8 flight controller, GPS module, telemetry radio.
    - **Tasks**: Receive and execute flight commands, stabilize the drone, control navigation, and manage altitude.
    - **Outputs**: Motor speed adjustments, navigation commands.

Snippet code for Flight Control Module:

```
def arm_and_takeoff(target_altitude):
    print("Basic pre-arm checks")
```

```
    while not vehicle.is_armable:
        print(" Waiting for vehicle to initialise...")
        time.sleep(1)
    print("Arming motors")
    vehicle.mode = VehicleMode("GUIDED")
    vehicle.armed = True
    while not vehicle.armed:
        print(" Waiting for arming...")
        time.sleep(1)
    print("Taking off!")
    vehicle.simple_takeoff(target_altitude)
    while True:
        print(" Altitude: ", vehicle.location.global_relative_frame.alt)
        if vehicle.location.global_relative_frame.alt >= target_altitude * 0.95:
            print("Reached target altitude")
            break
        time.sleep(1)
def go_to(location):
    point = LocationGlobalRelative(location.lat, location.lon, location.alt)
    vehicle.simple_goto(point)
def land():
    print("Landing")
    vehicle.mode = VehicleMode("LAND")
```

3. **Communication Module**:
    - **Components**: Raspberry Pi 4, APM 2.8, MAVLink protocol, telemetry radio.
    - **Tasks**: Establish and maintain communication between Raspberry Pi and APM 2.8 using MAVLink, transmit human coordinates to the flight controller, receive telemetry data from the APM 2.8.
    - **Outputs**: Control signals sent to APM 2.8, telemetry data received on Raspberry Pi.
4. **Human Following Algorithm Module**:
    - **Components**: Raspberry Pi 4, APM 2.8.
    - **Tasks**: Implement algorithms to adjust the drone's position based on the human's coordinates, calculate necessary movements to maintain a safe following distance, and update flight commands accordingly.
    - **Outputs**: Real-time navigation adjustments.
5. **Obstacle Detection and Avoidance Module**:
    - **Components**: Ultrasonic sensors, LiDAR (if applicable), Raspberry Pi 4.
    - **Tasks**: Detect obstacles in the drone's path using sensors, calculate avoidance maneuvers, and adjust flight path to avoid collisions.
    - **Outputs**: Adjusted flight commands for obstacle avoidance.

By integrating these modules, the human detection and following drone can operate autonomously, detecting and tracking human subjects while navigating safely in various environments. Each module's tasks and outputs are crucial for ensuring the system's overall functionality and reliability.

6.2 PHASES

The development of a human detection and following drone involves several distinct phases, each critical to the project's success. The initial phase is conceptualization and planning, where the project's goals, requirements, and technical specifications are defined. This includes selecting appropriate hardware components, such as the Raspberry Pi, camera module, and APM 2.8 flight controller. The next phase is hardware assembly and integration, where the drone's physical structure is built, and components are connected and configured. This is followed by the software development phase, where the Raspberry Pi is programmed with computer vision algorithms to detect humans using image processing libraries like OpenCV. Simultaneously, the integration of the Raspberry Pi with the APM 2.8 through communication protocols such as MAVLink is implemented to enable real-time data exchange and flight control.

The testing and calibration phase is crucial, involving rigorous testing of the system in various conditions to fine-tune the algorithms and ensure reliable performance. This includes adjusting parameters for accurate human detection and responsive following behaviour. The safety and compliance phase addresses safety features like obstacle detection and regulatory compliance to ensure the drone operates safely and legally. Finally, the deployment and refinement phase involve deploying the drone in real-world scenarios, gathering feedback, and making necessary adjustments to improve functionality and user experience.

Step 1: Ideation and Design

The initial phase involved outlining the key features and capabilities desired in the project. This conceptual framework served as a blueprint for the subsequent steps.

Step 2: Gathering Hardware Components

Based on the design, all necessary hardware components required to build the drone such as Frame, 4 motors, 4 ESCs, APM 2.8 flight controller, Ultrasonic sensor, Camera, Battery, Raspberry pi 4 and other electronic parts were procured.

Step 3: Prototyping

In our project the raspberry made the main role. At the startup we create a private WIFI network with a DHCP server (Dynamic Host Configuration Protocol) (to give IP address), this WIFI network has no internet access and this only to communicate with the smartphone.

