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Article

Solar Autopilot Drone

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I N F O

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A B S T R A C T

Advances in technology have made the drone an affordable tool for various purposes. This article focuses on gaining knowledge of drone at a working and conceptual level. Firstly, there is a detailed explanation of the construction of the drone. Some of the most essential elements of a drone include frame, propellers, engine, system of power the electronic control and communication system. Whether you fly your drone for commercial or recreational purposes, staying in the air as long as possible is the goal. But of course, the battery life of the drone can put a damper on how much you can accomplish while you're flying. Batteries serve as a major drawback because they get exhausted after 15 minutes of flight and thereby landing the drone on ground. The batteries used for powering the drones are lithium-polymer batteries. This project aims to provide an ingenious solution to this hurdle by introducing the current popular photovoltaic system into the UAV power system design. Solar drones use solar cells powered directly from the sun and solve major issues related to conventional drones such as increasing the flight time and risk of the drone losing connectivity with its controller. The design is to be modular for easy module upgrade and replacement. Using photovoltaic system minimizes the environmental impact, an issue that can be controversial for large projects built for utilities because they tend to spread across hundreds of acres of land in remote regions.

Keywords: Surveillance, Monocrystalline, Autonomously

Introduction

Drones, or known as Unmanned Aerial Vehicles (UAVs) consist of light composite materials to growth maneu verability even though flying and lessen weight. They are sometimes equipped with a large number of additional constituents like cameras, GPS guided missiles, Global Positioning Systems (GPS), navigation systems, sensors, and various other drone software and hardware. A quadcopter is a simple flying unmanned air vehicle with four arms, and in each arm there is a motor attached to a propeller. Quadcopters are aerodynamically unstable. Also, sometimes a flight computer is needed to translate input commands into commands that change the RPMs of the propellers to produce the required motion. Outmoded drones are powered by lithium polymer batteries but they get exhausted after 15 minutes. One of the major issues with defense-oriented or commercial drones is their ability to hold a charge for long trips. In recent years , awareness of the potential of photovoltaic design of drones has attracted many researchers. Solar drones support business efforts to avoid hazardous man-hours; reduce costs for maintenance, inspections, and repairs; and maximize energy production.

Till now the solar drones have been used for mapping, surveillance, remote sensing, etc.

They can also make available the much-needed internet connectivity to the rural area which is very beneficial. The solar energy used to fuel the drone is renewable which worthexpensesfewer money on drawing electricity from the grid to power the drones. The goal for unmanned vehicles is to fly for as long as possible. However, in the current situation flight times are limited by the battery life of the system. Adding a lightweight, renewable energy source significantly extends flight time. Adding power without compromising the weight, maneuverability or size of the aircraft is ideal for UAV systems that require power for long-endurance missions without returning to the ground.

Literature Review

There have been numerous pieces of research done in the field of unmanned aerial vehicles or now collectively called drones, and the basis of every project related to this is to maximize the thrust or lift with the minimum use of battery output while taking into consideration that the balance of the UAV should be constantly perfect (throughout the flight). One more type of paper are published which only focuses on increased flight time. We have also discussed about that thing.

In this field, the major area of research is the efficiency of the cell, flight time and value of thrust.

Quadcopters are not the only drones

Nowadays, drones come in various sizes, structures, and purposes. so according to their Arrangementand structure, there are following types of drones which are classified:

- Fixed-wing Drones
- Flapping wing drone
- Rotorcrafts

Fixed Wing Drones

These types of drones do not consist of motors and propellers. Instead of these, they consist of fixed-wing surfaces that produce a tremendous lift for the drone. These aircraft are also capable of carrying more equipment or weight for longer distances on less power.

These have the property of a standard airplane, so they have their properties also. Due to a lack of tires, they have to be thrown away before take off .As well as for landing, due to no tyres, landing is not that smooth.

- Cannot hover
- Non-smooth landing

Flapping wing Drones

These are of two types:

- Avian Flight (Flight Pattern of Hummingbird)
- Insect Flight (Flight Pattern of wasps and bees)

In both of the cases, the flight of the drone requires the flapping motion of the wings in order to move. And due to this property, these types of drones can hover over a point to some extent.

However modelling of these drones requires a lot of fluid dynamics computation.

Rotorcrafts

These basically consist one or more coaxial rotors spinning together to cause translation and rotation motion to the aircraft. That have hovering property and are also able to take off and land vertically, hence are also called Vertical Take-Off and Landing. These can be of two types:

- Rotary wing
- Multirotor/Multicopters

Rotary Wing UAV

The Rotary Wing UAV is an unmanned aircraft that drives the whole or a substantial part of its lift from a rotatory wing system-usually one or two electric motor fixed with the propeller.

