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3-Axis Camera Mount Gyroscopic Stabilization

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Abstract: Advances in radio controlled models have made it possible for model aircraft to conduct low-altitude aerial photography. This has benefited real-estate advertising, where commercial and residential properties are the photographic subject. Full-size, manned aircraft are prohibited from low flights above populated locations. Small scale model aircraft offer increased photographic access to these previously restricted areas. Miniature vehicles do not replace full size aircraft, as full size aircraft are capable of longer flight times, higher altitudes, and greater equipment payloads. They are, however, useful in any situation in which a full-scale aircraft would be dangerous to operate. Examples would include the inspection of transformers atop power transmission lines and slow, low-level flight over agricultural fields, both of which can be accomplished by a large-scale radio controlled helicopter. Professional-grade, gyroscopically stabilized camera platforms are available for use under such a model; a large model helicopter with a 26cc gasoline engine can hoist a payload of approximately seven kilograms.

The mechanical structure which holds the camera is called a gimbal. These can cover 1-3 axis of rotation, allowing for complete freedom of orientation for the camera. Considerations have to be given to weight, size, and construction when choosing the ideal one of your helicopters.

Weight of the mount has a vital affect in balancing the air craft. So, in order to reduce the effect the weight of the gyroscope should be minimized. But the gyroscope should maintain the strength to withstand external disturbances. To serve all these purposes we have used Composite materials. Composite materials are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties. Fiber-reinforced polymers or FRPs carbon-fiber reinforced plastic or CFRP, and glass-reinforced plastic or GRP are some of the composite fibers in which we have used CFRP. In general CFRP has good fatigue strength which may vary from 60-80% of the ultimate tensile strength for lives over 10^7 cycles.

Keywords – Radio controlled models, Model aircraft, Fiber-reinforced polymers, Carbon-fiber reinforced plastic, Glass-reinforced plastic

I. INTRODUCTION:

An Unmanned Aerial Vehicle (UAV) is an aircraft that flies without a human pilot onboard, controlled remotely or flown autonomously via pre-programmed flight plans or other automated guidance systems. Traditionally, UAVs were largely deployed in military missions, but are increasingly being adopted by civil applications including firefighting, law enforcement, assessment of natural disasters and environmental monitoring. UAVs are now a major component of the global war on terrorism. UAVs are extremely flexible devices, and can be used for a variety of applications beyond current military, counterterrorism and law enforcement requirements. Today, a wide range of international public service agencies and private corporations rely on UAVs for diverse, civil and commercial uses. UAVs are also an emerging business for the defense industry with a large potential for growth, at a time when the military worldwide is looking to cut back on big-ticket purchases such as fighter jets and navy ships. Combined with the aforementioned applications, the demand for UAVs in general and imaging cameras in particular is growing.

Aerial surveillance of large areas is made possible with low cost UAV systems. Surveillance applications include: livestock monitoring, wildfire mapping, pipeline security, home security, road patrol and anti-piracy. The trend for use of UAV technology in commercial aerial surveillance is expanding rapidly with increased development of automated object detection approaches. UAVs can be used to perform geophysical surveys, in particular geomagnetic surveys where the processed measurements of the differential Earth's magnetic field strength are used to calculate the nature of the underlying magnetic rock structure. Knowledge of the underlying rock structure helps trained geophysicists to predict the location of mineral deposits. The production side of oil and gas exploration and production entails the monitoring of the integrity of oil and gas pipelines and related installations. For above-ground pipelines, this monitoring activity could be performed using digital cameras mounted on one, or more, UAVs.

GYROSCOPE:

Gyroscope is a device for measuring or maintaining orientation, based on the principles of angular momentum. Mechanically, a gyroscope is a spinning wheel or disk in which the axle is free to assume any orientation. Although this orientation does not remain fixed, it changes in response to an external torque much less and in a different direction than it would without the large angular momentum associated with the disk's high rate of spin and moment of inertia. Since external torque is minimized by mounting the device in gimbals, its orientation remains nearly fixed, regardless of any motion of the platform on which it is mounted.

Applications of gyroscopes include inertial navigation systems where magnetic compasses would not work (as in the Hubble telescope) or would not be precise enough, or for the stabilization of flying vehicles like radio-controlled helicopters or unmanned aerial vehicles and camera mounts used for photographic surveys and studies. Due to their precision, gyroscopes are also used to maintain direction in tunnel mining.

Within mechanical systems or devices, a conventional *gyroscope* is a mechanism comprising a rotor journaled to spin about one axis, the journals of the rotor being mounted in an inner gimbal or ring; the inner gimbal is journaled for oscillation in an outer gimbal for a total of two gimbals.

The outer gimbal or ring, which is the gyroscope frame, is mounted so as to pivot about an axis in its own plane determined by the support. This outer gimbal possesses one degree of rotational freedom and its axis possesses none. The next inner gimbal is mounted in the gyroscope frame (outer gimbal) so as to pivot about an axis in its own plane that is always perpendicular to the pivotal axis of the gyroscope frame (outer gimbal). This inner gimbal has two degrees of rotational freedom.

The axle of the spinning wheel defines the spin axis. The rotor is journaled to spin about an axis, which is always perpendicular to the axis of the inner gimbal. So the rotor possesses three degrees of rotational freedom and its axis possesses two. The wheel responds to a force applied about the input axis by a reaction force about the output axis.

The behaviour of a gyroscope can be most easily appreciated by consideration of the front wheel of a bicycle. If the wheel is leaned away from the vertical so that the top of the wheel moves to the left, the forward rim of the wheel also turns to the left. In other words, rotation on one axis of the turning wheel produces rotation of the third axis.

