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Stable Flight Technology for Spying, Disaster Management, Flower Dropping, Flag Carrying

Saptarshi Mondal[1], Anindita Sarkar[2]

[1]*Electronics and Communication Engineering, JIS College of Engineering*
[2]*Electronics and Communication Engineering, JIS College of Engineering*

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Abstract - This project explores the integration of drone technology for efficient data collection, offering innovative solutions across various domains. By combining advanced sensors and imaging capabilities, methods have been developed to capture critical environmental data with high accuracy. To reduce costs, a custom telemetry system was designed, offering a cost-effective alternative to commercial options. This system enables seamless communication and autonomous control of the drone, allowing it to operate independently without human intervention. Additionally, the drone is equipped with an advanced GPS system that ensures stability and precise navigation in terms of altitude, latitude, and longitude, enhancing reliability during data collection missions. The system is designed to assign specific missions to the drone through the android application tailored for the drone, enabling it to autonomously complete tasks and return to its designated launch zone. Furthermore, the drones are capable of performing many functions, including flower dropping, flag raising, and flag flying, thereby broadening their range of applications. Overall, this project represents a significant advancement in Unmanned Aerial Vehicle (UAV), offering comprehensive solutions for environmental monitoring and extending its usability across various fields.

Key Words**:** Drone technology, Imaging Systems, Custom Telemetry System, GPS System, Unmanned Aerial Vehicle (UAV)

1.INTRODUCTION

The rapid advancement of drone technology has opened new evaluation in various industries, offering and promising opportunities for innovation and growth. However, despite their potential, drones face significant challenges, particularly in achieving stable in-flight performance and reducing the manual control. Traditional drones often struggle with maintaining consistent speeds in adverse weather conditions, which can compromise data quality and pose safety risks. Additionally, the dependency on human-operated controls limits their effectiveness, especially in critical situations such as disaster response, where real-time monitoring and intervention are essential. This project seeks to address these challenges by harnessing drone technology to revolutionize environmental data collection and monitoring. By integrating advanced sensors, custom telemetry systems, and GPS technology, the drones developed in this project are capable of precise and autonomous flight. This enables the efficient and accurate collection of vital environmental data, which is crucial for scientific research, conservation efforts, and disaster management.

The project extends the capabilities of traditional drones by adding various features, such as flower dropping and flag raising, demonstrating the adaptability and utility of these drones across various fields. The introduction of autonomous processing capabilities further enhances the drones' ability to navigate challenging environments, such as remote or hazardous areas, without human intervention. This autonomy not only improves data collection accuracy but also supports effective disaster management and environmental protection efforts.

Overall, this project represents a significant movement in drone technology, offering comprehensive solutions for environmental monitoring, disaster response, and beyond. By overcoming challenges and expanding the usability of drones, this work aims to transform practices in environmental protection and disaster management, ultimately contributing to the preservation of ecosystems and the safety of human lives.

2.SURVEY ON RECENT INVESTIGATIONS

I. Background

F.A.A's Aerospace Report of 2017 reveals forecasts for the future growth potential of the drone market for both model (hobby/recreational) and non-model (commercial) users [2]. As of December 2016, there were 626,000 hobbyists registered, and an estimation of around 1.1 million drones that belong to those hobbyists. FAA forecasts a total hobbyist fleet of 3.55 million drones by 2021 in a base scenario, and 4.47 million drones in a best-case scenario. On the other hand, FAA forecasts 422,000.

II. Methodology

It is often central to refer back (or forward) to vague sections. Such locations are made by designating the slice number, for case, "In Sec. 2 we exposed…" or "Section 2.1 contained a portrayal…." If the word Segment, Reference, Equation, or Figure starts a judgment, it is implied out. When occurring in the intermediate of a sentence, these disputes are abbreviated Sec., Ref., Eq., and Fig.

At the first manifestation of an contraction, spell it out followed by the acronym in additions, e.g., charge-coupled diode (CCD).

III. Discussion and Implications

Drone technology is emerging rapidly, and its applications are advancing beyond public knowledge. There are vast numbers of technical studies that emphasize improvements on the specifications of drones such as payload capacity, flight time, collision avoidance, and signal range, etc., and capabilities such as communication of swarms of drones, artificial intelligence, and virtual reality enrichments. However, an adequate understanding of policy, environmental, ethical, and societal.

IV. Civil Applications

Unmanned aerial vehicles can be practiced in various civilian uses due to their low preservation cost, deployment efficiency, high mobility, and ability to hover (Kardasz et al. 2016). Several civil applications are listed here and summarized in Fig. 5.