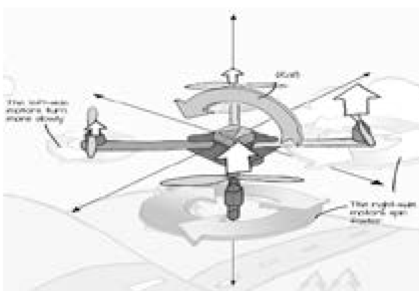
Multirotors

Multirotor are UAVs consisting of several motors (usually three or more than three motors) mounted on a fixed frame. the number of motors depicts the name of multi-rotor (i.e.- quadcopter, hexacopter, etc. They can be used in a mission that requires accuracy and precision. Multirotor has the following disadvantage:

- Simplicity in mechanical design
- Suitability in precise mission’
- High maneuverability
- High load capacity

Flight Pattern of Quadcopter

There are three different control mechanism which controls the flight pattern of Quadcopter called Quadcopter orientation. These are the controlled ways that measure angles and the based upon the axis of rotation known as Pitch, Roll, and Yaw which determine the direction and orientation. They have a specific part to do during the flight Pitch control forward and backward movement. Roll controls left and right movement. Yaw controls the rotation along with the vertical axis.



a) Roll

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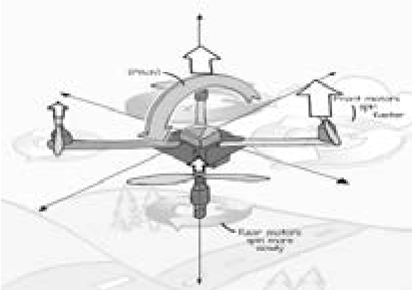
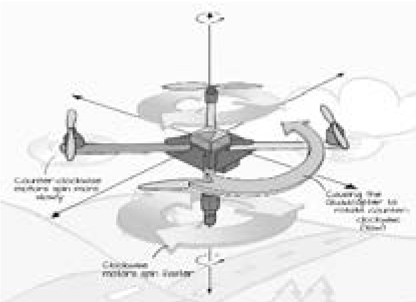


b)pitch



c) Yaw

History of Quadcopters

The Quadcopters, being under the family of aerial vehicles are built unmanned nowadays hence called unmanned Aerial Vehicle. These UAVs being unmanned operated by distance pilot or fly autonomously. The early experiment attempts of taking off with the help of rotorcraft were done with the help of a multirotor. The average power consumed by the tail rotor mounted on a single rotor helicopter design was between 10 to 15% of the engine power. It still created no lift or forward thrust and some amount of the main rotor rotates over the fuselage resulting in pushing down of washed air against it. Along with this, making large rotor blades, 4 or 5 cm long or even longer was a huge problem as it was making the vehicle heavier.

In recent times, the size of the quadcopter has reduced tremendously. Industry, open-source community, and the academic community have contributed a list of advancements to drone technology. In the previous years, many quadcopters, small in size have entered the market, which is manufactured by DJI innovations: which offers a range of mid-high end UA system platforms having special features like GPS and FPV(first-person view).

Review of Past Research works

In order to avoid the instability of quadcopter, it must be controlled properly (we are talking about its four motors simultaneously) and here comes the electronics systems such as intelligent PID which used to stabilize the UAV at a very high speed.

In the year 2011, there were researches carried out by engineers in order to improve stability. One research was carried out yo test the military utility of UAV by reducing its size so that it can perform crucial military operations. The main drawbacks were short flight time, less flight autonomy, and non-smooth flight stability.

In the year 2012 the major was done to tune the PID and SISO approach. Furthermore the control mechanism including overshoot integral error-index, robustness, and settling time was considered. The result was gone through modeling UAV's control structure its kinematics and flight dynamics. At last simulated in the MATLAB/Simulink software which will illustrate the efficiency of the applied control strategy.

Still less autonomous behavior of drone was a major problem along with battery weight.

In the year 2013 , stability and dynamics become the main area of research. Arduino UNO was used as a controller with better algorithms. It helped the drones to achieve the virtue of continuous hovering over a point, simultaneous localization and Mapping, and autonomous navigation with the help of GPS. Here also the rise of SWARM robotics occurred where the coordinated simulation was the major feature. Still there was a need for cv camera for obstructed landing and solar panel for autonomous flights.

In the year 2014 an interesting report was published where there ws a research in which itwas explained how to balance the drone if it lost one or two opposite or three propellors. Along with these researches, the secured autonomous landing was also in consideration in which camera captured image processing was involved to decide whether the place is with landing the drone or not. Work toward the system solar power charging also started.

In the year 2015 the efforts of unifying the growing technology of quadcopters and photovoltaics were on the peak to make a single device to perform an autonomous long flight. The main focus was to enhance the flight time to 33% which was attained by the additional solar cell. The commercial testing was also started by some companies by Amazon. To make it more commercial based drone, more weight lifting capacity was increase by making frame stronger and thrust was increased.

Research Methodology

Each and every project has its own methodology and technique to strategize the way for its outcome. Here we put all the ways, formulae, and tools together for the actualization of the project. The SAD is analyzed collectively and with the hardware & software with block diagrams and flowchart where necessary. The project is made up of two parts like other embedded or robotics system should be: The software part & the hardware part. So in this chapter, we have implemented the software and the hardware part where it felt necessary. The top to bottom approach is used in software design whereas the modular design approach is used in hardware design.

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Design Factor of Solar Autopilot Drone

The major factor which affects the design of the UAV is the manufacturing material. Due to the association of the solar power, the design should be light weighed solar autopilot drone.

In order to reduce the overall weight, these are some factors:

Strength and Weight of Materials of SAD

When we talk about the strength and weight of materials for UAV, there tends to be a perception that high strength materials are usually heavy in weight and vice-versa. It is however to find a balance between these properties that perfectly suites the application for the drone.

