

Flight Stabilization for Image Acquisition based on UAV

Oh-hoon Cho*, Eung-kon Kim*

*Department of Computer Science, Suncheon National University

{worldnet, kek}@suncheon.ac.kr

Corresponding Author: *Eung-Kon Kim*

Abstract. Monitoring technique using UAV(Unmanned Air Vehicle) means a technique of monitoring by mounting camera on UAV in case of having to monitor at an altitude where it is unable to shoot objects with general ground photographing equipment. Monitoring method by using UAV has an advantage of accessibility and speed compared with vehicle and monitoring of diversified compositions is possible. In addition, in order to perform UAV-based monitoring, it is very important for monitoring manager to collect image without shaking by manipulating UAV even though such manager does not have any professional knowledge. This thesis suggests a method of research on a design of flight stabilization system for acquisition of UAV-based monitoring image.

Keywords. Small unmanned air vehicle, Flight stabilization, Image acquisition system, Monitoring facilities, Image processing.

I. INTRODUCTION

Recently, at the time of occurrence of forest fire or disaster, site situation is identified by using helicopter in most cases. However, a research on intelligent type robot by which site situation is monitored in real time by mounting LTE wireless T/R system on UAV is being progressed actively. Multi-purpose watch and monitoring technology for traffic control, collection of weather information, monitoring forest fire prevention and crackdown on illegal architectures in addition to lifesaving, in particular, have been popularized for its advantage of being able to be utilized in diversified fields. Therefore, as importance of collecting stabilized image without shaking and data by manipulating UAV in a wireless mode even though such personnel does not have any professional knowledge or experience in order to perform monitoring by using UAV is being strongly emphasized, a research on flight stabilization system design for acquisition of UAV-based monitoring image was performed in this thesis[1-5].

Goal of this research is to design and suggest flight stabilization system that performs research on moving control module for identifying distance between UAV and monitoring target in real time by using ultrasonic sensor and maintaining pre-set altitude and distance automatically and monitors targets.

II. RELATED RESEARCH

Definition of UAV-based monitoring. UAV-based monitoring is performed by UAV that is mounted with small camera, communication equipment and various sensors or other equipments for operating such camera and sensors being remotely controlled by monitoring personnel on the ground or operated automatically according to pre-set control program. People does not directly get aboard this vehicle but if monitoring personnel controls UAV directly, indirectly by programming control contents for a specific work, UAV identifies arrival location and performs various works of its own accord based on information collected by several sensors mounted on UAV.

As its advantage, monitoring is possible at any place without being bound by space, data securing for monitoring in a short time at reasonable cost is convenient and accessibility to a place where people is hard to approach is allowed as well.

Currently, as a UAV type being mostly utilized for monitoring in the technical field of UAV, there are unmanned helicopter type being frequently used in producing video of film or CF as it is suitable for low, medium altitude and convenient for operating with maneuverability within limited space, electric-powered aerial vehicle that is suitable for photographing wide area such as long shot of wide feeling as its long-distance flight is possible and unmanned airship being utilized for civil T/K construction site and advertising as it is suitable for high altitude shooting and has high stability and in addition to these, paraglider type having relatively cheaper price and high maneuverability.

Among these, multicopter-based UAV utilizing advantage of cost-price, miniaturized helicopter type is being utilized frequently in general.

Type of multicopter. Multicopter was developed by supplementing disadvantages of helicopter and stable attitude control is possible without rotation of fuselage by backlashing each propeller.

As the more number of propeller is plenty, the more is its power getting strong, it has an advantage that take-off/landing is easy and stable flight control is possible based on its multiple propellers[6].

Multicopter is divided into multicoper and microcopter depending on its size and depending on number of rotor that gains lift and propulsion, it is divided into dualcopter, tricopter, quadcopter, hexacopter and octocopter. And a system for controlling UAV comprises ground base station, communication network and UAV.

Rotating mode of blade. In case of general UAV, a disadvantage of having to hover wide space is exposed in order to stay at a certain position in the space but blade plays a role of propeller that enables take-off/landing flight of helicopter and it is able to perform diversified works including hovering and stable flight in a limited space.

Fig. 1 shows overall blade arrangement in a form of quadrangle and in case of blade comprising 6, diagonally positioned blades facing with each other are designed to be rotated in the same direction and neighboring blades inversely.