• **Disaster management:** assessing the damage, locating victims, care of public safety, search and rescue actions and delivering aids (Hayat et al. 2016).

• **Construction and infrastructure inspection:** creating accurate 2D and 3D data, maps, and models, conducting surveys before, during and after construction, monitoring gas, oil and water pipelines (Greenwood et al. 2019).

• **Agriculture and remote sensing:** planting crops, disease finding, monitoring, irrigation, water quantity nursing, yield approximations, deficiency monitoring (Norasma et al. 2019).

• **Healthcare:** delivering medical services in remote areas (Wulfovich et al. 2018).

• **Waste management:** identifying garbage sites (Leizer 2018).

• **Utility inspecting:** telecommunication towers, tracking oil spills (Johnsen et al. 2020).

• **Urban planning:** providing instant mapping and ready to use data for planning (Noor et al. 2018).

• **Wildlife conservation:** monitoring the number of animals, species, collecting samples for conservationists to track porches (Ivosevic et al. 2015).

• **Geographic mapping:** acquiring high-resolution data, downloading imagery in challenging to reach locations like coastlines (Yavaşlı 2020).

• **Weather forecasting:** accessing weather trends to understand imminent dangers (Balaji et al. 2018).

• **Mining:** measuring minerals, surveying operations (Park and Choi 2020).

• **Law enforcement:** monitoring large crowds, tracking illegal activities (Stelmack 2015).

• **Real-time monitoring of road traffic flow:** field provision sides, rescue teams, traffic police, road inspectors, hovering roadside unit and hovering dynamic traffic signals (Elloumi et al. 2018).

• **Commercial photography:** images and videos are both popular outcomes from commercial drone jobs. These could be for wedding and commercial photography/videography, real estate marketing photography, or even filming with big-budget motion pictures.

Unmanned Aerial vehicles are declared to be highly propitious in places where a person cannot move or is incapable of performing in an exceedingly reasonable and sufficient practice. Improving work performance and potency, minimizing workload and merchandise cost, refining service, and customer relations, increasing precision, and fixing security problems on a broad scale are the first UAV uses that give industry globally. The rapid mobility of UAVs, frequent packet losses and weak connectivity between UAVs are addressed to affect data delivery reliability (Oubbati et al. 2019). The drones maintain the flexibility to achieve significant isolated areas with little to no human resources required and wish the smallest amount of energy, effort, and time. It is one of the most important goals of being embraced worldwide, especially by these four sectors: disaster management, precision agriculture, construction and infrastructure inspection and healthcare, as shown in Fig. 6. A detailed description of the four sectors is presented below.

A. Disaster Management

A disaster is an event caused by a natural or man-made hazard that occurs over a short or extended period. It results in significant physical harm or destruction, as well as mortality or a big alteration in the environment. The disaster management team supports search and rescue operations, such as public safety, locating victims, assessing damage, and delivering aids (Oubbati et al. 2020). Drones can step in for relief workers and manned vehicles in situations when they are needed. Drones can be easily used to access hard to reach areas. Drones are used to enable communication coverage during natural or man-made disasters such as floods or terrorist attacks, as well as essential infrastructure like water and electrical utilities (Tanzi et al. 2016). Drones provide timely disaster warnings as well as assistance in restoring public communication networks that have been interrupted. It can also supply medical aids to classified inaccessible areas and search missing persons/animals in disastrous situations like poisonous gas leakage, forest fires, and avalanches (Restas 2015). These are the main areas where drones help to improve search and rescue missions.

- Use of mapping and imaging technology to provide quick situational awareness.
- Help rescuers locate hot spots and examine property damage.
- Capture imagery for communications and news coverage.
- Search for survivors.
- Assess utility and infrastructure damage.
- Create before/after maps of the affected region (Erdelj and Natalizio 2016).
- Unmanned aerial vehicles have been applied in a wide variety of disaster management applications, but the following are the most common (Chowdhury et al. 2017):
- Pre-disaster planning refers to incidents linked to surveying that occur prior to the calamity.
- Evaluation of disasters: provide real time situational awareness of the event and complete logistic damage studies.
- Disaster response and recovery: Search and Rescue (SAR) missions, building the communications backbone, and insurance-related field surveys are just a few examples.