Solar Cell Efficiency and Size of SAD

This is one of the most important things inorder to make the UAV unmanned. There are several types of solar cells available for the restoration of the energy but Monocrystalline cells resulted in most efficient but the most

This is one of the most important thing in order to make the UAV unmanned. There are several types of solar cells available for the restoration of the energy but Monocrystalline cells resulted in most efficient despite being the most expensive. considering the functionality at the first place, the monocrystalline cell is chosen best for this application due to its high efficiency. According to its datasheet, each solar cell is the size of 125mmX125mm. In order to produce the desired power, the combination of these cells into modules is necessary.

Hence, considering the given factors, carbon fibre is the material used to build the low weight frame. And also it is easily found in the market.

Design Specifications of SAD

Considering certain factors that may affect the design of the SAD, it is now important to state the specifications of this prototype.

Solar Cell Specification

This is the first point of taking consideration. The best appropriate solar cell that can produce the desired power for the supply of the elements on board needs to be chosen, and in order to do this, a wild estimate of the total power utilization has to be made for the drone. There are some guided assumptions made related to some specification of the SAD, this was done to enable the finding of a starting point in the design. They are:

Brushless Motors

- Motor KV: 920 RPM/V.
- Motor Rotation: CCW./CW
- Thrust: Around 0.5 kg
- Litium -Polymer Batteries: 3S-4S
- Electronic Speed Controller: 30 A
- Shaft Diameter: 6 mm
- No load current:0.45Amp @ 10V
- Maximum current:14Amp for 60Sec
- Maximum operating temperature: + 80°C
- Voltage 11.1 v

Hence, maximum power which is consumed is 220W for a single motor; this is a static test. When the drone is on flight, it consumes about 14A for the four motors in total, hence, the power consumed for the given voltage is :

Power = I * V ……………………………..equation 1

= 14 * 11.1

= 155.4Watts for all four motor

Onboard Components (on UAV)

Flight Controller and Sensors

The Main Controller (MC) is the brain of the system, it communicates wit hall ESC sand RC trans mitter to carry out the autopilot functionality.I thasa built-in Inertial Measurement Unit (IMU) consists of one 3-axis accelerometer, one 3-axis gyrosco peandabaro meter for sensing the attitude an daltitude.

Table I

General	
Built-In Functions	• Three Modes forAutopilot • Enhanced FailSafe • Low VoltageProtection • S-Bus ReceiverSupport • PPM ReceiverSupport • 2-axle GimbalSupport
Peripheral	
Supported Multi-rotor	• Quad-rotor I4,X4; • Hexa-rotorI6,V6,IY6,Y6.
Supported ESC output	400Hz refresh frequency.
Recommended Transmitter	PCM or 2.4GHz with a minimum 4 channels.
Assistant Software System Requirement	Windows XP SP3; Windows 7
Electrical & Mechanical	
Working Voltage Range	• MC: 4.8V ~ 5.5V • VUInput:7.2V~26.0V (recommend 2S~6SLiPo) Output (V-SEN portredwire):3A@5V Output(V-SEN port red wire)burst current:7.5A

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Power Consumption	• MAX:1.5W(0.3A@5V) • Normal:0.6W(0.12A@5V)
Operating Temperature	-10°C~50°C(14F~122F)
Weight	• MC:25g • GPS:21.3g • VU:20g
Dimensions	• MC:45.5mm×31.5mm×18.5mm • GPS & Compass: 46mm • (diameter) x9mm • VU:32.2mm×21.1mm×7.7mm
Flight Performance (can be effected by mechanical performance and payloads)	
Hovering Accuracy (GPS Mode)	• Vertical:0.8m • Horizontal:2.5m
Max Yaw Angular Velocity	200°/s
Max Tilt Angle	45°
Max Ascent / Descent Speed	6m/s

Specification of flight controller according to the Naza -M -Lite datasheet

Surveillance and Autonomous Navigation Unit

The surveillance unit, using the raspberry pi(Rpi) as an example, consists of two cameras, which are the USB camera module (for surveillance) and the Pi Camera (for obstacle avoidance). This surveillance unit also consists of the USB Wi-Fi module. Working towards the power drawn by each of these components/elements:

The values used below can be found in .

- USB Camera Module attached:

500mA at 5Volt

Power drawn : 500mA * 5Volts= 2.5 Watts

- Pi Camera: 250mA at 3.3Volt

Power drawn : 250 mA * 3.3Volts= 825mWatts

- USB Wi-Fi Module: 500mA at 5Volts

Power drawn is 500mA * 5V = 2.5 Watts

- The Raspberry Pi 3: 2.5A at 5.1Volts

Power drawn is 2.5A * 5.1V = 12.75Watts

In the surveillance unit, the sum of the power drawn by the components connected to the RaspBerry Pi 3 is 2.5Watts + 0.825Watts + 2.5Watts = 5.825Watts. The Raspberry Pi 3 delivers these components' power. The Raspberry Pi 3 also consumes power within itself. A 2.5A power supply connected to the Raspberry Pi 3 will ensure that it has sufficient power to perform its tasks. Thus, the power consumed by the Raspberry Pi is assumed to be 2.5Ampere * 5.1Volts = 12.75Watts.

