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Energy Efficient Unarmed Ariel Vehicle For Outdoor Environment

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Abstract— **The military use of unmanned aerial vehicle (UAVs) has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. The large UAVs also provide a reliable long duration , cost effective , platform for reconnaissance as well as weapons. The questions arose for my project was whether small UAVs also had utility in military and commercial/industrial applications. The smaller UAVs can serve more tactical operation such as searching a village or a building for enemy positions. Smaller UAVs on the order of a couple feet to a meter in size, should be able to handle military tactical operation and the proposed work is attempting to validate this assumption are considered. To validate this assumption , many different UAV designs before settled on creating a Quad copter. The payload of the proposed Quad copter design includes a camera and telementry that will allow us to watch live video from the Quad copter on laptop that is locate dup to 2 miles away. This is currently experimenting with new software so that the Quad copter need not be controlled with an RC controller but will instead operate by sending commands from a remote laptop. One of the most significant problems to data been an ambitious development schedule coupled with very limited funds. Quad copter prototype is a very limited version of what could be created in a production facility using more advanced technology. Currently the proposed Quad copter has achieved only tethered flights because it cannot maintain a stable position when flying. The next step is to fix the software so that it can be achieve controllable untethered flight. Graphical user interface is also integrated which will allow us to have direct control over all system. It is also proven that it is possible to produce a small scale UAV that performs functions of interest to the military as well as commercial /industrial application.**

Keywords: Energy efficient,Quadcopter,UAV

I. INTRODUCTION

Quad copters are compact rotor craft air vehicles with vertical takeoff and landing capability. Like a conventional helicopter they can hover, but have significant other advantages such as ease of piloting and mechanical simplicity, they have no swash-plate mechanism. One of the earliest robotic Quad copters was proposed by Pounds et al. at a time when it was necessary to build a vehicle from scratch.

1.1 Unarmed Ariel Vehicle

UAVs are important when it comes to perform a desired task in a dangerous and are inaccessible environment. Recent technologies have brought advancement in energy storage devices, sensors, actuators and information processing have boosted the development of Unarmed Ariel Vehicle (UAV). UAVs rely heavily on accurate knowledge of their position for decision making and control. The rotorcraft UAVs has some advantage over fixed wing UAVs such as vertical take off and landing and aggressive maneuvering. Most UAVs can carry some sensing capabilities for localization, they simply cannot carry sensors that enable themselves to localize everywhere.

1.2 Energy Efficient

The efficient, reliable and robust four –rotor flying platform for indoor and outdoor navigation. These platforms are controlled at low frequencies due to hardware and software limitations. This causes uncertainty in position control and unstable behaviour during fast maneuvering.

Wireless sensor network have the promise of revolutionizing the capture processing and communication of mission critical data for the use of 1st operational forces.

Some optimal energy efficient flight fly through vertical moving of thermal cells.

II. EXISTING SYSTEM

2.1 Mikrokopter-

The Mikrokopter compromises of four DC motors each with its own speed controller. The flight control board has version 2.1 AtMega 1284 processor running at 20 MHz which decodes pulses stream from the radio control receiver. The flight controller has serial port which can be used to receive command and transmit status information.

The limitation of the existing system is excess power consumption and the limited wireless range. Also battery recharging should be done on the main supply which reduces the active time of the Mikrokopter. Commercially available copters have limited wireless capabilities which make the usage of wireless camera next to impossible.

III.RESEARCH GAP

The development of two separate quadrotor helicopters systems that are capable of autonomous navigation in unknown and unstructured indoor environments, rely only on sensors on-board the vehicle, and avoid relying on a prior map. Also a hierarchical suite of algorithms that accounts for the unique characteristics of air vehicles for estimation, control and planning, and that can be used for both quadrotor helicopters with distinct exteroceptive sensors were developed. The unmanned aerial vehicles have proven to be a viable, cost effective and safe platform for aerial surveying of sites in the order of low km2 being able to capture high resolution data at a professional survey grade.

Planning of information space has the problem of a helicopter localizing and navigating in GPS-denied environments.The helicopter uses laser range data and an existing map to localize, but the laser has a limited field of view, causing the helicopter to lose track of its own position in certain configurations and in some parts of the environment. This showes how the Belief Roadmap algorithm can be used to plan trajectories through the environment that incorporate a predictive model of sensing, allowing the planner to minimize the positional error of the helicopter at the goal using efficient graph search.

