Development of surveillance drone based internet of things (IoT) for industrial security applications

H Ali, L Y Hang, T Y Suan, V R Polaiah, M I F Aluwi, A A Mohd Zabidi, M Elshaikh

Faculty of Electrical Engineering Technology, UniMAP, 02600 Arau, Perlis, MALAYSIA

Abstract. Drones or mini-unmanned aerial vehicles, have becoming an emerging trends due to their boundless applications in surveillance, military and numerous public services. Nowadays, deployment of surveillance drone for monitoring or security application remains challenging and ongoing research. As Internet of Things (IoT) becomes more commercialized, various concept of IoT have been integrated with the drones due to efficient usage. Therefore, this paper proposed the development of surveillance drone system based on IoT for industrial monitoring-security applications. The rationale of integrating IoT with surveillance drone is that it allows authenticated users to login from any device, anywhere, and view video or images from surveillance drones in real-time for security awareness. In this work, the surveillance drone consists of mechanical system, electrical and electronic interfacing and IoT platform (mobile application system). In electronic system, power module, communication module, sensor and actuator as well as user interface module have been adopted and integrated into the systems. Besides, in software development system, user interface configuration was developed through mobile application to serve as IoT platform. A series of experiments shows that the surveillance drone based IoT able to operate with a promising flying distance with surveillance camera as the “eyes” of the drone system.

1. Introduction

Drones or mini-unmanned aerial vehicles (UAV) becomes an emerging trends due to sizeable impact in various applications ranging from military, public safety, communication, surveillance and government sector [5-9]. As drone becomes user friendly, efficient usage, various IoT concept have been integrates for example, into agriculture drone improving agriculture crops as well as helping the farmer to capture data, in real-time application. Shruthi et al. [3] utilized IoT based automation using drones for agriculture applications. They employed the system not only to monitor the crops but also to determine the health condition of the plant whether in health status or stressed using normalized difference vegetation index (NDVI). In similar work, Saha et al. [4] also utilized IoT based automation using drones with equip appropriate sensor, camera and modules for improving crop quality in the agriculture field. They able to gather accurate data using hyperspectral imaging techniques. On the other hand, one of the main issue that need to be resolved is the security problem in UAV [2]. Security and surveillance are one of the biggest growth areas in the ever-expanding UAV sector. When the public communications networks are disrupted or in certain disastrous situations like poisonous gas infiltration or wildfires, ability to accesses in hazardous area becomes even challenging and risky.
Recently, Ding et al. [1] had developed a new vision for amateur drone surveillance called Dragnet using cognitive Internet of Things (IoT) to empower amateur drone with a “brain” for high-level intelligence. This amateur drone surveillance however involved complex integration that utilized various passive and active surveillance such as fog camera, radar, sensor, surveillance drone, crowd of people that serves as local fog nodes. Thus, this paper proposed the development of surveillance drone system using Internet of Things (IoT) for industrial security application. The rationale of integrating IoT based surveillance drone is that it allows authenticated users to login from any device, anywhere, and view video or images from surveillance drones in real-time.

2. Material and Method

2.1. Proposed system description

Figure 1 shows the proposed surveillance drone system that consists of mechanical system, electronic system and software system. Each of the components is described in the following subsections. Figure 2 shows the product architecture for surveillance drone system based IoT. It related to the functional elements and physical components of products.

![Figure 1. The proposed surveillance drone system based IoT.](image-url)
2.2. Hardware development
This section presents brief hardware development of the proposed system. It consists of:

2.2.1. Prototyping concept. In this work, drone frame with four arms had been proposed. Due to fabrication difficulties, we have utilized the manufactured frame of drone as the main body components. Figure 3 shows the physical drawing of manufactured mainframe with specific dimension.

Figure 2. Product architecture of surveillance drone system based IoT.

Figure 3. Illustration of manufactured frame dimension
2.2.2. **Drone frame material.** Ultra polyamide nylon was selected as drone frame materials as it exhibits good strength and durable in terms of mechanical properties. Figure 4 shows the 3D view of mainframe components of drone body.

![Figure 4. Example of 3D view of drone main components](image)

2.2.3. **Motor.** The 2212 960kv brushless motor was used to provide thrust force to the drone as shown in Figure 5. Four motor (known rotors) are mounted to each of the propeller to spin (rotate). Two motors are attached to the propeller in clockwise direction and another two in counter-clockwise direction.

