EVTOL Drone Proposal

1. Introduction

1.1 Problem

How to efficiently detect the work flow is a major problem in nowadays society. For example, in the fields of agricultural inspection, power line and infrastructure inspection, environmental protection and wildlife monitoring, an effective, high-speed and wide-ranging inspection method will increase the productivity and accuracy of related industries.

1.2 Solution

The solution we give is to develop an eVTOL drone that can meet a certain load bearing, set up corresponding communication modules and cameras for it, and transmit real-time data back to the data cloud we build on the server, so as to achieve a large range and long distance accurate detection.

1.3 Benefits

In the fields of agricultural inspection, power line and infrastructure inspection, environmental protection and wildlife monitoring, an effective, high-speed and wide-ranging inspection method will increase the productivity and accuracy of related industries.

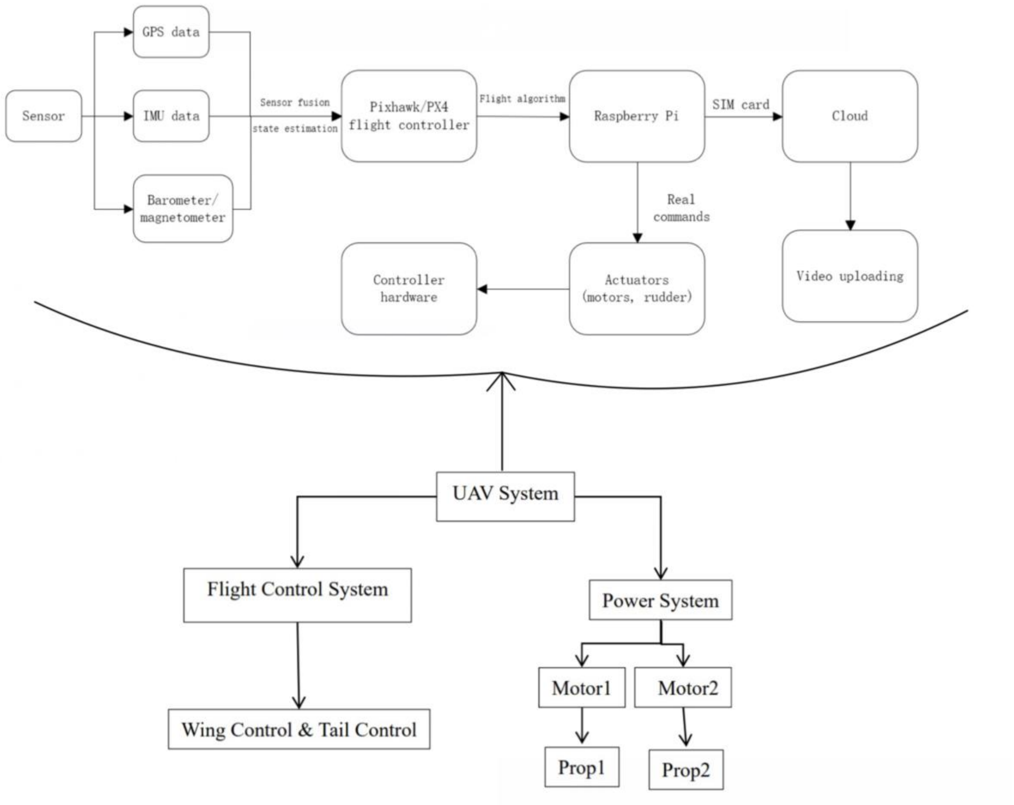
Higher inspection efficiency means higher production capacity and fewer losses, while our design also responds to environmentally friendly design principles to minimize the cost of assembling the aircraft.

1.4 High Level Requirements List

- The plane must be able to fly properly with a load of **2 kilograms**.
- Electric control is to ensure **hover and control**.
- Stable communication in **10 km** and **30 minutes** and upload the camera image to the cloud.

2. Design

2.1 Block Diagram



2.2 Block Descriptions

2.2.1 Power and Control

This design aims to create a drone with Vertical Take-Off and Landing (VTOL) capabilities, combining the hovering ability of quad-copters with the long-distance, high-efficiency flight characteristics of fixed-wing UAVs. The drone is equipped with five V2207 V2.0 KV1750 motors and five F5146 propellers, powered by a 1300mAh 6S 150C battery. The drone's body consists of upper and lower carbon plate frames, with fixed wings on both sides and a tail-fin at the rear, as well as necessary connectors to ensure structural stability.