By Using the Sunpower C60 Maxeon solar cell, its specifications as gotten from its datasheet is seen in the Table:

Table 2

s/n	Components	Qty	Total power consumption (watts)
1	BLDC Motor	4	155.4
2.	Flight controller	1	5.5
3	Pi 3	1	12.75
		Total Power	173.75

Table 3

Electrical Characteristics of Typical Cell at Standard Test Conditions (STC) **STC: 1000W/m², AM 1.5g and cell temp 25°C**						
Bin	**Pmpp (Wp)**	**Eff. (%)**	**Vmp-p(V)**	**Imp-p(A)**	**Voc(V)**	**Isc (A)**
G	3.34	21.8	0.574	5.83	0.682	6.24
H	3.38	22.1	0.577	5.87	0.684	6.26
I	3.40	22.3	0.581	5.90	0.686	6.27
J	3.42	22.5	0.582	5.93	0.687	6.28
All Electrical Characteristics Parameters are Nominal Unlaminated Cell Temperature Coefficients Voltage:-1.8mV/°C Power: -0.32% /°C						

Datasheet of sunpower solar cell

No. of cell required $= \frac{\text{Total Power consumed by UAV}}{\frac{(3.34+3.38+3.40+3.42)}{4}}$

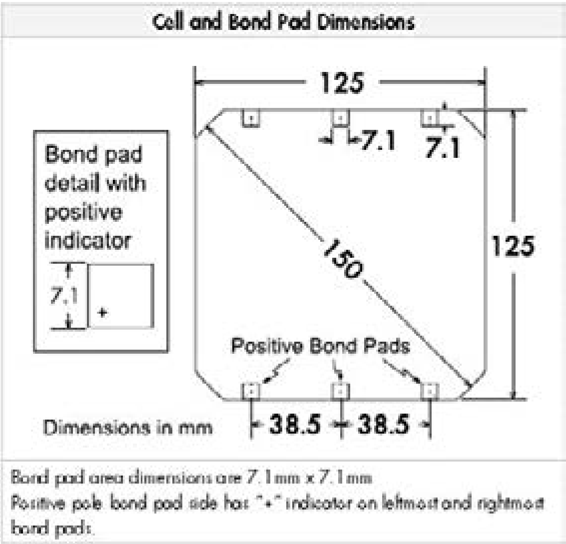
No. of solar cellsrequired $= \frac{173.75}{3.385}$

No. of solar cells required = 51.329394 ≈ 52 solar cells

From the analysis, it can be observed that approximately 62 solar cells are needed to power the SAD during flight. However, to carry such payload would affect the flight pattern, stability, capability to hover and agility of the quadcopter. Hence, in order to achieve the integration of the solar technology with UAV, a step up booster circuit is used to boost up the solar power within the drone.

Frame Specification

The frame is the housing of the quadcopter and it is important that is it is rigid enough to hold the onboard components, elements and withstand any disturbances. It holds all components of the quadcopter. Since the UAV



Structure of one cell of monocrystalline with 21.8% efficiency according to datasheet

is an aircraft, it should have the following properties for the optimal result: lightweight, low cost, and rigidity. Generally there is a caveat while making a choice for the best frame material such that material with high strength would be heavy, and material with lightweight is usually not sufficiently strong to handle mishaps or crashes that may occur during flight. Moreover, some materials can have both lightweight and high tensile strength but is of a high cost.

Hence, there is need to consider the different materials available to know the best suited in this application.

The various materials include:

- Carbon Fibre Material
- Fibre Glass Material
- Titanium Material
- Steel Material
- Polycarbonate Material
- Acrylic Material

According to the current scenario, the f450 frame is best suited for the lightweight quad that can have a better payload capacity and it is made up of polyamide-nylon

Specification of F450 frame

It is a 450mm quad frame in dimensions built from quality materials. The main frame of the quad is glass fibre while the other arms are constructed from ultra-durable polyamide nylon. This version of the F450 features integrated-PCB connections for the direct soldering of our ESCs.This, hence eliminates the need for a power distribution board or messy multi-connectors keeping our electronics layout very tidy. F450 also comes with stronger moulded arms, so there is no more arm breakage at the motor mounts on a hard landing.

Assembly is a breeze with pre-threaded brass sleeves for all over the frame bolts, so there are no lock-nuts required. It utilizes 1 size of bolt for the entire build, making the hardware very easy to keep in order and only requires one size of hex wrench to be assembled.

Features of F450 Quadcopter Frame

- Built from quality glass fibre and polyamide nylon
- Integrated PCB connections for direct soldering of your ESCs(for motors)
- Pre-threaded brass sleeves for all of the frame bolts on board
- Coloured arm for orientation to keep us flying in the right direction
- Large mounting tabs on main frame bottom plate for easy camera mounting for drone
- Easy assembly

Specifications of F450 Quadcopter Frame

Width: 450mm

- Height: 55mm
- Weight: 270gram (w/out electronics)
- Motor Mount Bolt Holes: 16/19mm

Brushless Motor (BLDC) Specification

The brushless motors are the best suited for aircraft applications due to:

- Thrust-to-Weight Ratio
- High Efficiency

In order to choose a brushless motor for our application, it is required by de facto that a motor that can produce a thrust of about twice the weight of the frame and its components. This weight is generally called the All-Up-Weight (AUW).

i.e., Total Thrust ≥ 2 * AUW

From this, every motor is required to produce at least a thrust that is equivalent to of the total thrust produced , i.e.,

Thrust of motor = (total thrust)/ 4 = (2* AUW)/4

Hence, for the brushless motor used, the following specifications were required:

Assuming an AUW of about 1KGram (after all components including the solar integration has been added)

Thrust of motor = (total thrust)/ 4 = (2* AUW)/4 = (2*1)/4 = 500gram

Hence, THRUST: 500g

Specification, of used brushless motor

- Motor KV: 920 RPM/V.
- Motor Rotation: CW and CCW
- Thrust: approx 0.5 Kgram

- LiPO Batteries: 3S-4S
- ESC: 30 Amp
- Shaft Diameter: 6 mm
- No load current:0.45Amp @ 10Volts
- Maximum current:14Amp for 60Seconds
- Maximum operating temperature: + 80°Celcius
- Voltage 11.1 v

Electronic Speed Controller (ESC) Specification

The speed controller is dependent upon the type of brushless motor chosen. It is safe to choose an ESCs that has a current rating i.e. 1.5 times greater than the current draw of the brushless motor it controls.

