# Autonomous Drone for Surveillance and Mapping

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***Abstract* - The demand for advanced, autonomous technologies in aerial mapping and surveillance has grown exponentially across industries such as environmental monitoring, urban planning, and security. This work introduces the development of an autonomous drone system designed to perform real-time mapping and surveillance with high efficiency. The proposed system integrates advanced navigation algorithms, precision sensors, and robust data processing capabilities, enabling it to operate with minimal human intervention. Notable features include GPS-based autonomous flight planning, real-time obstacle detection and avoidance, and high-resolution data capture through integrated LiDAR and RGB cameras. Additionally, 3D mapping via photogrammetry generates precise terrain models from captured video footage, enhancing the system's mapping accuracy. The drone's onboard processing unit allows for real-time data processing and live streaming to a ground station, enabling remote monitoring without any latency. Field trials and initial tests have confirmed the drone's ability to navigate diverse terrains, autonomously adjust flight paths, and provide high-accuracy, real-time mapping updates. This system offers a scalable, cost-effective alternative to traditional, labor-intensive aerial surveillance methods, providing enhanced efficiency and precision. This work aims to advance the research in autonomous aerial systems by tackling significant challenges, including real-time obstacle avoidance, data processing efficiency, and system reliability in varying environments. Future improvements may focus on enhancing battery life, increasing flight endurance, and enabling multi-drone coordination to extend the scope and capabilities of the system across a wider range of applications.**

***Keywords - Autonomous Drone, Surveillance, LiDAR, Obstacle Avoidance, Mapping, UAV, Real-Time Data Processing, 3D Mapping, Photogrammetry***

## I. INTRODUCTION

With the fast improvement of autonomous technology, drones have become go to tools for applications like mapping and surveillance. Traditional ways to view the ground using airplanes are neither convenient nor affordable for bigger or more dangerous tasks. Still, using autonomous drones is less expensive and more adaptable, letting them work effectively with less help from people. Because they can be set up in many ways, they are important for watching the environment, organizing cities and security systems.

There is a growing need for innovative solutions to improve national security and military operations. Drones with autonomy allow nations to stay safe and citizens to be well protected in unpredictable times. These groups deal with important issues, for example unconventional warfare and terrorism, by collecting data and doing surveillance from a distance to protect the military population.

On top of security, autonomous drones do an excellent job at mapping remote and difficult-to-access places. With no one controlling the vehicles, autonomous systems can survey and monitor areas that are dangerous or too remote for human visitors.

3D mapping using photogrammetry has now improved drones for analyzing locations. With photogrammetry, one can make topographic surveys, look at structures in detail and watch for environmental changes by using high-quality 3D models from aerial photos. When LiDAR, RGB and infrared sensors are used with 3D mapping based on images, drones become important for many smart applications

The paper examines how an autonomous drone system is made to overcome these problems. By adding advanced mapping, navigation and avoiding obstacles, along with data processing speed, the proposed system tries to boost efficiency and safety in its tasks. This research is advancing the field of autonomous drone technology by providing a flexible answer to today's security, environmental monitoring and related challenges.

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## II. LITERATURE SURVEY

Because demand for autonomous drones is increasing, there has been significant effort to improve technologies for package delivery, catching objects, guiding drones indoors and developing towns. Thanks to recent advancements in embedded systems, computer vision and machine learning, modern drones can handle complex jobs with just a little human help. The literature survey highlights important breakthroughs where hardware, software and algorithms are used together to make drones perform and scale up better.

Garg et al. (2022) [1] presented a quadcopter powered by an embedded system, designed for delivering packages autonomously with ArduPilot. The pickup and delivery steps are automated with little human need. The system was built with Ubuntu 20.04 LTS running, using ROS Noetic as the robot operating system and relying on PX4 for flight control. Testing the drone's performance was done using the Gazebo simulator. In addition, the image processing used OpenCV to detect ArUco markers which helped handle packages accurately. Among its hardware were the ArduPilot flight controller, 1200Kv motors, a carbon fiber frame, GPS, telemetry radios and a servo gripping device for moving packages. The drone was able to pick up packages, fly to a chosen location and deliver them largely on its own. Both in simulation and actual flight tests, the drone achieved results as expected, able to carry up to 1 kg and fly for one whole hour. The conclusion of the study mentioned that the drone's performance could be improved by making it able to lift more and fly longer and the system can be set up for military, emergency and industrial tasks.

