الجمهورية الجزائرية الديمقراطية الشعبية
People's Democratic Republic of Algeria
وزارة التعليم العالي و البحث العلمي
Ministry of Higher Education and scientific research
المدرسة الوطنية العليا للتكنولوجيات المتقدمة
National Higher School of Advanced Technologies
Department of Electrical Engineering and Industrial Computing

Final Year Project to Obtain the Diploma of

Master

Specialty:

Embedded Systems

-Subject-

Comparative Study of the Characteristics of MultiWii and Pixhawk Autopilot Boards

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Algiers, The 25/06/2024

Academic year 2023 - 2024

Comparative Study of the Characteristics of MultiWii and Pixhawk Autopilot Boards

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Abstract—This study presents a comparative analysis of two popular autopilot boards: MultiWii and Pixhawk, which are commonly used in Unmanned Aerial Vehicles (UAVs). MultiWii, which is based on the Arduino platform, is known for its simplicity, affordability, and suitability for DIY projects and educational purposes. In contrast, Pixhawk, which is developed by the PX4 and ArduPilot teams, offers advanced features, higher reliability, and robustness, making it ideal for complex and professional UAV applications. The comparison covers various aspects, including hardware specifications, software capabilities, cost, and community support. The study aims to provide an insights into the strengths and limitations of each autopilot board to guide users in selecting the most appropriate option for their specific needs.

Index Terms—MultiWii, Pixhawk, UAVs, Arduino, PX4, ArduPilot, DIY drones.

I. Introduction

A flight controller (FC) is a crucial component of Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs). It contains sensors like gyroscopes and accelerometers which detect the vehicle's movements and respond to pilot commands. Choosing the right FC board is essential for ensuring optimal performance and reliability. MultiWii and Pixhawk are two popular choices for both hobbyists and professionals. This article presents a comparative study of these two autopilot boards, highlighting their respective strengths and weaknesses to help users in making an informed decision.

Meanwhile, this article will discuss the different ways to control drones, known as flight modes. These flight modes are important for both beginners and experts in achieving the best performance from their drones.

II. Flight modes

Flight modes refer to the ways to control a drone depending on targeted tasks or flying conditions. They are important for both hobbyists and professionals to get the best performance from their drones. In what follows, we will focus on the most essential modes.

1) Acro Mode: short for "Acrobatic mode", is a flight mode for drones that provides full manual control without any stabilization assistance from the flight controller. Pilots can freely control the drone's orientation and movements as they wish. It is used for performing advanced maneuvers and tricks.
2) Alt Hold: Alt Hold stands for "Altitude Hold". It is a flight mode where the aircraft maintains its current altitude, typically by utilizing sensors such as barometers or ultrasonic sensors. This mode helps the pilot focus more on controlling the drone's horizontal movement [1].
3) Loiter Mode: In the context of drones, this mode enables the aircraft to maintain a specified location using GPS or other positioning systems, such as optical flow sensors that measure movement along the x and y axes, and sensors for altitude measurement. It doesn't need active control input from the pilot. Loiter mode is useful for tasks where the drone needs to stay in a particular location for observation, photography, or other purposes [2].
4) Return to Home Mode : It is a feature or mode in drone operation where the aircraft

automatically navigates back to its takeoff point or a predefined home location. This is often activated by the pilot or triggered automatically by low battery or loss of connection.

5) Auto Mode: Auto Mode typically stands for 'Autonomous Mode.' In this mode, the drone executes pre-programmed mission scripts stored in the autopilot. These scripts consist of navigation commands such as waypoints.In the example shown in Figure 5 below, the drone is programmed to fly in circular patterns [3].

