SURVEILLANCE DRONE FOR MILITARY APPLICATION

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ABSTRACT**:** UAV is defined as an aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expandable or recoverable, and can carry a lethal or nonlethal payload. It is controlled either autonomously by on-board computers or by remote control of a pilot on the ground. Its usage is currently limited by difficulties such as satellite communication and cost. A Drone has been built that can be operated by radio frequency controller and send live audio-visual feedback. The developed Drone control system has been simulated in MATLAB/Simulink. The simulation shows a very stable operation and control of the developed Drone. Microcontroller based drone control system has also been developed where a RF transmitter and receiver operating in the frequency of 2.4 GHz are used for remote operation for the Drone. Earlier, Drones were deployed for military applications such as spying on both domestic and international threats. The developed drone in this work can be used for a number of applications, such as policing, firefighting, monitoring flood effected areas, recording video footage from impassable areas and both military and non-military security work. In addition, using an Android mobile device incorporation with GPS has been used for live position tracking of Drone and real time audio-visual feedback from Drone.

KEYWORDS: Surveillance, Drones, UAV, Military applications.

I. INTRODUCTION

Unmanned aerial vehicles (UAV) are more properly known as Drone. Basically, drone is a flying robot. Working in combination with GPS, the flying machine may be remotely controlled or can fly autonomously by software controlled flight plans in their embedded systems. Drones are most often used in military services. However, it is also used for weather monitoring, firefighting, search and rescue, surveillance and traffic monitoring etc. In recent years, the drone has come into attention for a number of commercial uses. In late 2013, Amazon announced a plan to use unmanned aerial vehicles for delivery in the nearby area's future. It is known as Amazon Prime Air; it is estimated to deliver the orders within 30 minutes inside 10 miles of distance. So, it is clear that domestic usage of UAV has vast future possibility in different fields rather than military usage. Drones for military use were started in the mid-1990s with the High-Altitude Endurance Unmanned Aerial Vehicle Advanced Concept Technology Demonstrator (HAE UAV ACTD) program managed by the Defense Advanced Research Projects Agency (DARPA) and Defense Airborne Reconnaissance Office (DARO). This ACTD placed the base for the improvement of the Global Hawk.

The Global Hawk hovers at heights up to 65,000 feet and flying duration is up to 35 hours at speeds approaching 340 knots and it costs approximately 200 million dollars. The wingspan is 116 feet and it can fly 13.8094 miles which is significant distance. Motherland security and drug prohibition are the main needs Global Hawk was designed for. Another very successful drone is the Predator which was also built in the mid-1990s but has since been improved with Hellfire missiles. "Named by Smithsonian's Air & Space magazine as one of the top ten aircraft that changed the world, Predator is the most combat-proven Unmanned Aircraft System (UAS) in the world".

The original version of the Predator, built by General Atomics, can fly at 25,000 feet for 40 hours at a maximum airspeed of 120. Issues of drones can be classified in different ways like morally, ethically and legally. In many country's drone is not permitted to fly openly, but in some advance country is now allowing drone for social purposes. Also, there is a build up a decent drone marketplace in Singapore but from ethical point of view it has some conflict using drone. Military drone manufacturers are also looking for an upgrade civilian uses for remote sensing drones to spread their markets and this includes the use of drones for surveillance where it's needed. Drones will no doubt make possible the dramatic change in the surveillance state.

With the convergence of other technologies, it may even make possible machine recognition of faces, behaviours, and the monitoring of individual conversations. In the absence of government clearness, civil society has led substantial research on drone strikes. The Bureau of Investigative Journalism, a not-for-profit organization based at City University, London, has published figures that give some logic of the scale of such US operation. To illustrate, according to the Bureau between 2004 and 2012 there have been 330 attacks in Pakistan, with the entire reported quantity killed being between 2479 and 3180 people (and more than 1,000 other people being injured); and between 44 and 54 confirmed US operations in Yemen (with 31 to 41 drone strikes), with a possible further 87 to 96 operations (including 49 to 55 drone strikes).The total number reported killed was between 317 and 826 people. Activists for drones argue that drone operator's distance from the battlefield allows them to base their decisions on a range of supporting data types. However, it is more likely that the greater the physical and emotional distance to a target, the easier it is to kill. There is no empirical evidence that shows that the support data enables greater legal and ethical decision-making processes. Statistically the world has seen numerous civilian casualties from drone strike, which depicts that drones further dehumanize war.