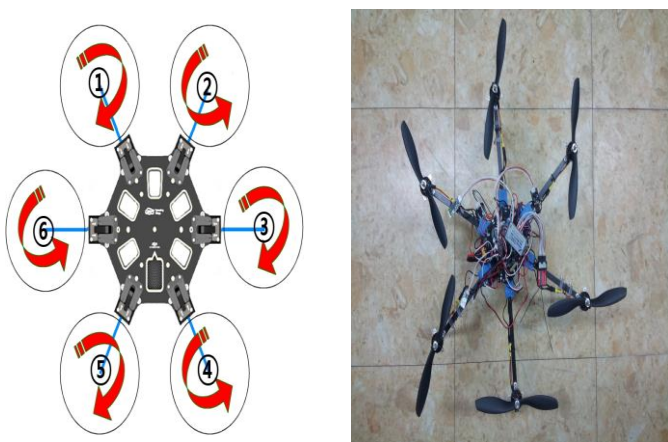


Figure 1. Rotating mode of blade

At this time, ascending and descending of UAV could be guided by regulating rotating speed power of overall blade depending on rotation mode of blade and by changing speed of front, rear blade (on the assumption that frontal side is X-axis), pitch moment is created and if speed change is regulated by binding left/right and front/rear of roll moment as a pair based on speed change of left/right blade, Yaw moment is generated. In other words, in case of quadcopter like UAV, its operation principle is simple compared with existing helicopter and additionally, as Gyro sensor for attitude control, Terrestrial Magnetism sensor for operator-based control and Barometric pressure sensor for altitude hold are mounted, this vehicle could be controlled skillfully without specialized knowledge for attitude control[7].

In particular, recently, as expensive UAVs are furnished with various diversified sensors, perfect GPS Position Hold, stable flight and excellent gimbal control function, its convenience is being increased further[8-9].

Fail safe function by using GPS Holding technology is a technology of preventing a risk of missing aerial vehicle under the situation that basic T/R signal between aerial vehicle and base station is interrupted and its typical function is to provide aerial vehicle with a function of auto hovering (auto pilot) or

of safely going home to and landing at its original take-off place until aerial vehicle is bound by T/R signal again.

III. RESEARCH CONTENTS AND METHOD

Research contents. Biggest advantage of multicoper is that its control is simple than existing helicopter and it is furnished with most of the advantages of aerial vehicle. Hovering function is provided and even in narrow working area like indoor, its positive working performance is possible and without changing direction, omni-directional movement (front/rear, left/right, up/down) is allowed.

This thesis designed flight stabilization system that performs accurate, convenient control of UAV movement in order to obtain precise image of monitoring using UAV.

As concrete R & D contents, in order to perform accurate monitoring by using UAV, a movement control method of identifying distance between UAV and structures in real time through ultrasonic sensor, moving setting distance up/down, left/right under auto mode and moving and stopping UAV at designated altitude was explored. As its control method, stable flight attitude for maintaining real time distance and levelling was controlled by mounting ultrasonic sensor and by mounting camera, acquisition possibility of high definition image was identified and performance of flight stabilization system was analyzed through site application.

Study method. Flight stabilization system was designed by collecting technologies relevant to target monitoring and latest trend of flight attitude control and autonomous flight and analyzing relevant theses. and regarding design of aerial vehicle's stabilization system design, a research was performed under the advice of professors of relevant major of Sunchon National University and outside experts and site application and performance analysis were performed under the advice of researchers of participating enterprises.

In this thesis, a method of enhancing attitude control performance of UAV was suggested based on hexarotor type UAV that has advantageous merit in terms of miniaturization and performance compared with its price, enables convenient vertical take-off and landing and of which kinematic structure is simple.

IV. A STUDY ON FLIGHT STABILIZATION

Ultrasonic sensor. Ultrasonic sensor is mainly used for measuring distance by using its features of emitting short high frequency pulse for a certain period of time and being transmitted with speed of light in an atmosphere.

Principle of estimating distance from target point is to estimate distance by using time difference between time of emitting pulse from ultrasonic sensor and time of echo signal that returns after colliding with a target object and at present, it is also acknowledged as a new standard technology of automation.

Ultrasonic sensor of microsonic is fit for measuring target distance from 20mm to 10m and it could detect targets under dusty air or ink sprayed condition. In addition, even though

film deposition is made on sensor surface, its function is not affected thereby and sensor having blind zone of app. 30mm and that with very narrow beam are able to detect even extremely minute process reliably.