SISO control structure of quadrotor is presented. Analytical optimization method is used to tune a conventional PID controller for stabilization and disturbance rejection of quadrotor. The time domain performance of designed control structure is evaluated with IAE objective function. A modular fuzzy logic approach was proposed for the autonomous control of quadrotors in general, without the need for a precise mathematical model of their complex and ill-defined dynamics. The hovering or static position of Quad copter is done by two pairs of rotors are rotating in clockwise and counter-clockwise respectively with same speed. By two rotors rotating in clockwise and counter-clockwise position, the total sum of reaction torque is zero and this allowed Quad copter in hovering position.

IV.PROPOSED WORK

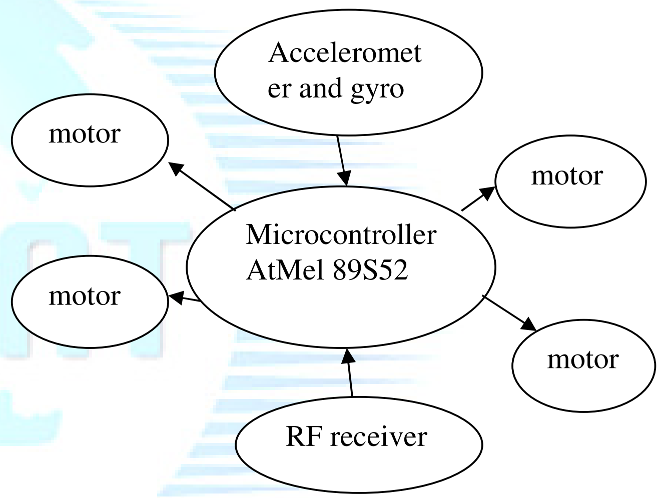
The proposed work presents several contributions. Firstly it show that a low-cost high-performance amateur-grade quadcopter,the MikroKopter, can be used for serious robotics research.Secondly we present details of the vehicle's sensors, controlsystem and dynamic performance as determined throughreverse engineering and system identification. Thirdly, we develop a velocity state estimator which is computationally cheap, easy to tune and effective.Finally, it demonstrates stable hover using the built-inlow-cost inertial sensors, a 10Hz laser scanner and a simple nested control loop architecture.

Some of the protocols used for the above functions are

4.1 Speed Controller

The major task of this copter is maintained and controlled by the given features:

- Read Gyro at 200Hz:
- Read Accelerometer at 200Hz
- Flight controls at 100Hz
- Read receiver at 50Hz



The software for this project called as de ArduCopter.This ArduCopter is a Arduino based quadcopter. The fact that the ArduCopter existed assured us our project was feasible.In order to transfer the ArduCopter code into the Atmega644 microcontroller it was necessary to convert the Arduino libraries. This was the most complicated part of the project, however it was also the part that benefited us the most. Our system uses improved hardware to reduce power consumption and increase the per watt/ hour of the life time of the battery. The wireless transceiver is improved for high data rate communication to accommodate the usage of camera. The body of copter is covered with solar wafer(traditional solar panels are heavy).

4.2 Flight Control open source software

Serial Hardware.h, Servo.h and Device_I2C.h were the most imported libraries that we converted to the atmega644. This was very useful since the atmega644 has only 6 PWM outputs hardwired and with a much smaller resolution and higher frequencies. Controlling speed on the motor controllers is as easy as controlling a servo (after they are programmed).

Serial hardware was a simple uart interface, however converting the library allowed us to minimally alter the Arducopter code in order for it to work in the atmega644.Finally Device_I2C.h is a library that gives functions that use protocol for two wire interface. This was used to communicate with the sensor board. This library allowed us to use simple read and write functions to the I2C lines without worrying about the low level interface, in main().

The main files in the project folder are.

Accelerometer.h : This file contains the header functions for the next file, this was done so that for the Arducopter to be flexible to different accelerometers, the actual functions will be in the Accelerometer_ADXL345.h.

Accelerometer_ADXL345.h : This file contains the functions that initializes the accelerometer using the I2C protocol, it also contains all functions that interact with the accelerometer, including measureAccel() and other usefull ones like evaluateMetersPerSec(). This last functions depends not only on the acceleration but also the time difference between readings.

AeroQuad.h :

All the general variables are defined in this file, this is used to isolate the main code from the variables associated with the quadcopter caracteristics, and the time variables.