Structural Design

- Main Fuselage: Made of lightweight and high-strength carbon plate materials for the upper and lower frames, providing structural support for the entire drone. The carbon plates are selected for their excellent mechanical performance and corrosion resistance to suit different flying environments.
- Motors and Propellers: Four motors and propellers are mounted at the corners of the drone for vertical takeoff and hovering; an additional motor and propeller are mounted at the front of the drone, specifically for propulsion during horizontal flight.
- Battery: A 1300mAh 6S 150C battery is chosen as the power supply unit, featuring a high discharge rate to ensure the drone has sufficient power output and a longer endurance.
- Fixed Wings and Tail-fin: The fixed wings on either side and the tail-fin at the rear are designed to provide lift and stability in horizontal flight mode, as well as aiding the drone's maneuverability at high speeds.

Control system

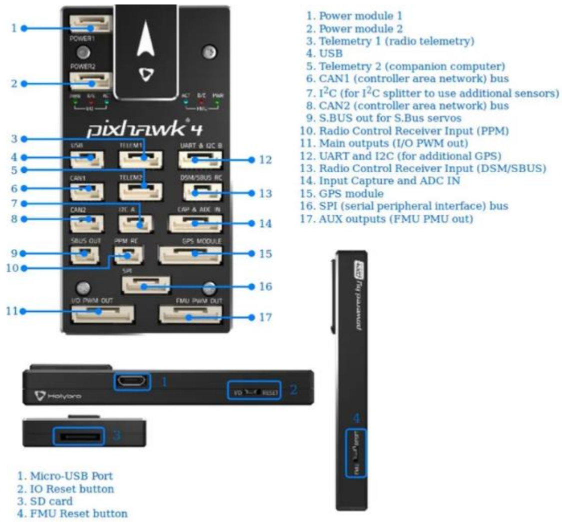
- Sensors: Various sensors such as GPS, IMU (Inertial Measurement Unit), barometer, and magnetometer provide data about the UAV's environment, position, and orientation.
- Sensor data: Each type of sensor data is processed separately to extract useful information and filter out noise.
- Sensor Fusion and State Estimation: Data from multiple sensors are combined using algorithms like Extended Kalman Filter to estimate the UAV's state (position, velocity, orientation, etc.).
- Flight Control Algorithms: These algorithms, such as PID controllers, take the estimated state and compute the necessary control commands to achieve desired flight behavior.
- Actuator Commands: These commands, typically in the form of PWM (Pulse Width Modulation) signals, are sent to electronic speed controllers (ESCs) to adjust the speed and direction of motors and other actuators.
- Motors/Actuators: These physical components of the UAV translate control signals into action, such as spinning motors or moving control surfaces.
- Pixhawk/PX4 Flight Controller Hardware: This is the physical hardware running the Pixhawk/PX4 flight control firmware, responsible for executing flight control algorithms and generating control signals.

Functional Design

- Takeoff and Hovering: Vertical takeoff and stable hovering are achieved through the motors and propellers positioned at the drone's corners. This design allows the drone to take off and land in tight or runway-less environments.
- Horizontal Flight: The motor and propeller at the front are activated for horizontal propulsion, while the fixed wings provide the necessary lift for efficient long-distance flight.
- Stability and Maneuverability: Through carefully designed fixed wings and a tail-fin, the drone is ensured stability and maneuverability during high-speed flight and turning.

2.2.2 Control Unit firmware and software

Pixhawk (connections between the hardware and UAV)



- Physical Mounting: Ensure that both the Pixhawk flight controller and the UAV are powered off. Mount the Pixhawk flight controller securely onto the UAV frame using appropriate mounting hardware. Align the connectors on the Pixhawk with the corresponding ports on the UAV frame.
- Electrical Connections: Connect the necessary cables from the Pixhawk flight controller to the various components on the UAV. These components may include motors, ESCs (Electronic Speed Controllers), GPS modules, telemetry modules, and other sensors.
- Power Supply: Ensure that the Pixhawk flight controller and all connected components receive power from a suitable power source. This may involve connecting the Pixhawk to the UAV's main battery or power distribution board.
- Firmware Setup: After making the physical connections, power on the UAV and connect the Pixhawk flight controller to the computer using a USB cable.
- Open the ground control station QGroundControl(software). Once the firmware is updated, configure the flight controller settings according to UAV's specifications. This may include calibrating sensors, setting up flight modes, and adjusting parameters.
- Sensor Calibration: Perform sensor calibration procedures using the ground control station software. This typically involves calibrating the accelerometer, gyroscope, compass, and other sensors to ensure accurate flight performance.

