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Design and Development of Surveillance Drone of Quadcopter Configuration

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Abstract— There are lots of problems faced by our Traditional security and surveillance methods.Surveillance Drones could be a better solution to the problem as it allows faster, most cost efficient and more efficient data collection.This method of Surveillance reduces the coverage of blind spots and gives the ability to access the distant locations with Real time action.Surveillance Drones can be employed in the cases where security staff is limited and large area needed to be monitored.Risk is reduced,ensuring the security and safety facilities,assets and more importantly personnel executing surveillance operations.This paved the way to design and Fabricate a Drone for Surveillance which is of quadcopter configuration mounted First Person View camera(FPV) to record the video , a Transmitter to transmit the video signal to the receiver at ground,a quadcopter configuration Aluminium Frame, 4 Brushless Direct Current) motor (BLDC with suitable propellers to produce required thrust and suitable Lithium-Polymer (Li-Po) battery of 5200mAh current capacity and 11.1 V to meet necessary current and voltage requirements.This Surveillance Drone is designed with a high Thrust to Weight ratio to have quick response during its operation and its stability also well maintained by nullifying the rotational Moments produced in the rotors.

Index Terms— Drone,Surveillance,Quadcopter,Brushless Direct Current motor,Propeller,Lithium Polymer battery,Thrust to Weight ratio,Rotational Moment.

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1 Introduction

Drone surveillance is the use of Unmanned Aerial Vehicles (UAV) to capture still images and video to gather information about specific targets, which might be individuals, groups or environments. Drones can be equipped with various types of surveillance equipment that can collect high definition video and still images ,the speed of operation will be faster with the drones as it can continue to fly for a particular time at a desired altitude .This method saves time,money and minimizes the risk to the personnel involved in surveillance .

The world's first quadcopter was created by inventor brothers Jacques and Louis Bréguet, in the year 1907 ,working with controversial Nobel Prize winner Professor Charles Richet. While undoubtedly exciting, it had some big limitations: being unsteerable, requiring four men to steady it, and in its first flight lifting just two feet off the ground. But it did innovate the quadcopter form factor we have today.

Transportation corporations and online retail companies are opting for drones as part of their logistics, which is an innovative way to elevate the level up the quality of their services to their clients. Amazon and EBay are now considering a new futuristic service such as using drones to improve product delivery systems that improve their operational framework. One main reason is to lessen expenditures when transporting a certain product from one place to another. Logistic drones can reach their consumers faster than the traditional human powered delivery of goods and services.

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When users intend to capture a photo or video, drones provide a better accessibility than the traditional camera to lessen effort. Drones are smaller and more convenient than the traditional large cameras, which require your whole body to carry the camera just to capture images and videos. The only thing that a user must consider is to virtually operate their mobile device attached to the control system of the drone. We can use the drones for a longer period of time because it does not cause any fatigue to the body while navigating the environment and recording important clips from the surroundings.

2 Literature Survey

Linxin Li.(2015) [1] developed an UAV for Surveillance of high voltage and ultra high voltage overhead power lines.UAV monitoring not only the related parameters of line patrol,also analyzing the acquisition of information and existing defects through remote sensing technology.The final results show that the uav patrol can get rid of the bad weather conditions, and dangerous geographical environment.It can accurate detects data. There is a huge advantage, compared with the human visual. Therefore, it is imperative to develop the UAV patrol.

Eluwande Abayomi David and Ayo Olayinka Omowunmi.(2016) [2] proposed a solution using an UAV technology for real-time monitoring and surveillance of the entire pipeline network. The overall aim was to build a drone (quadcopter) together with a pipeline monitoring system which acted as a surveillance system and reacted to attacks on above-ground oil pipelines, majorly for areas not easily accessible by security personnel.

