Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, No.3, June : 2024

A STABLE FLIGHT INTELLIGENCE TECHNOLOGY OF MULTIPURPOSE AUTONOMOUS AERIAL NAVIGATOR FOR FLOWER SHOWERING / DISPLAYING FLAG & PROGRAMME BANNERS

Krishnendu Mondal, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Sneha Singh, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Heena Patel, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Akash Biswas, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Avirup Chakraborty, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Ishpita Roy, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Mr. Anirban Ghosal, Assistant, Professor, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Mr. Sumanta Chatterjee, Assistant, Professor, Department of Computer Science & Engineering, JIS College of Engineering, Kalyani, Nadia WB India.
Dr. Indranath Sarkar, Professor, Department of Electronics and Communication Engineering, JIS College of Engineering, Kalyani, Nadia WB India,

ABSTRACT
The rise of drone technologies has opened up promising opportunities for innovation and growth across various industries. However, significant challenges have hindered their full potential [1]. In our proposed methodology, we have designed a custom telemetry system, which provides a cost-effective alternative to commercial solutions [3]. Our methodology allows for seamless communication with drone, allowing it to fly autonomously without human intervention. The controller is programmed to interact with mobile using Android App where the flying route of a drone can be instructed. In this way, the flying route is entirely autonomous and no manual control is required to take off / land a drone. The controller is mapped in RTL mode; so that if signals are lost or battery is drained during flying time, the drone will immediately return to the take-off point to land safely. Additionally, our drone is equipped with an advanced GPS system [2], which provides stability with altitude, latitude and longitude accuracy. Furthermore, we have designed drone to perform multiple functions such as dropping flowers from air, carrying flag in air etc. Overall, our proposed system represents a major advance in drone technology, offering more stability, user friendly control and several autonomous works in a cost-effective way.

Keywords:
Flight controller, GPS module, telemetry, Tower application, GPS module.

I. Introduction:
The advent of drone technologies has opened up exciting possibilities for innovation and growth in numerous industries. However, inherent challenges have constrained the full potential of drones. One such challenge is the on-going issue of in-flight stability. Traditional drones often struggle to maintain stable speeds, especially in bad weather or turbulent environments, resulting in data a quality and safety risks come with it [7], and the reliance on remote controls for drone operations has proven to be very limiting. Human-controlled drones require constant monitoring and intervention, limiting their

effectiveness in situations where real-time monitoring and response are needed, especially for disaster operational scenarios in which the inability to autonomously fly drones to hazardous or remote areas further compounds the challenges faced by emergency responders and maintenance personnel [6]. To meet these challenges, our drone project seeks to transform the field by designing solutions that overcome stability issues, eliminate the need for remote manual operations. By combining advanced GPS technology, customized telemetry systems, and autonomous processing capabilities, our drones provide stability, navigation high accuracy, and the ability to conduct missions without human intervention. This autonomy allows drones to enter remote or dangerous areas, and collect real objects time data , giving us the ability to help support effective disaster management and environmental efforts by providing reliable and efficient solutions for data collection and management, our drone project goals is to enhance stability of drone in gusts of wind, reducing crash probability of drone by auto adjustment of air balance, automatic flying route without human interventions [10], automated several jobs like dropping flowers, flag raising and flag flying and safe automated landing of drone due to signal lost or battery drained out. In our proposed system, we combine advanced sensors, custom telemetry and GPS technology, enable precise and autonomous flight with versatile features including flower dropping and flag/banner carrying. Our design proves versatile and useful for a variety of applications. Overall, our work signifies a significant leap

