Smart Drone Control System

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Introduction

Background

Drones are originally for military use but currently, instead of only focusing on military, various types of drones are developed for consumers and industries in many fields including aerial photography/video, racing, geographic mapping, safety inspections and cargo delivery etc. [1].

Objectives

- Nonlinear nature and under-actuated configuration → Unstable → A control system to achieve flight stability
- User experience
  → Lack of human-interaction → Voice Control, Remote control, Image transmission with VR, "Follow-me"
  → Different purposes or different levels of experience → A control system to equip with various flight modes
- Low flight endurance (battery life) & Low energy sustainability → Wireless Charging system

Methodology

General Procedure: Build up the smart drone with a minimum setup (a flight controller, brushless motors, Electronic Speed Controllers (ESCs), battery, power module and RC transmitter, etc.) → Interpret the codes from open-source platform such as APM and PX4. → Design and modify the flight stack and middleware and integrate different flight modes and functionalities into our control system. → Configure and calibrate the flight controller in the Ground Station. → Simulate, debug and test the control system of the drone.

Flight Control

Basic Assembly / Wiring Infographic [2]

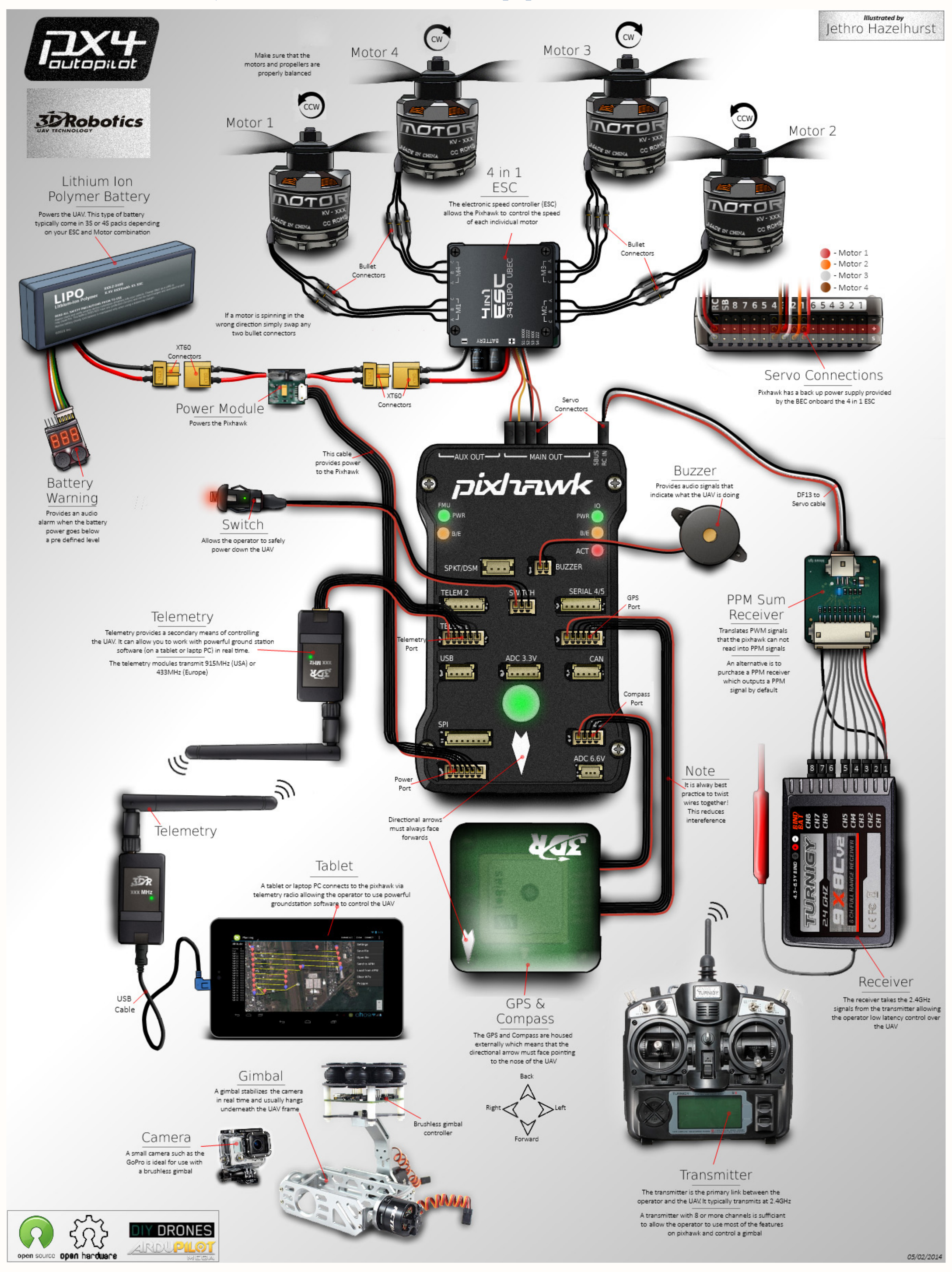

Figure 1: Basic Assembly / Wiring Infographic [2]