Adarsh.A, Pranav.M , Manjunath , Soumya K. N.(2018) [3] proposed design of a drone mounted High Resolution camera to detect the percentage of fruitful plants and which aren't. Once this is detected, farmers can find alternate ways for the best results.Drones can be used to find the percentage of fruitful/infected plants using image processing. It's easier to find the percentile of plants which will provide fruits in the near future. This also helps to cover large areas, reduce manual work, and can be used to extract the required results. Drones can be used to avoid bird feasting in the plantation area.

Tim Leggett.(2019) [4] described a method of Surveillance with Drone equipped with high-resolution digital and infrared cameras, and connected to GPS satellites by real-time kinometric (RTK) positioning. The resulting images captured by the drone showed numerous defective cells on 30 solar panels. The cells were repaired, resulting in improved system performance and reduced energy costs. During traditional thermographic inspections of rooftop solar fields, there is rarely enough space to crawl under the panels to get straight-on, close-up images. Instead, technicians climb to the roof and walk the perimeter, scanning the rows of solar panels at an angle, which makes it more difficult to detect anomalies. The data also becomes less reliable because of reflections. Flying a drone over the roof, and close to each panel, helps reduce the reflections and enables the drone to capture more accurate images.

Waqas Malik and Sakhawat Hussain.(2019) [5] developed a smart quadcopter with improved flight dynamics and stability.Design of the quadcopter frame, interfacing of the brushless DC motors and bluetooth module with the microcontroller, and adjustment of the roll, pitch, and yaw for keeping the smooth flight dynamics by flight controller board containing gyroscope, accelerometer, magnetometer, and pressure sensors. The repeated simulation and testing has been carried out in MATLAB for the mathematical modeling of the dynamics of the system. The improvement in the parameters of the flight dynamics and removing the errors to gain stability in the frame are the main core issues which have been achieved by the several iterations. A closed-loop control system has been simulated and carefully designed for stabilizing the actual angle from the sensors and desired angle from the pilot. The reduced error rate of 0.05 degrees after every 10 s was achieved.

3 DESIGN AND WORKING OF QUADCOPTER

To Design a Quadcopter first we have to Estimate our Payload which is the weight of the First Person View camera and the weight of the transmitter that transmits the video signal then with respect to the weight of the payload ,motor, Propeller, Electronic Speed Controller, has to be selected. Battery has to be selected by knowing the current and voltage requirements of the components.Then the thrust requirement has to be calculated and finally the frame of the copter has to be designed by determining required arm length which should be decided by knowing the propeller dimensions,clearance between two rotating propellers and the dimensions of the plate carrying Flight controller and Receiver.

3.1 Payload Estimation

The weight of the payload is calculated by taking the weight of the FPV camera and the Weight of the Transmitter.

TABLE 1
PAYLOAD DATA

PARTS	WEIGHT IN (GRAMS)
FPV Camera	12
Transmitter	58
Total	70

3.2 Construction

The prefix Quad-copter implies ("Quad" =four), is a drone configuration where there are four arms. The main frame is made of square tube of Aluminium material with each arm length of 230 mm. At each free end of the arm, a motor will be fixed and propelled will be mechanically coupled to the motor. For all four motors the output side of an ESC will be connected and the input side of the ESC will be connected to the flight controller. The other input of the ESC will be connected to the power distribution board where the power supply is provided by the Li-Po battery. In a similar fashion all the other ESC's, motors and propellers are connected. A receiver will be connected to the Flight controller to receive signals from the transmitter. An FPV camera and a transmitter
Connected to each other is connected to the flight controller.The landing frame of height 140 mm is connected to the main frame so that the camera will be safe and it will not touch the ground.

3.3 Working

The signals will be transmitted from Transmitter and it will be received by the Receiver in the drone. From the receiver the signal goes to the Flight controller where the signal will be processed with accelerometer and gyroscope sensors. The processed signal will be sent to the ESC, which allows the specific amount to the motor based on the signal it receives. The propellers are mechanically coupled to the motors so that they rotate and produce thrust. The FPV camera takes current supply from the flight controller and it records the video, the

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video signals will be processed by the transmitter and it will be received by the receiver on the ground.