Figure 1: Prototype of multipurpose drone with flower and flag box

forward in drone technology, providing enhanced stability, user-friendly controls, and multiple autonomous functions in a cost-effective manner. The drone industry emphasizes continuous flight technology, which is crucial for numerous applications such as surveys, disaster management, flower dropping, and flagging. Advanced GPS technology, supported by at least 13 satellite locks, enables drones to achieve precise accuracy and stability at specific altitudes, longitudes, and latitudes [8]. We have designed our drone for autonomous operation minimizes the need for constant human oversight. In our proposed system, users can set specific trajectories, modes, and functions via a mobile app interface. Once the mission starts, the drone carries out its tasks, such as flying, reconnaissance, or other operations, without human intervention. The mobile app interface streamlines mission planning and management [9]. Users can easily outline survey areas by drawing boundaries on maps. This precise targeting feature makes the drone highly efficient for several investigation assignments. After completing the mission or if any issue arises, the drone automatically returns to its launch pad. This functionality ensures the safe return of the drone, minimizing the risk of it being lost or trapped in unfamiliar areas. The drone features a versatile payload capacity, making it suitable for various applications. It can be equipped with cameras, sensors, and props for activities like flower dropping or flag deployment during ceremonies. This adaptability allows drones to take on multiple roles in investigations, disaster response, and incident management.

II. Technology and Methodology

This study employs a qualitative research design to explore the experiences of multipurpose autonomous cost-effective drone. We have used the F450 Quad copter Frame, featuring four arms, is constructed from high-quality glass fibre, enhancing its toughness and durability. The arms are manufactured using ultra-durable polyamide-nylon [11], which offers superior strength and improved thickness compared to traditional moulded arms. Arm size is 220 x 40 (LxW) mm having Arm mounting holes on frame and on arm 3mm and 2mm respectively. Four numbers of 920 KV Brushless motors are used, having maximum thrust 500 gm. LittleBee BLHeli-S Spring 30A OPTO Electronic speed controllers (ESCs) are used to control and adjust the speed of the drone's electric motors. A signal from the flight controller instructs the drone's ESC to adjust the voltage to the motor, thereby altering the propeller's speed as needed. 9 inches two clockwise and two anti-clockwise drone propellers made with ABS materials having shaft diameter 7 mm (Flat Side) and 8 mm (Round Side) with total length 230 mm were connected with brushless motors. Drone propellers generate lift by spinning and producing airflow, creating a pressure difference between their upper and lower surfaces [12]. We have used very light weight 82-gram open source APM 2.8 Multirotor Flight Controller [13] which having processor ATMEGA2560 and ATMEGA32U-2 and sensor 3-Axis Gyroscope, Accelerometer, High-performance Barometer. Since this drone is designed for tasks, such as dropping flowers or carrying flags/banners to specific locations, it must maintain high stability during flight to successfully complete these tasks. M8N GPS Module has connected to provide crucial information to the pilot or flight control software. Using this GPS module, we configure our flight controller for fully autonomous flight, allowing it to follow predefined routes accurately and maintain a stable position by determining its surroundings in real time. The drone's GPS module picks up signals from several GPS satellites orbiting the Earth. These satellites constantly transmit their position and the precise time each signal is sent. By picking up signals from at least four satellites, the GPS module employs triangulation to determine the drone’s exact coordinates (latitude, longitude, and altitude). The time delay between sending and receiving the signal helps calculate the distance to each satellite. The GPS module analyses the satellite signals to determine the drone's exact location. This process involves solving complex equations to accurately pinpoint the drone's coordinates. Accurately determining a drone's coordinates often requires utilizing various technologies, including GPS, inertial navigation systems (INS), and sensor fusion methods. Below are essential equations and concepts involved in these techniques. GPS calculates the drone's coordinates (latitude, longitude, altitude) by triangulating signals received from several satellites. The basic GPS equations involve solving for the position (x,y,z) using the distances di to at least four satellites with known positions (xi,yi,zi) [4]:

$$d_i = \sqrt{(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2}$$

These equations are solved together to determine the drone's position. Inertial Navigation System (INS) estimates the drone's position, velocity, and orientation by using accelerometers and gyroscopes to integrate measurements of acceleration and angular velocity over time. The key equations for INS are:

- Acceleration to Velocity

$$v(t) = v(t_0) + \int_{t_0}^{t} a(\tau)d\tau$$

- Velocity to Position

$$p(t) = p(t_0) + \int_{t_0}^{t} v(\tau)d\tau$$

Where:

- a(t) is the acceleration vector at time t.
- v (t) is the velocity vector at time t.
- p (t) is the position vector at time t.