The rapporteur also highlighted the creating of a PlayStation mentality, where drone operators tend to regard their actions as a computer game. However, in this thesis project mainly we are designing the Roll Trolls(s), pitch Tpitch(s) and yaw Tpitch(s) angle control system design and simulation of the designed control system. In addition, we are going to integrate android mobile device, GPS and 3G communication technologies to gather real-time audio-visual geo location information.Many methodologies have been tried to improve real-world aircraft with vertical take-off and landing abilities. First, Nikola Tesla introduced a vertical take-off and landing vehicle concept in 1928. Advanced VTOL aircrafts uses a single engine with thrust vectoring. Thrust vectoring illustrates that the aircraft can send thrust from the engine in different directions, so that vertical and horizontal fight can be controlled by one engine. The Harrier Jump Jet is one of the most famous and successful fixed-wing single-engine VTOL aircraft. In the 21st century, UAVs are becoming progressively conventional. Many of these have VTOL capability, especially the quad copter type. We were also interested by the requirements of DARPA's UAV forge. UAVs competition which was posted around the time, we started our project. The UAV forge contest us basically to design and build a micro-UAV that can take off vertically, go to the destination and surveillance the area for three hours. We know transporting and resupplying troops is a great challenge in war field.

To meet this challenge DARPA initiated a program in 2010 demonstrating four-person vertical takeoff and landing vehicle. Lockheed Martin's Skunk Works® is foremost a group with Plawecki Aircraft to improve the next generation of dynamic vertical take-off and landing (VTOL) transport systems under the ARES program. ARES VTOL flight unit is designed to work as an unmanned platform capable of transferring a variety of payloads. The flight unit has built in digital flight controls, remote command-control interfaces, power system and gasoline. Twin tilting ducted fans would deliver effective flying and landing abilities in a compact structure. It is capable of rapid change to high-speed travel voyage. However, this project is under development now. Our project has similarities with this Lockheed Martin's research and the flying methodology is partially similar to their machine. On the other hand, using drone in firefighting has already been taken place in history. It delivered firefighters up-to-the-minute information. In addition to the military practices of the drones, we were concerned in evaluating applications in the industrial, commercial and as well as government sector. In addition, new markets and uses will emerge if small drones are very available. Potential new markets in business and modern applications incorporate reviewing pipelines or actually investigating perilous regions like an emergency site at an atomic force plant. Although the designs of different UAVs are charming, our interest was in attempting to produce a small UAV which could support a broad mission capability.

II. DESIGN PERSPECTIVES

To build such a dynamic unmanned aerial vehicle we need to attach many complex electronic devices. In this implementation, we have used many intelligent electronic devices like brushless DC motor, KK2.1.5 Multi-Rotor board, ESC (electronic speed controller), digital servo motor and 3300 mA Lithium Polymer battery. In this chapter, we will discuss about all those electronic components and their behavior. Also, development of telemetry system for real time communication with drone is introduced in this section. In addition, control system design and MATLAB simulation result analysis are included in this session. In order to develop this project, we have used Brushless DC motors, Electronic Speed Controllers (ESC), KK2 Multicolour Controller Board, 3300mAh Li-Po battery, Aluminium bar (as rotor holder) and Landing gear.

2.1 Brushless DC motor

We have used EMAX bl 2815/09 motor for the propeller. The Emax BL2815/09 is a 3.9 ounce, 1000KV, 450 watts out runner brushless motor. It's used for sport planes weighing 709 to 1550 gram.

2.2 KK2.1.5 MULTI-ROTOR CONTROL BOARD

In this project, we have used kk2.1.5 Multi-Rotor control board to control the drone. This KK2.1 Multi-Rotor controller controls the flight of multirotor. Its purpose is to stabilize the aircraft during flight and to do this, it takes signals from on-board gyroscopes (roll, pitch and yaw) and passes these signals to the Atmega324PA processor, which processes signals according the users designated firmware and passes the control signals to the mounted ESCs (Electronic Speed Controllers) and the mixture of these signals commands the ESCs to make fine adjustments to the motors rotational speeds which stabilizes the craft. Once processed, this data is sent to the ESCs which adjusts the rotational speed of each motor to control flight orientation (up, down, backwards, forwards, left, right, yaw). Technical specifications of KK2.1.5 board:

- Size: 50.5mm x 50.5mm x 12mm
- Weight: 21 gram
- IC: Atmega644 PA
- Gyro/Acceleration: 6050MPU
- Auto-level: Yes

We have used "Dual copter" firmware that is pre-installed in the board. However, we had to tune it as per our model because automatic settings were not working properly for our model. Basically, settings are very different and unique for each model. Without customized settings this board is not going to work properly.

