A Review on Aerial Surveillance and Public Safety

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Abstract — Aerial surveillance cannot be done round the clock due to human pilot and can only fly for certain time. This problem can be solved by introducing the drone where there is no pilot physically present on these plane/drone due to the remote piloting system. If there is a need to change the pilot, these plane/drones can hold there altitude while the change of pilot's takes place at base station/control station. Surveillance and target acquisition have evolved in a way that these process can be done remotely using drones. These drone can fly for indefinite times because of aerial refueling techniques and also helps us in rescues operation were its difficult to send any reconnaissance plane due to bad weather or risk life of the pilot and crew. Drone surveillance assist ground forces to get a live footage of hostile in an area. The cruising speed and altitude so it cannot be easily detected from radars.

Keywords — ***Drone, DJI Naza, Public Safety, Military, Surveillance, Emergency Communication, IOT***

I. INTRODUCTION

Design an autonomous and unmanned aerial platform capable of control and target acquisition. The designed aerial platform can be able to achieve the objectives at a standard high of working effectivity and efficiency. Complete design of the system as well as system integration will be the focus of the project. Drones were originally developed for military purposes and are deployed in high-risk military areas; technology is improving and becoming more affordable. A growing demand for the use of drones in the military sector has, recently, spread into civilian contexts.

The soul motivation of this design is that it can perform the surveillance in best possible manner so that it doesn't cause more inapprehensible damage that create more chaos.

Manned helicopter/plane were used to locate the target which proved to be very difficult due to their manoeuvrability was quit restricted as they could not turn at sharp angles and the acceleration was not that quick to serve the modern situation. Another reason was there massive size when it was compared with a drone with same surveillance equipment on board.

The surveillance drone can move in sharp angles as they are smaller in size. The drone have less radar cross section with respect to manned helicopter/plane. In this context, it is clear that the need for a solution that can really address the problem, being able to be quickly deployed and that can keep track of an area. Use of a surveillance drone to search the target or rescue the target.

II. LITERATURE SURVEY

The surveillance cannot be done round the clock due to human pilot that can only fly for a certain time period. This problem can be solved by the introduction of remote controlling the plane or drone where there is no pilot physically present on these plane/drone due to the remote piloting system. If there is a need to change the pilot, these plane/drones can hold there altitude while the change of pilots takes place at base station/control station

- **Drones for Public Safety:**

Drones can fly autonomously in the sky and are associated with different applications in civilian tasks such as transportation, communication, etc. They are a promising technology because of their rapid and easy deployment, ability to dynamically change location in an emergency situation, quick reconfiguration, and flexible technology. Furthermore, they can provide effective communication for a public safety network. Moreover, drones can move around to provide large disaster coverage area faster and achieve ubiquitous connectivity within a minimum time in a public.

- **Coverage Area of the Drone:**

The coverage can be extended with a number of drones. These drones can connect with each other and with first responders over an emergency or disaster area for delivering services accordingly. A drone lifts a flying platform by incorporating communication technologies such as Ad hoc, WiFi, WiMAX or LTE equipment to provide efficient communication services. A disaster generally destroys all of the communication and electric supply infrastructure. Figure 1 gives an understanding about the coverage area. For some people, the availability of electricity means the difference between life and death. Electric power is required for lighting medical aid stations, ventilation and delivering water to people in shelters. Therefore, power is beamed from a drone to the rescue and relief team receiver devices over the disaster area.

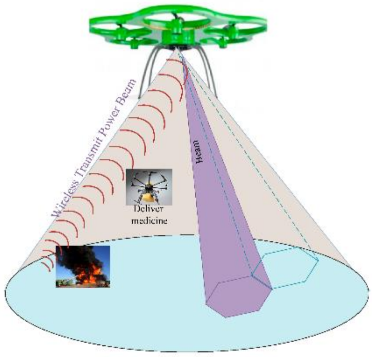

Figure 1: Coverage area

- **Public Safety:**

Connected devices over internet have a vital role in enhancing the performance of a public safety network in terms of accuracy, efficiency, and predictability [1]. Figure 2 gives an understanding about the public safety. Furthermore, IoT devices have to analyse, aggregate information, and transmit without human intervention. This ensures the accuracy of received information and enhances the ability to anticipate crimes and other incidents.

