Development of compact platform for low altitude remote sensing

Daisuke.Yamanaka,Taisuke.Namie*,Motohiro Tanaka*,Shinichi Kumano*, Takakazu.Ishimatsu*
Mitsuaki.Ueda, Shunji.Moromugi*K.Onodera and Kazuichi.Onodera**

*Department of Mechanical System Engineering, Nagasaki University
Bunkyo-mach1-14, Nagasaki city, Japan 852-8521
**Department of Environmental Science, Nagasaki University 1 2 0
Bunkyo-mach1-14, Nagasaki city, Japan 852-8521
Tel : +82-95-819-2508 Fax : +82-95-89-2508 E-mail: ishi@net.nagasaki-u.ac.jp

Abstract: In this paper we propose a platform that is applicable to low altitude remote sensing. Basic idea of the platform is based on the model helicopter. On big difference from the conventional model helicopter is that our platform has four main rotors. Furthermore, vision control strategy is introduced so that operator can use the platform without any specialized intensive knowledge

Keywords : Helicopter, Platform, Remote sending, Robot vision, Flight control

1. INTRODUCTION

Remote sensing technology is widely used in civil engineering, marine engineering and also environmental research. Satellite and airplane are mainly used as a platform to obtain image data. The application fields of the remote are expanding. One typical example is resource management of rice field in Japan. While farmers grow rice, they needs to care the fertilizer, wilt disease, water supply, climate and so on. On advanced technology to support rice cropping is to use remote sensing technology. Already some tests are executed using satellite data in Japan. However, one practical problem is that the clouds often disturb satellites data. Furthermore, cost of the satellite data and possible frequency are serious problem. As a solution to cope with these problems, a low altitude remote sensing technique is proposed. Image data at low altitude (30 m or 50m) offers high resolution data and are not disturbed by clouds. Some platform to enable low altitude remote sensing are proposed like balloons, radio controlled airplane and helicopter. These platforms have some drawbacks considering the portability and required skill. On attractive platform is a compact model helicopter which is computer controlled like robots. If the helicopter is compact and obedient to the operator like animals, the robotic helicopter can be effective platform. Of course many researchers studied to develop robotic helicopter. While some of them succeeded to auto-navigation of the helicopter, the conventional helicopter still has some drawbacks like complex pitch control mechanisms, a dangerous tail rotor and a main rotor.

In this paper we propose a platform that is applicable to low altitude remote sensing. Basic idea of the platform is based on the VTOL(vertical take off and landing plane). Conventional helicopters can move toward any direction by varying pitch angle of the main rotor during one rotation. Suppose pitch angle of the main rotor in the front side is larger than that in the rear side, the helicopter is inclined backward and moves toward rear direction. Our platform proposed here has four main rotors. Employing four main rotors our platform can move toward any direction without pitch control of the main rotors. Instead of the pitch control, our four-rotor platform requires rotating speed control of each rotor to enable desired movement. In order to simplify the usage of the platform, the vision control of the platform is employed. Three-dimensional position of the platform is measured by the stereovision on the land. The vision system is realized using FPGA technologies offer by Altera Co.Ltd. A prototype of our platform is realized by using compact direct drive motors.

The prototype worked effectively. Because of the superior features of the platform, the proposed system could be readily applicable to low altitude remote sensing.

2. CONFIGURATION OF SYSTEM

In Fig. 1 a platform with four main rotors is shown. Four rotors are actuated by four sets of brush less direct drive motors. On the platform one camera to get remote sensing images is mounted. Furthermore, an altimeter, a tilt meter and an azimuth sensor are mounted. Also one chip computer is mounted. The one chip computer controls the posture and the orientation of the platform. A radio signal transmitter

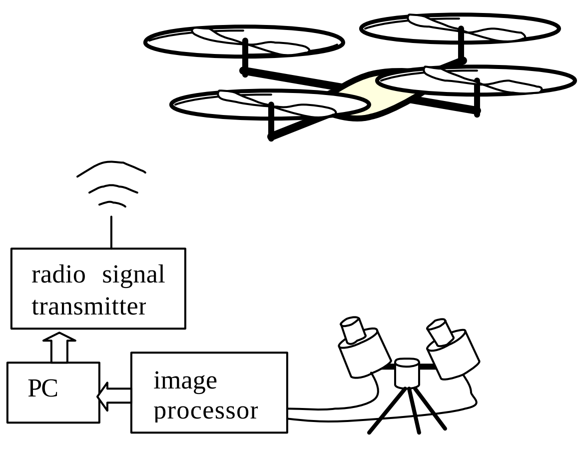

Fig.1 System configuration

on the platform transmits the data of these sensors to the land. Auto-navigation of the platform can be achieved by introducing a vision control system. A stereovision system is settled on the land. The stereovision system detects the 3D position of the platform.

