War field Intelligence Defense Flaying Vehicle

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Abstract- They discussed the development of a mini-quad rotor system for indoor application at Konkuk University. The propulsion system consists of X-UFO blade propellers and brushless direct current (DC) motors assembled on a very stiff airframe made of carbon fiber composite material. The attitude control system consists of a stability augmentation system as the inner loop control and a modern control approach as the outer loop. The closed-loop control is a PID controller, which is used for the flight test to validate aerodynamic modeling. To perform an experimental flight test, basic electronics hardware is developed in a simple configuration. An microcontroller AVR as the embedded controller, a low-cost 100 Hz AHRS for inertial sensing, infrared (IR) sensors for horizontal ranging, and an ultrasonic sensor for ground ranging. A high performance propeller system is built on an X-UFO quad rotor airframe. The developed flying robot is shown to have an automatic hovering ability with aid of a ground control System that uses monitoring and a fail-safe system.

Keywords: X-UFO, PID, AVR

I.INTRODUCTION

Recently, quad rotor development has become more popular in academic research. Several techniques and methods for modeling, simulation, and control design have been developed. Quad rotor structures and dynamics are simpler than in conventional helicopters or coaxial-rotors; thus, a quad rotor has less control complexity. However, the quad rotor is an unstable system, so the first issue in the design of an autonomous system is the implementation of attitude stabilization control. The report on the progress made during more than one year of quad rotor development. The quad rotor has four powerful rotors running at a very high rotational speed. Key issues include attitude sensing quality and a reliable frame structure. On the vehicle, there is a high magnetic field from brushless direct current (DC) motors and very high vibration from the propulsion system. An adequate sensor is required measure a correct value under such conditions. Since we require a light-Weight device to be attached to the frame, the challenge is to find a low-cost Initial.Measurement Unit (IMU) with goodperformance.

II.QUADROTOR CONFIGURATION

The proposed flight control system is driven by an NXP LPC1768 with an ARM-7 MCU that operates using a system clock at 100 MHz The control system consists of a data acquisition system for acquiring six degree of freedom (DOF) sensor data from an XA3300 AHRS at a maximum of 100 Hz, and a flight controller that implements the control algorithm. The control system drives four channels for four electronic speed controllers using i2C communication. The fast response propulsion system here rather than using a PWM speed controller.Measurement Unit (IMU) with good performance.

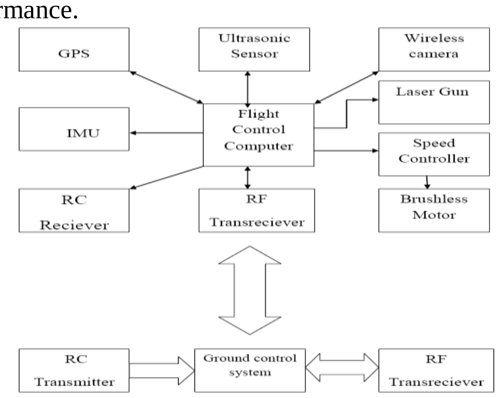


Fig.1Diagram of quad rotor

In the configuration shown in Fig. 1, the quad rotor system is controlled autonomously by a ground control system using a 900 MHz radio frequency (RF) modem, and a radio control (RC) pilot can Take over manually. The flight control system (FCS) also has the ability to auto-lock the command input in a standby mode as a safety feature, then wait to receive a special command input as a password to unlock the system. A 1200 mAh 11.1 V Li-Po battery is used to drive all the electronics and the four 2500 rpm/V DC brushless motors. A battery checker system in the FCS can prevent an uncontrolled situation when the power goes down or is depleted during the flight; thus, the quad rotor can make an automatic landing.

III.MODELING

The introduction of our quad rotor model based on the dynamics of the quad rotor, as shown in Fig. 2. The main motion factor is the speeds of the four rotors. The motion can be varied by changing this speed.

