Autonomous UAV (Unmanned Aerial Vehicle) For Navigation & Surveillance Purposes

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Abstract

The use of autonomous vehicles, for a wide variety of applications, has been increasing during the latest years. Land-based vehicles can be used for many purposes, but are not as versatile as could be desired, because they are dependent on the terrain. Aerial vehicles, such as aero planes and helicopters, do not depend on the terrain in the area of operation, as the land based vehicle. An autonomous helicopter has an advantage in maneuverability compared to an autonomous aero plane, which is not able to hover (stand still in the air). This and the ability to take off and land in limited spaces are clear advantages of the autonomous helicopter. An autonomous helicopter is a versatile platform for a wide variety of applications. It can be used in situations as agricultural crop dusting, search and rescue missions, inspection of bridges or power lines, surveillance of larger areas etc. Helicopters are complex, high performance machines designed to ensure the safety of their occupants during their expected lifetimes. To accomplish their goals, helicopters require extensive maintenance during their lifetimes at set intervals, whether necessary or not. To help alleviate the need for unnecessary maintenance, condition based maintenance systems are under heavy development, with the military expressing much interest in such systems. As the name implies, condition-based maintenance systems rely on information about the condition of various mechanical components to determine when maintenance is necessary. This has the potential to greatly reduce cost and enhance safety. The system developed here uses data from three sensors to monitor the condition of a radio-controlled helicopter. Data from the sensors is transmitted to a microcontroller, where it is processed before being transferred to actuators and eventually to a computer for storage and visualization. The system must fulfill several requirements imposed by the constraints of the radio-controlled helicopter, mainly small

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Index terms—

Autonomous UAV (Unmanned Aerial Vehicle)

For Navigation & Surveillance Purposes Chetan Khemraj ? , Jitendra Kumar ? , Ashish Srivastava ? & Gaurav Srivastava ? Abstract -The use of autonomous vehicles, for a wide variety of applications, has been increasing during the latest years. Land-based vehicles can be used for many purposes, but are not as versatile as could be desired, because they are dependent on the terrain. Aerial vehicles, such as aero planes and helicopters, do not depend on the terrain in the area of operation, as the land based vehicle. An autonomous helicopter has an advantage in maneuverability compared to an autonomous aero plane, which is not able to hover (stand still in the air). This and the ability to take off and land in limited spaces are clear advantages of the autonomous helicopter. An autonomous helicopter is a versatile platform for a wide variety of applications. It can be used in situations as agricultural crop dusting, search and rescue missions, inspection of bridges or power lines, surveillance of larger areas etc. Helicopters are complex, high performance machines designed to ensure the safety of their occupants during their expected lifetimes. To accomplish their goals, helicopters require extensive maintenance during their lifetimes at set intervals, whether necessary or not. To help alleviate the need for unnecessary maintenance, condition based maintenance systems are under heavy development, with the military expressing much interest in such systems. As the name implies, condition-based maintenance systems rely on information about the condition of various mechanical components to determine when maintenance is necessary. This has the potential to greatly reduce cost and enhance safety. The system developed here uses data from three sensors to monitor the condition of a radio-controlled helicopter. Data from the sensors is transmitted to a microcontroller, where it is processed before being transferred to actuators and eventually to a computer for storage and visualization. The system must fulfill several requirements imposed by the constraints of the radio-controlled helicopter, mainly small size and low power usage, while still being powerful enough to perform processing on sensor data with on-board processing. The system is able to communicate with two different types of sensors, an inertial measurement unit and global positioning satellite receiver, perform calculations of statistics, and transmit the processed data reliably to a computer, where it is displayed in a custom graphical interface.

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1 Background And Motivation

n Unmanned Aerial Vehicle (UAV) as the name suggests is a remote-controlled or completely autonomous vehicle designed to carry out a prespecified task in a particular way. The vehicle is either programmed or trained beforehand to accomplish such a task .Development of remotely controlled vehicles is as old as the 1950s. However, the history of Vertical Take-Off and Landing (VTOL) UAVs started in early 1960s when the US Navy studied the feasibility of such a vehicle for the first time. Some close and short range (50km and 200km respectively) vehicles were developed.

Recent advances in controls, microelectronics, micro electromechanical systems (MEMS) and wireless communication have led to the development of long range UAVs. Currently long range i.e. endurance aircraft is being developed that is meant to be used for cinematography, search, surveillance and transportation.