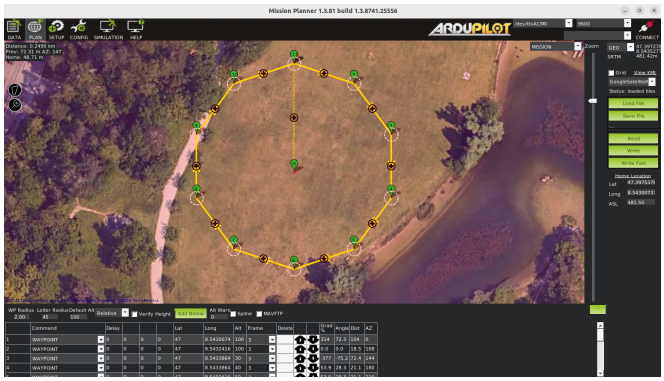

Fig. 1. Circular Path Navigation

III. Background Information

Autopilot systems are crucial components in UAVs, providing automated flight control and navigation. These systems use sensors, microcontrollers, and software algorithms to maintain stable flight and execute complex missions. Over time, autopilot technology has changed a lot, offering better capabilities and reliability. Understanding the development and features of MultiWii and Pixhawk is important.

A. Overview of MultiWii

MultiWii is an open-source project using the Arduino platform that provides flight control software for multirotors and aircraft. It was originally designed to work with Wii MotionPlus sensors, which is why it is called MultiWii, where "multi" stands for multirotor. MultiWii supports various gyroscopes, accelerometers, and other sensors.People often use MultiWii in DIY drones and other small UAV projects because it is easy to customize and affordable [4].

B. Overview of Pixhawk

Pixhawk represents a more advanced autopilot system developed by the PX4 open hardware project and the ArduPilot team. Designed to control drones and other unmanned vehicles, Pixhawk is known for its reliability and stability in flight. Many professionals and researchers prefer Pixhawk for complex UAV applications due to its advanced features ,robust performance , and extensive community support [5] [6].

IV. Hardware Specifications

A. MultiWii

- Processor and Memory: Typically uses the Atmel AVR series microcontrollers, such as the ATmega328P or ATmega2560, suitable for basic to intermediate UAV applications with limited memory space [7].
- Sensors: Supports various sensors,including gyroscopes,accelerometers (MPU6050) and sometimes the HMC5883L (magnetometer).
- Connectivity Options: MultiWii generally supports I2C and SPI interfaces for sensors , and UART ports for communication with GPS modules or telemetry , it is also support SBUS and PPM input signals.
- Power Requirements: operates on low power requirements, suitable for smaller UAVs and DIY projects.

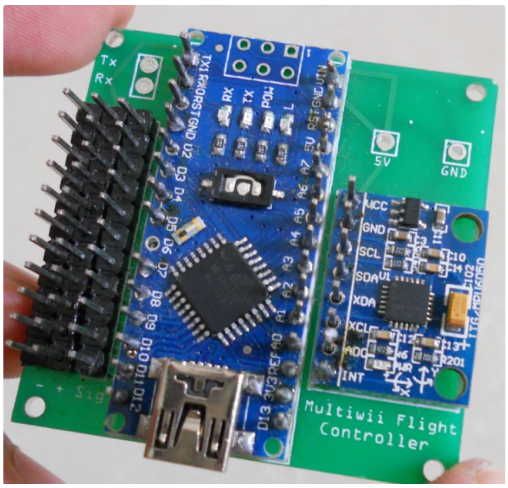

Fig. 2. Arduino Nano and MPU6050

B. Pixhawk

- Processor and Memory: Utilizes more advanced processors, such as 32-bit ARM Cortex M4 cores (STM32F427). These types of processors offer higher computational capabilities and greater memory capacity compared to MultiWii, enabling advanced flight control algorithms and handling multiple sensor inputs simultaneously.
- Sensors: Pixhawk boards feature a wide range of integrated sensors, including accelerometers, gyroscopes, magnetometers, and barometers. Unlike MultiWii, Pixhawk uses two gyroscopes and two accelerometers. The MPU6000 is the main sensor for both, and an ST Micro 16-bit gyroscope is used as well. This redundancy ensures higher reliability and accuracy in flight data, making Pixhawk a more robust choice for complex UAV applications.
- Connectivity Options: Supports a wide range of peripherals, including I2C, SPI, UART, and CAN bus interfaces. Additionally, it supports GPS modules, telemetry radios, and extra sensors such as optical cameras. Pixhawk does not support PWM input signals but supports PPM and SBUS input signals.
- Power Requirements: Requires higher power due to its advanced features [8].