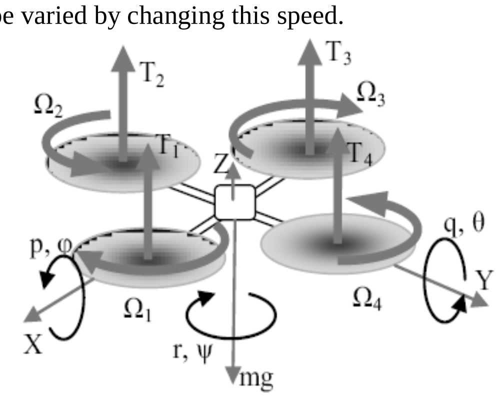


Fig. 2 Dynamics of the quad rotor.

The thrusts of each rotor (T1, T2, T3, and T4) are generated from rotational speeds of the motors (Ω1, Ω2, Ω3, and Ω4), and by the aerodynamics of the propeller blade. Thrust generation is represented by the following equation.and vertical dynamics translation. In other words, this increase may generate the same thrust from all propellers

Z = [-mg + (cos φ*cosΘ)(T t0t) – kz]/m -- (2)

Two rotors (Ω1 and Ω3) rotate clockwise while the other two rotors (Ω2 and Ω4) rotate counter-clockwise. Based on this configuration, yawing motion (r, ψ) can be produced by making all the counter-clockwise rotors greater than the clockwise. With the assumption that each of the four thrust values is equal, the yawing motion can be assumed to be stable even though the dynamics of the quad rotor produce an unstable system.

φ= L(-T1+T2-T3+T4-Kφ)/lzz ------- (3)

Collectively increasing each rotor's speed may increase lift in all motors

Generating a variation in the thrust T1 and T3 oppositely by varying Ω1 and Ω3 produces a pitching motion (q, θ).

T 1,2,3,4 = C tρA (ΩR rad)*2 --- (1)

Where is the thrust coefficient, is the air density, is the blade area, and is the blade

ϰ= (cos φ* sinΘ*cosψ + sinφ*sinψ)(T t0t)- K ϰ/m --- (4)

Θ= L(-T1+T2-T3+T4-Kφ)/lyy (5)

The rolling motion (p, φ) can be created by generating a variation in thrust T2 and T4 oppositely by varying Ω2 and Ω4. This is also applicable to the horizontal translation.

φ= L(-T1+T2-T3+T4-Kφ)/lxx (7)

y= (cos φ* sinΘ*cosψ+sinφ*sinψ)(T t0t)- K y/m (8)

Where m is the total mass, L is the distance of the propeller to the center of interconnection, <55 is the moment of inertia, and > are the drag coefficients.

The model using MATLAB/Simulink® software for simulation and as a basic reference for designing the control system As shown in Fig, the model is divided into several blocks. Each block required validation according to the real system. We used a rotor transfer function from a previous study with an additional response time delay due to the communication exchange between the microcontroller and speed controller.

IV.CONTROL SYSTEM

For validation purposes, implemented a proportional-derivative controller on the quad rotor to acquire flight data to compare with the simulation. A control input using a standard helicopter joystick radio control was employed with at least four control parameters, vertical control, longitudinal cyclic control, lateral cyclic control, and directional control.

The first control algorithm that we implemented is shown in Fig. 3. The system consisted of a damper and attitude holding for roll, pitch, and yaw. The control linkage was represented by the rotor dynamics of the devices that linked the control output to the dynamics of the vehicle in certain constants. The base controller used a reference of zero, also known as the Equilibrium due to the hovering mode of the quad rotor.

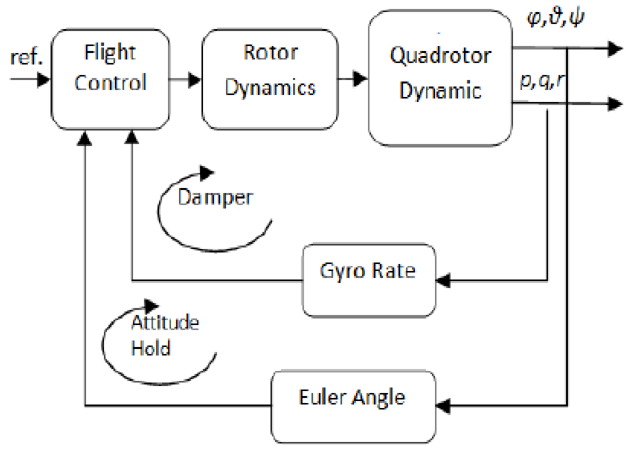


Fig 3 control system as a inner loop

Experiments are conducted to determine the control parameters one-by-one for the all members of the single-input single-output (SISO) from the inner loop to the outer loop. First, we implemented the proportional control described by as a damper, using rate gyro sensor data to stabilize the angular rate in each axis