Research is being carried out in different universities to develop a completely autonomous vehicle that is able to perform complex tasks on its own and different groups are exploring new techniques to make this concept practical. Towards this end engineers are exploring different configurations of VTOLs to exploit specific advantages associated with their particular design. For example Autonomous Helicopter' group at Carnegie Mellon University is working on vision based stability. A group at Stanford University is trying to achieve acrobatic maneuvers using apprenticeship and reinforcement learning. In simple words, reinforcement learning involves adaptive algorithms that a machine learns by observing actions taken by an intelligent teacher agent, which in most cases is human, in certain environmental situations.

2 II.

3 Main Challenges

In designing a system like a UAV one need to take care of certain issues. The basic consideration in designing an autonomous or remote control aircraft is the choice of electronics. It should have minimum but sufficient electronics to carry out complex maneuvering tasks. The weight and placement of electrical components also play an important role and should be distributed carefully about the center of gravity. The system also needs to have a robust communication link because in case of an autonomous vehicle it would be utilized in sending important information back to a base station.

The major challenge in this report was integration of different of-the-shelf components and modifying their firmware to meet the timing and rate synchronization requirements among them. Even in the design phase i.e. system identification, which is not needed for the vehicle once the model is established, the hard thing was to keep track of input/output time periods for analysis purposes.

Another issue was to mount a rigid platform on the helicopter that can carry all the electronics and sensors. Again this platform has a weight and care was taken to mount it so that the overall weight distribution remained unchanged.

Since the helicopter was built starting only from the mechanical structure a lot of things were adjusted manually and by performing experiments, which included but are not limited to adjustment of: (1) servos/ swashplates linkages for collective pitch (2) position given to each servo for varying collective and cyclic pitch (3) calibration of collective and cyclic pitch using a pitch gauge (4) throttle given to brushless DC motor (5) gear ratio for enough RPM to take-off (6) position of Inertial Measurement Unit (IMU) etc.

This project concerns the problem of modeling an autonomous helicopter (UAV) and thereafter stabilizing the model using optimal control for the purpose of surveillance and reconnaissance.

This system can be used for target & decoy, reconnaissance & civil purposes, which are very tedious and dangerous, if performed by humans .Thus this system can be proved much more efficient and helping for human beings.

4 III. Hardware Design & Methodology

The choice of hardware in any UAV is dependent upon a number of criteria, which include, but are not limited to, compatibility with other components, light weight, cost, and ease of integration in the system and the flexibility in firmware. Fortunately most of these criteria are design considerations of companies like Spark fun, a company based in Boulder Colorado, whose products have been used in this project.

Below is the list of all the hardware (mechanical and electronics) components that have been used and which is subsequently explain in detail: (1)

5 Methodology

Step 1 : Designing and testing of helicopter prototype for providing mechanical stabilization.

Step 2 : Calibration of servo motors and Rotor head motor for proper swash plate orientation and proper Rotor head speed.

Step 3 : Installing CPU and IMU units for testing stabilization of the platform.

Step 4 : Programming CPU with Arduino IDE.

Step 5 : Installing GPS with IMU unit for providing Autonomous Navigation to the UAV platform.

Step 6 : Installing Camera and mount with gesture capability.

Step 7 : Interfacing the system with computer for telemetry.

Step 8 : Installing distance sensor for providing ability, to this system to avoid any object in its path.

V.

6 Control System

Our control system is made from the CPU, IMU, Telemetry system and sensors. We use the Arduino Duemilanove 328 for the CPU .It is act as brain of the system.IMU unit is made up from accelerometer & Gyro which is stabilizes our system. We use wireless camera for live video streaming and RF 434 module for the transmitting & receiving of data. We take supply from the battery of 11.1 V and 20C Li-Po(Lithium Polymer) and give to the system. Our CPU i.e. Arduino take all the data from sensors and give the processed data to the all motors i.e. servo and out runner brushless motors. There are four types of servo motors i.e. aileron servo, elevator servo, pitch and rudder servo which is used for cyclic, collective and tail rotor pitch control respectively. ? With decreased cost, the area of application can be widened ? These systems can be armed with less lethal weapons for combat purposes ? These can be used by homeland security

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Figure 1: Fig 1 :

[Advances in unmanned Aerial Vehicles and control (2003)] *Advances in unmanned Aerial Vehicles and control*, Sept. 2003. p. . (Kimono Valavanis. Invited paper)

[Nikolas and Valavanis] 'Evolutionary path planner for UAV'. K P Nikolas , Valavanis . SMC-17. *IEEE Transactions on Systems, Man, and Cybernetics*

[Lozano ()] *Unmanned Aerial Vehicleembedded controls*, Rogelio Lozano . 1977. New York: Academic Press.

[Christian and Capp (1997)] *Unmanned Aerial Vehicles Designs and Their Applications*, M Christian , Capp . Oct. 1997. Lubbock, TX. Texas Tech University (Ph.D.Dissertation)