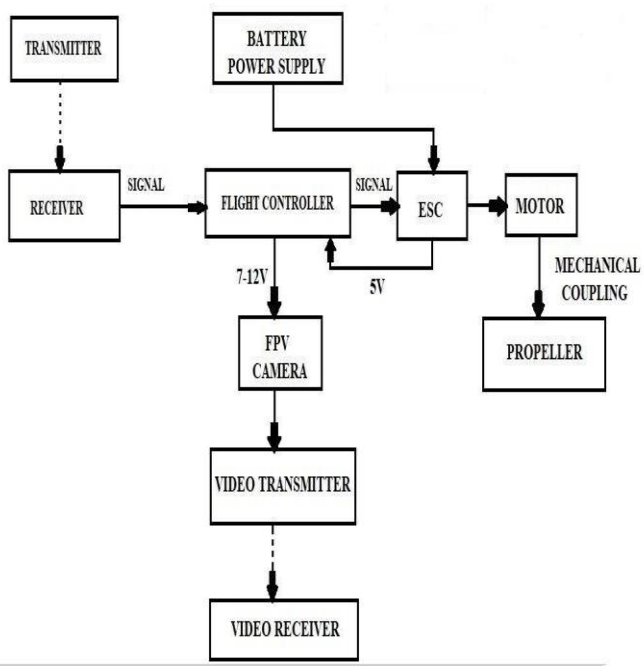

Figure 1 Block diagram of working process

3.4 Components used

3.4.1 Motor

Outer runner BLDC motors in which there are no brushes,they have a permanent magnet. The RPM of the motor can be controlled by varying the input current. This motor A2212/6T 2200KV produces 24,420 maximum Revolutions Per Minute(RPM) with 3s Li-Po battery and it produces a maximum thrust of 4783 grams with 10X4.5 inches propeller.

Figure 2 A2212/6T 1000 BLDC motor

3.4.2 Propeller

The propeller is of 10 inches length and has 4.5 inchespitch.It is made up of plastic and it has less weight.But plastic propellers do not have High strength to weight ratio .

Figure 2 10X4.5 inches propeller

3.4.3 ESC

It stands for Electronic Speed Controller and it is used to vary the RPM of the motor. 30A rated ESC is used as perthe motor and battery specifications.

Figure 2 30 A rated ESC

3.4.4 Battery

The battery that can be used is a Li-Po battery of 5200mAh capacity and 11.1 V. In this batter three cells are connected in series (3x3.7=11.1V).

Figure 4 Li-Po battery

ISSN 2229-5518

3.4.5 Flight controller

The flight controller helps in the maneuvering operations and also it provides Auto level function. The accelerometer and gyroscope sensors in the Flight controller processes the signals from the receiver and gives the output to the ESC. The kk2.1.5 Flight controller board can be used in the drone as it has inbuilt firmware.It uses ATMEL Mega 644PA 8-bit AVR RISC- based microcontroller with 64K of memory. The features of this Flight controller board are much easier for calibration.

Figure 5 KK 2.1.5 Multi- Rotor Flight Controller

3.4.6 Radio Transmitter and Receiver

The Transmitter and receiver used are FlySky CT6B 2.4Ghz 6CH Transmitter and FS-R6B Receiver. This combination provides a range of about 1000 meters. This Transmitter and receiver provide upto 6 channel options.

Figure 6 Fly sky CT6B 2.4 6CH Transmitter and FS-R6B Receiver

3.4.7 FPV Camera ,Video Transmitter and Receiver

Figure 7 FPV Camera

Figure 8 Video Transmitter

5.8G UVC receiver is used to receive the video signals. It can be connected to the android mobile which has installed the GO FPV application in it.

Figure 9 5.8 UVC OTG Receiver

3.5 Weight Build-up

TABLE 2
COMPONENTS WEIGHT DATASHEET

ISSN 2229-5518

PARTS	WEIGHT (GRAMS)
Frame	244
Landing Frame	300
Battery	360
Motor(4 No's)	232
ESC(4No's)+power distributor	128
propeller(4No's)	34
Flight controller	20
TOTAL	**1318**

The overall weight of the drone is calculated by adding the total weight of components and the weight of payload.