PI Editor		P Gain:	P Limit:	I Gain:	I Limit:
	Axis: Roll (Aileron)	200	40	0	0
	Axis: Pitch (Elevator)	200	40	0	0

	Axis: Yaw (Rudder)	200	40	0	0
Receiver Test	Aileron: 0	Elevator: 0	Throttle: 0	Rudder: 0	Auxiliar y: 0
Mode Settings	Self Level:	Link Roll Pitch:	Auto Disarm:	CPPM:	
	aux	No	Yes	no	
Stick Scaling	Roll (Ail):	Pitch (Elev):	Yaw (Rud):	Throttle:	
	36	53	52	90	
Misc. Settings	Min Throttle:	Height Dimen:	Height D. Limit:	Alarm 1/10 Volts:	Servo Filter:
	10	16	30	105	50
Self-Level Settings	P Gain:	P Limit:	ACC Trim Roll:	ACC Trim Pitch:	
	90	89	0	0	
Camera Stab Settings	Roll Gain: 0	Roll Offset: 50	Pitch Gain: 0	Pitch Offset: 50	
Sensor Test	Gyro X:	Gyro Y:	Gyro Z:	ACC X:	ACC Y:
CPPM Settings	Roll (Ail):	Pitch (Elev):	Throttle:	Yaw (Rud):	Aux:
Mixer Editor	Throttle:	Aileron:	Elevator:	Rudder:	Offset:
Ch: 1	100	100	0	0	0
Ch: 2	100	-100	0	0	0
Ch: 3	0	0	-100	-75	32
Ch: 4	0	0	100	-75	49
Show Motor Layout	②-----①				
Load Motor Layout	Dual-copter				

Table 1 : KK2 board setting

2.3 ESC (ELECTRONIC SPEED CONTROLLER)

An electronic speed controller or ESC is a device installed to a remote controlled electrical model to vary its motor's speed and direction. It needs to plug into the receiver's throttle control channel.We have used 60A electronic speed controllers to control each brushless motors in this experiment which can constantly supply required current to drive brushless motors.

2.4 SERVO MOTOR

For tilting the motors we have used small servo motors. In this experiment we have mounted two Futaba S-140 servo motor to tilt the brushless motors to a certain angle. This servomotor is can rotate up to 180º. So we can rotate each brushless motor up to 45º from normal as the brushless motors needs to be at 90º for vertical takeoff or landing. This servomotor is connected with the KK2.1.5 multi-rotor board to get signals and power both.

2.5 Li-Po BATTERY

As the brushless motor we have used in this experiment needs high amount of current so we have used 3300mAh 11.1V 3 cell Li-Po (Lithium Polymer) battery. It can provide approximately 3A current constantly.Specifications:

2.6 LANDING GEAR

For safe landing and to reduce landing pressure we have used a flexible plustic landing gear. It is very efficient and usefull. It spreard the landing pressre and saves the body parts from crash.

III. CONTROL SYSTEM DESIGN

This section contains control system, software, electrical and wireless communication part. Different electrical components were used to implement this machine such as brushless DC motor, electronic speed controller (ESC), KK2 multicomputer board, and high torque servo motor. We have built a GPS tracking android application to keep a track where it is traveling and used an IP camera software to get live video stream from the Drone which is also described elaborately in this chapter.