A distinct advantage of four-rotor platform is that movements to arbitrary direction can be achieved only by controlling the rotating speed of each rotor. In order to cancel the reaction force caused by rotating each rotor, motor A and B rotate clockwise, and motor C and D rotate counter clockwise. Suppose rotating speed of motor B and D are increased, the platform inclined with right hand side up.

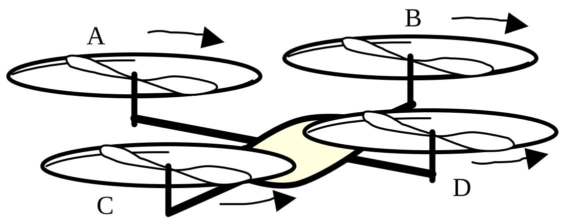

Fig.2 Rotating direction of each rotor

A prototype of four-rotor platform is shown in Fig.3 where diameter of each rotor is 25.5mm. Motors are direct drive blushless and sensorless motors AXI2212/34(model motor Co.Ltd.). Battery used is Li-Po battery

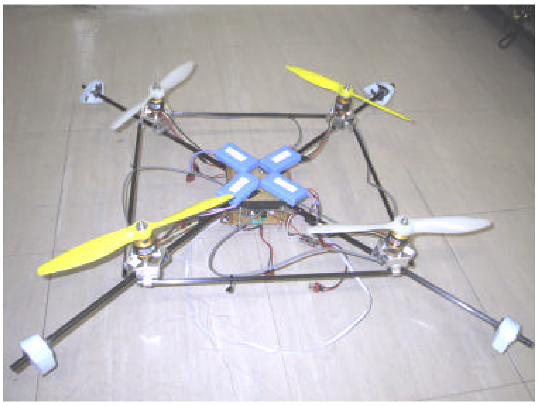

Fig.3 Prototype of four-rotor platform

The image processing system designed inside the FPGA receives the image and extracts the landmark on the platform images. By analyzing the geometry of the landmark on the platform images, the 3-D position of the platform can be obtained. Based on the data obtained, the control signal of the platform is determined so that the desired position can be realized.

The clinometer detects the roll and pitch angles by measuring the capacity change inside the sensor. Output data from the clinometer are obtained as PWM signals.

The direction of helicopter can be obtained by using an azimuth sensor.

3. VISION SYSTEM

A robot vision is introduced to our system. The main object of the robot vision is to measure the geometrical relation between the platform and the landmark. Based on the data measured, the helicopter is controlled to keep the specified height and the posture. The robot vision system is implemented inside the FPGA board (Stratix offered by Altera Co.Ltd). By implementing the vision system for two camera, system can be compact enough to install on the helicopter.

3.1. Hardware Configuration

The altitude of the helicopter can be measured by an aneroid barometer. But we introduce a vision system to measure the altitude more exactly. The principle to measure the altitude is based on the stereovision. Therefore, the vision system implemented in the FPGA has two CPUs.

Images of two CCD cameras are digitized to eight-bit data. The data are transferred to FIFO memory in the FPGA circuit. Two CPUs read out the data from FIFO memory and perform data processing.

3.2 Software Configuration

Data processing of the vision system is shown in Fig.4. Labeling program is executed on both CPUs. The land mark image can be extracted based on the area and surrounding length. The image data of the landmark are compared between two CPUs considering the matching conditions.

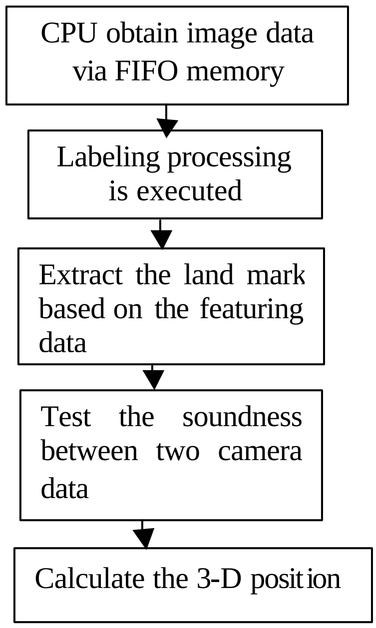

Fig.4 Image data processing

4. EXPERIMENT

Instead of four-rotor platform, vision control experiment of double-rotor helicopter was executed. Test helicopter was a radio control helicopter X.R.B-lama made by HIROBO Co.Ltd. In order to simplify the image processing, two LED marks are attached at the bottom of the helicopter. By detecting these two LED marks, three-dimensional position could be detected. Control test was executed as follows. First the helicopter was manually controlled and moved to the hovering position around

1.5m high. Secondly the control strategy was started to keep the helicopter at the hovering position.