Autonomous flight attitude by utilizing ultrasonic sensor. UAV was controlled by identifying its autonomous attitude in a way of utilizing features of ultrasonic sensor like this so that its stable flight is enabled and at the time of its take-off/landing, UAV was controlled by sensing 3cm-3m in a way of utilizing ultrasonic wave of 40KHz in order to ensure its stable take-off and landing.

In order to use ultrasonic sensor, NaviBoard is required. NaviBoard is an Expansion board that plays a role of estimating current inclination angle by using proper attitude algorithms (DCM, Kalman Filter, etc.) by mounting 3-axial Gyro sensor, Terrestrial Magnetism sensor, Acceleration sensor and Barometric pressure sensor in addition to GPS.

By making divergence angle of ultrasonic wave as 0° , it could be realized that inclination measurement control of UAV is possible depending on inclination angle of the ground surface. Based on an experiment like this, inclination of UAV was made to be controlled by ultrasonic sensor only under the condition of maintaining distance of 100cm from an obstacle like rice paddy and fixing distance of 100cm from the ground surface also.

The system was programmed in a way that 4 sets of sensor were made to control blade motor for 10 times per second by alternately sensing obstacle for each 1 time in 0.1 second so that it may specify distance of front/rear, left/right obstacles after mounting 8 sets of ultrasonic sensor on the lower part of hexacopter center and in parallel, remaining 4 sets of sensor for measuring inclination were made to control blade motor for 10 times per second by alternately sensing obstacles for each 1 time in 0.1 second.

At this time, reliability was enhanced by filtering value below 95cm above ground and measured value over 105cm above ground among the values being measured continuously considering size of UAV of which diameter is 60cm.

Fig. 2 is a system schematic drawing for flight stabilization. Control system of UAV that receives control signal from base station was made to receive data signal of distance, altitude and inclination angle being collected from ultrasonic sensor for measuring distance and inclination with obstacles mounted on expansion board. Therefore, blade motor RPM was made to be controlled by comparatively analyzing constant distance, altitude and inclination of UAV based on programmed control program.

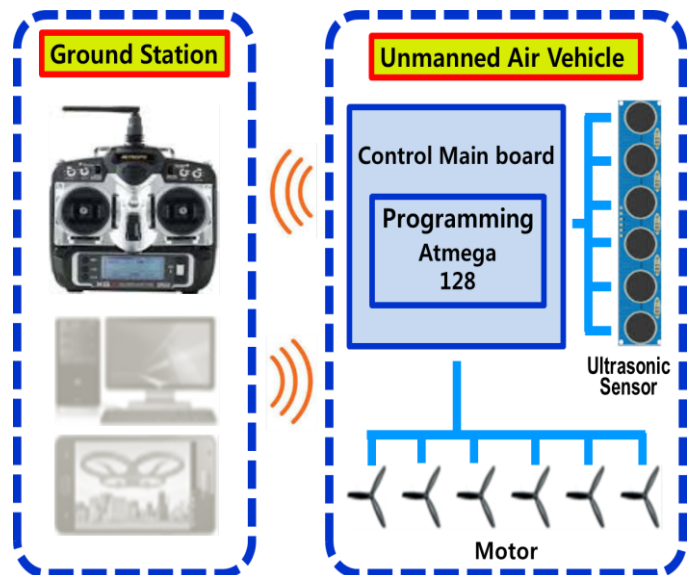


Figure 2. Schematic drawing of flight stabilization system.

Measurement experiment of ultrasonic sensor inclination.

Fig. 3 shows inclination experiment of UAV based on ground surface inclination angle of 0° , 5° , 10° , 15° under the condition that distance from wall obstacles is maintained at 100cm.