A gyroscope flywheel will roll or resist about the output axis depending upon whether the output gimbals are of a free- or fixed- configuration. Examples of some free-output-gimbal devices would be the attitude reference gyroscopes used to sense or measure the pitch, roll and yaw attitude angles in a spacecraft or aircraft.

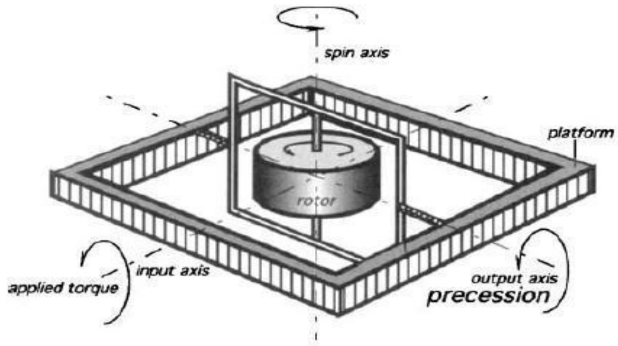


FIGURE 1: AXES OF GYROSCOPE

The centre of gravity of the rotor can be in a fixed position. The rotor simultaneously spins about one axis and is capable of oscillating about the two other axes, and, thus, except for its inherent resistance due to rotor spin, it is free to turn in any direction about the fixed point. Some gyroscopes have mechanical equivalents substituted for one or more of the elements. For example, the spinning rotor may be suspended in a fluid, instead of being pivotally mounted in gimbals. A control moment gyroscope (CMG) is an example of a fixed-output-gimbal device that is used on spacecraft to hold or maintain a desired attitude angle or pointing direction using the gyroscopic resistance force.

ROLE OF CAMERA MOUNTS:

The mechanical structure which holds the camera is called a camera mount. These can cover 1-3 axis of rotation, allowing for complete freedom of orientation for the camera. Considerations have to be given to weight, size, and construction when choosing the ideal one for a UAV. Camera mounts are designed to orient the camera in the desired position. The increasing emphasis on the image quality has also lead to an increased focus in the design of the camera mounts. A stealthy camera mount has become indispensable for high quality imaging for applications ranging from military and exploration of natural resources through aerial surveillance. Weight of the mount has a vital affect in balancing the air craft. So, in order to reduce the effect the weight of the mount and camera should be minimized. Also as it holds the camera, the design of mount should be in such a way that the mount should not obstruct the lens of the camera.

FIGURE 2: 2-AXIS CAMERA MOUNT

CAMERA STABILIZATION:

Stability Theory and Requirements

In order to obtain an unblurred image the camera must remain relatively stable relative to its subject while the shutter is open. Acceptable levels of vibration depend on the shutter speeds and features of the digital camera. For example, a camera with an image stabilizing lens will produce a much clearer image in the presence of vibration than a lens without this technology.

In practice it is possible to obtain an image that appears unblurred to the naked eye even if there was a slight shift in the relative position while the shutter was open. The intensity of the blurring is a function of shutter speed, lighting levels, and the relative velocity of the camera and subject. In a longer exposure, photo with a low light subjected to lighting levels do not vary greatly over the displacement distance and a shutter speed greater than several seconds in length a displacement which lasts only fractions of a second and then restores the initial relative positions will not have a large impact on the blurriness of the image. However, a displacement which is a significant fraction of the shutter speed in duration or which does not restore the relative positioning or in which the lighting levels vary greatly over the displacement distance will result in a blurry image.

Image size and resolution also plays a role in the perception of an image. A large image which is viewed from a distance will appear relatively clear unless it is viewed adjacent to a truly clear version of the image. The blurring only becomes apparent as one gets closer to the image and notices the lack of object boundary definition and contrast characteristic of an unclear image. Photo editing software packages such as Adobe Light room and Photoshop can also aid in sharpening a slightly unclear image using the special features included in such software. The process introduces some noise into the digital image but in general it does not greatly degrade overall image quality.

II. PROPOSED ALGORITHM

The ultimate objective of this undertaking is successful camera stabilization with a variety of sensor systems using dynamic data. The objective which will be met in several phases.

The first phase of this plan is designing, constructing and testing a camera stabilization system that will clearly meet the requirements of the course. In parallel to this the second phase of the project intends gathering the data and considering other aspects of stabilization. The third and final phase of this plan involves assembling the servomotors, sensor boards, communication and data recording systems required for a successful launch off light with camera mount.

As the unmanned air vehicles are light in weight, use of heavy materials such as aluminum, high speed steel, mild steels etc. is not applicable despite their high tensile strength. Hence use of composite materials is recommended as a good substitute for the typical steel alloys. Out of the currently available composites, carbon fiber has the highest strength to weight ratio and is considered ideal for the current application.

In particular the overall equipment has been remodeled to reflect the simplest form of design to increase its usage in multiple areas. The scope is limited to the construction, methodology, and testing of the camera stabilization system.

1. AVAILABILITY OF MATERIAL

As of now the material being used by us, CARBON FIBER is still under testing and development stage and is expected to be of much use in near future. Therefore, the availability of material today is scarce and had to be sourced from established manufacturers.

2. PRECISION

Because of the economic constraints in the project, the servos and motors used are of low cost their precision levels are limited to our typical requirements and are not intended to be of high precision as the ones used in high precision applications like hawk-eye cameras in cricket.

3. PROTOTYPE

Everything what we have made is just a prototype; suitable modifications have to be made for it to be directly installed in any machinery or industry for official use. Depending on the application a lot of research and testing needs to be done to enhance its usability.