Step 4: Creating the Application

The application is made in html/CSS/JavaScript with Cordova. Cordova is a technology who permit to create an application with web technology compatible with android, iOS. The user think it is a standard android app but in fact this is a web view.

Step 5: Assembling the quadcopter

First, we connect the 4 motors to ESCs and then connect the ESCs to APM 2.8 Flight Controller. Raspberry pi and APM 2.8 Flight Controller are connected. All these components are then placed on the frame.

Step 6: Software Integration

We compile APM 2.8 Flight Controller firmware into the board. Configure raspberry pi for the drone. Python quadcopter programming and OpenCV is done on Raspberry pi for image recognition and object tracking in the Pi camera.

Step 7: Testing the Hardware Assembly

The prototype was then subjected to a series of tests to ensure that all the components and the image detection were functioning correctly.

Step 9: Refining the drone so that it can follow humans

At last, we had to make the drone follow human, to achieve this we have to integrate face following algorithm.

CHAPTER 7

SYSTEM TESTING

System testing of a human detection and following drone is a critical phase in ensuring its reliability, accuracy, and safety in real-world scenarios. This phase involves evaluating the integrated hardware and software components, as well as the overall performance of the autonomous system.

Firstly, functional testing verifies whether each component of the drone, including the Raspberry Pi, camera module, APM 2.8 flight controller, and sensors, operates as intended. This includes validating image processing algorithms for human detection, flight control algorithms for navigation and obstacle avoidance, and communication protocols between onboard and ground-based systems.

Next, performance testing assesses the drone's capabilities under various conditions, such as different lighting environments, weather conditions, and distances from the human subject. This involves measuring the accuracy and speed of human detection, the responsiveness of the drone to commands, and the stability of flight during following maneuvers.

Safety testing is paramount to identify and mitigate potential risks associated with autonomous flight. This includes testing emergency procedures, such as failsafe mechanisms for landing or returning to home in case of communication loss or battery depletion. Additionally, testing collision avoidance systems ensures that the drone can detect and react to obstacles in its path to prevent accidents.

Overall, systematic testing of the human detection and following drone validates its functionality, performance, and safety, instilling confidence in its ability to operate autonomously and reliably in real-world environments.

7.1 TYPES OF TESTING

Testing for a human detection and following drone involves various types of assessments to ensure its functionality, performance, and safety. Here are some key types of testing applicable to such a system:

- **Functional Testing:** This type of testing verifies whether each component of the drone, such as the Raspberry Pi, camera module, flight controller, and sensors, performs its intended functions correctly. It includes testing image processing algorithms for human detection, flight control algorithms for navigation, and communication protocols between onboard and ground-based systems.

- **Performance Testing:** Performance testing evaluates the capabilities of the drone under different conditions. It assesses factors such as the accuracy and speed of human detection, the responsiveness of the drone to commands, and the stability of flight during following maneuvers. Performance testing also measures battery life and operational range.
- **Integration Testing:** Integration testing checks how different components of the drone work together as a unified system. It ensures that data flows correctly between modules and that interfaces are functioning as expected. Integration testing is crucial for detecting and resolving compatibility issues between hardware and software components.
- **Safety Testing:** Safety testing assesses the drone's ability to operate without posing risks to people, property, or itself. It includes testing emergency procedures, such as failsafe mechanisms for landing or returning to home in case of communication loss or battery depletion. Safety testing also evaluates collision avoidance systems to prevent accidents.
- **Environmental Testing:** Environmental testing assesses how the drone performs in different environmental conditions, such as varying light levels, weather conditions (e.g., wind, rain), and terrain types. It ensures that the drone can operate reliably in real-world scenarios.
- **Usability Testing:** Usability testing evaluates how easy and intuitive it is to operate the drone, both manually and autonomously. It assesses factors such as user interfaces, control mechanisms, and the clarity of feedback provided to the operator.

7.2 TEST CASES

Test cases for a human-following drone include scenarios to evaluate its performance in various conditions. These may involve testing the drone's ability to detect and track humans accurately in different lighting conditions, crowded environments, and varying speeds of the target. Other test cases may assess the drone's responsiveness to changes in terrain, obstacles, and unexpected movements of the human subject, ensuring reliable and safe operation in real-world scenarios.