Overall weight = Payload + Weight of components

= 70 + 1318

= 1388 grams(approx.)

3.6 Thrust calculation

The Thrust to weight ratio of the Drone should be more for this particular type of Application so that the Drone maneuverability and response will be quick.High Thrust to Weight ratio can also help the Drone to surveillance the fast moving objects.So this Drone is designed to have Thrust to Weight ratio of 3.45

Thrust produced by one propeller with one motor= 1200 grams

Total thrust produced at 100% RPM = 4 x 1200 = 4800 grams

Thrust to weight Ratio = Thrust produced / total weight of drone

= 4800 / 1388

= 3.45 : 1

3.7 Battery Drain Time Calculation

For a safer side, the battery drain time has to be calculated by considering the distance to be covered and the time for the drone to return safely.

TABLE 3
CURRENT REQUIREMENT TABLE

COMPONENTS	CURRENT REQUIREMENT IN (AMP)
Motor(4 No's)	48
Receiver	0.1
Flight controller	0.1
ESC(4No's)	0.8
Camera	0.32
Video Transmitter	0.31
TOTAL	**49.63**

Current output from battery= 5200 mAh

Total current consumption of all components = 49.63 A

Battery endurance = current output from battery/ Total current consumption of all components

= 5200 MAh / 49.63A

= 5.2*60 / 126.63 A

= 6.28 MINS. (AT 100% THROTTLE)

Since the Thrust to Weight ratio 3.45:1 ,the Drone starts Hovering at 30% of Throttle and if the maximum throttle is controlled within 60% then the current consumption of motors will differ.At 60% of Throttle the current consumption of each motor is around 7.2A, so total current consumption of all 4 motors is 28.8A.

Battery Endurance(max 60% Throttle)=5.2*60 A min/30.43A =10.25 Minutes

3.8 Structural Description

The Main frame is Designed using CATIA V5 software. A 2D diagram is made to determine the Arm length.To determine the Arm length some of the factors must be considered like the Propeller dimensions, Clearance between two rotating

ISSN 2229-5518

Propellers and the dimensions of the plate carrying Flight controller and receiverThe dimension in mm are briefly mentioned in Fig 10 .