4. DELAY

This also can be termed as lag caused because of the limited resources and limited budget for the type of electronic board and sensors used. To decrease the project cost and to make our prototype work effectively the board we have used is appropriate and so has a very minute lag and delay.

III. Experiment and Result

DESIGN PARAMETERS

Forces:

Support should be strong enough to resist the air currents. The external forces should not have any turning effect on the gyro support.

Weight constraint:

The main component of the gyroscope is its frame in which camera, electronics, gears etc.., are mounted. Therefore the weight of the frame should be minimized so that it does not increase the drag on the aircraft.

Portability

The gyro should be easy to handle, portable, and should not require any special care or handling of the gyro should be as easy as possible.

Complexity

The design and fabrication of the gyro should not be complex. It should be made easy and simple and it should also accommodate all the other components and assembly is to be made easy.

Material

The material used for fabrication should be light to minimize and also strong enough to resist to the forces.

Other parameters

The lubrication of the mating parts is to be properly maintained so that friction can be reduced to maximum extent. It should be economical.

Considering the standard co-ordinate axis, the Y-axis (or yaw) to be stabilized by the 'C' shaped frame. The following are the reasons for considering 'C' frame:

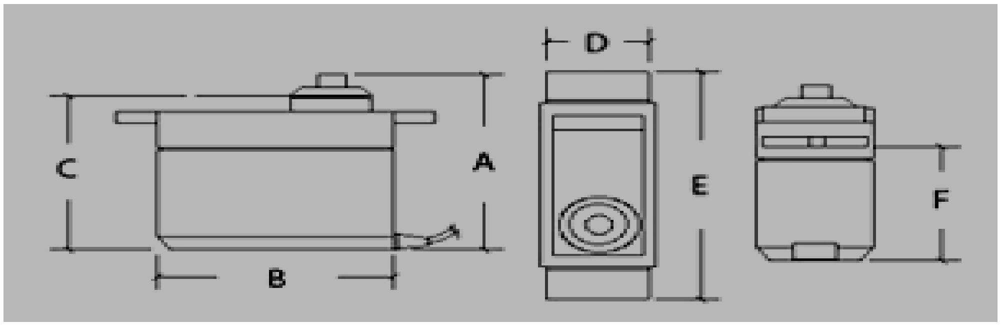
- **To minimize the weight**:
  As weight is one of the major constraints we have decided to make a C shaped frame instead of a rectangular frame
- **To increase the strength:**
  As the material used for fabrication is carbon fiber, its strength will be maximum when the load is applied along the direction of the fibers. Hence we came up with a C shaped frame although we have more weight reduction in a semi-circular frame.
- **Facilitates in assembly**:
  Fabrication of a double faced C frame helps us in both assembling the other frames and to mount different electronics into it.

SPECIFICATIONS:

The following are the specifications of servo motor used:

Weight	38 grams	A	41 mm
Torque	4.3kg	B	40 mm
Speed	0.17 sec/60°	C	37 mm
		D	20 mm
		E	55 mm
		F	26 mm

TABLE 1: SPECIFICATIONS OF SERVO MOTOR & DIMENSIONING OF SERVO USED



Size	39 x 30 x 15mm
Operating voltage	4.8v-9v
Operating temperature	20 -45c°
Weight	30g

TABLE 2: The specifications of 3-axis electronic gyroscope

The specifications of the frame are:

Inner diameter of rotating gimbal	188 mm
Outer diameter of rotating gimbal	249 mm
Groove on rotating gimbal	6 mm
Inner diameter of supporting gimbal	240 mm
Outer diameter of supporting gimbal	260 mm
Width of C-frame	60 mm
Length of C-frame	335 mm
Height of C-frame	250 mm
Total frame height	300 mm

TABLE 3: SPECIFICATIONS OF FRAME

The specifications of deep groove ball bearing are:

Inner diameter	9 mm
Outer diameter	23 mm

TABLE 4: SPECIFICATIONS OF DEEP GROOVE BALL BEARING

WORKING:

SERVO MOTOR:

A servomotor is a motor which forms part of a servo-mechanism. The servomotor is paired with some type of encoder to provide position/speed feedback. A stepper motor is one type of servomotor. Servos are controlled by sending them a pulse of variable width. The control wire is used to send this pulse. The parameters for this pulse are that it has a minimum pulse, a maximum pulse, and a repetition rate. Given the rotation constraints of the servo, neutral is defined to be the position where the servo has exactly the same amount of potential rotation in the clockwise direction as it does in the counter clockwise direction. It is important to note that different servos will have different constraints on their rotation but they all have a neutral position, and that position is always around 1.5 milliseconds (ms).

The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse width Modulation. The servo expects to see a pulse every 20 milli seconds. The length of the pulse will determine how far the motor turns. For example, a 1.5 ms pulse will make the motor turn to the 90 degree position (neutral).

When these servos are commanded to move they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is the torque rating of the servo. Servos will not hold their position forever though; the position pulse must be repeat to instruct the servo to stay in position.

FIGURE 3: Digital Servo

When a pulse is sent to a servo that is less than 1.5 ms the servo rotates to a position and holds its output shaft some number of degrees counterclockwise from the neutral point. When the pulse is wider than 1.5 ms the opposite occurs. The minimal width and the maximum width of pulse that will command the servo to turn to a valid position are functions of each servo. Different brands, and even different servos of the same brand, will have different maximum and minimums. Generally the minimum pulse will be about 1 ms wide and the maximum pulse will be 2 ms wide.