Table 7.1: Test Cases

Test Cases	Test Case Description	Test Steps	Expected Result	Pass/Fail Criteria
01	Basic Functionality Test	Power on the drone, ensure all components are operational	All components power up and initialize correctly	All systems show green status on ground control software
02	Human Detection Accuracy	Place a human subject in the drone's camera view	Drone correctly identifies and marks the human subject in the camera feed	Human detection accuracy of >90% in varied lighting conditions
03	Human Following Response	Move the human subject within the drone's operating range	Drone follows the human subject smoothly and maintains a safe distance	Drone consistently follows human without lag or losing track, maintaining 1-2 meters distance
04	Obstacle Avoidance	Introduce static and moving obstacles while the drone is following a human	Drone detects and avoids obstacles while continuing to follow the human	No collisions occur, and the drone adjusts its path to avoid obstacles
05	Low Light Detection	Conduct human detection in low light conditions	Drone successfully detects the human subject in low light	Human is detected in lighting conditions as low as 10 lux
06	Battery Life Performance	Operate the drone continuously in a follow mode	Measure duration the drone can operate before battery depletion	Drone operates for at least 20 minutes in continuous follow mode

07	Communication Loss Fail-Safe	Simulate communication loss between the drone and the ground control station	Drone initiates fail-safe procedure (e.g., return to home or safe landing)	Drone safely lands or returns home without manual intervention

CHAPTER 8

CONCLUSION AND FUTURE ENHANCEMENT

8.1 CONCLUSION

In conclusion, the development of a human detection and following drone represents a significant advancement in autonomous aerial systems, offering innovative solutions for various applications. By leveraging technologies such as computer vision, machine learning, and precise flight control, these drones have the potential to revolutionize industries ranging from search and rescue to security and surveillance, as well as personal photography and videography.

The successful implementation of such a drone requires rigorous testing, ensuring functionality, performance, and safety in real-world scenarios. Functional testing validates the operation of individual components, while performance testing assesses the drone's accuracy, responsiveness, and stability. Integration testing ensures seamless communication between hardware and software, while safety testing addresses potential risks and emergency procedures. Environmental testing validates the drone's ability to operate in diverse conditions, and usability testing evaluates the user experience.

Overall, the human detection and following drone holds immense promise for enhancing efficiency, safety, and convenience across various domains. As technology continues to advance and regulatory frameworks evolve, these drones are poised to become invaluable tools, contributing to the advancement of society and the expansion of possibilities in aerial robotics.

8.2 FUTURE ENHANCEMENT

Future enhancements of human detection and following drones are poised to revolutionize aerial surveillance, search and rescue operations, and various other applications. Here are some potential advancements:

- **Enhanced Sensing Technologies:** Integration of advanced sensors such as multispectral cameras, LiDAR, and RADAR can improve the drone's ability to detect humans in various environmental conditions, including low visibility scenarios such as fog or smoke.

- **Artificial Intelligence and Machine Learning:** Utilizing AI and ML algorithms can enhance the drone's capability to recognize human behavior patterns, gestures, and postures. This enables more intelligent decision-making in tracking and following individuals while reducing false positives.
- **Multi-Modal Tracking:** Implementing multi-modal tracking techniques combining visual, thermal, and acoustic sensors can improve tracking accuracy and robustness, especially in challenging environments with obstacles or occlusions.
- **Real-Time Data Fusion:** Integrating real-time data fusion techniques enables the drone to combine information from multiple sources, including onboard sensors, GPS, and external data feeds, to create a comprehensive situational awareness and make informed decisions autonomously.
- **Collaborative Swarm Operations:** Future drones may operate collaboratively in swarms, sharing information and coordinating actions to track and follow multiple targets simultaneously over a wide area. This enables more efficient surveillance and search operations.
- **Adaptive Navigation and Obstacle Avoidance:** Implementing adaptive navigation algorithms allows drones to dynamically adjust their flight paths based on detected obstacles and environmental changes, ensuring safe and reliable operation in complex environments.
- **Longer Endurance and Extended Range:** Advancements in battery technology and energy-efficient designs can increase the drone's endurance and operational range, enabling it to cover larger areas and conduct prolonged surveillance missions.