B. Agriculture

The rapid improvement and growth of UAVs as a remote sensing platform, as well as advances in device downsizing and data systems, have resulted in increased adoption of this technology in metropolitan areas and remote sensing social networks. Drones can be used to collect data from ground sensors and distribute it to ground base stations. Drones with sensors can be used to create an aerial sensor network for disaster management and environmental monitoring (Tsouros et al. 2019). Drones, remote sensing applications from tree species, water quality monitoring, disease detection, crop monitoring, yield predictions, and drought monitoring are just a few of the data sources. Some of the applications of drones in agriculture are:

- Crop monitoring: The crop fields are vast and challenging to monitor volatile weather conditions, increasing the field risk and labour costs. Unmanned aerial vehicles equipped with RGB or multispectral cameras help to eliminate these challenges (Hassan-Esfahani et al. 2015).
- Precision agriculture: Vegetation that focuses on crop diseases, nutrient deficiencies, and pest infestation reduces productivity. Crop data is collected by UAVs and processed with AI techniques to address these challenges (Radoglou-Grammatikis et al. 2020).
- Irrigation management: UAVs assist in obtaining critical irrigation data at any time and at a low cost (Kim et al. 2019).
- Aerial mustering: Aerial stock mustering occurs when a UAV is used to locate, direct, and concentrate livestock while flying below 500 ft above ground level. It is utilised to supplement the employment of horses and motorcycles in traditional mustering tactics (Katke 2019). Mustering operations are defined as activities linked to the aerial monitoring and control of livestock that is handled by helicopter and fixed-wing aircraft and include: animal culling, aerial stock mustering and aerial stock spotting (Barbedo et al. 2020).
- Artificial pollination: The decrease in the honeybee population has gained immense concern worldwide. Hence, UAVs act as pollinators to transport pollen from flowers using hair coated with gel (Potts et al. 2018).

C. Construction and Infrastructure Inspection

Unmanned aerial vehicles used in real-time monitoring development project sites and examining high voltage of power synchronized lines. Drones are used to recognize the buildings near the power lines and the location of trees (McCabe et al. 2017). Small UAVs are deployed, observe the facilities, infrastructure, including water, gas, oil pipelines. The gas controller unit is deployed in UAVs to identify gas, air leaks and content. Drone inspection applications throughout the construction cycle (Anwar et al. 2018) are mentioned below:

- Monitoring project progress: Project maps are built using drone data for regular monitoring and planning, avoiding delays and additional expenses. Progress monitoring helps the projects to move according to their plan with no deviations. Construction/deconstruction sequences, crane positions, perimeter security, and many other aspects are evident due to UAV-based progress monitoring (Shahmoradi et al. 2020).
- Construction site mapping: The creation of drone maps has become more straightforward, inexpensive and results in less intense civil engineering work than older methods. Drones may now easily access any location using topographic surveys to create visual representations for evacuations, stockpile measurements, and correct transport prices. For real-time computer mapping of information, Pix 4D software is used (Getsov et al. 2017).
- Volumetric measurement: To keep records of the onsite raw materials used during construction to improve efficiency and reduce stock waste. In stockpiles volume estimates, 99% accuracy is achieved by incorporating state-of-the-art technology, such as machine learning. Volumetric measurements are high speed, precise, and cost-effective using Equinox drones (Fan and Saadeghvaziri 2019).

• Building surveillance: Inspections of buildings can be dangerous and challenging for humans to carry out independently. Building UAV surveillance helps lower personal safety risks and boosts productivity by recording vast and essential data. Drone surveillance or aerial surveillance helps in finding potentially risky scenarios for better decisions more efficiently. Drones equipped with thermal sensors are popular amongst building surveillance projects to evaluate roofs for faults without going there.

Health care

Drones have the potential to collect real-time data and deliver payloads at a low cost, and they have sped up the development of various industrial, commercial, and recreational applications. Telecommunication drones are used for diagnosis and treatment, perioperative evaluation, and telemetering in remote locations (Rosser Junior et al. 2018). Microbiological and laboratory samples, drugs, vaccines, emergency medical supplies, and patient transportation can all be delivered using drones. Drones have a variety of practical applications that have much potential and are listed below:

• Emergency supplies or medications on board: EpiPens, poison antidotes, and oxygen masks are just a few types of life-saving kit (Thiels et al. 2015).

• Blood and tissue sample collection: Drones may be able to provide goods and services while also allowing for speedier return transit to labs that are adequately prepared, eliminating human work and time (Konert et al. 2019).

• Accessibility to far-flung patients: People are typically found in situations where the infrastructure for efficient emergency or continuity of care is lacking. Drones are being used to provide telemedicine, vaccinations, prescription drugs, and medical supplies to people at home.

• Integration of cloud and internet of things (IoT): It presents a cost-effective way to connect heterogeneous devices and address rising data demands in healthcare applications, including seamless application deployment and rendering service (Malleswari and Vadivu 2019).