Fig. 3. Pixhawk 2.4.8 board

V. Software Specifications

A. MultiWii

MultiWii runs on simple and flexible open-source flight control software based on the Arduino platform. Initially developed for quadcopters, it has expanded over time to support various multirotor configurations and fixed-wing aircraft. The software is highly customizable, allowing hobbyists to modify and add new features. MultiWiiConf, the graphical user interface (GUI) for MultiWii, makes it easy to set up and adjust the flight controller. While MultiWii can perform many functions like other flight controllers and its code is easy to understand and change, it is not suitable for complex UAV applications because it relies on the Arduino board [9].

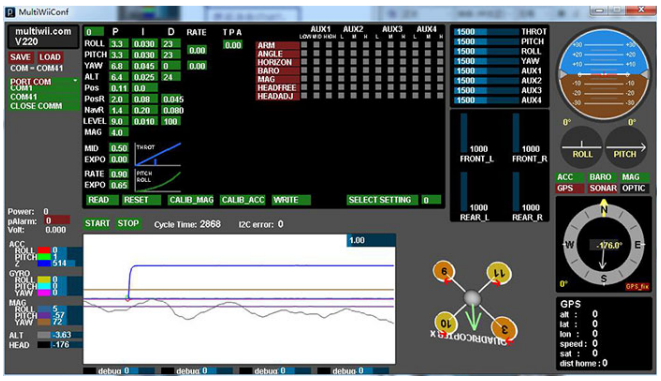

Fig. 4. MultiWiiConf

B. Pixhawk

Pixhawk boards utilize more advanced open-source flight control software, namely PX4 and ArduPilot. These software platforms offer a wide range of features and support complex flight operations with various unmanned vehicles. Both PX4 and ArduPilot are highly configurable, supporting advanced flight modes and autonomous missions. Pixhawk can be used with ground control stations (GCS) such as QGroundControl and Mission Planner, enabling detailed parameter tuning and real-time flight data analysis. Additionally, Pixhawk supports MAVLink, a lightweight protocol, and some tools like MAVSDK and DroneKit. It also works with Software in the Loop (SITL), allowing users to simulate autonomous missions.

Fig. 5. Mission Planner

VI. Comparing Flight Modes

We conducted extensive testing of both Pixhawk and MultiWii flight controllers across various flight modes to evaluate their performance, reliability, and advanced features. We tested each controller under the same conditions to ensure a fair comparison. Below, we explain what we found for each flight mode.

A. Arco Mode:

Both Pixhawk and MultiWii boards support this mode. However, Pixhawk may offer advantages compared to MultiWii boards due to its advanced features such as more precise control algorithms, higher processing power, and better integration with various sensors.

B. Alt Hold:

Both Pixhawk and MultiWii boards usually support Alt Hold mode well. Again, Pixhawk's advanced altitude control algorithms and sensor capabilities make it particularly adept at maintaining precise altitude hold even in challenging environmental conditions.

C. Loiter Mode:

Pixhawk generally offers better performance in Loiter mode because it has advanced GPS features and more sophisticated firmware. This makes Pixhawk a potentially better choice for this mode compared to MultiWii.

D. RTH Mode:

Both Pixhawk and MultiWii boards can support Return to Home mode. However, Pixhawk may offer more advanced features and greater reliability in this mode.

E. Auto Mode:

Pixhawk is often chosen for autonomous missions because it has excellent and comprehensive waypoint navigation capabilities and supports complex mission planning. While MultiWii can handle basic autonomous missions, Pixhawk offers more advanced features and better reliability.