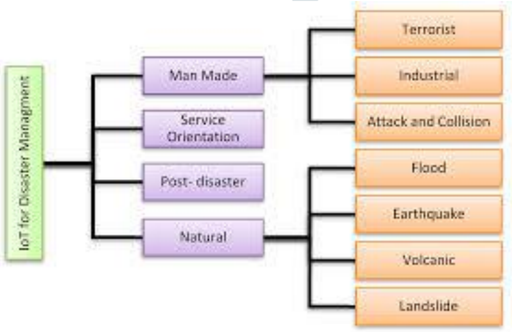

Figure 2: Public safety

III. METHODOLOGY

❖ **Basic Physics Behind a Quadcopter:**

The rotor act as wings. They generate thrust by rotating at fast speeds, which pulls the air downwards and keeps the quad in the air. The thrust cancels out the acting weight and quad hovers. A directional thrust causes the quad to move in that direction. Or a decrease in thrust overall causes the Drone to lose height.

❖ **Setup of Motor in a Quadcopter:**

The setup done to a quadcopter for flying is such that:

- Two adjacent motors spin in the opposite direction.
- Two opposite motors spin in the same direction.

Out of 4-motors, 2-motors will have a clockwise spin and the other 2-motors will have a counter-clockwise spin. So, according to the setup mentioned above 5 & 6 will rotate in counter clockwise direction while 2 & 3 will rotate in clockwise direction as shown in figure 3.

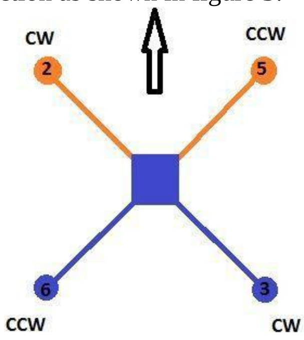

Figure 3: Setup of Motor in a Quadcopter

❖ **Setup of Rotors:**

It is so because the physics says to be in stable state the net forces acting on a body should be zero. So if all the rotors were to spin in the same direction, it would result in a net torque (rotating force) causing the complete quad to rotate.

❖ **Lifting of Quadcopter:**

When lift is caused or produced in a quadcopter due to the thrust proposed by the propeller. It is created by the force exerted by a fluid flowing past the surface of the body. The rotational speed of motors determines the magnitude of lift each propeller produces. Thus by adjusting the relative speed of the four rotors the flight controller is able to cause the multirotor to rotate around any of the directional axis or change the altitude.

❖ **Directional Axis:**

The directional axis gives us the direction of where a quadcopter is moving (in which direction and on what axis). Following are the three directional axis Roll, Pitch and Yaw as shown in figure 4.

- **Roll -** The roll of the multirotor describes how the craft is tilted side by side rolling the multirotor causes it to move sideways.
- **Pitch -** The pitch angle of the multirotor describes how the craft is tilted forwards of backwards. Pitching the multirotor causes it to move forwards or backwards.
- **Yaw -** The Yaw angle of the multirotor describes its bearing, or, in other words, rotation of the craft as it stays level to the ground.

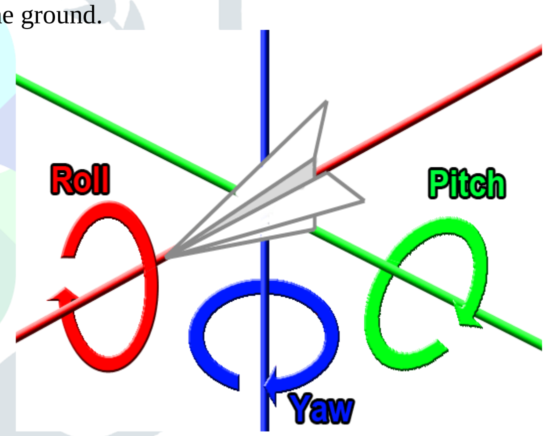

Figure 4: Representation of Directional axis

❖ **Controlling of Roll:**

Motors on one side must spin faster than the motors on the other side. Motors on one side will have more lift, thus lifting the quadcopter. Suppose we want to roll the quadcopter towards left, the Thrust on the motor of right side is increased. And we also decrease the Thrust on the motors on the left. This is to keep the Net Torque zero and allowing a leftwards Net force.

❖ **Controlling of Pitch:**

Make motors on one side spin faster than motors on the other side to create more lift on one side & tilt the quadcopter. To pitch forwards (Towards us) - The power to the quadcopter rear motors is increased. This creates a net forward force which causes the Drone's nose to pitch downward.

❖ **Controlling of Yaw:**

In this case the Torque of one pair of rotor blades (which are across from each other) is not equal to that of the other pair of rotor blades. Unequal torques leads to a net torque, resulting in rotation of the entire body due to angular acceleration. To Yaw clockwise - We increase the Thrust on the Anti-Clockwise moving motors. And decrease the thrust on clockwise rotating motors. Due to this there is a resulting Anti-clockwise torque and the quad rotates in clockwise to conserve the angular momentum.