![Figure 5. The 2212 920 kv brushless motor](image)

2.2.4. **Power module.** The 11.1V 30C 3S 2200mah rechargeable Li-Po Battery was used to supply the power to the entire system.

2.2.5. **Microcontroller.** The Arduino Uno and Raspberry Pi B+ are adopted as microcontroller in performing the operation of the proposed system.

2.2.6. **Raspberry Pi Camera.** The raspberry pi B+ was used as surveillance camera to mimicking “eyes” of the drone. Figure 6 shows the connection of raspberry pi B+ camera with microcontroller.

![Figure 6. Raspberry Pi camera (left) and Arduino microcontroller](image)

2.2.7. **Electronic Speed Controller.** Use to adjust the speed of the brushless motor.

2.3. **Electrical & Electronic Interfacing Configuration**

Figure 7 shows the schematic diagram of mechanical, electrical and electronic interfacing. The 4 channel receivers was connected to pin 8, 9, 10, 11 of the Arduino Uno (which it receives the transmitter signal from the user). Then, pin SDA and SCL of Arduino Uno were connected to a MPU-6050 Gyroscope to control the stability and balancing of the drone using PID controller. In addition, the brushless motors configuration were not connected directly to the Arduino Uno microcontroller. Their output signal need be passed through the Electronic Speed Controller (ESC) first for speed adjusting. The ESC then will
receive a signal from the microcontroller and adjust the speed of the brushless motor. Two brushless motors were connected in clockwise (right rear, left front) and another two motors were connected in counter-clockwise rotations (right front, left rear).

Figure 7. Raspberry Pi camera (left) and Arduino microcontroller

2.4. Software Development: Camera Configuration & Mobile Application
The camera acts as ‘eyes’ of a drone, in which it can be used to view, record and stored the images. It also has capability to detect and track the motion in the specific area of interest. Having small size and capable in recording and capturing up to 72 degree, it is considered the best possible range for surveillance view. In this work, camera was connected to the camera module port on raspberry pi B+ via the CSI cable. Figure 8 depicts the camera configuration and the interfacing software.
In developing IoT platform, MIT Apps environment was used in designing the mobile application. Figure 9 shows the example of mobile app design in MIT environment.

Figure 8. Camera configuration and interfacing software
3. Results and Discussion

3.1. Surveillance Drone System

Figure 10 illustrates the results of the development of surveillance drone system. It consists of integration between mechanical, electrical and electronics components. For a drone to take off, the power source is supplied to the brushless motors. It used to generate torque of the propellers to spin. Each of the propellers will generate the thrust, if the thrust generated is higher than the drone’s weight, the drone will take off and fly. To change the direction of the drone, the user will send signals via a transmitter to the receiver connected on the drone. By adjusting the thrust generated at each motor, the quadcopter is able to change its direction and orientation.

Figure 10. Surveillance drone system.

3.2. Mobile Application based IoT

Figure 11 shows results of mobile application develop in MIT environment. It displays the welcoming message at the homepage of surveillance drone. In this apps, it requires the user to login the IP address. Then, the system will check the IP address entered whether correct or not. If correct, the surveillance camera will operate otherwise it go back to entered the valid IP address. The process of surveillance will continue until the user ask to exit of finish the task. Figure 12 shows the block function of the whole process with camera button, user IP address, error notification and the exit button with respective operation.

Figure 11. Front page of mobile apps.
3.3. Overall Surveillance Drone System Based IoT

The overall surveillance drone system based IoT using mobile application is depicted in Figure 13. A series of experiments has been conducted to simulate and testing the performance of the system. Results show that the surveillance drone system based IoT gives promising flying distance with the camera acts as “eye” of the drone system. However, further studies should be conducted on the proposed system to improve the performance such as stability, robustness and also drone distance travel. Development of surveillance drone based IoT can improve the security and safety in the industrial applications.

4. Conclusion

This paper has presented the development of surveillance drone system based on Internet of Things (IoT). The proposed system consists of the integration of mechanical, electrical and electronic interfacing and mobile application software system. Based on the results obtained, the drone system shows a promising flying distance with camera acts as the “eye” of the drone to perform the surveillance task. Thus, in this research the surveillance drone system based Internet of Things (Io) platform able to improve the security system especially in the industrial area. Surveillance drone based IoT able to provide coverage view better than traditional surveillance camera. However, further studies should be conducted on the proposed system to increase the robustness as well as enhancing real-time application using surveillance drone system based IoT.

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