Flight Control Stack Design

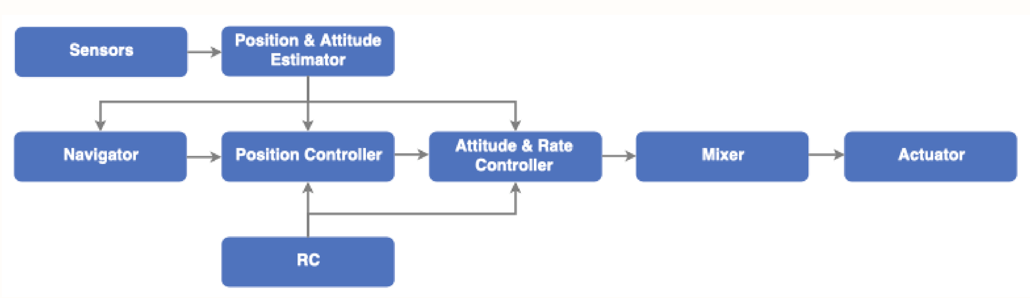

Figure 2: Control Pipeline

Estimator: Sensor Inputs → Vehicle State (e.g. attitude)
Controller: Value of the Measurement or Estimated State → Correction to match the Setpoints.
Mixer: Force command → Individual Motor Command

Drone Position Controller

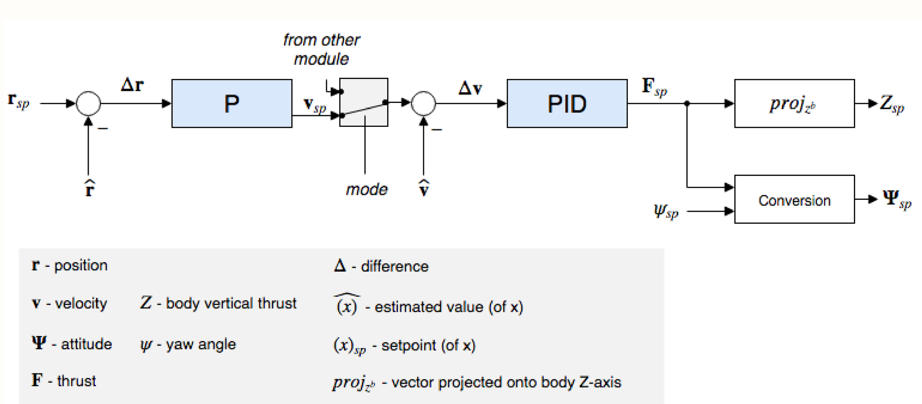

Figure 3: Drone Position Controller

Note: Estimated values are from Extended Kalman Filter (EKF) algorithm.

Wireless Charging

The theories: Faraday's Law. Furthermore, the magnetic introduction will be used in our design.
The objective: output a 5V voltage with the 12V voltage input, and the ideal efficiency is more than 60%.
The main material: coil cooper, power module, STM32 core board, circuits components.
Procedures: Firstly, build a simple circuit to let LED light on.Secondly, design the wireless charging module. In addition, design and construct the PCBs with STM32 core board.

Voice Control

The voice control module explores the key IoT platform aspects like device registry, device shadows provided by Amazon web services (AWS) IoT service to enable communication between Raspberry Pi, F450 drone and a custom Amazon Alexa skill giving the ability to control the drone via voice commands.