Hence,

$ESC_{current} \geq BLDC_{current} * 1.5$

Assuming the brushless motor has a maximum current draw of about 12A. Then,

ESC Current ≥ 12 * 1.5 Amp

ESC current ≥ 18Amp

Specification of ESC used in the prototype

- Continuous Current: 30Amp
- Burst Current: 35Amp
- BEC Model: Linear mode
- BEC Output: 5V 2Amp
- Li-ion/Li0poly:2-4S,or Ni-MH/Ni-Cd:4-12NIMH
- Weight: 25g
- Size: 32mm x24mm x7mm
- There is No buffering of the input signal, resulting in more than 490Hz response rate.

Battery Specification

The best battery for the quadcopter (drone) or general flight applications is the Lithium Polymer batteries. This is because of their:

- High Discharge rate
- High capacity
- Light weight

To choose the right battery, the BLDC has to be considered, some require 3-cell LiPo batteries while some others require 4-cell LiPo. By Choosing a 3-cell LiPo, the following specifications are given:

Battery Type: Lithium Polymer (LiPo) NUMBER OF CELLS: **3 Voltage:** 11.1Volts
Estimated Flight Time: 15mins (0.25 hours)
Capacity: Capacity = Total Current Draw * Flight time ……………….equation 2

From the assumption made to obtain the solar specification:

Total current drawn =(Total Power Consumed)/ Battery Voltage

Total current drawn = 173.75/11.1 =15.65 ~ 16 Amp

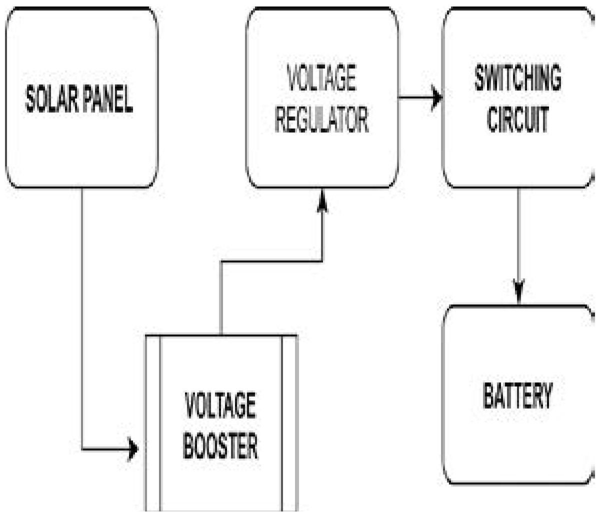
Total current draw = 16A

Hence, from equation 2,

Battery Capacity = 16 * 0.25 = 4.0Ah CAPACITY: 4000mAh for at least 15mins flight time.

Solar Power System

The system is put together to harvest the renewable energy obtainable from the sun. Once light rays strike the photovoltaic modules over the cell, made of semiconductor material, they instantly absorb the photons coming from the sun, present in light ray, and transfer the energy to the electrons presented in the semiconductor material. With the absorption of energy from the photons, these electrons now can cause current flow in the electrical circuit to which these PV modules are connected. And the power generated from these systems, for this application, needs to be stored. Hence, there comes a need for batteries. Batteries for this work, need to be lightweight and should be of high capacity for the efficient running of the SAD system. The power system is described below:



Block diagram of solar power system

Block Diagram of Solar Power System

PID Control Implementation and Calibration

In order to obtain a smooth flight for the SAD, a control system has to be in place for a smooth operation of the SAD. This was achieved using the PID algorithm stated below (in figure) for compensating for the error from each axis of the IMU sensor. In order to this to be implemented, the algorithm/equation has to be translated to code as shown in the calculatePID() function in the flight control code. the PID algorithm has gained for each term (P, I & D) and these values have to be tuned for the SAD as this is very hardware-specific. The gains were obtained using the method of Trial and Error to obtain gains for PID calculation.

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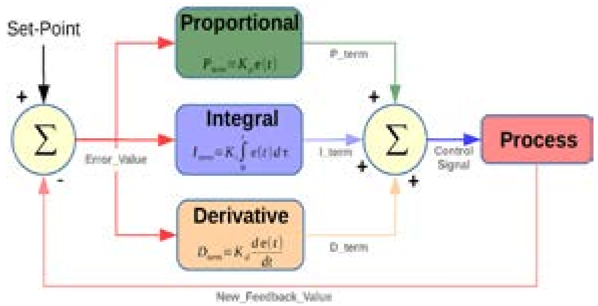
Classic Dependent PID Equation:

$$u(t) = K_c e(t) + \frac{K_c}{\tau_i}\int_0^t e(t)dt + K_c \tau_d \frac{de(t)}{dt}$$

Classic Independent PID Equation:

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt}$$

Pid Algorithm



PID blockdiagram

Fail-Safe

Advanced Fail-safe method will be triggered when MC loses the control signal sent, no matter what mode you fly the quadcopter. This could be one of the following situations estimated:

The Signal lost between transmitter and receiver (for example multi-rotor is out of the range of the communication, or transmitter is down, and so on.)