The authors outline, in the International Journal of Emerging Technologies and Innovative Research, how they used OpenCV to create an autonomous drone system for real-time object detection and tracking. The key aim was to manufacture a drone that could automatically supply supplies to regions hit by disasters. To increase efficiency in challenging environments, the hardware features aimed to optimize routing and add sensors for stability, with a flight controller, engines and camera all put together. Object detection was handled by using OpenCV, so the drone could find and monitor targets on its own. With its low expense and open code, the system became a great solution for many purposes, among them surveillance, inspection and emergency rescue missions. Both methods delivered promising results for running live object detection which suggests the drone is suitable for several practical uses. [2].

Pakruddin et al. (2021) real-time object detection and following in drones was studied for urgent applications, for example, when helping in rescue missions. The research found that lightweight machine learning models are best for using on a Raspberry Pi 3 or similar limited machines. A reason for deciding on the Haar cascade classifiers is that they require little data which means that fast object detection with decent accuracy (70-80%) is achievable. A Raspberry Pi, a 5 MP camera and an ArduPilot flight controller were used to design the drone for stability and navigation. Data on live video was sent from the satellites to ground stations by using a server-client approach. The system suggested that drones might assist during disasters by quickly detecting and tracking humans or animals, mainly to keep people safe by reducing the need for hands-on operations by responders. [3].

Putra and Saputra (2022) studied how drones can be guided indoors using virtual 3D maps when sensors provided are close to none. The system working off a combine dead reckoning and a 3D virtual map was created to let drones stay precisely positioned without lots of sensors which is normally missing in smaller drones. The approach depended on IMU data to determine position and tested both inertial navigation and a non-positioning approach using pre-planned routes. The authors used a system in which a drone was controlled remotely from the ground and tested the prototype in a maze built from cardboard. Results from the research show that it's possible to guide indoor drones in areas with bad GPS coverage, with efficient calculations needed for small drones. [4].

Bahabry et al. [5] designed a means of avoiding incidents and planning efficient flying of urban drones in groups. Via pathfinding with Dijkstra's algorithm and MILP for scheduling, the system functions efficiently and saves energy. For example, the role of hover mechanisms in avoiding collisions and station areas for charging shows that the system can easily adapt for use in smart cities.

## III. METHODOLOGY

The proposed autonomous drone system integrates sensors, algorithms, and real-time data processing to improve surveillance and mapping ability.

*A. System Components*

1. Flight Controller: Drone stabilization and control
2. LiDAR and VL53L0X Sensors: Detect obstacles and map terrain in real-time.
3. RGB Camera: Capture high-resolution (720p) images and videos,
4. Battery (LiPo): Powers all onboard components.
5. Brushless Motors & ESCs: Precisely controls flight of drone.

*B. Algorithms*

1. Obstacle Avoidance:
- LiDAR detects objects.
- Energy efficient routes determined by path finding algorithms.
2. Preprogrammed Flight:
- Preset path is followed by the drone.
- Adjusts for path deviations automatically.

*C. Software Stack*

1. Cygnus IDE**:** For code testing and development.
2. Pluto Controller App**:** To arm up the drone and manually land the drone.
3. Sensor Integration**:** Processes real-time data from LiDAR and cameras.
4. Poly.cam : Photogrammetry software