Another parameter that varies from servo to servo is the turn rate. Turn rate is the time a servo takes to change from one position to another. The worst case turning time is when the servo is holding at the minimum rotation and it is commanded to go to maximum rotation. This can take several seconds on very high torque servos.

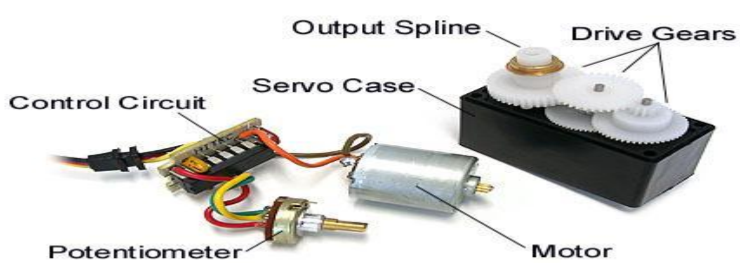


FIGURE 4: SERVO MOTOR DESCRIPTION

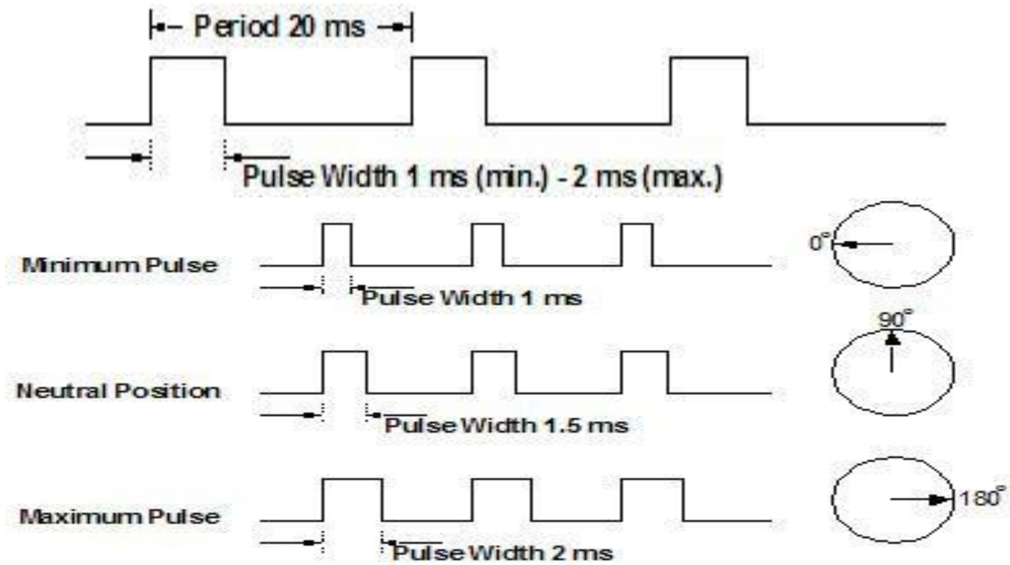


FIGURE 5: PICTURE SHOWING THE FREQUENCY

FIGURE 6 : STANDARD ANALOGUE SERVO.

Specifications

- Torque: 3.8kg @ 4.8v, 4.3kg @ 6v
- Weight: 38g
- Speed: 0.21 / 60deg @4.8v, 0.17 / 60deg @ 6v
- Voltage:4.8v~6v
- Plug: JR Style

TRANSMITTER

A Transmitter or radio transmitter is an electronic device which, with the aid of an antenna, produces radio waves. The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. A transmitter can be a separate piece of electronic equipment, or an electrical circuit within another electronic device. A transmitter and receiver combined in one unit is called a transceiver. A transmitter can be a separate piece of electronic equipment, or an electrical circuit within another electronic device. A transmitter and receiver combined in one unit are called a transceiver. The information is provided to the transmitter in the form of an electronic signal, such as an audio (sound) signal from a microphone, a video (TV) signal from a TV camera, or in wireless networking devices a digital signal from a computer. The transmitter combines the information signal to be carried with the radio frequency signal which generates the radio waves, which is often called the carrier. This process is called modulation. The information can be added to the carrier in several different ways, in different types of transmitter.

FIGURE 6: TRANSMITTER

RECEIVER:

In radio communications, a radio receiver is an electronic device that receives radio waves and converts the information carried by them to a usable form. It is used with an antenna. The antenna intercepts radio waves (electromagnetic waves) and converts them to tiny alternating currents which are applied to the receiver, and the receiver extracts the desired information. The receiver uses electronic filters to separate the wanted radio frequency signal from all other signals, an electronic amplifier to increase the power of the signal for further processing, and finally recovers the desired information through demodulation. A radio receiver may be a separate piece of electronic equipment, or an electronic circuit within another device.

FIGURE 7: RECEIVER

This **RF module** comprises of an **RF Transmitter** and an **RF Receiver**. The transmitter/receiver (Tx/Rx) pair operates at a frequency of **434 MHz**. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmit.

A gyroscope sensor has the following basic specifications:

- Measurement range
- Number of sensing axes
- Nonlinearity
- Working temperature range
- Shock survivability
- Bandwidth
- Angular Random Walk (ARW)
- Bias
- Bias Drift

Measurement range

This parameter specifies the maximum angular speed with which the sensor can measure, and is typically in degrees per second (˚/sec).

Number of sensing axes

Gyroscopes are available that measure angular rotation in one, two, or three axes. Multi-axis sensing gyros have multiple single-axis gyros oriented orthogonal to one another. Vibrating structure gyroscopes are usually single-axis (yaw) gyros or dual-axis gyros, and rotary and optical gyroscope systems typically measure rotation in three axes.