There are one or more connections of A, E, T, R, U channels between MC and receiver loses. In case this happens before takeoff, motors will not work when we push the throttle stick; if this happens during the flight, LED yellow light will flash/blink to warn in addition to the failed-safe method. Choose any one method for your failed-safe function: Landing or Go Home.

Landing: the aircraft will land after 6s of hovering.

Go Home and Landing: Before taking off, the initial position of multi-rotor will be saved as home point by MC automatically when you push the throttle stick first time after 6 or more GPS satellites are found (blinks once / no blinking) for 8 seconds.

Versatile Unit / Smart Battery Device

Specially designed for the NAZA-M LITE. It gives a solution for the consumption of high power problem of the multi-rotor system, supplies, and monitors power for NAZA-M LITE and other electronic pieces of equipment. It also consists an LED which indicates different operating states of NAZA-M LITE and a USB interface to configure the NAZA-M LITE unit and firmware upgrade.

First Level Protection

- **No Load (No Load Voltage):** Self-Defining Warning Voltage. Needs Our Input.
- **Loss (Line Loss Voltage):** The Battery Voltage Drop During The Flight Time. Needs The Input.
- **Loaded (Loaded Voltage):** The real-time battery voltage during the flight time. This is the actual warning voltage monitored by MC. It doesn't need our input, calculated by No Load and Loss.

Voltages Magnitude Relation

- No Load: Ist level >IInd level.
- Loss: Ist level = IInd level.

Loaded: Calculated, Ist level >IInd level.

Protection Switch

To prevent our multi-rotor from a crash or other harmful consequence that happen due to low battery voltage, there are 2 levels of low voltage protection available to use. You can choose to use or not to use them, still we strongly recommend to use the protections which are available!

The Second Level Protection

- Fill the warning voltage and the line loss voltage in No Load and Loss by above described method.
- When the second level of protection is triggered during the flight, the LED warning will be on. Whereas the center-point of the throttle stick will now move up slowly to 90% of the endpoint, you must land as soon as possible to prevent your multi-rotor from crash or other harmful consequences!
- When the center-point is at 90% of endpoint, multi-rotor will still start to ascend gradually, if you continue to pull the throttle stick back, and the control of Roll, Pitch, and Yaw is the same as before. Do land as soon as possible to prevent your multi-rotor from crash or other harmful consequences!

Simulation

We, during the test runs, tried to move a drone from one point to another point by running a script where we already given the coordinates of the initial and final position. This was the first step toward the autopilot/autonomous flight of the quadcopter.

The task was not just to send the drone from one point to another point, but also to hover it over that point for a while. To perform this specific task, a certain value of kp, ki and kd were required. These constants were important for the stability of the drone.

During the simulation we also entered some raw values of some constants to check the error percentage and deviation from the desired value. And at last, we succeeded to hover a drone over a point for a given time autonomously.

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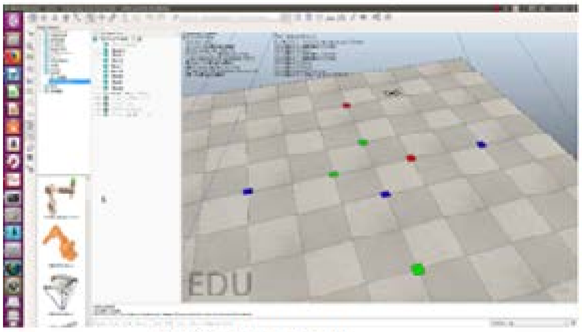
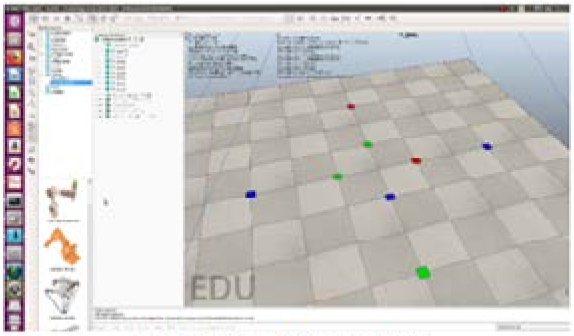
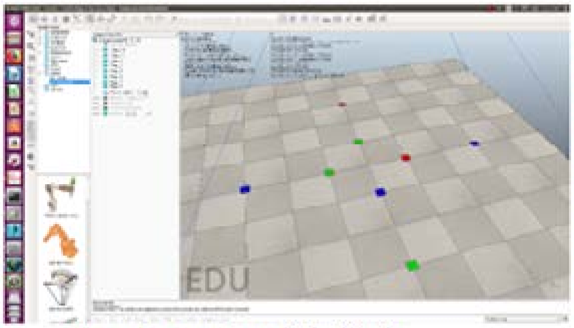