Integrating data from GPS and INS using methods like the Kalman Filter can enhance the accuracy and reliability of the drone's coordinates. The Kalman Filter offers the best estimate of the drone's state (position, velocity, etc.) by merging predictions with actual measurements.

- Prediction step

$$\widehat{\boldsymbol{x}}_{k|k-1} = \boldsymbol{F}\widehat{\boldsymbol{x}}_{k-1|k-1} + \boldsymbol{B}\boldsymbol{u}_k$$
$$\boldsymbol{P}_{k|k-1} = \boldsymbol{F}\boldsymbol{P}_{k-1|k-1}\boldsymbol{F}^T + \boldsymbol{Q}$$

- Update step

$$\boldsymbol{K}_k = \boldsymbol{P}_{k|k-1}\boldsymbol{H}^T\left(\boldsymbol{H}\boldsymbol{P}_{k|k-1}\boldsymbol{H}^T + \boldsymbol{R}\right)^{-1}$$
$$\hat{x}_{k|k-1} = \hat{x}_{k|k-1} + \boldsymbol{K}_k(\boldsymbol{z}_k - \boldsymbol{H}\widehat{\boldsymbol{x}}_{k|k-1})$$
$$\boldsymbol{P}_{k|k-1} = (\boldsymbol{I} - \boldsymbol{K}_k\boldsymbol{H})\boldsymbol{P}_{k|k-1}$$

Where, $\widehat{\boldsymbol{x}}_{k|k-1}$ is the predicted state estimate, $\boldsymbol{P}_{k|k-1}$ is the predicted estimate covariance, **F** is the state transition matrix, **B** is the control input matrix, $\boldsymbol{u}_k$ is the control vector, **Q** is the process noise covariance, $\mathbf{K_k}$ is the Kalman gain, **H** is the measurement matrix, **R** is the measurement noise covariance, $\boldsymbol{z}_k$ is the measurement vector. By integrating GPS and INS data, the system can correct the drift that occurs in INS and enhance the overall accuracy of the position estimate. The Kalman Filter is especially effective for this task because it can manage the uncertainties and noise present in both systems. Imagine a situation where a drone starts from a known location and periodically receives GPS updates while constantly updating its position using INS. The Kalman Filter can combine these data sources to offer a precise estimate of the drone's current position [5]. This fusion process includes: a) Using INS to predict the drone's position and velocity b) Receiving GPS updates and using them to correct the INS estimates c) Applying the Kalman Filter to combine these inputs optimally. We utilized two HC12 Transceiver Modules (Telemetry Data Links) to connect the drone with an Android application. The HC12 Transceiver Modules [14] serve as a wireless bridge connecting the drone and the Android app. They facilitate the transmission of telemetry data (like position, altitude, and speed) from the drone to the app. Similarly, the app can send instructions (such as controlling the drone's movement or camera) to the drone through these modules. This two-way communication is crucial for live monitoring and controlling the drone via the Android app. We have done mission planning using Android application named "Tower" to move Drone in pre-defined routes. After powering on the drone, the flight controller initializes its settings. If there is no RC input, a warning is issued; otherwise, the drone is ready to be armed. RC input is essential for any autopilot system, as it provides the pilot with control over the airframe, allows for mode changes, and enables control of auxiliary equipment. If the controller is prepared for arming, it will verify the flight mode. If the flight mode is set to altitude hold and the HDOP value is below 1.5, the home location is recorded, and the drone is armed for take-off. When altitude hold mode is activated, the throttle is automatically adjusted to keep the drone at its current altitude. Roll, pitch, and yaw functions work the same as in Stabilize mode, allowing the pilot to directly control the roll and pitch angles and the direction of the heading. We noticed that when the GPS module connected to more than 16 satellites, the HDOP value dropped below 1.5. The entire mission planning process is explained with flow chart below. The complete mission planning process is illustrated in the flowchart below.