These enhancements promise to enhance the capabilities and versatility of human detection and following drones, making them more effective tools for various applications while addressing privacy and safety concerns. Continued research and development in these areas are crucial for unlocking the full potential of autonomous aerial systems in the future.

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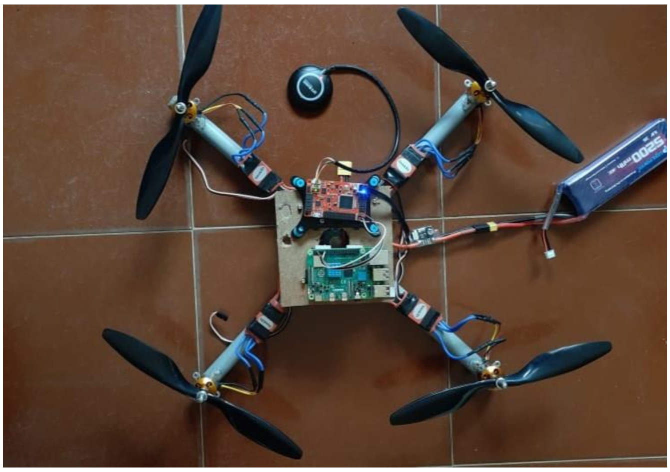
APPENDIX A

Snapshots



A1: Drone

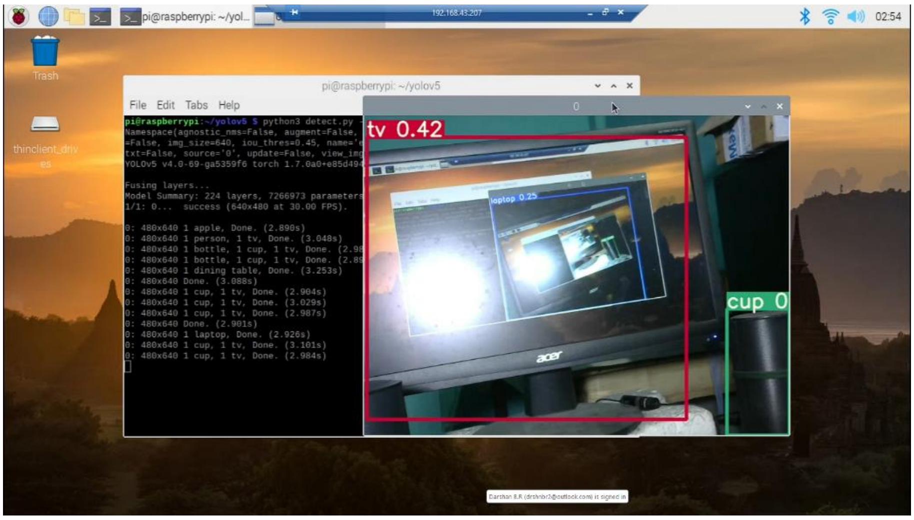
The above figure shows the structure of drone with all the necessary hardware components along with Raspberry Pi 4 and APM 2.8.

A2: APM Firmware

The firmware is the code that runs on the board. There are many different firmware bases to choose from. Depending on what code you load, you can use the APM to control fixed wing aircraft, multi rotors, helicopters and also rovers.

A3: Mission Planner Software

APM software is the program that runs on your PC, it is used to load the firmware, and change the settings on your APM board. You can also use this software to plan missions and monitor your drone on the map.



A4: YOLO running on RPi

YOLO (You Only Look Once), a real-time object detection system, can run on a Raspberry Pi by utilizing optimized versions like Tiny YOLO for reduced computational load. This setup enables efficient, low-power image recognition for applications such as security cameras and home automation.

A5: Drone Flight

The human detection interface in a Raspberry Pi drone utilizes advanced computer vision algorithms to analyze real-time video feeds, enabling accurate identification and tracking of human subjects. This interface processes image data directly on the Raspberry Pi, facilitating quick and autonomous responses to detected individuals.

A6: Human Detection

The first drone flight of the project successfully demonstrated the integration of Raspberry Pi and APM 2.8, showcasing the drone's capability to autonomously detect and follow a human subject with precision. This initial test validated the hardware and software configurations, paving the way for further enhancements and more complex operational scenarios.