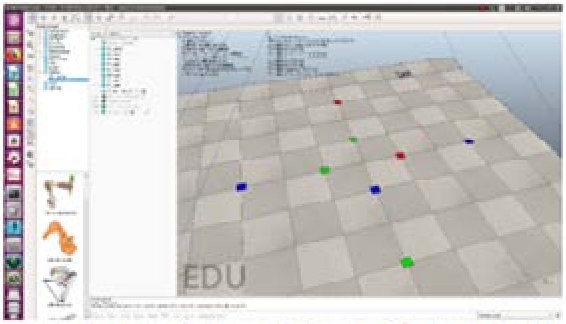
During the take off



holding high altitude position

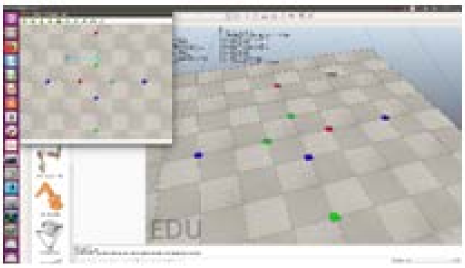


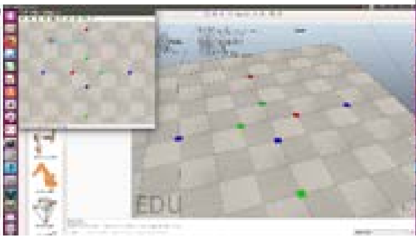
Drone is on extreme high altitude

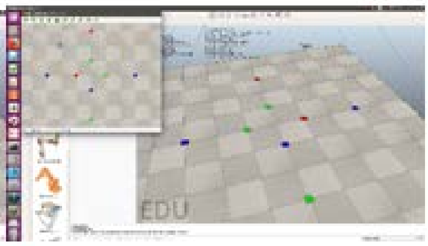


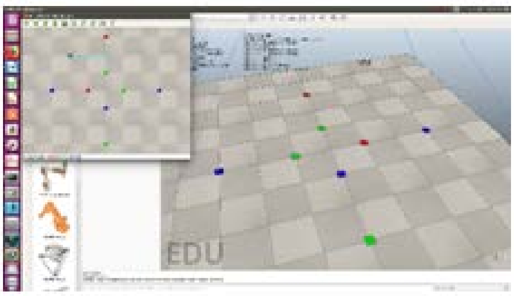
drone moving towards given point autonomously

HOWERING on a coordinate given on the script









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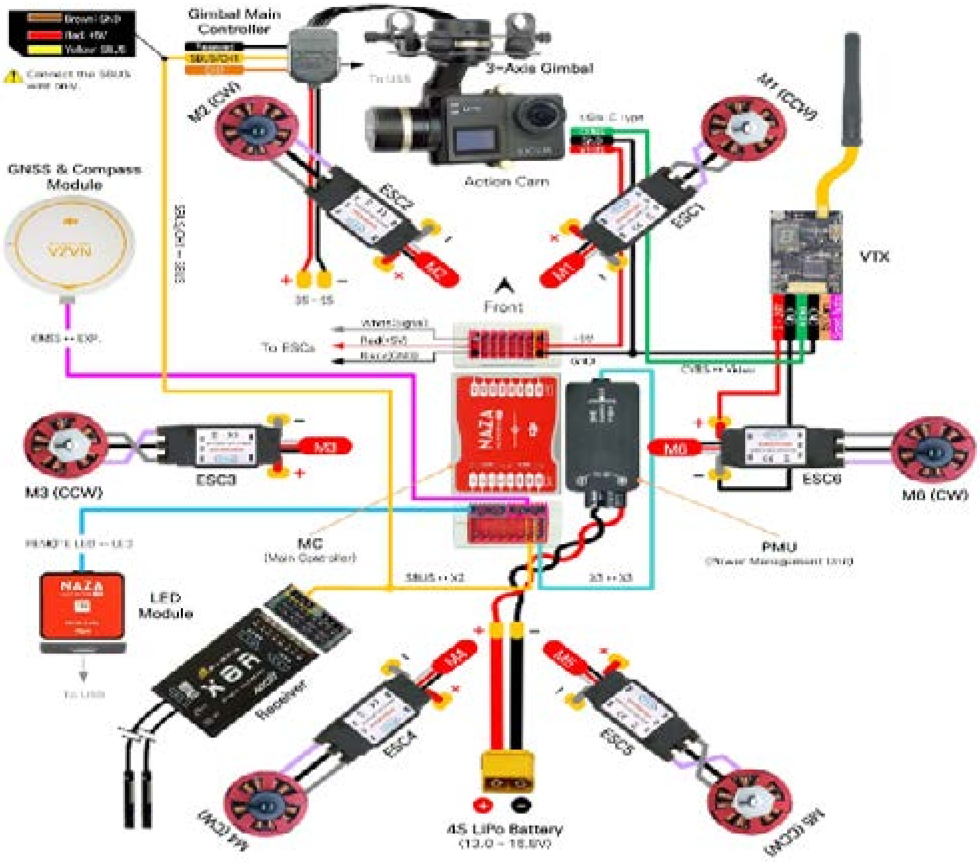
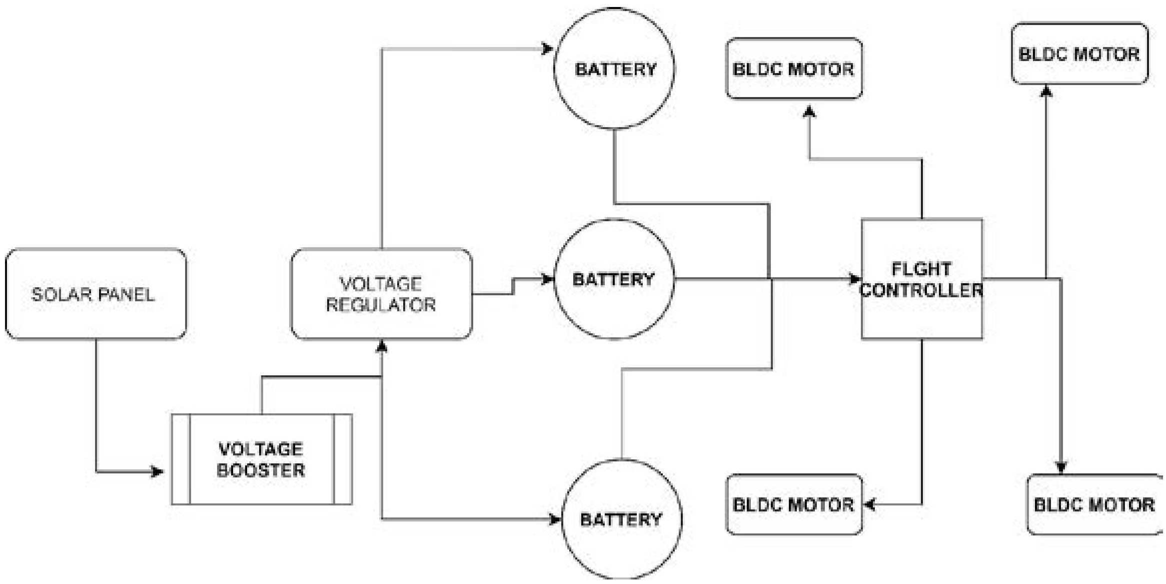
Connections and Block diagram