3.1 CONTROL SYSTEM

Considering all environmental disturbances we have designed our UAV's control system. In this section step by step everything is described. Figure 2.7, 2.8 and 2.9 illustrates the roll, pitch and yaw control system where, G1 = Left BLDC motor transfer function; G2 = Right BLDC motor transfer function = G1 G3 = Left Servo motor transfer function; G4 = Right Servo motor transfer function =G3 PI = PI controller transfer function; D = Gaussian noise (Disturbances) F = feedback

3.2 BLDC Motor Transfer Function

The BLDC motor we have utilized for this project is the Emax Bl4030. It is a 385kv, 11.5 ounce (326g), 1300 watt out runner brushless motor. Contingent upon the propeller and battery utilized, it is generally comparable to .60 to .90 2 stroke nitro engines. The parameters we used in the modeling are extracted from the datasheet of this motor with corresponding relevant parameters used. Table 2.3 contains the major extracted parameters used for the modeling task. The physical parameters for our example are:

RPM (n)	6100
Power (P_W)	1300 W
Electric resistance (R)	0.22 ohm
Electric inductance (l)	8.5 mH
Maximum Current	55 A
Moment of inertia of the rotor (j)	0.089 kg m^2

Table 2. – BLDC motor parameter used

IV. CONCLUSION

Main aim of this project was to develop a Drone which can be used in several surveillance purposes and deliver light weight products. For controlling the Drone, 2.4 GHz radio frequency transmitter, receiver, microcontroller, electronic speed controller, brushless DC motor and servo motor have been used. MATLAB®/Simulink® has been used to developed the Drone roll, yaw and pitch control system simulation. The proportional, integral controller action shows the better performance of controlling the roll, pitch and yaw of developed Drone. For live GPS tracking and live video footage feedback is also demonstrated. Demonstration shows the successful operation of Drone tracking and video footage transmission from Drone

REFERENCES

[1] M. Rouse, "Drone," Whatis.com, December 2013. [Online]. Available: http://whatis.techtarget.com/definition/drone. [Accessed 3 April 2015].

[2] D. C. L. Kristen Boon, "Warrant Requirement and Suspicionless Drone Searches," in The Domestic Use of Unmanned Aerial Vehicles, USA, Oxford University Press, 2014, p. 228.

[3] V. Vitto, "Report of the Defense Science Board Task Force on the Investment Strategy for DARPA," DARPA, Washington, D.C., July 1999.

[4] G. B. Matt Parker, "Quadcopter," Colorado State University, Fort Collins, Colorado 80523, 2012.

[5] R. L. Weiger, "MILITARY UNMANNED AIRCRAFT SYSTEMS IN SUPPORT OF HOMELAND," U.S. Army War College, Pennsylvania 17013, 30 March 2007.

[6] B. G. Williams, Predators: The CIA's Drone War on AlQaeda, Dulles, Virginia 20166: Potomac Books, 2013.

[7] J. P. Campbell, Vertical Takeoff & Landing Aircraft, New York: The MacMillan Company, 1962.

[8] "ARES," Lockheed Martin, 2013. [Online]. Available: http://www.lockheedmartin.com/us/products/ares.html. [Accessed 4th March 2015].

[9] J. Cohen, "Drone Spy Plane Helps Fight California Fires," Science Journal, vol. 318, no. 5851, p. 727, 2007.

[10] M. R. Roberts, "5 drone technologies for firefighting," Fire Chief, 20th March 2014. [Online]. Available: http://www.firechief.com/2014/03/20/5-drone-technologies-firefighting/. [Accessed 4th April 2015].

[11] O. J. Oludayo, "PID Control Of Brushless Dc Motor And Robot Trajectory Planning And Simulation With Matlab®/Simulink®," Aalto University, Finland, 2009.

[12] D. Andrisani, "Simulink Models of the Futaba S148 Servo," Purdue University, 6th May 2011. [Online]. Available: https://engineering.purdue.edu/~andrisan/Courses/AAE451%20Fall2000/Servo.html. [Accessed 31st January 1015].

[13] M. M. Noh, "Proportional- Integral (PI) Control," Underwater Robotic Research Group (URRG), [Online]. Available: http://urrg.eng.usm.my/index.php?option=com_content&view=article&id=106:proportional-integral-pi-control-&catid=31:articles&Itemid=70. [Accessed 10 4th April 2015].

[14] J. E. L. Charles E. Dole, Flight Theory and Aerodynamics, USA: John Wiley & Sons, 2000 .

[15] "Drones," Reaching Critical Will, [Online]. Available: http://www.reachingcriticalwill.org/resources/fact-sheets/critical-issues/6737-drones. [Accessed 4th March 2015].