Nonlinearity

Gyroscopes output a voltage proportional to the sensed angular rate. Nonlinearity is a measure of how close to linear the outputted voltage is proportional to the actual angular rate. Not considering the nonlinearity of a gyro can result in some error in measurement. Nonlinearity is measured as a percentage error from a linear fit over the full-scale range, or an error in parts per million (ppm).

Working temperature range

Most electronics only work in some range of temperatures. Operating temperatures for gyroscopes are quite large; their operating temperatures range from roughly -40˚C to anywhere between 70 and 200˚C and tend to be quite linear with temperature. Many gyroscopes are available with an onboard temperature sensor, so one does not need to worry about temperature related calibrations issues.

Shock Survivability

In systems where both linear acceleration and angular rotation rate are measured, it is important to know how much force the gyroscope can withstand before failing. Fortunately gyroscopes are very robust, and can withstand a very large shock (over a very short duration) without breaking. This is typically measured in g's (1g = earth's acceleration due to gravity), and occasionally the time with which the maximum g-force can be applied before the unit fails is also given.

Bandwidth

The bandwidth of a gyroscope typically measures how many measurements can be made per second. Thus the gyroscope bandwidth is usually quoted in Hz.

Angular Random Walk (ARW)

This is a measure of gyro noise and has units of deg/hour$^{1/2}$or deg/sec$^{1/2}$. It can be thought of as the variation (or standard deviation), due to noise, of the result of integrating the output of a stationary gyro over time. So, for example, consider a gyro with an ARW of 1°/sec$^{1/2}$ being integrated many times to derive an angular position measurement: For a stationary gyro, the ideal result - and also the average result - will be zero. But the longer the integration time, the greater will be the spread of the results away from the ideal zero. Being proportional to the square root of the integration time, this spread would be 1° after 1 second and 10° after 100 seconds.

Bias

The bias, or bias error, of a rate gyro is the signal output from the gyro when it is NOT experiencing any rotation. Even the most perfect gyros in the world have error sources and bias is one of these errors. Bias can be expressed as a voltage or a percentage of full scale output, but essentially it represents a rotational velocity (in degrees per second). Again, in a perfect world, one could make allowance for a fixed bias error. Unfortunately bias error tends to vary, both with temperature and over time. The bias error of a gyro is due to a number of components:

- calibration errors
- switch-on to switch-on
- bias drift
- effects of shock (g level)

Individual measurements of bias are also affected by noise, which is why a meaningful bias measurement is always an averaged series of measurements.

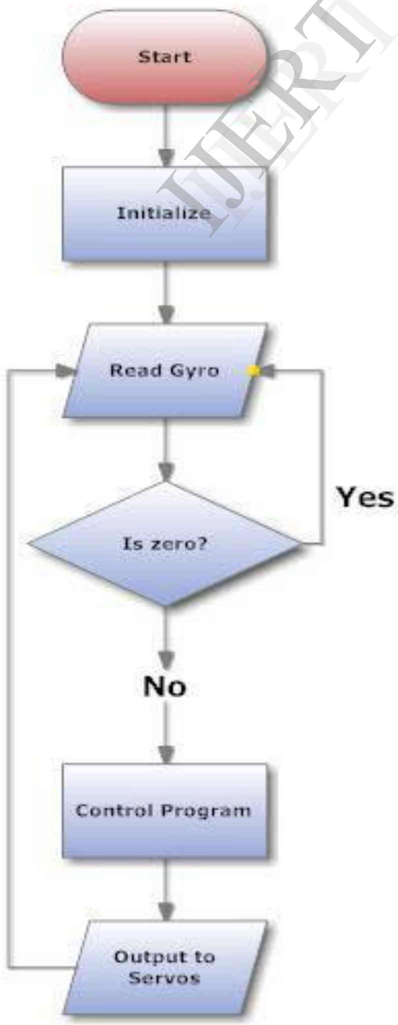
Bias Drift

This refers specifically to the variation of the bias over time, assuming all other factors remain constant. Basically this is a warm-up effect, caused by the self heating of the gyro and its associated mechanical and electrical components. This effect would be expected to be more prevalent over the first few seconds after switch-on and to be almost non-existent after (say) five minutes

FIGURE 8: 3-AXIS GYRO PPC CONTROL FOR CALIBRATION OF ELECTRONIC GYROSCOPE.

Control Algorithm:

The project team tested several variations of PID control code in testing and tuning the stabilization system. The system reads angular rate data from the electronic gyros and uses that data to output position data to the servo motors to counteract any motion experienced by the gyro. The program flow diagram is shown below



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MECHANICAL DESIGN

The project team considered a variety of mechanical design for the implementation of the stabilization system. The objective was to keep the system as simple as possible and use inexpensive. The main components selected for the majority of designs included digital gyroscope sensors, servo motors and an Arduino microcontroller. These parts are inexpensive and relatively versatile to fit a variety of mechanical implementations.

The layout and shape of the payload will play a critical role in determining the suitable stabilization system or vice versa so the team designed and considered several options for mechanical implementation. The basic idea for the design was to use a gyro and servo for each axis of rotation we wished to stabilize. In the draft design this was done using a rotating bracket set inside a rotating enclosure. This design suffers from several flaws which would make PID control tuning difficult such as the location of the servo on the axis of the center of mass. A better design would incorporate some kind of gearing and utilize any available inherent stability and balance.