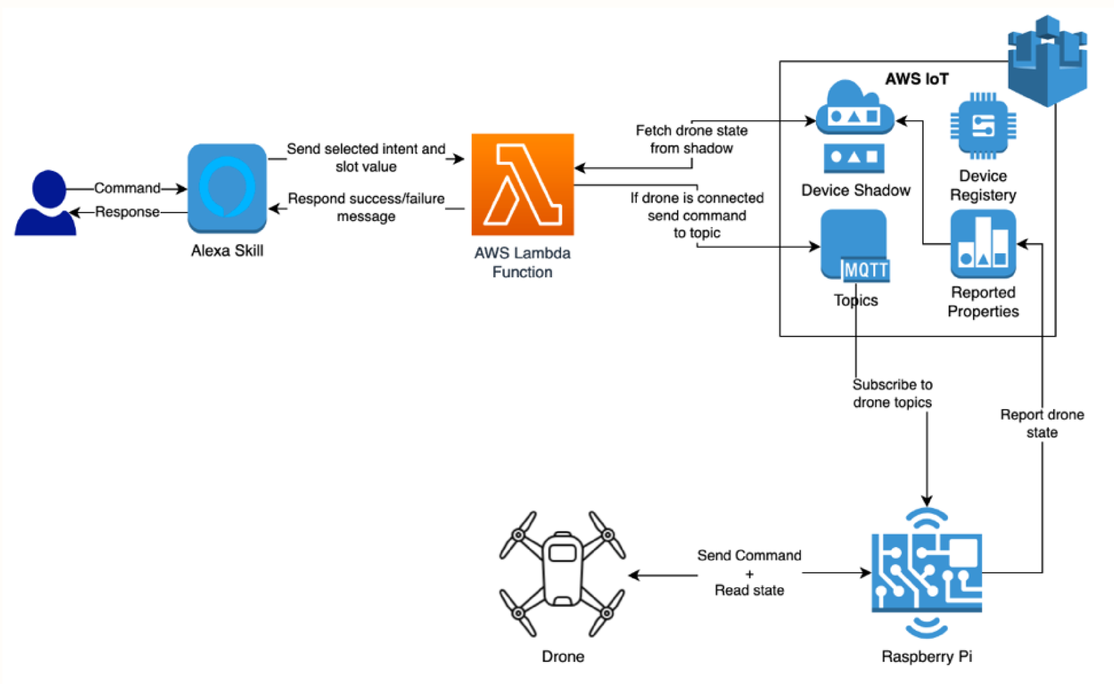

Figure 4: Voice Control Module

- User invokes the Alexa skill (in our case drone pilot) and issues a voice command
- Alexa skill validates this command with the available set of intents associated to the skill.
- Alexa then sends the identified intent to the configured AWS Lambda function endpoint, serving as the interpretation for the function of drone flying, such as take off and land.
- The lambda function receives incoming command,
  - Queries the device shadow service to check if the drone is online.
  - Creates the command message and sends it to the AWS IoT device via MQTT channel, abbreviated for Message Queuing Telemetry Transport, which is commonly used in IoT applications.
  - Responds to the Alexa command with a success/failure message.
- A Raspberry Pi zero (connected to the F450 via Telemetry)
  - Subscribes to the AWS IoT MQTT channel for new messages.
  - On regular intervals, keeps on reporting the drone telemetry like speed, battery status, wifi strength to the AWS IoT device shadow
- Upon receiving a message, the the Raspberry Pi interprets the MQTT message and issues a corresponding F450 specific command in 915 Mhz telemetry channel.

Video Transmission

The video transmission system is just a process of signal processing. The transmission and reception of the signal are completed by the video transmitter and video receiver respectively. In this project, the motion camera is used as a signal acquisition tool to transmit the signal to a 5.8GHz channel and finally get feedback on the screen. In order to reduce the load of the drone as much as possible, this group tried to integrate the video transmitter and the motion camera in the design stage. In terms of the power supply of the video transmission system, the optimal solution is to connect the motion camera and video transmitter directly to the flight control system.