3. PROPOSED SYSTEM

A. Physical Structure of Proposed System

Fig 1: Top view of Drone

Fig 2: Front view of Drone

B. Hardware Components

I. F450 Quadcopter frame:

The F450 Quadcopter Frame features a robust design with a wheelbase of 450mm, combining high-quality Glass Fiber with ultra-durable Polyamide-Nylon to ensure toughness and durability. The frame is designed for a 450mm motor-to-motor distance, which is considered a medium size for quadcopters, providing stability and versatility. The arms, measuring 220mm in length and 40mm in width, are molded with enhanced thickness, providing added strength. The motor mounting holes on the arms have a diameter of 3mm, while the frame’s arm mounting holes also measure 3mm, and the arm's own mounting holes are 2mm in diameter.

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Fig 3: F450 Quadcopter Frame

II. DJI 2212 920KV Brushless Motor:

The 2212 model brushless motors, essential for drone operation, utilize electromagnetism and a sophisticated control system to deliver efficient performance. The motor is composed of two main components: the stator, which contains electromagnetic coils, and the rotor, which includes permanent magnets. This motor operates at 920 KV (RPM/V) and can generate a maximum thrust of 500 grams. It is compatible with 3S to 4S LiPo batteries and requires a 30A ESC for optimal performance. The motor is designed with a 6mm shaft diameter and is rated for voltages between 7V and 12V. The compact motor measures 28mm in both length and width, with a height of 46mm, and weighs 60 grams.

Fig 4: DJI 2212 920KV Brushless Motor

III. Favourite LittleBee BLHeli-S Spring 30A OPTO ESC:

Electronic Speed Controllers (ESCs) are essential devices that enable drone flight controllers to regulate and adjust the speed of the drone's electric motors. By receiving signals from the flight controller, the ESC modulates the voltage supplied to the motor, thereby controlling the speed of the propeller. These ESCs are lightweight and powered by a SILABS EFM8BB21F16 MCU running at 48MHz, featuring a dedicated driver chip for precise control. They are compatible with 6V to 25.2V batteries (2-6S LiPo) and are built on a robust 4-layer PCB with 3 oz copper for enhanced durability. The motor wires measure 70mm and are 20AWG, while the signal wires are 120mm long. The ESCs come with BLHeli_S firmware, supporting Oneshot/Oneshot42, Multishot, and Active Braking in dampened light mode, offering advanced and responsive motor control for various drone applications.

Fig 5: Favourite LittleBee BLHeli-S Spring 30A OPTO ESC

IV. APM 2.8 Flight Controller:

The APM 2.8 Multirotor Flight Controller is a highly acclaimed open-source autopilot system, renowned for its success in the Outback Challenge UAV competition. This versatile flight controller is designed to convert any fixed or rotary wing aircraft into a fully autonomous flying machine. It features ports for MUX (UART0, UART2) and operates within an input voltage range of 12 to 16 VDC. The APM 2.8 is equipped with a 3-Axis Gyroscope, Accelerometer, and a high-performance Barometer for precise flight control. Its processing power comes from the ATMEGA2560 and ATMEGA32U-2 microcontrollers. The flight controller measures 70mm in length, 45mm in width, and 15mm in height, with a total weight of 82 grams. This compact yet powerful controller offers advanced functionality and reliability for various multirotor applications.

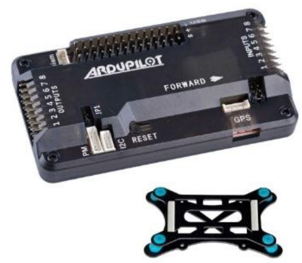

Fig 6: APM 2.8 Flight Controller

V. M8N GPS Module:

The GPS navigation and positioning system provides essential information for autonomous flight and precise route-following, utilizing the Ublox M8 engine. It features a 72-channel receiver type and is powered by the Ublox NEO-M8N main chip. With an input supply voltage range of 0.5 to 3.6 VDC, this system offers superior sensitivity with tracking and navigation accuracy of -161 dBm. The position accuracy is within 2 to 2.5 meters, and it supports a navigation update rate of up to 18 Hz. The system operates efficiently within a temperature range of -45°C to 105°C. It has a rapid boot time of 1 second, with an average cold start time of 30 seconds and a warm start time of 1 second. The GPS system supports a maximum altitude of 18,000 meters and weighs just 23 grams, making it a compact and reliable choice for precise drone navigation and positioning.

