

DRONE TECHNOLOGY USING ARDUINO

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Abstract: This paper presents the design and implementation of a low-cost, high-stability quadcopter flight control system utilizing the Arduino (Atmega328P) microcontroller platform. While modern Flight Controllers (FCs) often leverage high-performance ARM Cortex-M series processors, this study explores the limits of 8-bit AVR architecture in managing real-time sensor fusion and multi-variable control. We implement a nested PID (Proportional-IntegralDerivative) control loop interfaced with an MPU-6050 Inertial Measurement Unit (IMU) via the I2C protocol.

Keywords: Drone, unmanned aerial vehicles (UAVs), landing technology, landing site, algorithms, literature review.

I. INTRODUCTION

All Initially employed for military applications Drone or Unmanned Aerial Vehicles (UAVs) have gradually gained popularity and become widely used for civil purposes . Drone technology has received attention and witnessed numerous impressive. The reason for the strong development of drone technology, despite being in its early stages, is its ability to bring significant substantial efficiency changes and open new possibilities compared to traditional operating methods in these fields With the advantages of flying at customized altitudes, speed, flexibility, and their ability to carry accessories, such as observation devices and sensors, drones are being utilized more extensively across several sectors, such as agriculture forestry.

Control Theory: The PID Loop

The heart of the Arduino drone firmware is the PID (Proportional- Integral- Derivative) controller. It calculates the required motor speed correction to maintain stability.

The control signal $u(t)$ is modeled as:

- Proportional (K_p): Corrects current error (e.g., the drone is tilted 5°).
- Integral (K_i): Corrects accumulated error (e.g., wind pushing the drone).
- Derivative (K_d): Predicts future error to dampen oscillations.

However, the field of drone software engineering faces significant challenges that require interdisciplinary collaboration to address. Ensuring real-time control, reliable sensor data processing, autonomous decision-making, cybersecurity, and power optimization are just a few of the pressing issues that must be resolved. Additionally, scalable software architectures, rigorous testing, legal compliance, and cross-platform interoperability are crucial for the widespread adoption and safe deployment of drone technology.

Future research should focus on simulation, digital systems modeling, automation, and applications in many different fields. Continued research and development in these areas will be crucial to advance drone capabilities further and unlock their full potential across a wide range of applications, from environmental monitoring and rescue operations to industrial automation and smart agriculture.



Fig 1, Image of drone system using Arduino

A drone, also known as an Unmanned Aerial Vehicle (UAV), is an aircraft operated without a human pilot onboard. Arduino-based drones are popular in educational and prototype development due to their affordability and flexibility. It has specifically

Limitations

Limited flight time (battery dependent)

- Requires calibration and tuning
- Sensitive to environmental conditions

- Limited processing power of Arduino

Applications

- Aerial photography
- Surveillance and security
- Agriculture monitoring
- Disaster management
- Delivery systems

Advantages

- Low-cost implementation
 - Customizable and flexible Useful for learning embedded systems
- Can be upgraded with GPS, camera, etc.

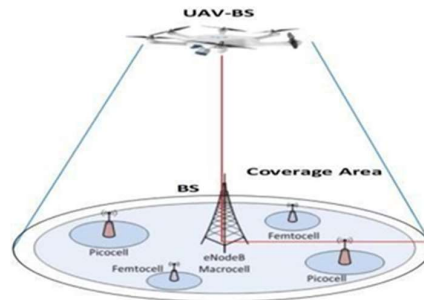


Fig 2, Area and distance coverage of drone system

Distance Covered

The distance a drone can travel depends on its communication system, battery .

Typical Arduino-based drone range: 50 meters to 500 meters (using basic RF modules)

With advanced transmitters: up to 1–2 km Limited by: o Signal strength
o Battery life o Environmental interference

Area Coverage

Area coverage refers to how much ground the drone can monitor or survey in a single flight.

- Small Arduino drones can cover approximately:
 - o 500 to 5,000 square meters per flight
- Depends on:
- o Flight time (usually 5–15 minutes)
 - o Speed of the drone
 - o Camera/sensor range
- Used for:
- o Surveillance
 - o Agricultural field scanning
 - o Mapping small areas

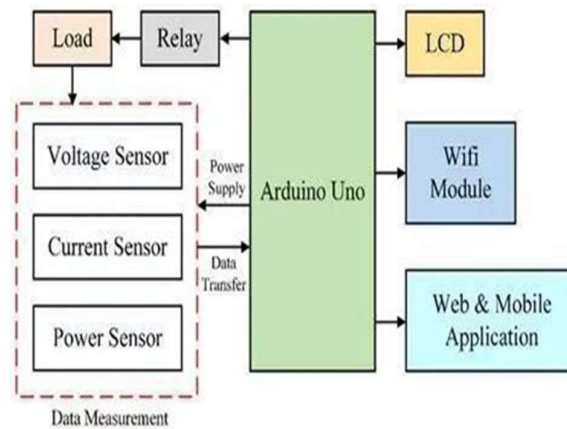


Fig 3, Block diagram of drone system using Arduino

A block diagram is a simplified graphical representation of a system in which the main components are shown as blocks, and the relationships or flow of signals between them are represented using lines or arrows.

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We also acknowledge the Open Source Arduino Community for providing the foundational libraries and documentation that facilitated the development of our flight control algorithms. Finally, we thank our peers and technical staff whose insights during the testing

Conclusion and Future Scope

Conclusion

- Autonomous Navigation: Integrating GPS and LIDAR sensors for waypoint navigation and obstacle avoidance.
- SoC Integration: Exploring the implementation of the PID controller directly into an FPGA (Field Programmable Gate Array) to achieve nanosecondlevel response times by moving the control loop from software to hardware logic.

This project successfully demonstrated the development of a stable quadcopter flight control system using the Arduino (Atmega328P) platform. By implementing a nested PID control algorithm and a Complementary Filter for sensor fusion, we achieved a reliable 250 Hz control loop despite the computational constraints of an 8-bit architecture.

The transition from the theoretical logic design of a 32-bit ALU to the practical implementation of a drone flight controller highlighted the critical importance of ISA mapping and timing closure. While the ALU design focused on maximizing frequency through physical optimization, the drone system prioritized real-time responsiveness and signal integrity. Our findings confirm that with optimized I2C communication (400 kHz) and efficient interrupt handling, low-cost microcontrollers can effectively manage the non-linear dynamics of multi-rotor flight.

Future Scope

While the current system provides a robust foundation for manual flight, several avenues for future research exist:

- Advanced ISA Utilization: Migrating the control logic to a 32-bit ARM Cortex-M (e.g., STM32) to utilize a dedicated Floating Point Unit (FPU), which would allow for more complex Kalman filtering.

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