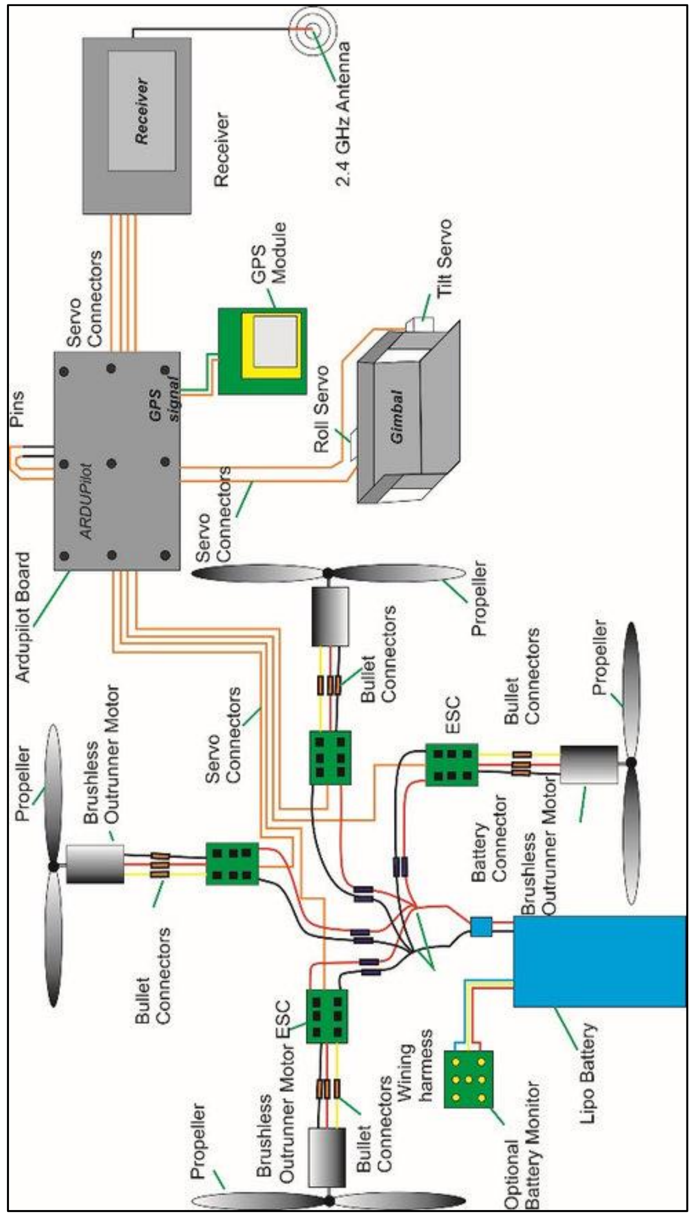


Fig 1: Typical Quadcopter Layout

## IV. RESULTS AND DISCUSSION

*A. Preliminary Testing*

1. Flight Speed: ~5 m/s
2. Max Altitude: ~50 m
3. Battery Life: ~8-10 minutes
4. Control Range: ~50 meters in open environments
5. Mapping Accuracy: ±10 cm
6. Processing time: 3min per 100 images

*B. Observations*

1. Real-time object detection ensured safe movement in diverse terrains.
2. High-resolution cameras provided clear video feed.

3. Having photogrammetry in addition to LiDAR imaging raised the level of detail in map areas.

*C. Challenges*

1. Limited battery life restricted operational range.
2. Environmental factors, such as wind, affected stability
3. Large-scale photogrammetry requires high computational power, which could be optimized by edge computing solutions or cloud-based processing.

## V. CONCLUSION

An autonomous drone developed for mapping and surveillance connects real-time video, obstacle detection and GPS steering in one flexible aviation system. The Cygnus IDE and VL53L0X sensor are used in this project to reveal how drones can be valuable in security, environmental monitoring and inspection of infrastructure. Swarm intelligence and 3D modeling are two of the area's drones advance now, contributing to technology and providing useful advantages to society such as safer public spaces and higher yields for agriculture. In the end, this work emphasizes the positive effects of UAV systems on industry development and drone technology, establishment a major step towards integrating autonomous systems into diverse sectors.

## VI. FUTURE SCOPE

*Advanced Swarm Intelligence*

Future studies might try to create methods that allow drones to move collectively as a group. Advances such as these would let drone fleets work together, making risky activities like search and rescue, overseeing nature and large surveys easier.

*Customizable Payloads for Versatile Missions*

Having the ability to order or modify the camera, sensor or arm used by drones makes them incredibly flexible for many applications. Because of their flexibility, drones could be used for photography, inspecting dangerous materials or checking over parts of infrastructure.

*5g - Enabled Drones*

Adding 5G capabilities to drones could dramatically improve their tasks through very low lag time, superfast connections and strong long-range communication. This would prove ideal for live data transfer, controlling drones from far away in cities and group drone projects.

*AI-Enhanced Photogrammetry*

Machine learning can be used in the future to automate the work involved in photogrammetry which increases accuracy. Using machine learning, drones help gather geospatial information faster, cut down on human labor and support smart choices in construction, farming and city planning.

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