Fig 7: M8N GPS Module

VI. HC12 Transceiver Module x 2 (Telemetry Data Link):

The telemetry system provides crucial data from the drone to the controller or device, including speed, altitude, battery level, GPS position, and more. This information helps optimize flight performance and safety. The telemetry system operates with a voltage range of 3.2 to 5.5V and offers a maximum transmission power of 20dBm. It operates within the frequency band of 433.4 to 473.0 MHz and has a reference distance of up to 1000 meters. The system features a spring antenna or antenna socket for connectivity. It can function in varying humidity levels from 10% to 90% and withstand temperatures ranging from -25°C to +75°C.

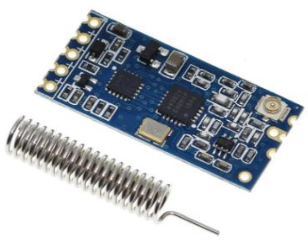

Fig 8: HC12 Transceiver Module x 2 (Telemetry Data Link)

VII. Flysky FSI6 Proportional Radio Control System:

The drone transmitter, also known as the remote control or controller, is essential for piloting and navigating the drone. It operates with 6 channels and communicates wirelessly over a frequency range of 2.4055 to 2.475 GHz. The controller has a bandwidth of 500 kHz and operates within the 140-band RF power range, below 20 dBm. It utilizes the 2.4G system with AFHDS 2A and AFHDS 2B protocols for enhanced communication reliability. The transmitter's sensitivity is set at 1024, and it features a PS2 DSC port. It offers various output options, including PWM, PPM, and I-BUS. The dual antenna setup includes antennas of 26mm length each. The controller weighs 392 grams and features a type positive transflective STN display with a 128x64 dot matrix, providing clear and effective visual feedback for the pilot.

Fig 9: Flysky FSI6 Proportional Radio Control System

VIII. FPV Camera 1200TVL:

The FPV (first-person view) camera provides a real-time visual feed for remotely controlled operations, making it ideal for use in security, defense, and various other applications. It features a 1/3 CMOS SUPER HAD II image sensor, delivering a high horizontal resolution of 1200 TVL. The camera performs well in low-light conditions with a minimum illumination of 0.01 Lux/1.2 F. It includes Automatic Gain Control (AGC) and Backlight Compensation for improved image clarity. With a signal-to-noise ratio (S/N Ratio) greater than 60 dB, it ensures clear and detailed images. The camera operates within a temperature range of -10°C to 50°C and has compact dimensions of 26mm x 26mm x 30mm, weighing only 15 grams. This makes it a lightweight and effective choice for a wide range of FPV applications.

Fig 10: FPV Camera 1200TVL

IX. Analog Video Transmitter – VTX:

The transmitter and receiver system facilitates the broadcasting and reception of audio and video signals. The

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transmitter broadcasts signals from a connected audio-video device, while the receiver outputs these signals to a connected television. It also includes a remote-control relay for operating equipment via infrared remote controls. The system features a male RP-SMA antenna type and operates within a frequency range of 5.6 to 5.9 GHz with 48 channels. The audio bandwidth is 6.5 MHz, while the video bandwidth is 8 MHz. It supports video formats NTSC and PAL. The rated power of the transmitter is 600 mW, and it operates with a current of 0.22 A. The system functions within an operating temperature range of -10°C to 85°C and can handle a voltage range of 7 to 24V. The compact dimensions of the unit are 54mm in length, 32mm in width, and 10mm in height.

Fig 11: Analog Video Transmitter - VTX

X. Analog Video Receiver – VRX:

The ROTG01 (UVC OTG FPV Receiver) is designed for use in UAVs to receive and process video signals for display on monitors or projectors. It features 150 channels and operates within an RF range of 5645 to 5945 GHz, with a receiver sensitivity of -90 dBm. The receiver requires a 5 VDC operating voltage and has a current consumption of 200 mA. It functions within an operating temperature range of -10°C to 60°C. The device connects to antennas via an SMA female connector and supports antenna lengths up to 110 mm. It is compatible with NTSC and PAL video formats. The receiver is housed in a compact, white enclosure, with dimensions of 61mm x 33mm x 0.9mm and a net weight of 28 grams.

Fig 12: Analog Video Receiver – VRX

XI. Orange Lipo Batter 5200mAh 3S 40C:

The lithium polymer (LiPo) battery is a high-performance rechargeable battery known for its high energy density, making it an ideal choice for powering drones and UAVs. It features a weight of 360 grams and provides an output voltage of 11.1 VDC. The battery supports a charge rate ranging from 1 to 3 C and comes equipped with an XT-60 discharge plug and a JST-XH balance plug. Its dimensions are 134mm in length, 40mm in width, and 27mm in height. The battery offers a maximum burst discharge rate of 80C (416.0A) and a maximum continuous discharge rate of 40C (208.0A), with a maximum charge rate of 5 C.