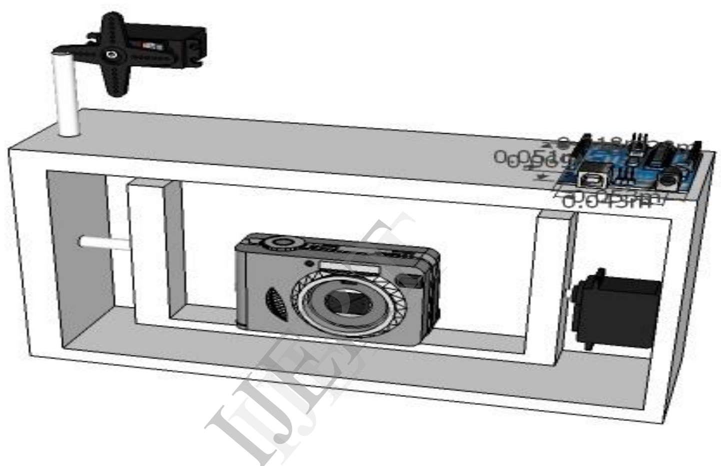

FIGURE 9: DESIGN OF THE FRAME

The next iteration of design improved on the location of the servos and reduced the amount of material in the mechanical design but still failed to provide much consideration for inherent stability and balance. It was thought that this configuration would result in a very difficult PID system to tune and that the response time would be much less than that required to meet our stability criteria. For this reason the project team decided to keep working toward a more theoretically sound mechanical design instead of constructing and testing the early iteration designs.

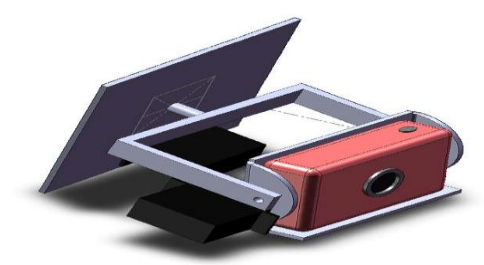

FIGURE 10: MODIFIED DESIGN OF THE FRAME

The below figure is an improvement over the second iteration design shown in which features two servo motors to control the camera about the Z and Y axes. This design also brings with it the idea of separating the still camera system from the rest of the payload. This idea would allow more freedom in designing the camera stabilization system than the first two iterations shown above because we do not have to consider the placement of radio and data components. The radio and sensor payload is not shown in any of the figures and its design is beyond the scope of this recommended report.

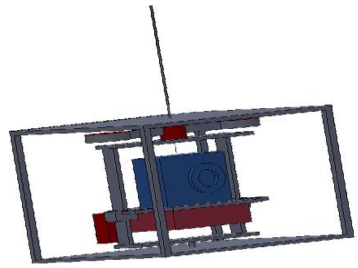

FIGURE 11: IMPROVED DESIGN OF THE FRAME

The alternate design shown below takes this design a step further by adding a gyroscopic stabilizer to the camera platform which will provide some inherent stability due to the high angular momentum of the spinning gyro. This is a stabilization feature common in high level and professional stabilization units. The open enclosure concept in these last three designs gives the camera a wide and unobstructed view with which to capture images satisfying the tilt required to clear the image of the Earth. It has the disadvantage of being very susceptible to the environmental changes in temperature and moisture the payload will experience during the flight.

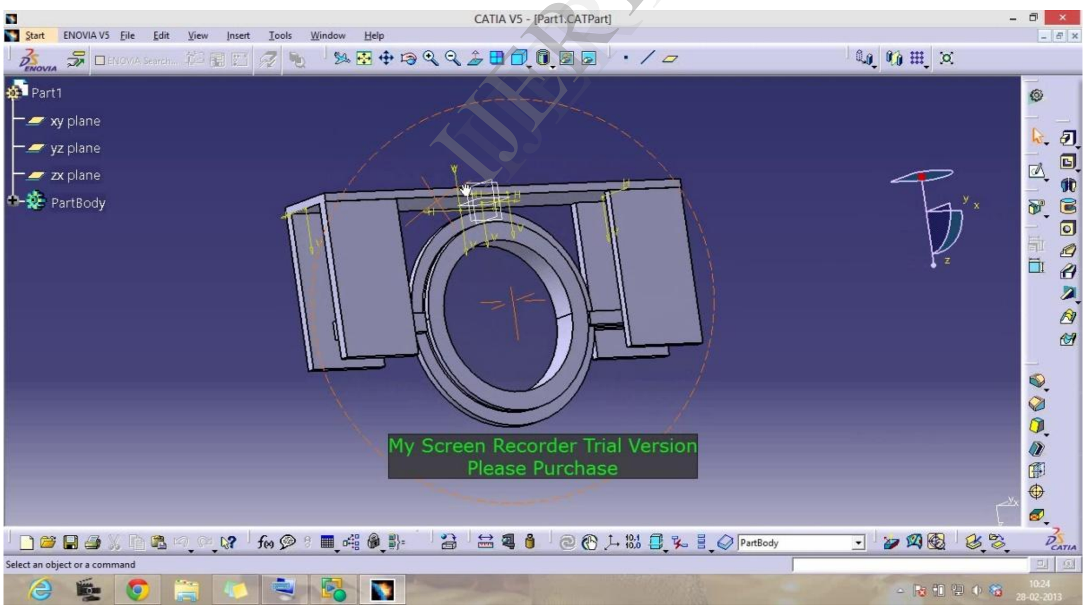

FIGURE 12: FINAL DESIGN OF THE FRAME.