Raspberry pi(microcomputer)

- Autonomy and Mission Planning: Raspberry Pi can run software for autonomous flight control and mission planning. This includes tasks such as waypoint navigation, path planning, and obstacle avoidance.
- Sensor Fusion and Data Processing: Raspberry Pi can process sensor data from onboard sensors such as GPS, IMU, cameras, and environmental sensors. It can perform sensor fusion to improve navigation accuracy and provide more comprehensive situational awareness.
- Communication and Telemetry: Raspberry Pi can handle communication tasks, such as transmitting telemetry data to ground stations or remote operators, receiving commands and mission updates, and facilitating communication between multiple UAVs in a swarm.
- Payload Processing: If the UAV carries payloads such as cameras or sensors for data collection, Raspberry Pi can process and analyze the data in real-time or store it for later retrieval.
- Onboard Computer Vision: Raspberry Pi can be used for onboard computer vision tasks, such as object detection, tracking, and recognition, which can enhance the UAV's capabilities for tasks like search and rescue, surveillance, and agricultural monitoring.
- Customization and Experimentation: Raspberry Pi provides a flexible platform for experimentation and customization. Users can develop and integrate custom software modules, algorithms, and peripherals to tailor the UAV's capabilities to specific applications or research needs.

2.3 Risk Analysis

- Battery Endurance: Balancing the battery capacity with the drone's power consumption is an important consideration in the design. While ensuring sufficient power output, the weight of the battery and its impact on overall flight performance must also be noted.
- Structural Strength: The carbon plate frames must undergo precise mechanical analysis to ensure stability and safety when subjected to various forces during flight, such as lift, thrust, and inertial forces.
- System Integration and Testing: The integration of all electronic components and mechanical structures needs to be precise. The testing phase should include flight tests under multiple scenarios and conditions to ensure the design's reliability and safety.

3. Ethics and Safety

3.1 Ethics

- According to the provisions of IEEE CODE, we ensure that drones will not generate ethic concern from the following aspects:
- During the testing and use phase of the drone, we read and ensure that the drone is in full compliance with all applicable airspace management and drone operation regulations.
- EVLOT is equipped with advanced safety features, such as obstacle avoidance testing, emergency handling and automatic homing when controlling signal terminals, to ensure its safety in various flight missions.
- EVLOT drones use electric energy and foam panels and have less environmental damage than traditional transport vehicles.
- The cloud uses encryption protocols and complies with relevant privacy protection laws to ensure that users' private information is not disclosed

3.2 Safety

- For the electrical safety, we have chosen a circuit board with a good battery management system, overload protection, short circuit protection, isolation design to put into use.
- For the mechanical safety, the structure is designed in accordance with international or regional safety standards, and regular inspection and maintenance are conducted to ensure long-term safe use, and the parameters of all aspects of the fuselage are accurately calculated.
- And set up the development of emergency shutdown mechanism, used to quickly interrupt the flight in emergency situations, to minimize possible damage.
- For the lab safety, we use simulation software, the operation of UAV in the actual environment has been simulated in the computer for many times to reduce the risk that may occur in the actual test.
- At the same time, from static testing, gradually transition to dynamic testing in limited space, and then to full functional testing in open space. In addition, we have done a series of risk assessments to respond to and prevent hazards that occur during laboratory testing.

- For the user safety, we use the software restrictions on geofencing, flight height and distance prevent accidents caused by user misoperation.

4. Citations and references

https://autoflight.com/zh/aircraft/
https://m.tb.cn/h.5wOQko6NXuiVgPn?tk=lm26WnaZJbJ
https://m.tb.cn/h.5wOjNJTe7kkUdRv?tk=ayZTWna0RBU
https://github.com/Intelligent-Quads/iq_sim
https://docs.px4.io/main/zh/
https://blog.csdn.net/caiqidong321/article/details/132013439
https://zhuanlan.zhihu.com/p/92175850
https://github.com/PX4/PX4-user_guide