Cd (s) = Gr * Kp (9)

The proportional control is implemented for each angular rate (p, q, r), examining the maneuverability of the vehicle. The low damping ratio maintains the vehicle in a frisky unstable system otherwise the vehicle will be sluggish. In the next step, implemented the PD controller for attitude holding described, for the roll, pitch and yaw

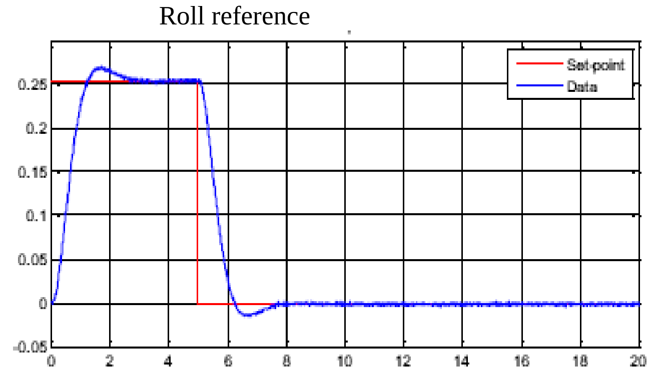
Cah(s) = [ɷref(s)- ɷ(s)] (Kp +Kd s)

By taking the sum of Esq., we derived the following total inner-loop control equation

C(s)= Cah(s) + Cd(s) (11)

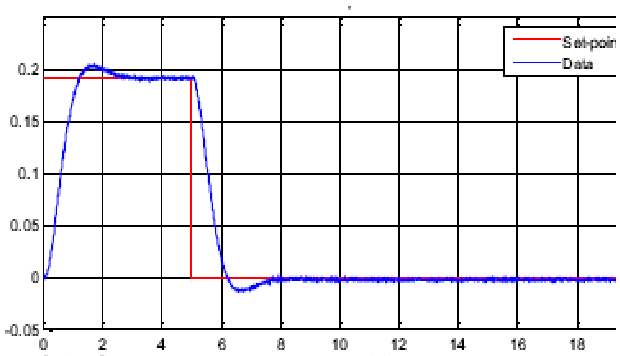
Where R(S) represents the rate damping controller,

Roll reference



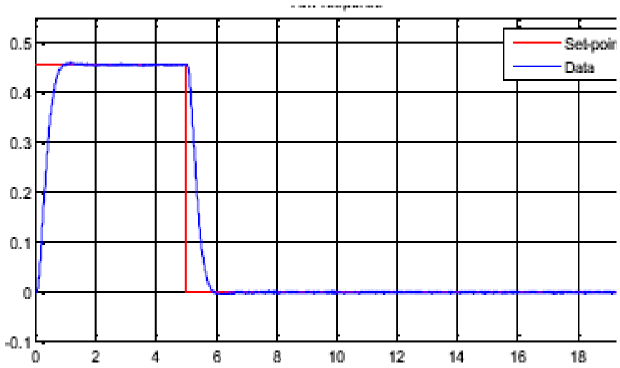
Roll (rad) Time(s)

Pitch reference



Pitch (rad) Time(s)

Yaw reference



Yaw (rad) Time(s)

Fig.4.Quadrotor model with LQontroller under simulation

Fig.4 shows our simulation results. The roll and pitch response was slower than that of the yaw; thus, we conclude that the roll and pitch attitude is sluggish, and also deviated slightly from the zero point (this is known as steady state error).

V. FLIGHT TEST

Figure 5 shows the flight test instructions. The RC controller is connected to the GCS through a USB port. The RC controller sent the signal to GCS, and the control signal will transferred to KU quad rotor.