In comparing flight modes, both Pixhawk and MultiWii boards demonstrate capabilities across various modes. However, Pixhawk shows advantages due to its advanced features, such as more precise control algorithms, higher processing power.

VII. Safety Features

To imporve the safety of drone operations, especially in more complicated and important situations.It is essential to add additional features.Both MultiWii and Pixhawk are two systems that help keep drones safe by using different safety features,but there are notable differences in their implementations and capabilities.

A. MultiWii Safety Features

1) Fail-Safe: MultiWii includes basic fail-safe mechanisms that are activated during loss of signal from the remote controller. When this occurs, the system can be configured to hover, land, or return to the home point if GPS is available.
2) Battery Management: MultiWii includes a feature that notifies the pilot once the battery voltage reaches a certain level configured by the pilot. This feature helps prevent crashes.

B. Pixhawk Safety Features

1) Fail-Safe: Pixhawk offers advanced fail-safe features, including Return-To-Home (RTH), SmartRTH, and automatic landing mode. These features are triggered by conditions such as signal loss, low battery levels, or redundancy hardware failures. RTH ensures the drone returns to its take-off location when it enters fail-safe mode, while SmartRTH calculates the best return path considering battery levels and environmental factors. Unlike traditional RTH,

SmartRTH takes into account wind speed, obstacles, and other variables for a more efficient and safe return, even adjusting the landing location if necessary. It can change its route to ensure efficiency and safety, This makes SmartRTH particularly useful in complex environments. Additionally, the drone can be configured via parameters to do nothing.

2) Battery Management: Pixhawk includes sophisticated battery management systems that monitor not just voltage, but also current draw and remaining capacity. This comprehensive monitoring allows for more accurate fail-safe actions related to power management.
3) Geofencing: Pixhawk supports geofencing, which creates virtual boundaries for the UAV. If the drone reaches these boundaries, the system can be programmed to automatically return to the home point or land safely.
4) Pre-Flight Checks: The Pixhawk system includes a pre-flight feature using a switch button that ensures all systems are functioning correctly before takeoff. This includes checks on GPS lock, sensor status, and battery level.

VIII. Cost Evaluation

A. MultiWii

Multiwii boards are generally more affordable, Additionally components and peripherals are also cost-effective, making Multiwii an attractive option for hobbyists and beginners. Maintenance and upgrades are straightforward and inexpensive.

B. Pixhawk

Pixhawk boards are more expensive, ranging from 100$ to 250$, reflecting their advanced capabilities. While peripherals for Pixhawk are more expensive, they offer higher performance and advanced features. The long-term maintenance costs are low due to the board's durability and quality components, providing good value for the initial investment.

IX. Community Support

Community support is a crucial factor in choosing an autopilot board because it influences the availability of resources and the ease of troubleshooting.

A. MultiWii

The MultiWii community is smaller but helpful, primarily used by hobbyists and DIY enthusiasts. Although the documentation on the MultiWii website is limited, there are other resources available, including wikis, forums, and hobbyist websites. However, gathering information still requires significant effort [10].

B. Pixhawk

Pixhawk, on the other hand, provides extensive and well-organized documentation, along with active community support and frequent updates,which is best for professional, commercial, and research applications.The Pixhawk documentation is comprehensive and well-structured, available through official websites such as PX4.io and ArduPilot.org. These resources include detailed manuals, setup guides, troubleshooting tips, and developer resources [11] [12] .

X. Conclusion

The choice between MultiWii and Pixhawk autopilot boards depends on the specific requirements of the UAV project. Pixhawk is a good choice for complex and professional applications due to its advanced features and robust performance. On the other hand, MultiWii is better suited for hobbyists and educational projects due to its simplicity and affordability.

Acknowledgment

I would like to express my gratitude to Mr. Bouchachi and Abbadi, my supervisors, for their support and guidance throughout this study.

I also extend my appreciation to the online communities and forums dedicated to UAV technologies for their shared knowledge and experiences.

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