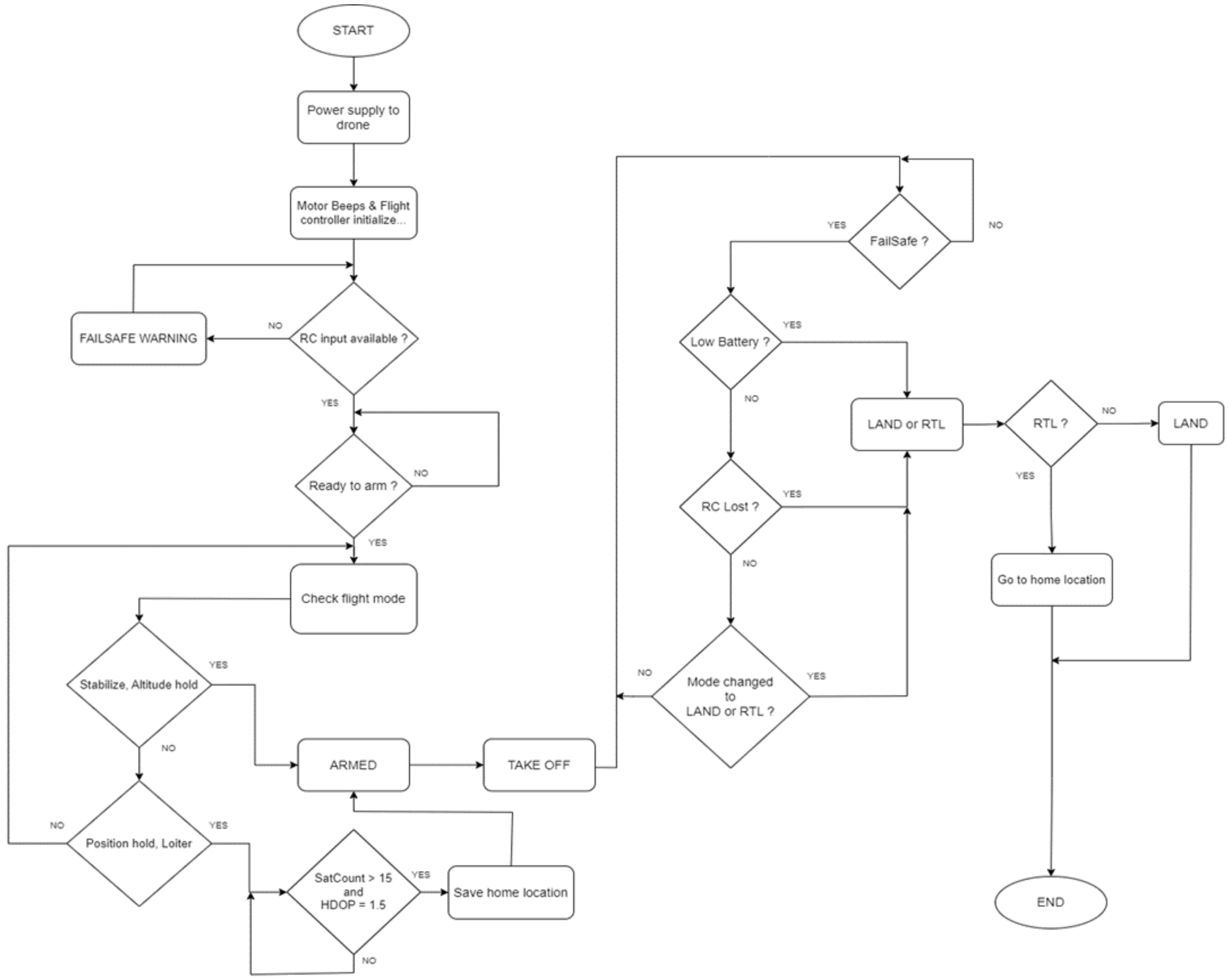

Figure 2: Flowchart of mission planning of drone in auto pilot mode

We choose waypoints on a map interface provided by the ground control station (GCS) software named Tower, where we set the latitude, longitude, and altitude for each waypoint. The flight path for the drone is mapped out using the Tower Application. We determine the sequence in which the waypoints should be visited to accomplish the mission objectives. After the mission is planned, it is uploaded to the drone's on-board autopilot system. The autopilot then autonomously carries out the mission, ensuing the preloaded waypoints and guidelines. At this point, we can add various mission instructions between waypoints to access the drone's characteristics. These directives might contain varying the flight altitude, regulating the speed, activating definite activities, or staying at a waypoint for definite period. While the mission is being executed, we use the GCS interface [15] to observe the drone's progress and make modifications if required. Our project's mission planning backings a wide spectrum of autonomous assignments, extending from simple point-to-point navigation to multifarious plotting, mapping, and reconnaissance tasks. This permits for well-organized and accurate task of automated drones in numerous applications, such as farming, mid-air photography, exploration and rescue, and flower dropping or carrying flag/banner in some occasions.

Figure 3: Drone with flower box

Figure 4: Drone with hanging banner

We switch the transmitter to GPS mode and use the Android app to arm and launch the drone. The drone takes off and follows the path set in the Tower application, completing its survey of all waypoints before safely returning to its starting position. We created a box to carry flowers and attached a banner to it. The bottom of the box can be opened as needed. Out of the six channels on the receiver, four are connected to the flight controller. Channel 5 controls the mode switch, and Channel 6 operates a servo motor attached to the flower box. The servo motor's shaft opens the bottom of the box to release flowers or display the banner during flight.

Result and Discussions:

We have tested our drone with the specified features. We set six waypoints in an "S" pattern and connected the GPS module to 21 satellites. Using the Tower application, we armed the drone and instructed it to take off. The drone successfully navigated all the waypoints and safely landed back at its takeoff point. Our drone, equipped with a flower box and banner, was showcased at JISTECH 2K23. The tasks of dropping flowers and displaying the banner were successfully completed. We have designed this multipurpose drone to be cost-effective. Our design won first place, as chosen by all judges, at both JISTECH 2K23 and IHMMC 2K24.

Figure 5: Six waypoints for drone navigation

Figure 6: Dropping flowers and displaying the banner

Further Development Prospects:
Despite efforts to propose viable solutions to the UAV challenges discussed earlier, many issues remain unresolved and require new, effective approaches. Recently, machine learning and deep learning algorithms have gained significant support in various UAV applications, including resource allocation, obstacle avoidance, tracking, path planning, and battery management. Advancing these algorithms and enhancing on board computational power will enable the creation of nano UAVs that are smaller, lighter, and more intelligent than current models, allowing them to complete missions accurately and without collision risk. Moreover, the availability of precise data will help UAVs perform accurate control, path planning, and vision tasks.

Conclusion:
In conclusion, the development of a cost-effective GPS-guided drone capable of flower dropping and banner displaying demonstrates significant advancements in UAV technology. This innovative design integrates precise GPS navigation, reliable waypoint tracking, and versatile payload management, making it a practical solution for various applications. The successful implementation and recognition at events like JISTECH 2K23 and IHMMC 2K24 highlight the effectiveness and potential of this multipurpose drone. By prioritizing affordability and functionality, this project sets a precedent for future UAV designs that combine efficiency, versatility, and ease of use, paving the way for broader adoption in both commercial and recreational contexts.