Results

Product Display

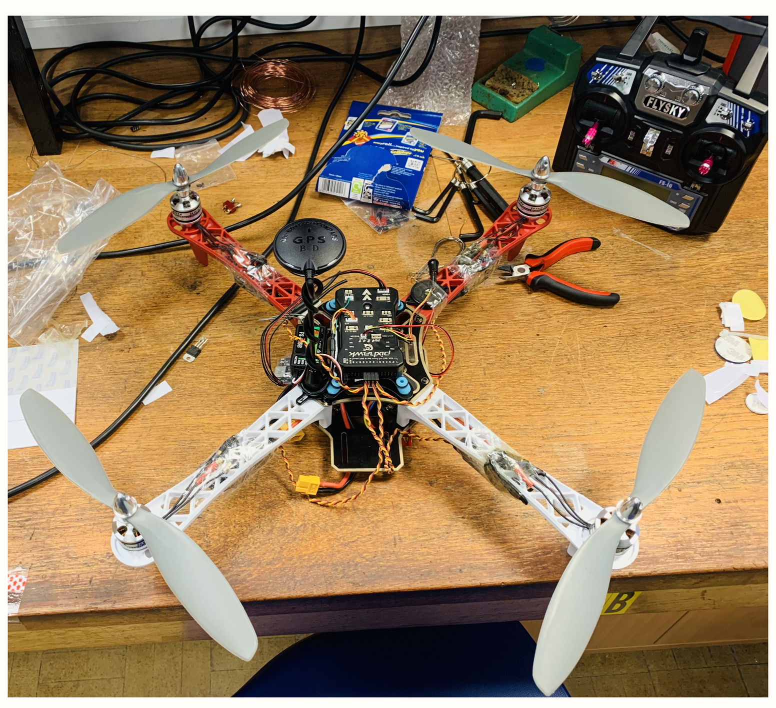

Figure 5: Product Display

Stable Flight with Different Flight Modes

Manual Modes (With RC):

Manual/Stabilized: Level out and stop once the roll and pitch sticks are centered.

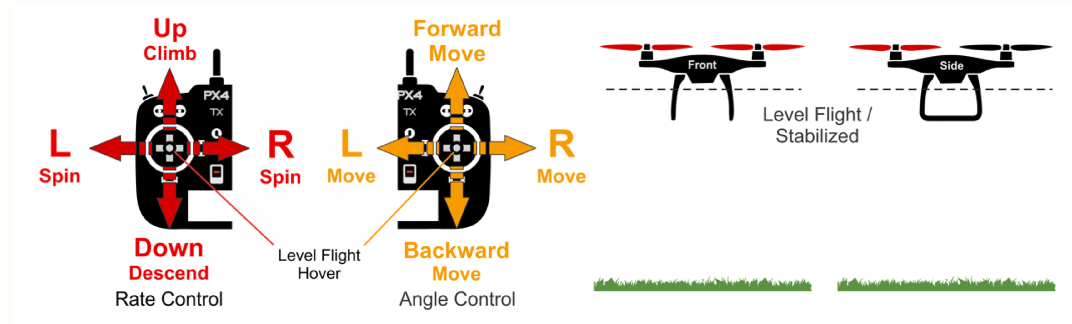

Figure 6: Manual/Stabilized RC control

Figure 7: Fly Test

Acro Mode & Rattitude Mode: Allow acrobatic movements e.g. rolls and loops.

Autonomous Modes (Without RC):

Land, Hold, Return, Mission, Takeoff and "Follow Me" (follow the target from a specified relative position, horizontal separation and height) modes.
(Note: When GPS does not work, no Position, Hold, Return, Mission, Takeoff or "Follow Me" modes. However, these modes can be achieved theoretically)

Wireless Charging

I finished the simple circuits, and the PCBs design which is However, the materials didn't arrive as schedule, and I cannot construct the circuit, which I will explain in report.

Voice Control

The demonstrations are illustrated in outdoor video recording and indoor micro drone voice invocation test.

Video Transmission

Image display is the best way to verify the results of the video transmission system. In order to highlight system innovation and improve user experience, the project team finally used vr glasses instead of display screens as system terminals, which made the project results closer to the definition of FPV.

Conclusion

Contributions

In summary, the smart drone equipped with an effective control system with various flight modes, wireless charging method and human interaction functionalities such as voice control, remote control and image transmission system was achieved in this project as discussed above.

Limitations

- Some of the flight modes cannot be tested due to poor GPS ability.
- The wireless charging system cannot supply a required voltage to the drone Li-Po battery.
- The communication between the Raspberry Pi and flight controller was not achieved.
- The pictures captured by the drones cannot be stored into local devices.

Future work Some development and improvement for the smart drone control system are listed as follows. Firstly, more flight modes, features and functionalities can be integrated into the drone based on new sensors, configurations and firmware without affecting its stability and robustness. Examples may include emergency response and disaster area relief. Second, investigate how to improve the charging efficiency and to stabilize the output voltage of the wireless charging system. Next, the MAVlink (communication) between the flight controller with other microcontrollers such as Raspberry Pi should be further studied. Finally, the integration of the image transmission system into the flight controller should also be advanced.

References

[1] https://www.digitaltrends.com/cool-tech/history-of-drones/

[2] https://docs.px4.io/master/en/assembly/quick_start_pixhawk.html

[3] https://github.com/erviveksoni/alexa-controlled-drone#connecting-raspberry-pi-to-tello

Blog Link Reference: https://dteng8.wixsite.com/liverpoolsmartdrone