Fig 13: Orange Lipo Batter 5200mAh 3S 40C

XII. SKYRC IMAX B6 MINI Professional Balance Charger:

A balancing charger is crucial for ensuring that all cells in a LiPo battery are charged evenly, preventing any differences in voltage and avoiding the risks associated with overcharging. It operates with an input voltage of DC 11-18V and provides a maximum charging power of 60W. The charger supports a charge current range of 0.1-6.0A and a discharge current range of 0.1-2.0A, with a maximum discharge power of 5W. It is compatible with various battery types, including 1-6S LiPo, LiFe, and Li-Ion cells, as well as 1-15S NiMH/NiCd cells and Pb batteries with a voltage range of 2-20V. The charger is compact, with dimensions of 84mm in length, 102mm in width, and 29mm in height, and it weighs just 233g.

Fig 14: SKYRC IMAX B6 MINI Professional Balance Charger

XIII. 12V 5A SMPS:

A switched-mode power supply, often referred to as a switcher, is an electronic power supply that efficiently converts electrical power by incorporating a switching regulator. This power supply operates with an input voltage of AC 100-264V at 50/60Hz and delivers an output voltage of 12V DC with a current of 5A, providing a total power of

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60W. The output voltage can be adjusted within a ±20% range. It is equipped with several protections, including overload, over-voltage, and short circuit, with auto-recovery features after protection events. The power supply supports universal AC input across a full range and is designed with a built-in EMI filter to improve signal precision. Its compact size, light weight, high efficiency, and reliability make it ideal for various applications. The power supply is housed in a metal case with an aluminum base, and its dimensions are 165mm x 98mm x 42mm (6.50 x 3.85 x 1.57 inches).

Fig 15: 12V 5A SMPS

4. FLOWCHART

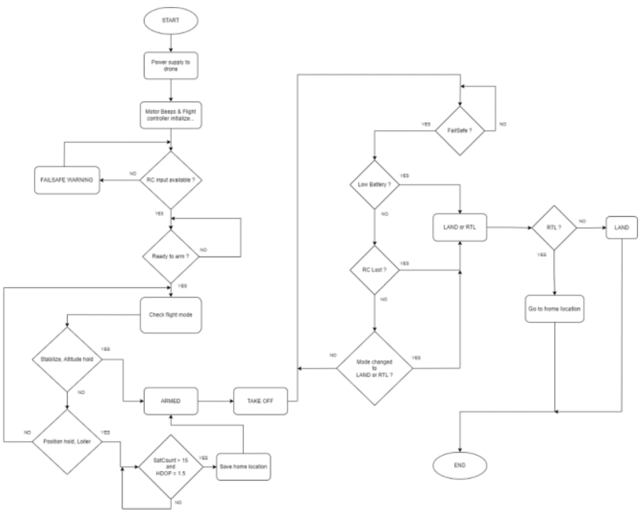

Fig 16: Multipurpose Autonomous Aerial Navigator

5. EXPERIMENTAL RESULT

I. Mission Planning:

What is mission planning: Mission planning refers to the process of creating a sequence of waypoints and commands for an unmanned vehicle, such as a drone or rover, to follow autonomously. ArduPilot is an open-source autopilot software suite that provides navigation, guidance, and control capabilities for autonomous vehicles. In mission planning, users typically use ground control station (GCS) software, such as Mission Planner or Tower, to define a mission. A mission consists of a series of waypoints, which are specific geographic coordinates that the vehicle should navigate to, as well as other commands such as loitering at a specific location, changing altitude, or triggering payload actions like taking a photo or dropping a payload. The mission planning process usually involves the following steps:

A. Waypoint Selection: Users select the waypoints on a map interface provided by the GCS. They can specify the latitude, longitude, and altitude of each waypoint.