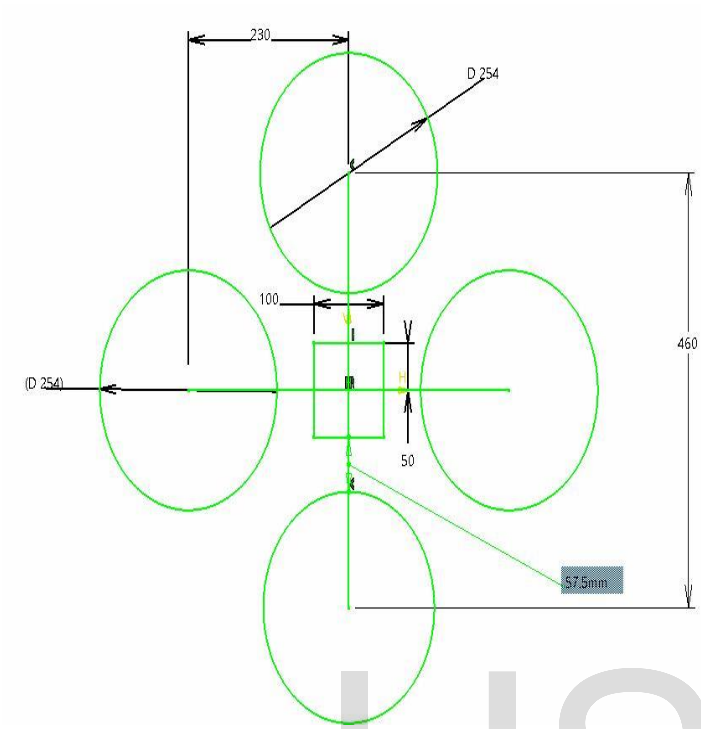

Figure 10 2D diagram of Main Frame

3.9 Fabrication of Main Frame

Aluminium Square tube of 2mm thickness is used to Fabricate the Main Frame.Two square tubes of length 460mm were taken and they were joined together with a Lap joint at the center.Tungsten Inert Gas(TIG) welding is done at the contacting surfaces to attach both the Square tubes.At the free end of each Arms four holes of 2mm diameter are made to mount motor and to fix the Landing Frame.

3.10 Analysis Of Frame Deflection Under Loading Conditions

Considering the loads acting on the Frame at 100% Throttle which is around 1200 grams of Thrust at each free end of the Arms.

3.10.1 Theoretical Calculation

Each arm is considered as a Cantilever beam and the deflection formula □=WL^3/3EI, where W=Magnitude of force,L= Length of the Cantilever beam,E=Young's modulus,I=Moment of Inertia.

Thrust acting at 100% RPM=1200 grams

Length of the arm from Fixed end to Free end=230mm

E=70000N/mm2 for Aluminium

I=10860mm4

□=(1.2/9.81)*230^3/3*70000*10860

□=0.062mm

3.10.2 Analytical Approach

The Analysis is made using ANSYS R19.1 software.The 3D geometry of the Main Frame is Designed in Catia v5 software and imported to ANSYS workbench.With the help of Static Structural tool the analysis is made with all boundary condition and the Element size is taken as 1mm in Meshing so that the results will be more accurate.Fig11 shows the Analysis Report from which the deflection obtained as 0.082mm.

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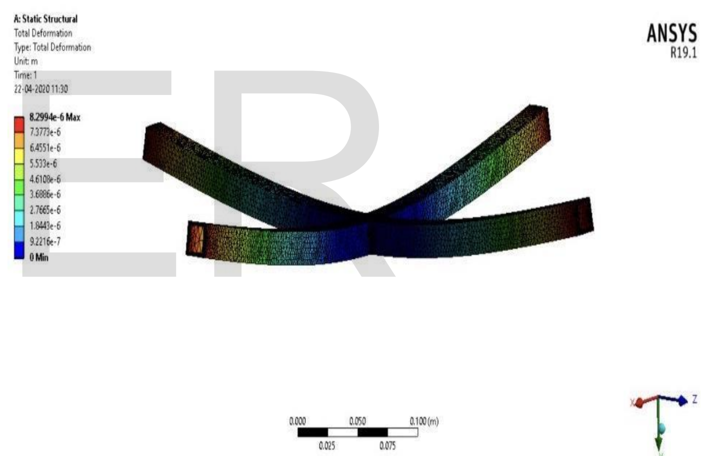

Figure 11 Analysis Report of Main Frame

From the Analysis it is clear that the load that acts on the Main Frame will not produce major deflection and the Frame is capable enough for the Application.

3.11 Fabricated Model Of the Drone

Two Arms were Yellow color and the other two Arms were black color.This is because ,during sunshine it is difficult for the Drone pilot to recognize the face of the Drone which is at a longer distance.So the Arms colored Black do not reflect the sunlight and it can be easily viewed from a longer distance.

Figure 12 Fabricated Model of the Drone

4 Conclusion

This paper describes the Importance and Requirement of Surveillance Drones to reduce the risk to the personnel involved in Surveillance operations.This Design of Surveillance Drone with High Thrust to Weight ratio helps to surveillance the fast moving objects .This Surveillance Drone can be used for Traffic Surveillance, Surveillance during any form of disaster to monitor the situations where human intervention is not possible and it can also be employed in basic inspections like inspection of pipeline, solar panels and Electrical lines.