The 19deg of rotation required to remove the Earth from the image sets a limit on the gear ratios allowed by the mechanical design. The range of motion of the servo is 180deg so a gear ratio of 4:1 with a maximum camera tilt of 22.5deg will allow the required 19deg of tilt and still leave 3.5deg available for stabilization.

FABRICATION:

Pre requisites for fabrication:

Material:

Carbon fiber, alternatively graphite fiber, carbon graphite or CF, is a material consisting of fibers about 5–10 μm in diameter and composed mostly of carbon atoms. The carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber. The crystal alignment gives the fiber high strength-to-volume ratio (makes it strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabric. Each carbon filament thread is a bundle of many thousand carbon filaments. A single such filament is a thin tube with a diameter of 5–8 micrometers and consists almost exclusively of carbon. Carbon fiber is a super strong material that's also extremely lightweight. It is five times as strong as steel, two times as stiff, yet weighs about two-thirds less. Carbon fiber is basically very thin strands of carbon -- even thinner than human hair. The strands can be twisted together, like yarn. The yarns can be woven together, like cloth. To make carbon fiber take on a permanent shape, it can be laid over a mould, then coated with a stiff resin or plastic

Resin:

Resin used for fabricating the component is LY 556 Araldite. This is generally used for Industrial composites and Structural composites. Since it has Amine-cured laminating system without reactive diluent, it shows excellent flexibility and high reactivity properties. This resin is used in winding processes like Filament Winding, Pressure Moulding, Resin Transfer Moulding (RTM), and Wet Lay-up.

Property	Range	Units
Viscosity	10000 – 12000	cps
Density	1.15 - 1.20	[g/cm^3]

TABLE 5: PROPERTIES OF CARBON FIBER

Processing Data Mix Ratio: The resin should be weighed with an accurate balance to prevent mixing inaccuracies which can affect the properties of the matrix system.

Mould: C Frame:

Trail-1

Collapsible Mould is prepared with a dimension of 300*200*50 mm consists of three planks each of 15mm are joined and taper cutting is done on the both sides of the middle plank with a particular angle and also to adjacent sides of the other two planks (This tapering of the sides is done so that removing of the mould from the component becomes easier). A C-shaped wooden piece is aligned on both the edges of the wooden mould. This mould is made up of new wood.

Trail-2

In this the wooden mould is provided with a handle by just increasing the length. The handle helps in adjusting the mould in the chuck so that the winding is done directly on the mould.

Pressure plate:

Initially G.I sheets were used as pressure plates but the component which was obtained was not strong enough due to insufficient pressure. Later on dead weights were used for this purpose.

Wet winding:

The method which we have used for winding was Wet winding. In the wet winding method, the fiber picks up resin either by passing through a resin bath or from a metered application system.

Main procedure

'C' Frame:-

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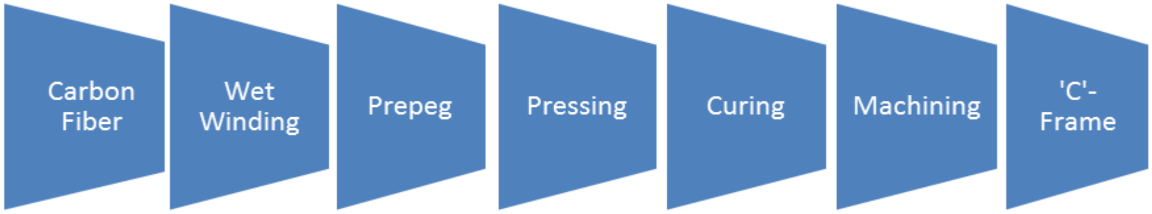

FIGURE 13: PROCESS OF FABRICATION

Trail-1

Initially a plastic sheet is rolled on the cylinder on which the winding will be done. Now the carbon fiber is passed through the resin bath and is winded on cylinder which is attached to a lathe machine. Lathe machine helps the cylinder to revolve; there by a carbon fiber layer is formed on the cylinder. This whole process is known as wet winding. After the winding is finished another plastic sheet is placed on the carbon fiber layer, now the carbon fiber layer is removed from cylinder. After carbon fiber is removed from the cylinder it is cut to the require shape. Now the prepeg is placed on the mould and pressure plates are attached and fixed to it with the help of 'C' clamps. This setup is left for 8-10 hours for the resin to solidify. The middle plank is separated from the mould so that the remaining two planks will collapse and the 'C' frame is easily removed. Machining (Filing and Grinding) is done to remove the irregularities and there by obtaining a good surface finish. Due to inappropriate pressure plates used the 'C' frame couldn't get enough strength and hence the trail was failed.

Trail-2:

In this trail again wet winding is done and carbon fiber is cut into required shape and placed on the collapsible mould same as the previous one. To overcome the defects obtained in the first trail we have used glass cloth to obtain a good strength. The glass cloth is placed on the prepeg and then pressure plates are attached with the help of 'C' clamps. As earlier the setup is left for 8-10 hours to solidify the resin. The 'C' frame separated from the mould, but this it has enough strength with irregularities. These irregularities are due to inept pressure plates and hence this trail was also failed.

Trial-3:

Instead of collapsible mould a wooden rectangular block of required dimensions is used for winding. A handle is provided to the block so that it can be attached to mandrel. This time we have used dry winding technique which is done on the wooden block. In the dry winding method, the reinforcement is in the preimpregnated form termed tow preg. After several layers are wound, the component is cured and removed from the mandrel (or in some cases the mandrel becomes part of the component). In this trail we have used both Carbon Fabric as well as Carbon Fibers.