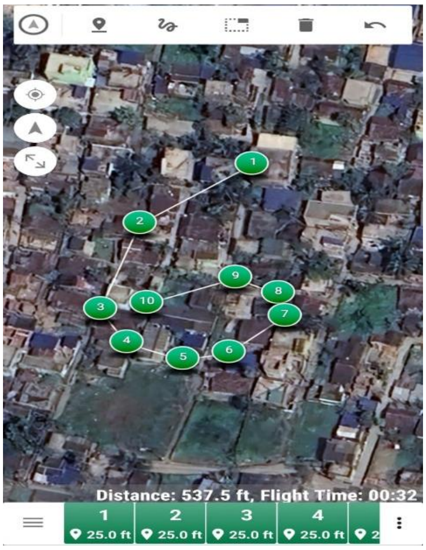

Fig 17: Waypoint Selection on map

B. Mission Upload: Once the mission is planned, it is uploaded to the autopilot system onboard the vehicle. The autopilot then executes the mission autonomously, following the predefined waypoints and commands.

C. Mission Commands: Users can insert various mission commands between waypoints to control the vehicle's behavior. These commands may include changing flight altitude, adjusting speed, triggering actions, or waiting at a waypoint for a specific duration.

D. Mission Monitoring: During the mission execution, users can monitor the vehicle's progress and adjust if necessary, using the GCS interface. Mission planning in ArduPilot allows for a wide range of autonomous missions, from simple point-to-point navigation to complex surveying, mapping, and surveillance tasks. It enables efficient and precise operation of unmanned vehicles for various applications, including agriculture, aerial photography, search and rescue, and environmental monitoring.

II. Advanced Mission Planning:

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Geo-Fencing in Mission Planner: Sets virtual boundaries for drones to operate safely within defined geographical limits.

Defining Boundaries: Users draw polygonal shapes or specify circular boundaries on a map, including horizontal and altitude limits.

Activation: After setting boundaries, the geo-fence is activated, prompting the autopilot to enforce these restrictions during flight.

Enforcement: The autopilot monitors the drone's position via GPS, triggering responses like slowing down or returning if boundaries are crossed.

Alerts: Real-time notifications are provided when boundaries are approached or violated.

Purpose: Enhances safety, compliance, and control, preventing unauthorized access and accidents in sensitive or restricted areas.

III. Altitude Fencing:

Altitude fencing in Mission Planner is a feature that allows users to set altitude limits for unmanned vehicles, such as drones, during flight operations. Like geo-fencing, altitude fencing adds an additional layer of safety by restricting the vehicle's altitude within predefined limits.

A. Setting Altitude Limits: Users specify minimum and maximum altitude limits within which the vehicle is allowed to operate. These limits can be defined based on regulatory requirements, safety considerations, or operational needs.

B. Activation: Once the altitude limits are configured, users activate the altitude fencing feature in Mission Planner. This tells the autopilot system to enforce the specified altitude restrictions during flight. Monitoring during Flight: As the vehicle flies its mission, the autopilot continuously monitors its altitude using onboard sensors such as barometers or GPS.

C. Response to Violations: When a violation occurs, the autopilot may take various actions depending on the configuration and settings. It could initiate a corrective maneuver to bring the vehicle back within the permitted altitude range, issue warnings to the operator, or trigger a failsafe mode to ensure the vehicle's safety.

D. Alerts and Notifications: Mission Planner may provide real-time alerts or notifications to the user when altitude limits are approached or violated. This allows operators to stay informed and take appropriate actions as needed.

Fig 18: Implementing Altitude fencing in ARDUPILOT

6. DRONE SURVEILLANCE: APPLICATIONS, TECHNOLOGY, AND CONSIDERATIONS

Overview: Drone surveillance involves using UAVs equipped with cameras and sensors to gather intelligence from the air, becoming increasingly vital across multiple sectors.

Security & Law Enforcement: Monitoring events, patrolling borders, and aiding search and rescue.

Military: Reconnaissance, intelligence gathering, and targeted strikes.

Infrastructure Inspection: Efficient inspection of power lines, pipelines, and bridges.

Agriculture: Crop monitoring, pesticide spraying, and soil assessment.

Technology:

Cameras: High-resolution, infrared, and thermal imaging.

Sensors: Detect radiation, chemical agents, and environmental data.

GPS & Navigation: Precise geolocation and navigation.

Communication Systems: Real-time data transmission to ground stations.

Autonomy: Predefined routes and tasks with minimal human intervention.

Privacy & Legal Considerations: Drones raise privacy and legal issues, with regulations varying by country, including restrictions on flight zones and data usage.

Ethical Implications: Concerns include potential abuse, civilian risks in military use, and impacts on privacy and civil liberties.

Future Trends: Advancements in autonomy, sensor technology, AI-driven data analysis, and endurance will shape the future of drone surveillance.