❖ Hovering of Drone:

For Hovering of a quadcopter there are some conditions:

- The lift generated must be equal in magnitude to the force of gravity on the aircraft.
- Therefore, there is a net force of zero and a constant velocity.
- Each rotor must be generating the same amount of lift.
- The torque of two sets of rotors cancels out.

Hovering is not a fixed setting due to many variables acting on the quadcopter so constant adjustments are required -

- A Gyroscope independently corrects the Thrust of the motors.
- Trim adjustment controls are used manually to correct any drift.

❖ Altitude Control of Drone:

If lift produced by rotors is greater than the force of gravity then the quadcopter will ascend. To achieve this increase the speed of all the motors equally. If lift is less than the force of gravity then the quadcopter will descend. To achieve the condition decrease the speed of all the motors equally.

❖ Thrust in Drone:

It is a reacting force explained by Newton's second law and third law. When the engine does work and accelerates the gas to the rear of the engine. A force equal in magnitude but opposite in direction from the accelerated gas is generated. Dependent on the amount of gas that is accelerated. (In case of quadcopter the difference between the pressure at the lower and higher part of the propeller creates the thrust that causes the quadcopter to lift). Thrust is used to overcome drag.

❖ Dynamic Thrust:

All thrust test are done on a static (or stationary) motor. Once a propeller in dynamic situation, the thrust changes. Putting the throttle to 100% & starting from 0 mph, the prop. Will be at maximum thrust. Thrust is generated from a propeller due to a pressure difference between front and rear of the propeller. As the propellers rotates, the underside of the blade compress and pushes the air which creates a high pressure area. The topside of the propellers, as it rotates, creates a low pressure area since air is rushing into the space the prop once occupied. This pressure difference is greatest when the quad is at a standstill since the pressure difference created is related to the velocity of the incoming air.

❖ What is a Drag?

- It is a type of Friction, referred to as air resistance.
- It is parallel to the fluid's flow direction.

As our quad increases in speed, the amount of drag force it encounters also increases. The quad will keep accelerating till the thrust force is greater than the drag force. Once these forces are equal, we stop accelerating and the velocity will become constant. So now thrust is being used up in 2 different ways:

1. Acceleration
2. Drag offset

❖ Drag Equation

Practically the thrust decreases linearly with speed up to the theoretical pitch speed. To reach pitch speed, we have a thrust of zero meaning we would have to eliminate drag completely. To move faster, more thrust should go towards acceleration and less power is soaked in drag.

$$F_D = \frac{1}{2} \rho * v_2 * C_D * A$$

where:

F_D : Drag force
ρ : fluid density
v : Relative velocity between the fluid and the object
C_D : Drag coefficient
A : Transversal area or cross sectional area

The only two variables we have a direct control over is A & C_D. The main thing to keep in mind here is that the v is squared. That means if we cut our A or CD in half, our overall FD will only be cut by ¼. Not only that, we will have an increase in velocity which means FD won't even be cut by1/4. However, since frame designs are so poorly designed for aerodynamics, we can easily gain a significant amount of speed by reducing our area and streamlining the frame.

❖ Drone Component –

These are the equipment/components used to in a drone. These component may vary from application to application, but the taking in consideration of all the drone dynamics. Figure 5 gives an understanding about the basic black diagram of a drone.

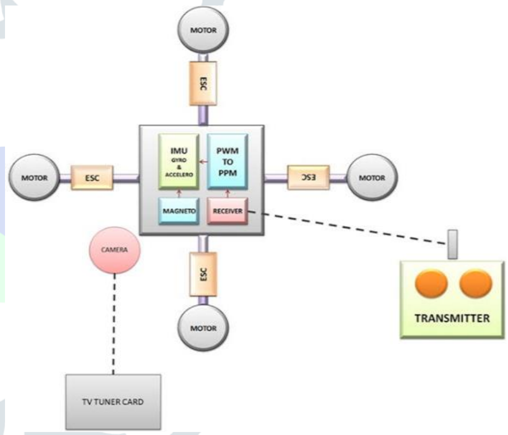

Figure 5: Block diagram

Propeller:

The propeller is a component which generate thrust and makes the drone to perform activities such as pitch, roll and York. The thrust produced by a propeller depends on the density of the air, on the propeller's RPM, on its diameter, on the shape and area of the blades and on its pitch. A propeller's efficiency relates to the angle of attack which is defined as the blade pitch minus the helix angle (the angle between the resultant relative velocity and the blade rotation direction). The efficiency itself is a ratio of the output power to the input power. Most well-designed propellers have an efficiency of 80%+. The angle of attack is affected by the relative velocity, so a propeller will have different efficiency at different motor speeds. The efficiency is also greatly affected by the leading edge of the propeller blade, and it is very important that it be as smooth as possible. Although a variable pitch design would be best, the added complexity required as compared to a multirotor inherent simplicity means a variable pitch propeller is almost never used. Figure 6 gives an understanding about the Propellers.