5 Future scope

- Manual control can be changed into autonomous control with GPS technology and auto return home option.
- With image processing Techniques, the Drone can be involved in High Security Level Surveillance operations.
- The surveillance process can be advanced by including Ultrasonic sensors and Thermal Imaging Camera.

References

[1] Linxin Li,"The UAV Intelligent Inspection Of Transmission Lines"International Conference on Advances in Mechanical Engineering and Industrial Informatics (AMEII 2015),ISSN 2352-5401,April 2015.

[2] Eluwande Abayomi Davidand Ayo Olayinka Omowunmi , "Above-Ground Pipeline Monitoring and SurveillanceDrone Reactive To Attacks" , 3rd International Conference on African Development Issues(CU-ICADI2016), ISSN:2449-075X, May 2016.

[3] Adarsh.A, Pranav.M , Manjunath , Soumya K. N,"Fruit Farm Surveillance Using Drones",International Journal of Trend in Scientific Research and Development (IJTSRD), Volume -2,Issue-4,May 2018.

[4] Tim Leggett,"Using Infrared Drone Technology to Inspect Solar Panels and Wind Turbines",Power Magazine,dated March 31,2019

[5] Waqas Malik and Sakhawat Hussain,"Developing of the smart quadcopter with improved flight dynamics and stability",Journal of Electrical Systems and Information Technology,Dec 2019.

[6] Zainab Zaheer,Atiya Usmani,Ekram Khan,"Aerial surveillance system using UAV",2016 Thirteenth International Conference on Wireless And Optical Communications Networks(WOCN),10.1109/WOCN.2016.7759885,July 2016.

[7] Seon jin kim and Gino J.Lim,"Drone-Aided Border Surveillance with an Electrification Line Battery Charging System",Journal of Intelligent & Robotic systems,**92**, pages657–670(2018),Jan 2018.

[8] Kazi Mahmud Hasan,S.H.Shaz Newaz,Md. Shamim Ahsan,"Design and development of an aircraft type portable drone for surveillance and disaster management",International Journal of Intelligent Unmanned Systems ,ISSN: 2049-6427,Volume 6 Issue 3 ,July 2018.

[9] Admir Mulahusic,Nedim Tuno,Seat-Yakup Kurtović,"Collecting Geospatial Data Using Unmanned Aerial Photogrammetric System",Advanced Technologies, Systems, and Applications IV - Proceedings of the International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies,DOI:10.1007/978-3-030-24986-1_45,Jan 2020.

[10] Tomoya MORIBE, Hiraku OKADA, Kentaro KOBAYASHI, KATAYAMA, "Combination of a Wireless Sensor Network and Drone Using Infrared Thermometers for Smart Agriculture", 15th IEEE Annual Consumer Communications & Networking Conference (CCNC) ,2018 .

[11] Admir Mulahusic,Jusuf Topoljak,Jasmin Ćatić,Using the Semi-professional UAV System in Surveying the Medium Size Area of Complex Urban Surface,In book: New Technologies, Development and ApplicationIII,DOI:10.1007/978-3-030-46817-0_96,May 2020.

[12] Piotr Kardasz ,Jacek Doskocz,"Drones and Possibilities of Their Using",Journal Civil and Environmental lEngineering ,DOI:10.4172/2165-784X.1000233,Jan 2016.

[13] David W. Matolak (2015), "Unmanned Aerial Vehicles: Communications Challenges and Future Aerial Networking", Institute of Electrical and Electronics Engineers(IEEE),**DOI:** 10.1109/ICCNC.2015.7069407 ,March 2015.

[14] D. W. Matolak, "Air-Ground Channels & Models: Comprehensive Review and Considerations for Unmanned Aircraft Systems", *Proc. IEEE Aerospace Conference Big Sky MT*, March 2012.

[15] Hariz Shaharizuan,"Surveying with Photogrammetric Unmanned Aerial Vehicles (UAV) – an industrial breakthrough",Thesis for: BSc. (Hons) Quantity Surveying,DOI:10.13140/RG.2.2.33110.29764,May 2019.