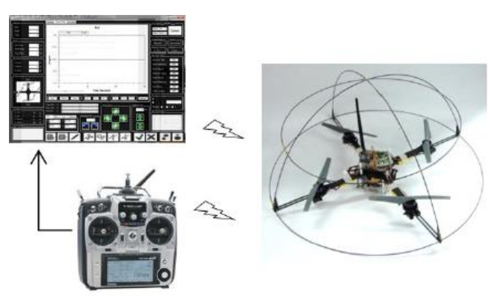
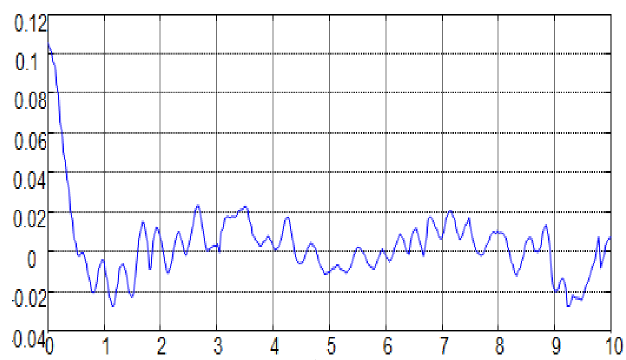


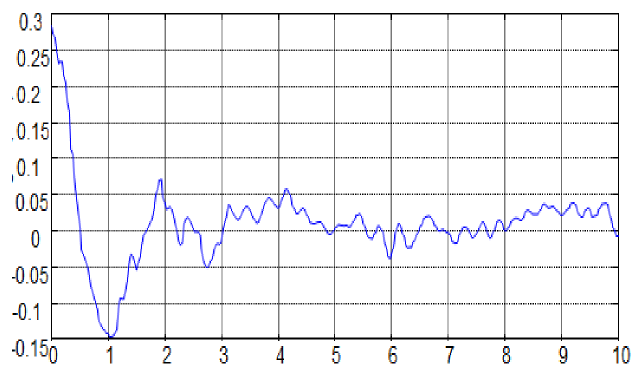
Fig. 5. GCS, RC controller, and KU quad rotor vehicle for flight test.

Satisfying the all gain conditions through experimental direct tuning on the test bed resulted in “able to fly. We validated the control model based on the flight data. As shown in fig this model includes feedback control as a stability augmentation system that used the same gain as the control model. The pilot adjusted the throttle input due to the voltage drop in order to maintain the vehicle in a hovering flight state during the flight test. When the battery power decreases after a number of flights, the throttle input should be increased to generate the same thrust. We implemented a compensator in the simulation to consider a variable value from the joystick of the radio control that will recorded in the flight data. The compensator adjusted the throttle coefficient factor due to battery voltage drop during the flight. Our outdoor flight test will successful.



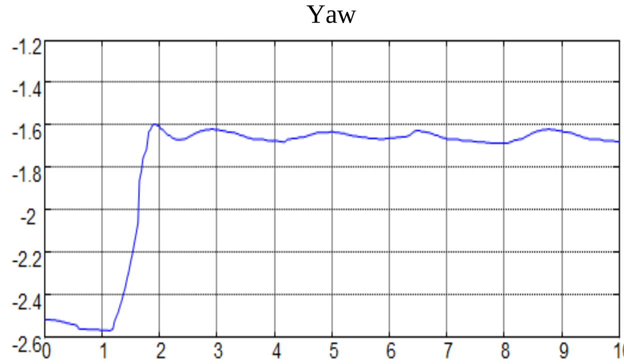
Angle (rad) Time(s)

Pitch



Angle (rad) time(s)

Yaw



Angle (rad) time(s)

Fig. 6 Inner loop controller of roll, pitch, and yaw angle stabilization in a real system.

VI.CONCLUSION

The proposed quad rotor is able to fly with a PID controller as the inner loop control. The established model included the same feedback control as the real system using a stability augmentation system (SAS). Validation in hover is adequate for the design of an optimal control based on modeling, such as the linear quadratic controller that is already implemented in simulation.

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