Fig.5 Control test of double rotor helicopter

The vision control system is shown in Fig.6 where images are captured by two cameras. Images are processed by multi CPU designed on the NIOS CPU board and the results are transferred to PC. Three-dimensional position of the helicopter was calculated on the PC. And the control data of the double rotor helicopter is determined. And radio signal transmitter transmits the control data to the helicopter. In the manual control mode, the operator uses the radio control signal transmitter in the Fig.6. PC in Fig.6 can read the control signal emitted from the radio control signal transmitter so that at the switching instance from the manual mode to the control mode the control signal is changed smoothly.

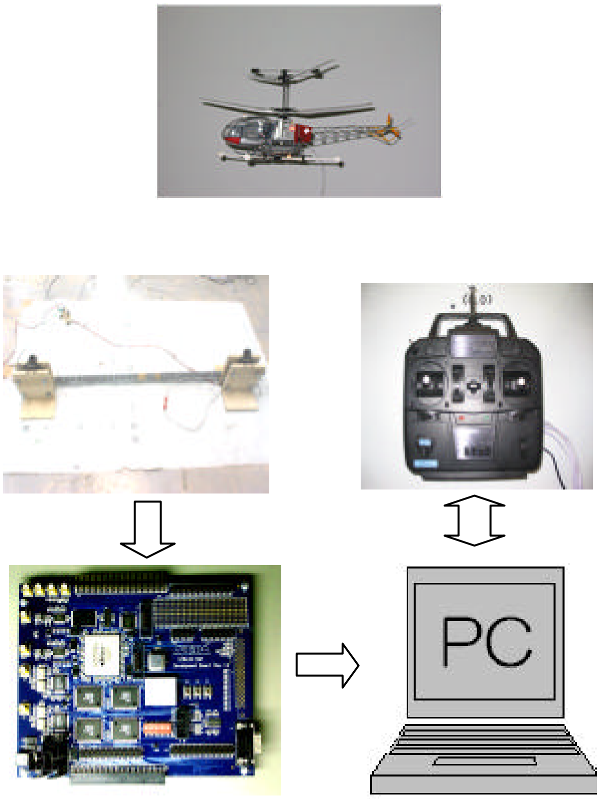

Fig.6 Vision control system

As an effective control algorithm, PD(Proportional and Derivative)control algorithm was introduced. In Fig.7, control signal in the x direction (leftward direction) and resultant x position data are shown. While vibrations with frequency 1Hz was observed, the helicopter could keep original position and posture. In Fig.8, the helicopter at the automatic hovering status is shown. The helicopter can keep the hovering status until the battery is exhausted.

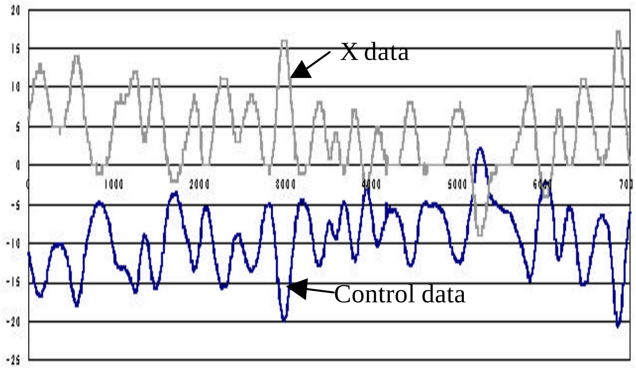

Fig.7 Control signal and results

Fig.8 Hovering control by vision

A platform of the four-rotor platform at base test under string support is shown in Fig.9. It was clear that the motors have enough power to levitate the total body.

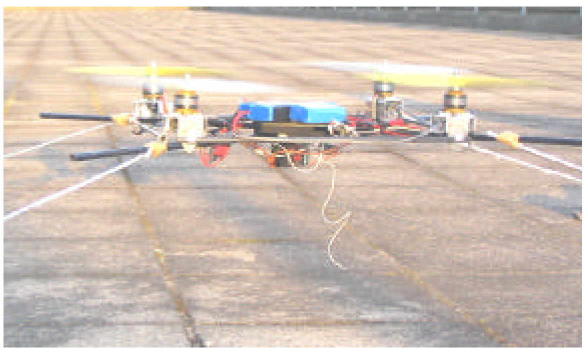

Fig.9 Motor test of four-rotor platform

5. CONCLUSION

In this paper a low altitude platform for the remote sensing is proposed. A feature of the system is the new type platform with four main rotors is introduced. Another feature is that vision control is introduced. The vision system was successfully applied to a double rotor helicopter. We are now applying vision control system to a four-rotor platform. After that we intend to apply our platform and vision control system to a commercialized low altitude remote sensing.

References

[1] T.Yamaguchi et al. "Intelligent control of flying vehicle of using fuzzy associative memorysystem",Proc.IEEE Int. Conf.on Fuzzy System,pp.1139-1149(1992)

[2] C.Kang and Ishimatsu:"Hovering control of model helicopter by vision",Jr. Artificial and Robotics,Vol.3,1999