Connections of Naza – m – lite with all the components



Block diagram of Solar Autopilot Drone

Conclusion

Drones are now common all over the world, and they find applications in various fields. There remains the underlying factor of maximum flight time. This limits the range and extent of application. Thus, the need to find a sustainable provision of energy that will go a long way in breaking the shackles of limitation in the application of energy.

The Solar-Autopilot Drone (SAD) was considered as a vital area worthy of research because of many factors. From a global perspective, the demand for an effective

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surveillance systems has grown rapidly; quadcopters are useful devices to this end. The details of the design of the SAD was adequately carried out on each of the sub-parts and in accordance with the earlier stated objectives. The materials for construction were purchased and assembled after studious technical considerations.

It is obvious that drone technology is an important part of the future.The fact that drones technology poses a threat to the liberties of people around the world is also not unnoticed.

The design of the surveillance unit of the SAD was achieved with the use of wireless communication via a Wi-Fi network (operating at a frequency of 2.4GHz and a range of 150m). This network was made between a laptop computer and a Raspberry Pi SBC (the Single-Board Computer) used for this application. The laptop computer is responsible for the reception of the video feed sent by the Raspberry pi computer with the integrated camera device. The Raspberry pi runs an Operating System (OS) called the Motioneye OS, a Linux distribution made specifically for the surveillance application.

We carried out the required test runs in order to get the desired results. We successfully managed to hover , send SAD from one point to another point(autonomously). Using the monocrystalline solar panel. We attained the desired efficiency for the flight of the Drone and increased the flight time in the prototype.

Challenges Encounterd

- Component sourcing
- Weight balancing
- Compass Callibration
- Solar Panel integration
- High built-in cost
- Difficulty in weight reduction
- Enabling autopilot feature
- Uncontrolled motion in manual mode of drone
- RF module range
- PID tuning for autopilot feature

References

1. Sunpower datasheet on sunpower.com or "http://eshop.terms.eu/_data/s_3386/files/1379942540-sunpower_c60_bin_ghi.pdf
2. Naza -M-Lite user manual. http://dl.djicdn.com/downloads/naza-m%20lite/en/NAZA-M%20LITE_User_Manual_v2.00_en.pdf
3. Parker M, Robbiano C, Bottorff G. Quadcopter, 2011.
4. Chmelař P. Building and Controller a quadrocopter, 2011.
5. Zuriadi AHB. Quadcopter Embedded Controller for Altitude Hold and Surveillance. *UniverstiTeknikal Malaysia* Melaka, 2012.
6. Hanafi D, Qetkeaw M, Ghazali R et al. Simple GUI Wireless Controller of Quadcopter. *Int. J. Communications, Network and System Sciences* 2013; 52-59.
7. Abidali A, Burba I, Fani PJF et al. Wojewoda, *Solarcopter,* 2013.
8. Mueller MW, D'Andrea R. Stability and control of a quadrocopter despite the complete loss of one, two, or three propellers. *IEEE International Conference on Robotics & Automation* (ICRA), June 2014.
9. Sefidgari BL Shamchi SP. Auto Landing Process for Autonomous Flying Robot byusing Image Processing based on Edge Detection, 2014.
10. Solar Power System For Experimental Unmanned Aerial Vehicle(UAV): Design And Fabrication Mohsen Sadi& A.Y. Varjani, IInd Power Electronics, Drive System and Technologies Conference, 2011.
11. A Solar-Powered HALE-UAV for Arctic Research. H.Runge&W.Rack. 1st CEAS European Air and Space Conference, Berlin[2007].
12. Drones and Possibilities of Their Using. PiotrKardasz & 3 others Journal of Civil & Environmental Engineering, 2016.

ISSN: 2456-1401
DOI: https://doi.org/10.24321/2456.1401.202003