References:
[1] S. George Fernandez, K. Vijayakumar, R Palanisamy, K. Selvakumar, D. Karthikeyan, D. Selvabharathi, S. Vidyasagar, V. Kalyanasundhram, “Unmanned and autonomous ground vehicle”, International Journal of Electrical and Computer Engineering (IJECE) p-ISSN 2088-8708, e-ISSN 2722-2578.
[2] S, Mohandas PIT, Conrad JM, “A survey of quadrotor unmanned aerial vehicles” , Paper presented 2012 Proceedings of IEEE Southeastcon. IEEE; Orlando, Florida, United States of America.
[3] Kim J, Moon H, Jung H (2020) Drone-based parcel delivery using the rooftops of city buildings: Model and solution. Appl Sci 10(12):4362.
[4] James Bao-Yen Tsui, “Fundamentals of Global Positioning System Receivers A Software Approach”, A John Wiley & Sons, Inc., Publication.
[5] Guoqiang Mao, Sam Drake , Brian D. O. Anderson , “Design of an Extended Kalman Filter for UAV Localization” , Information, Decision and Control, 2007. IDC '07.
[6] Dimiter Velev, Plamena Ventseslavova Zlateva, Lyudmila Steshina, Igor Petukhov, “Challenges Of Using Drones And Virtual/Augmented Reality For Disaster Risk Management”, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, JUNE 06, 2024.
[7] Milad Ghasri , Mojtaba Maghrebi, “Factors affecting unmanned aerial vehicles’ safety: A post-occurrence exploratory data analysis of drones’ accidents and incidents in Australia”, Safety Science, Volume 139, July 2021, 105273.
[8] Dlnya Aziz, Sameer Algburi, Sameer Alani, Sarmad Mahmood , “Design and Implementation of GPS Based Quadcopter Control System”, Proceedings of the 1st International Multi-Disciplinary Conference Theme: Sustainable Development and Smart Planning, IMDC-SDSP 2020, Cyperspace, 28-30 June 2020.
[9] Hirad Goudarzi, Arthur Richards, “UAV Mission Monitoring and Sequencing”, International Conference on Unmanned Aircraft Systems (ICUAS), IEEE, 2020.
[10] Duncan Hine, Arthur Richards, Hirad Goudarzi, “Mission Automation for Drone Inspection in Congested
[11] Mohd Fathullah, Shayfull Zamree Bin Abd Rahim, Norshah Afizi Shuaib Norshah Afizi Shuaib,

Muhamad Saifuldin Abdul Manan, "Investigation on Nylon PA66 Side Arms Using Taguchi and ANOVA Analysis in Reducing Cost of Producing Urinary Catheters", International Review of Mechanical Engineering (IREME), November 2011.
[12] Pierre-Jean Bristeau, Philippe Martin, Erwan Salaün, Nicolas Petit, "The Role of Propeller Aerodynamics in the Model of a Quadrotor UAV", Proceedings of the European Control Conference 2009 • Budapest, Hungary, August 23–26, 2009.
[13] W Suparta1, A Basuki, M Arsyad, "The development of quadcopter using Arducopter APM 2.8 with autopilot for tracking point of drop-off goods", IOP Conf. Series: Earth and Environmental Science, 1151 (2023) 012032 doi:10.1088/1755-1315/1151/1/012032.
[14] Sumendra Yogarayan, Siti Fatimah Abdul Razak, Mohd. Fikri Azli Abdullah, Afizan Azman,Vethanayagi Arultas, Suneetha Sri Raman, "Comparative performance study of HC-12, nRF24L01, andXBee for vehicular communication",International Journal of Informatics and Communication Technology (IJ-ICT)Vol. 12, No. 1, April 2023, pp. 54~61ISSN: 2252-8776, DOI: 10.11591/ijict.v12i1.pp54-61
[15] Rune Hylsberg Jacobsen, Lea Matlekovic, Liping Shi , Nicolaj Malle ,Naeem Ayoub ,Kaspar Hageman, Simon Hansen ,Frederik Falk Nyboe, Emad Ebeid , "Design of an Autonomous Cooperative Drone Swarm for Inspections of Safety Critical Infrastructure", Journals Applied Sciences Volume 13 Issue 3 10.3390/app13031256.