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Development of Micro Aerial Vehicle (MAV) for Military Indoor Surveillance

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Abstract – *Unmanned Aerial Vehicles or UAV's are used in various fields for various applications. Every field requires a different UAV design that will fulfill the need or work of that particular field. UAV's are already in use by the military worldwide, various drones are used depending on the situation or operation. There are certain situations when target locations are congested and easy to hide dense areas. The normal surveillance drones cannot monitor such areas due to many obstacles. This is where the problem occurs. What if we had something similar to a surveillance drone but in micro size with the same functions, which can go through such congested and dense areas. So, we are developing a micro UAV (Micro Aerial Vehicle- MAV) for military surveillance. It will have a compact micro design which makes it easy to fly through small areas without getting in visual range of target. This MAV will be used for surveillance of targets hidden in buildings, dense areas, etc. where a normal size UAV cannot be used. Most military operations are carried out during the night so this MAV will be equipped with an auto day/night vision camera. It will have an auto-angle adjustment mechanism for the camera for different angle visuals. Video/ audio FM transmitter will be mounted in this MAV which will give live video/audio feed to the operator on the monitor. We are trying to develop this MAV in-house under 'Make in India' initiative taken by the Government of India, at the low cost possible with the same functions. Rather than depending on other countries' technology and buying them at a high cost, we are trying to make it our self for our country.*

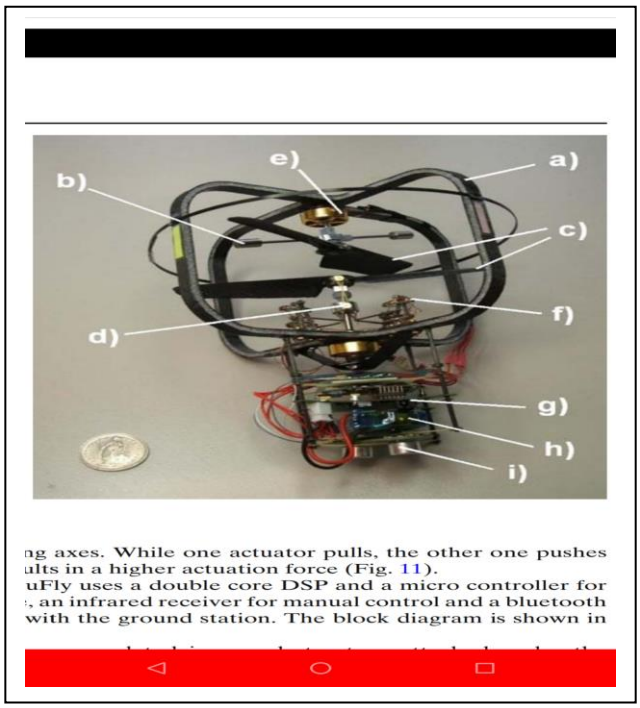
Key Words: MAV, Coaxial, rotorcraft.