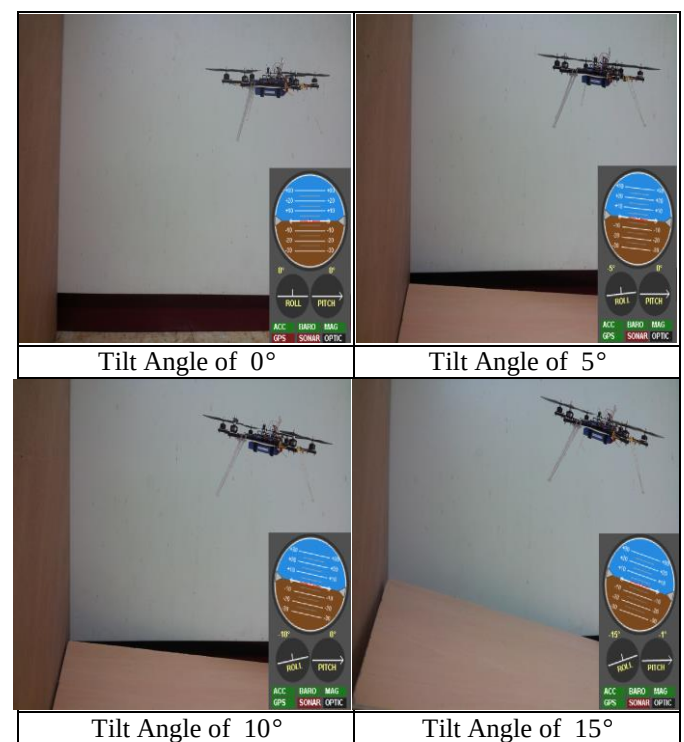


Figure 3. UAV inclination experiment

Altitude and Obstacle distance of Air Vehicle	Tilt Angle to the Ground	Tilt Angle of Air Vehicle
95~105 Cm	0°	0~1°
95~105 Cm	5°	4~6°
95~105 Cm	10°	9~11°
95~105 Cm	15°	14~16°

Table 1. UAV inclination experiment

In above Table 1, it could be realized that stable attitude control of UAV inclination is possible by UAV inclination experiment based on maintaining distance from obstacles and ground inclination angle by using ultrasonic sensor and therefore, motor rotation speed control of blade could be utilized.

In order to measure accurate angle, there was a working problem that angle between ultrasonic sensors is required to be coincided accurately and reliability for accuracy value may be somewhat lowered due to currently furnished cheap observing equipment but as an experiment was performed through same method of 5 times in order to maintain precision as closely as possible, it is considered that reliability for an experiment objective would be sufficient even with its approximate value.

Blade motor RPM control. Blade motor RPM was made to be controlled in a way of controlling flight condition of UAV after sensing distance from obstacles and inclination, altitude of UAV by using ultrasonic sensor. Blade motor RPM was made to be controlled based on value difference being obtained by converting value of ultrasonic sensor into distance value in order to control RPM after measuring it with PWM wave form. In other words, stable autonomous flight of UAV was made to be maintained by controlling RPM of each blade based on distance from obstacles and inclination of UAV.

V. CONCLUSION

At present, a lot of UAVs including UAV for military purpose, multicopter type, airship type and paraglider type being frequently used for industrial or hobby purpose and micro type UAV resembling birds or insects have been developed but a lot of limitation are entailed for utilizing them in an actual world.

Typically in case of helicopter, as its mechanical analysis for its automation is difficult, control based on experiment rather than control by formular is attempted. Under this situation, in order to develop aerial vehicle that could be conveniently analyzed based on flight dynamics and enables autonomous flight without difficulty, control experiment was performed by manufacturing aerial vehicle as follows. And as a result of

determining control function status through this experiment, sufficient control function was represented and so, it was judged that this test vehicle could be developed further in the future.

As a future research development direction, a method of autonomous flight to destination by bypassing obstacles under autonomous diagnosis and judgment when unexpected obstacle was encountered on the way to destination for monitoring by utilizing ultrasonic sensor was suggested and by performing a lot of sustained researches, flight stabilization and autonomous flight system for acquisition of UAV-based monitoring image are intended to be implemented.

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Oh-hoon Cho

Oh-hoon Cho received the B.S. degree from Korea National Open University, Korea, in 2006, His M.S. degree from department of computer science, Suncheon National University, Korea, in 2013. His currently a Ph.D. student in computer science at the Suncheon National University, Korea, His current research interests include augmented reality, image processing, computer graphics.

**Eung-kon Kim**

Eung-kon Kim received the B.S. degree from Chosun University, Gwangju,, Korea, in 1980, his M.S degree from department of electronics, Hanyang University, Seoul, Korea, in 1987, his Ph.D. degree from Chosun University, Gwangju, Korea, in 1992. His current research interests are computer vision, virtual/augmented reality, image processing, and computer graphics. Currently he is a professor in

department of computer engineering, Sunchon National University, Korea.