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Fig 19: Captured images from Drone

7. CONCLUSION

Unmanned aerial vehicles are now being built with highly versatile technology, continually developing creative ways to provide more outstanding service. This paper provides a detailed systematic literature analysis of the context classification, UAVs specification, and applications to the respective models. The study also presents various aspects of drones such as technological requirements, drone models, parts, possible payloads, and sensors. The use of UAVs is rapidly increasing in substantial civil application domains. Compared to other studies, this paper comprehensively analyses existing literature and UAV uses that accurately represented their civil applications while further analyzing the research trends, key challenges, and potential perspectives for each category. This analysis covers the different types of drone models currently being used, their configuration and applications, and the imminent technical enhancement of UAV technology. Unmanned aerial vehicles are widely employed in precision agriculture for crop management and tracking, weed detection, irrigation scheduling, disease detection, pesticide spraying, and field sensor data collection. Artificial intelligent pollinators are a wonder in precision agriculture. In the future, UAVs will play a vital role in precision agriculture by incorporating image processing techniques such as georeferencing, mosaicking, classification algorithms, and collecting high-resolution images. The key research challenges in precision agriculture raise the opportunities and further pave the way for researchers to develop future drone applications.

8. FUTURE SCOPE

Despite efforts to propose acceptable solutions to address the UAV challenges discussed in the previous section, a significant number of unsolved difficulties require new effective solutions. In this section, we highlight new opportunities for the UAV systems, including security and privacy, battery charging, machine learning, and other interesting future research topics and directions.

Swarm UAV Systems: In swarm UAV systems, a set of UAVs work together to achieve a specific goal. Each UAV has a small mission which is a part of a bigger mission; this concept was mainly developed by the military for reconnaissance and surveillance applications. Civilian applications also adopted the same concept for several applications, including precision agriculture and SAR operations.

Machine Learning and Deep Learning: Machine learning and deep learning algorithms have recently received a high level of support in different applications related to UAVs, such as resource allocation, obstacle avoidance, tracking, path planning, and battery scheduling. The development of more accurate algorithms and improvement of onboard computational power will lead to the design of nano UAVs that are much smaller, more lightweight, and smarter than available UAV models to achieve the required mission accurately and without the risk of collision. Furthermore, the availability of accurate data can facilitate UAVs to perform accurate control and path planning and vision tasks. Several applications of deep learning in UAVs were reviewed, such as feature extraction using UAVs. By implementing different cameras on the UAV, various types of images can be taken for further processing. UAV planning, including path motion, navigation, and manipulation planning were presented, as the UAV navigates the environment to find a suitable path. Another application is the motion control of UAVs based on deep learning.

Security and Privacy: The security and safety of UAVs are essential parameters due to their wireless connectivity and limited computational capabilities. They 68 receive potential threats from intruder attacks which can disrupt the privacy and confidentiality of the collected data. It might be stolen or replaced. Therefore, new onboard techniques are required to ensure privacy on the mission. Recent techniques, such as blockchain and physical layer security, require further research and improvement to achieve a required security level with the required quality and reliability.

Trajectory and Path Planning: Tracking and path planning techniques should be improved to optimize the mission path of UAVs while minimizing the energy consumption of flights with collision avoidance. Recent work on the topic of tracking is mainly based on heuristic algorithms, while path planning of complex paths to avoid obstacles and find the shortest path to consume low energy can be carried out by using a multi-objective optimization algorithm.

Energy Charging: Recent developments in battery technologies, including enhanced lithium–ion batteries and hydrogen fuel cells and green energy sources such as solar energy, have been used recently to extend flight times. However, energy collecting efficiency is low due to random energy arrivals. Novel energy-delivering technologies, such as energy 69 beamforming through multiantenna techniques and distributed multipoint WPT, can enhance the charging efficiency.

Optical Communication: Optical Wireless Communications (OWCs) have proved their efficiency in 4G, 5G, and beyond 5G mobile networks. They are widely adopted in UAV communication, and they are expected to be used in the 6G mobile network. However, several challenges facing this technology need to be addressed, including the high blockage probability of the signals, the power consumption, and weather conditions.

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BIOGRAPHIES

Saptarshi Mondal is currently pursuing a Bachelor of Technology in Electronics and Communication Engineering at JIS College of Engineering, where he has maintained an outstanding academic record. He is serving as a Project Staff at the School of Nano Science and Technology, IIT Kharagpur, contributing to the development of embedded systems for healthcare applications, including the SenFlexT COPD diagnostic device, an automated CPAP-BiPAP system and a Oral Cancer detection
With three published patents and several accolades in national and international competitions, his areas of interest include embedded systems, autonomous technologies, and innovative hardware solutions for real-world challenges.