1. INTRODUCTION

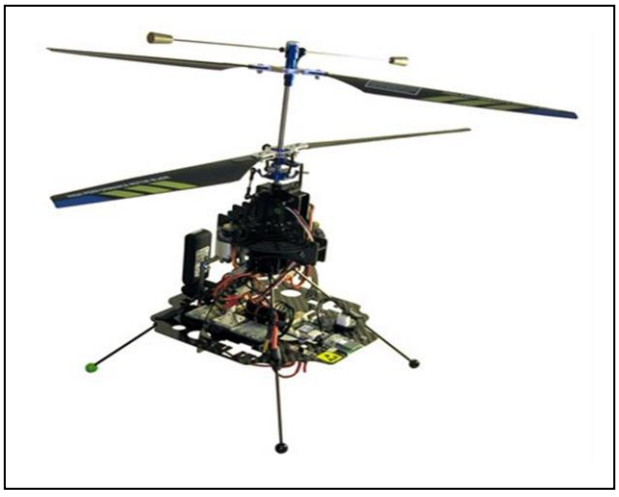
The Unmanned Aerial Vehicle is a drone with multiple capabilities. Unmanned Aerial vehicles can be remote-controlled aircraft (e.g. One in which a pilot flies at a ground control station) or can fly autonomously which can be based on pre-programmed flight plans or with the help of more complex dynamic automation systems. Unmanned Aerial vehicles have always been associated with the military but they are also used for various other activities search and rescue, surveillance, traffic monitoring, weather monitoring, and firefighting, among other things. The Micro Aerial Vehicle is a concept of having multiple domains on a single UAV such that an aerial vehicle primarily it is able to hover above the ground. This project gives detailed explanations and studies to introduce the multi-domain feature on MAV's. The project also provides the advantages of multi-domain features and future scope. A Micro Aerial Vehicle (MAV) is a military robot used to augment the capabilities of an infantry unit or replace said unit entirely. This type of robot is generally capable of operating indoors and in dense areas, functioning in place of UAVs. A coaxial mechanism with two rotors is used in the design. Because of its unique design compared to the traditional Quadcopter, it allows a more stable platform, making MAV ideal for tasks such as surveillance and rescue operations. The MAV exists in many different sizes. From as small as an insect up to a bird. The regular helicopter has two rotors one big rotor to provide all the lifting power and a little tail rotor to offset the aerodynamic torque generated by the big rotor (without it, the helicopter would spin almost as fast as the propeller) like a helicopter, rotorcraft MAV has two rotors. Development of sensors and mathematical algorithm to achieve the more and more precise navigation and stabilization of UAVs. We can find a similar tendency in the development of MAV's control system. The goal of this paper is to present a brief overview of the available open-source control system to describe the building of a MAV, based on one of these systems and the first result of a field test, which was carried out with this low-cost system.

2. LITERATURE REVIEW

Dario Schafroth (2008): in this paper of 'muFly Micro helicopter' they have developed a micro coaxial helicopter. They performed various aerodynamics & flight dynamics. Cyclic pitching of swashplate & balance bar is studied. The experiment includes measuring thrust & drag torque of different rotor blades design. They measured rotor forces & moments with a 6-axis force sensor. The below figure shows the muFly helicopter with i)carbon fiber sandwich cage, ii) stabilizer bar iii) carbon fiber rotor blades, iv) swashplate, v) BLDC motor, vi) linear actuator, vii) PCB mainboard with double core DSP, viii) lipo battery, ix) ultra-sound sensor.



Zelimir husnic (2014): The flight dynamics of the micro coaxial helicopter were studied and a simplified model for the autonomous flight control system design was constructed. System identification techniques that are used in full-scale helicopters have been successfully applied to the micro coaxial un-manned helicopter. The essential parts of system identification include model theory, parameter estimation, experimental data acquisition, and model validations. The multivariable tracking and H2 control theory were employed to design a fight control system that would provide desired performance and stability for the autonomous fight of different maneuvers mentioned above. With a well-designed autonomous flight control system, the micro coaxial helicopter can be deployed for battlefield awareness in battlefields, surveillance for search and rescue, border patrol, counter-terrorism operations, etc.



Christian Bermes (2

Christian Bermes (2008): These developments include shrouded quadrotors, cyclocopters, ducted fans, biologically inspired samara vehicles, which is one bladed rotor. Also, the use of insects as a power source for small aerial vehicles has been investigated. A new class of aerial vehicles has been born – the Micro Aerial Vehicle (MAV). With so much freedom in the design of systems, and with the relatively cheap availability of components to build such systems, MAVs have grown their own area of scientific research and are no longer restricted to military needs and funding. This thesis aims to contribute to the research area in the domain of coaxial rotary-wing MAVs that can operate fully autonomously in indoor environments.