Figure 6: Propeller

Motor:
The KV rating / value of a motor relates to how fast it will rotate for a given voltage. For most multirotor aircraft, a low KV is desired (between 500 to 1000 for example) since this helps with stability. For acrobatic flight however, you might consider a KV between 1000 and 1500 and also consider using smaller diameter propellers. If the KV rating for a particular motor is 650rpm/V, then at 11.1V, the motor will be rotating at 11.1V x 650 = 7215rpm. Figure 7 gives an understanding about the Motor.

Figure 7: Motor

ESC:
An ESC (acronym for "Electronic Speed Controller") is what allows the flight controller (covered in the next lesson) to control the speed and direction of a motor. The ESC must be able to handle the maximum current which the motor might consume, and be able to provide it at the right voltage. Most ESCs used in the hobby industry only allow the motor to rotate in one direction, though with the right firmware, they can operate in both directions. Figure 8 gives an understanding about the ESC.

Figure 8: ESC

Battery
Batteries used in UAVs are now almost exclusively Lithium polymer (LiPo), with some more exotic ones being Lithium-Manganese or other Lithium variations. Lead acid is simply not an option and NiMh / NiCad are still too heavy for their capacity and often cannot provide the high discharge rates needed. LiPo offer high capacity with low weight, and high discharge rates. The downsides are their comparatively higher cost and continued safety issues. Figure 9 gives an understanding about battery.

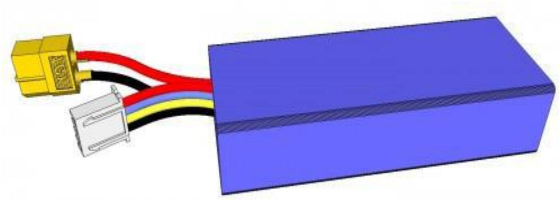

Figure 9: Battery

Receiver:
The receiver is the unit responsible for the reception of the radio signal sent to the drone through the controller. The minimum number of channel that are needed to control a drone are usually 4. However it is recommended that a provision of 5 channel be made available. There are very many different types of receiver in the market and all of them be used making a drone. Figure 10 gives an understanding about the Receiver.

Figure 10: Receiver

Transmitter:
The transmitter in the unit responsible for the transmission of the radio signal from the controller to the drone to issue command of flight and direction. Just like the receiver are available in the market for drone manufacture to choose from. The receiver and the transmitter must use a single radio signal in order to communicate to the drone during flight. 4 channels are needed for transmission but 5 is usually recommended. Each radio signal has a standard code that help in differentiating the signal from the other radio signal in the air. Figure 11 gives an understanding about the Transmitter.

Figure 11: Transmitter

Flight Controller:
The flight controller is basically the motherboard of the drone. It is responsible for all the command that are issued to the drone by the pilot. It interpret input from the receive the GPS module. The Battery monitor and the onboard sensors. The flight controller is also responsible for the regulation of motor speed through the ESC and for the steering of the drone. Any commands such as trigger of the camera, controlling the autopilot mode and other autonomous function are controlled by the flight controller. Figure 12 gives an understanding about the Flight Controller.

Figure 12: Flight Controller

Camera Module:
This module is made to be able fit the size of the drone. This is the key component for surveillance. This send the data to the receiver/base station. Figure 13 gives an understanding about the camera module.

Figure 12: Camera Module

Figure 13: Final Image of Assembled Drone

IV. Conclusion

There are several new potential uses of drones, as we have seen in the previous sections, in the public and in the private sectors, and in the agriculture, commerce, environment, and energy sectors.
Drone technology is immensely being applied to improve first responses and public safety, due to the important features such as easy deployment, low cost and ease of maintenance and operation.
Drones also offer sophisticated remote sensing solutions in many jading areas, medical supply delivery to remote locations, and military application.
From this work, it is concluded that reliable public safety networks could be developed through the application of drone technology. The drone-based surveillance provide efficient connectivity services in the evacuation of affected people and can control crime much more conveniently with the interaction of relief, rescue, and police teams.
Thus, the embedded system and drones can be deployed during red alerts at unreachable sites for achieving data communication with a large coverage area. Hence, the collaboration of connected devices and drones would provide instant connectivity services with enhanced surveillance parameters

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