DataStorage.h :

This file contains the functions that read and write to EEPROM including functions that read and write floats. This allows for the program to keep the PID values after pwer cycling, allowing for the quadcopter to always stay calibrated. Gyroscope_ITG3200Common.h

Device_I2C.h :

This file contains all the functions necessary to implement a two wire protocal, allowing for the accelerometer and gyroscope functions to call the sensors without worrying about the communication protocol.

Flight Command Processor.h:

This file contains a single function called, read Pilo tCommnads, this functions ensures that the motors are only armed under certain conditions and also that some of the controllers configuration activate configuration mode.

Flight Control Processor.h:

This file contains the most important functions for the good functioning of the quadcopter, it contains all the functions that correct the error for the motor speeds. It also ensures that the motors signals never go over or under the 1ms to 2ms pulse width.

Flight Control Quad X.h :

This file defines the physical layout of the quadcopter, numbering the motors in such a way that the X, Y and Z axis align correctly.

Fourt Order Filter.h :

This file contains the functions that preform a Chebyshev fourth order filter for the sensor values. This is done so that the vibrations are damped allowing for a smoother flight.

GlobalDefined.h:

This file only contains the axes definition so that throughout the project they can be mentioned as 'XAXIS' instead of a number.

Gyroscope.h:

This file contains the headers for the following two files. This was done so the Gyroscope in the Arducopter can be interchangeble.

Gyroscope_ITG3200.h:

This file contains all the functions that interact with the gyroscope. It contains functions like calibrateGyro(), so that the gyroscope is initialized properly.

Gyroscope_ITG3200Common.h :

This file contains the common function between gyroscopes, containing the actual measureGyro(), which returns the actual gyro values. It also contains functions to detect the gyro drift compensating with the accelerometer information.

Kinematics.h :

This file contains the files that convert all the speed and rotation to actual psysically meaningfull values. This means that for example the values that come from the accelerometer will be converted to meters per second squared.

Kinematics_ARG.h:

This file also contains very important functions that stabelize the quadcopter. These functions convert the arguments for flight control into real physical values already filtered and processed so that the quadcopter stabelizes properly.

Motors.h :

This file contains the declation of the motor numbers and is the header for the functions that write to the motors. The actual functions will be on the next file. This is done so that the method used to write to the motors is independed from the actual function.

Motors_PWM.h :

This file contains the motor control functions. These functions take advantage of the servo.h file to create the pwm necessary to control the motor. It is also in this file that internal clock ISR is written, meaning that every millisecond the clock will increment a variable called AbsoluteTime, this variable will be used by most functions as an internal clock. It will only overflow every 71 minutes.

PID.h :

This file contains all the PID calculations. This was taken from the arduino.cc page and converted for the Atmega644, based on lab 4 from ECE 4760.

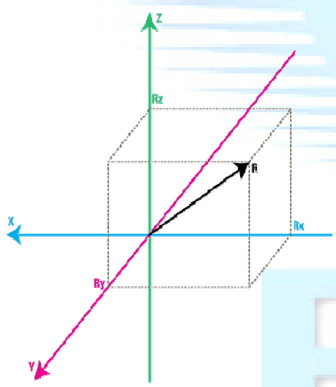
Receiver.h :

This file defines all the initial values for all the receiving parameter from the RF receiver. It also includes all the global variables that are to be affected by the human interface, like Throttain code we didn't need to worry about the lower details simplifying the code.

4.3 Communication Protocols

The transmitter and the receiver that we used are TWS-BS-6 and RWS-374-3. Their frequency range is 2.4 GHz. We send 4 bytes of information at a time. Checksum is (Addr+Data) and when the receiver receives 4 bytes, it adds tbruptly exert too much throttle, and without being tied down to the test stand, the quadcopter could fly off and crash onto obstacles.

V. CO-ORDINATION SYSTEM

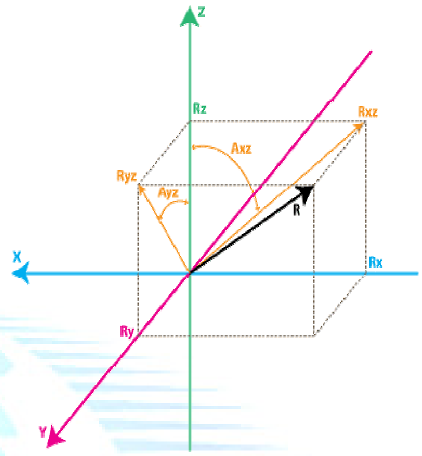


This graph explains the stability criteria of the Quadcopter. Accelerometer has 0g voltage level. As we know the constant value of gravitational force , g = 9.8m/s^2. Here voltage shifts from 0g volt to delta volt Rx which is converted to Rx V0g. Accelerometer is sensitive ,which is given as mV/g. The calculation made for calculating the stability is given as:

Rxg=(Rx-VzeroG)/sensitivity

Ryg=(Ry-VzeroG)/sensitivity

Rzg=(Rz-VzeroG)/sensitivity



Each gyroscope channel measures the rotation around one of X,Y,Z axis. Rxz is the proportional inertial force vector R on the XZ plane. Axz is the angle between the Z- axis and Rxz. Therefore accelerometer data cannot be trusted full 100% due to vibration and mechanical noise.

R=Rx,Ry,Rz ,projections of R vector.

Rest=Rxest,Ryest,Rzest; Rest(0)=Racc(0);
regular measurement at T sec.

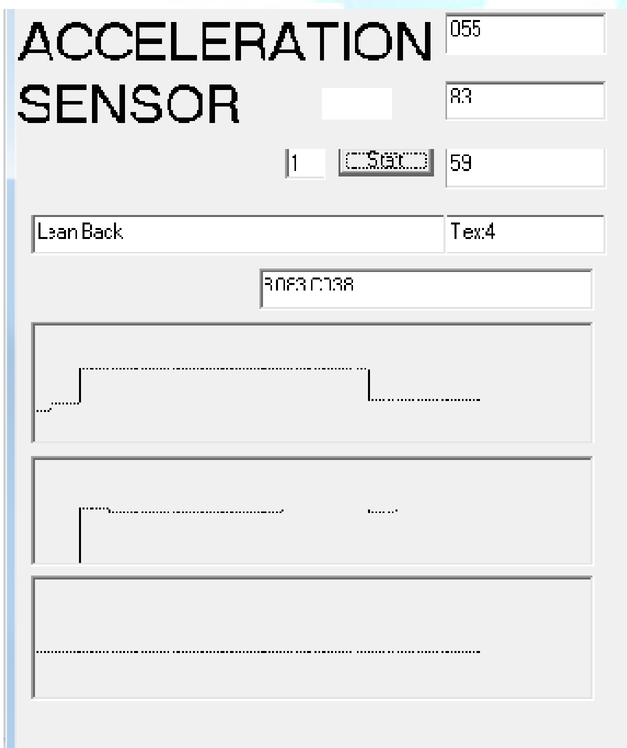
Axz(n-1)=a tan 2(Rxest(n-1) ,Rzest(n-1));
Axz(n)=Axz(n-1)+RateAxz(n)*T
To overcome the problem of accelerometer and gyroscope value is comibined together for better accuracy.

VI. RESULT AND ANALYSIS

In the graphical representation of other researches done , it maintains the position in the horizontal plane while the altitude is controlled by the laser. These graphs defines the position of the copter with respect to time . The vehicle shows good hover performance with standard deviation of 0.13m and 0.09m in the x- and y-directions respectively. The random drift is caused by disturbance forces on the vehicle from air circulation and vortices, and room clutter which confounds the scan matcher since the room profile observed by the laser is a complex function of vehicle height and attitude.

	Trace goal convariance	Graph build time	Path search time
PRM	16.046	0.036	0.001
BRM, Uniform sampling	4.223	18.920	0.039
BRM, Sensor uncertainity	1.049	25.589	0.032

In my project , the axis have been increased its performance graph towards Z-axis using a complementary filter to combine vertical acceleration.



Accelerometer data cannot be trusted 100% due to accelerometer sensitivity to vibration and mechanical noise. Gyroscope also has problems such as drifting even when rotation stops So, we combine accelerometer data and gyroscope data for better accuracy.

VI. CONCLUSION

In this paper the quadcopter that is relevant for both horizontal and vertical motion is described. A large program of ongoing work. Firstly, the extended approach to the z-axis using a complementary filter to combine vertical acceleration, laser altimetry and barometric pressure and a nested controller. Secondly, exploring changes to the flight control firmware to improve the performance of the attitude control, and to increase the frequency with which inertial state is reported over the serial link. The migration of the pose estimator to the onboard Gumstix processor which eliminates the complexity, limited range and unreliability of the communications link. Finally, the investigations are made using other extroceptive sensors such as cameras with wide-angle fields of view and the Kinect range camera. Thus it is possible to produce a small scale quadcopter to perform functions of interest to the military as well as commercial application.

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