3. DESIGN OBJECTIVES

The objective of this project are:

1) Indoor Military surveillance.
2) Search & rescue operations
3) Reconnaissance in confined areas
4) Bird's eye view for situational awareness

4. METHODOLOGY

This project started with the research of nano & micro drones. There were various micro-drones being developed, as small as possible in size with maximum possible functions. We wanted a micro drone with lightweight easy to operate and stealth in operation. After comparing many designs and their advantages & disadvantages we finalized the rotorcraft design which has one main rotor and a tail rotor for yaw.

5. COMPONENT FUNCTION & SPECIFICATIONS

1) Coreless Motor: This coreless 8520 motor for micro drones is a very compact and lightweight DC motor. They are rated at 50000 RPM which is more than needed to lift. These are less noisy with low resistance. Speed: 50000 rpm· Low resistance · Less noisy operations · This is a high-speed low torque motor · Diameter 8.5mm · Length 20mm · Shaft dia 1mm.

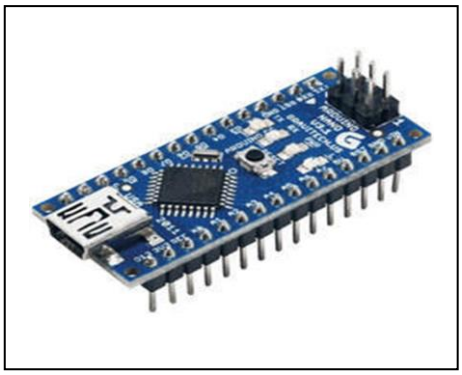
2) Tail motor – This coreless 1607 motor for micro drones is a very compact and lightweight DC motor. They are rated at 25000 RPM. These are less noisy with low resistance. Speed: 25000 rpm· Low resistance · Less noisy operations · This is a high-speed low torque motor · Diameter 7mm· Length 16mm· Shaft dia 1mm

3) Transmitter & Receiver:

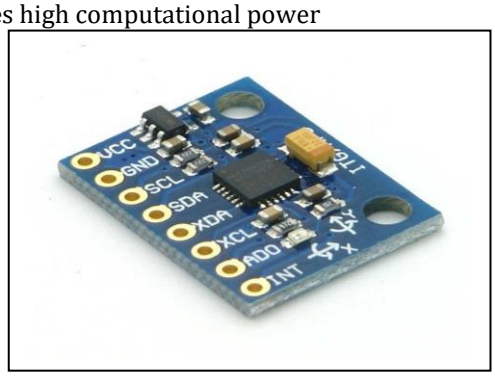
Transmitter: This is the Flysky FS-i6 2.4g 6ch PPM Rc transmitter with an FS-Ia6b receiver. it is a 2.4GHz radio transmitter that weighs 400gms. It is also really practical with a 3-position switch. Output PPM· 6 ch 2.4GHz radio with telemantry capabilities · 20 model memory· LCD screen· Easy to use.

Receiver: This is a PPM output Fs-Ia6b receiver. it is compact lightweight. 6chreceiver. Input power 3.7v to 4.8v· 6 channel · Weight 10g· PPM output · 25mmx45mm

4) Arduino Nano: Arduino nano is one type of microcontroller board, and it is designed by ardunio.cc. Another microcontroller like atmega328 can also be used. Because of the small size board and its flexibility with a wide variety of applications. Operating voltage: 5V· ATmega328P microcontroller · Input/output pin: 22· Flash memory: 32kb· Weight: 7g· CLK speed 16MHz · Size: 18x45mm