Release fabric is wound on the block so that the fabric does not stick to the block. Resin is applied to carbon fabric and it is overlapped on the release fabric. Now winding is done on the fabric simultaneously resin is applied on carbon fiber. Above procedure is repeated again depending upon the thickness we require. This time dead weights are used as pressure plates instead of G.I sheet metals and it is clamped with the help of 'C' clamps. The final product what we got was strong enough and it has no surface irregularities and this trail was successful.

Inner and Outer Ring:-

The mould which is been used was a circular disc with of diameter 26cm. Carbon Fabric is placed on the plastic sheet and then resin is applied to the Fabric. Now the fabric is cut in the circular shapes using wooden disc. According to the thickness required the fabric layers are layup and kept between the dead weights to solidify.

STRUCTURAL ASSEMBLY:

The C frame is provided with a rod on the center of the top to mount the equipment wherever required. This rod also helps us in rotation about y axis. A gear is fixed to the rod so that there is no relative motion between the rod and gear. A servo which has a gear head that matches with the gear on the rod is fixed on the frame firmly. As the rod is fixed the servo along with the C frame rotates in the direction according to the signal generated and thus stabilizes about Y-axis

The legs of the C frame are fixed with the nylon cubic blocks on both sides to add strength to the structure as the maximum load is concentrated on the legs. This also helps in mounting the inner and outer gimbals to the C frame. Nylon blocks are used as they have high strength and very low weight compared to other materials. As it is a soft material it has an added advantage of easy machining. The blocks on both the sides are aligned on the same axis so that axis of rotation of the outer gimbal is parallel to the X-axis.

The outer gimbal needs to be settled in the groove provided on the surface of the inner gimbal. For this purpose the outer ring is cut into two halves and is made to settle inside the groove. Two rods are provided on each side of the ring to hold the two halves and also to rotate the entire ring about the X-axis. The nylon blocks fixed to the legs of the C frame have a through hole and a bearing on one side. The rods holding the outer ring should pass through the holes and bearings provided inside the blocks. Bearings are provided for the easy movement of the rods.

One of the rods is provided with the gear at the end to transmit the required motion from the servo. The servo is rigidly fixed on the corresponding block.

The inner gimbal is now supported by the outer one as its groove is settled in the outer ring. The walls of the groove are cut into gears so that it meshes with the servo gear head and rotates about Z-axis as per the motion required. This servo have no relative motion with respect to the outer gimbal. Thus it is stabilized about Z-axis.

The inner gimbal is provided with a camera mount with a facility to adjust the position of the lens whenever required.

RESULTS AND TESTING OF CARBON FIBER:

As mentioned earlier the most important reason for selecting carbon fiber material over other materials for the construction of frame is due to its high strength/weight ratio. The following are the testing results of various specimens of different dimensions.

TEST 1

This test is conducted comparing various specimens like iron, stainless steel and carbon fiber (A-GRADE).

SPECICATIONS

- Initial gauge length 50 mm
- Initial width 21.16 mm
- Initial thickness 2.01 mm

Specimen	Peak load(KN)	Tensile strength(N/mm^2)	Weight (grams)	Strength/weight ratio.
Iron	14.76	347.04	106	3.27
Stainless steel	25.98	610.8	74	8.25
Carbon fiber	19.86	466.95	14	33.35
Carbon fiber high grade	31.74	527.07	14	37.69

TABLE 6: TESTING RESULTS OF VARIOUS MATERIALS

The above results clearly depict that the strength/weight ratio to carbon fiber is 10 times to that of iron and 4 times to that of stainless steel.

TEST 2

This test is conducted comparing various specimens like iron, aluminum and carbon fiber (B-GRADE).

SPECIFICATIONS

- Initial gauge length 50 mm
- Outer diameter 3.94 mm

Specimen	Peak load(KN)	Tensile strength(N/mm^2)	Weight (grams)	Strength/weight ratio.
Iron	8.82	723.41	243	2.97
Aluminum	9.60	787.39	74.07	10.63

Carbon fiber	3.72	305.11	12.20	33.35

TABLE 7: TESTING RESULTS OF VARIOUS MATERIALS

The above results clearly depict that the strength/weight ratio to carbon fiber is 10 times to that of iron and 4 times to that of stainless steel and 3 times greater than that of aluminum.

IV.CONCLUSION

UAV'S have become a critical part of any country's defense forces. An important component of UAV is a camera and the structure associated with it. A camera mount decides the clarity of image sought and therefore plays an important role in the design of a UAV. The importance is also reflected in recent advancements in the camera mounts with the usage of principles of gyroscope in particular. However literary survey done in this area has shown a need gap in the low precision photography for simpler applications.

A balanced approach has been taken to decide on the material strength and the intended usage. The typical camera mounts that are currently in use employ materials of high strength suitable for the purpose of defense services but not other economic applications. A certain choice of material and design has been arrived at which most feasible for low precision UAV applications. The above ideas are put into action by choosing composite materials which reduces the overall weight of the UAV while at the same time increasing the strength of the overall structure. Also the design has been simplified to a large extent using traditional gyroscope principle in 3-axis.considerable effort has been made to study the existing composites as a potential construction material.

Carbon fiber whose other applications are still to be seen, was found to be the best bet addresses the project's purpose. The whole process of manufacturing the carbon fiber is studied as a part of the project.post material selection, an important aspect of the project emphasized on is to reexamine the design and reduce the complexity of the design for it to be easily replicable with data tabulated where it was found necessary, the 3-axis camera mount stabilizer that has been extensively discussed exactly achieves the purpose.

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V. REFERENCES

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