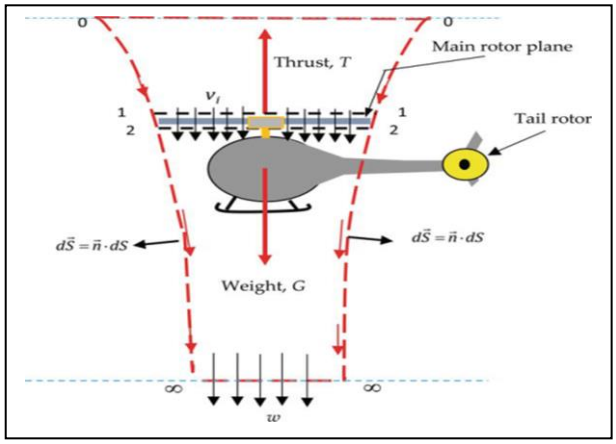
5) MPU6050: MPU6050 is a micro-electro-mechanical system (MEMS) that consists of a 3-axis accelerometer and a 3-axis gyroscope inside it. It also has (DMP) digital motion processor inside it which helps to perform complex calculations. MEMS- 3-axis accelerometer and 3-axis gyroscope values combined· Power supply- 3-5v· 12c protocol communication· Built-in 16-bit ADC provides high accuracy· Configurable IIC address· Built-in DMP provides high computational power



6) Lithium Polymer Battery: lithium polymer or lipo batteries are used in drones as a power source. These batteries are specially made for drones. In this project, a KP 702035 3.7V 350 maH drone battery is used.

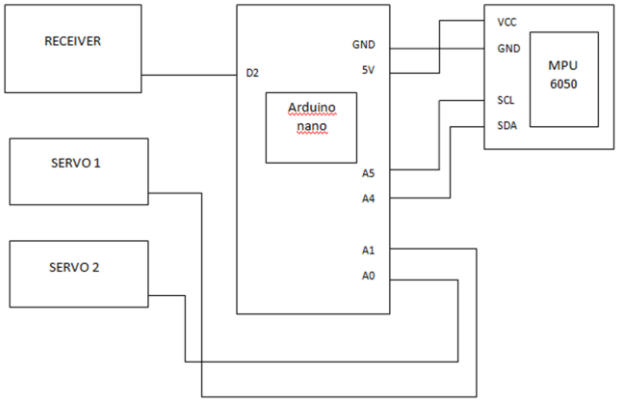
7) FPV Camera: 40 ch AIO FPV camera. This camera is used in micro racing drones. 3.7v input, the range is around 100 meters.

6. WORKING PRINCIPLE



This drone consists of three main electrical circuit boards. The receiver, Arduino nano & MPU 6050. The receiver is connected to the transmitter wirelessly and can be controlled up to a range of 700 meters. It is a 6 channel receiver so 6 different servo motors can be controlled. MPU 6050 is an electrical gyroscope module for a drone that can be programmed and controlled using Arduino nano. The receiver has a PPM output (Pulse Position Modulation) by which it talks to the Arduino nano. The PPM pin is connected to Arduino Nano pin D2. The two servo motor data pins are connected to A0 & A1 as these are analog servos. The main motor ESC and tail motor ESC are connected to channel 3 & 4. MPU6050 module is connected to Arduino nano. The schematic diagram of this setup is shown below.

PIN CONNECTIONS: MPU6050 pin SCL is connected to A5 of Arduino nano, SDA is connected to A4 of Arduino nano. VCC is connected to 5V of Arduino nano & GND is connected to GND. Receiver pin PPM is connected to D2 pin of Arduino nano. 1Servo data pin is connected to A0 & 2servo data pin is connected to A1.



7. PERFORMANCE SUMMARY

Advantages:
1) Indoor Military surveillance
2) Search & rescue operations
3) Reconnaissance in confined areas
4) Bird's eye view for situational awareness

Limitations:
1) Flight time - 8 minutes
2) Noisy blades
3) Camera range only 100 meters

Applications:
Only for military use

8. CONCLUSION

In this project, as we developed this MAV many technical problems occurred. We use the 3D printing method to develop the parts of MAV. There are many things that need to be done with more Research & Development in this MAV project design. We worked on this project at our level and in conclusion, we found that this MAV design is possible if developed as a military-only use drone.

9. ACKNOWLEDGEMENT

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10. CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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