A study on improvement of the surveillance system of an Indoor blimp robot

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Abstract

Blimp robots are attractive as indoor flying robots because it can float in the air, land safely with low energy, and stay in motion for a long time compared with other flying robots. However, controlling of blimp robots for surveillance is difficult, because it has nonlinear characteristics, is influenced by air streams and is easy to be influenced of inertia. Therefore, it is not easy to control blimp robot only by PID control and to carry out position control.

However, since PID control can change the control characteristic easily by adjustment of a parameter, it is thought possible to use for rough control of operation Therefore, when performing control of blimp robot of operation, PID control performs rough operation. And application of blimp robot is considered to round and surveillance by using the more precise control method for detailed control of operation near the surveillance point.

By this research, in order that the control instructions from the outside may make operation there is nothing independently possible, having improved the certainty of round surveillance is shown by developing blimp robot which carried all the parts for control and in which autonomous control is possible. Using learning control near the surveillance point and using PID control between surveillance points.

1 introduction

As compared with other flight move objects, floating and movement are possible for Blimp robot with low energy. Therefore, it is observed as a flight robot for indoor. Recently, researches have studied ways to make the best use of the features of blimp robot and how to apply it to indoor applications, such as situation, the area and house that received the calamity survey [1], indoor security [2].

Blimp robot will be wanted direct motion when flying, example through narrow spaces for security and round an indoor surveillance. The thrust unit of an indoor blimp robot must be designed high mobility. And, blimp robot has to operate in the limited range. the entire blimp robot must be kept small. Buoyancy decreases by miniaturizing the airframe. In designing a blimp robot, one must considering the weight of the controller unit, thruster unit, and the sensor unit on the airframe. Characteristic of blimp robots is influenced of inertia; establishing original control architecture compares the other robots.

Based on the flight navigation of insects [5], by position detection using beacons [6], and based on camera pictures [8] are researched about the method of controlling Blimp robot. In addition, investigation in outdoor environment has been conducted using cooperative operation with ground robots [4], an original method is proposed by each research. The research on the round system that uses the PID control is performed. [10]

2 Experiment

This chapter explains the experimental environment and the experiment blimp robot to show that blimp robot accurately reaches the target surveillance point.

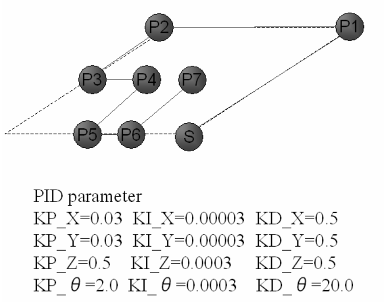
2.1 Experimental environment

Experiment environment is an inside of a building. And the blue and red circle are arranged with a diameter of 0.50m at intervals of 0.75m to the floor at the space for an experiment. As experiment space, it is referred to as over 3m at width, depth, and height for experiments in Blimp robot.

2.2 Experiment operation

"S" was made a starting point, and the operation of Blimp robot in the actual experiment was set for the straight line to move in order of P1~P7. In this experiment, P1~P7 is made a relay point, and it makes it to surveillance point.

1. When the camera installation part of blimp robot enters the space of 50cm in the radius for the point where P1~P7 is observed, it switches to the learning control[11].
2. It rotates when is in the space of 30cm in the radius for five seconds for each surveillance points of P1~P7.
3. After rotations are made, it moves to the next point.



$$S = (-100,0,200)$$
$$P1 = (-100,200,200)$$
$$P2 = (100,200,200)$$
$$P3 = (100,50,200)$$
$$P4 = (50,50,200)$$
$$P5 = (50,0,200)$$
$$P6 = (0,0,200)$$
$$P7 = (0,100,200)$$

Fig.1 Round condition and PID parameters

2.3 Blimp robot and PID controller

Figure 2 showed appearance of blimp robot. The balloon is a column type, and the diameter is 0.94m, and 0.80m in height for enough to obtain buoyancy [8]. And, it has a controller and driving part under the balloon.

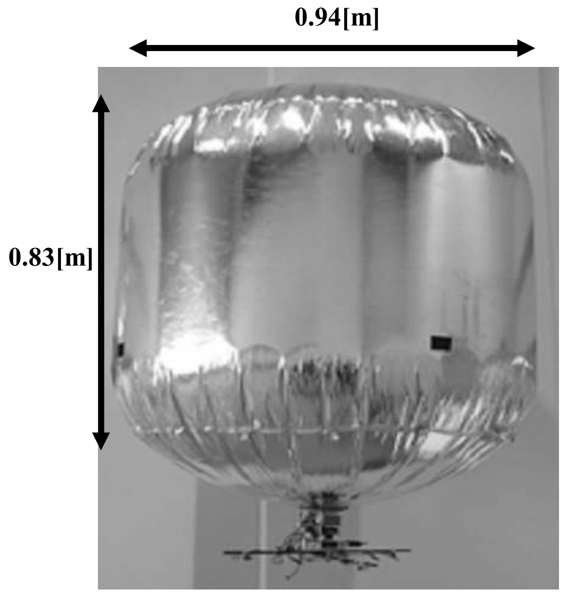


Fig.2 Appearance of developed Balloon Robot

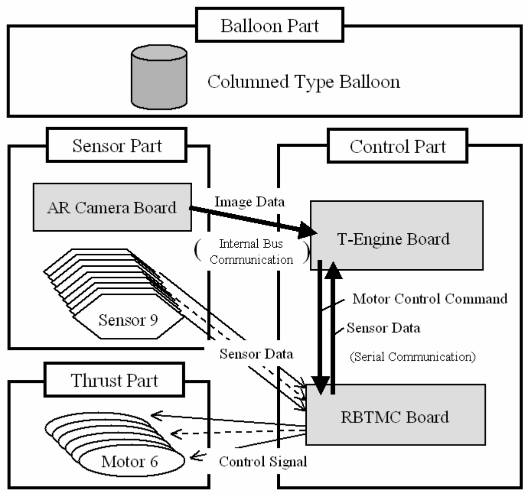


Fig.3 Abstraction of the Developed Blimp Robot

In this research, the camera of the resolution of 160×144pixel is installed and the RGB 16bit color image to be able to acquire the location information by recognizing the landmark in the experimental environment is position acquired. μ T-Engine calculates information and the image data processing from the sensor, and taken image and sensor value are processed ⊿T=0.3 sec or less of the sampling duration of the propeller motor control.

Fig.3 shows the block diagram of developed blimp robot, μ T-Engine board (M32104) controls the DC motor driver of the RBTMC one-board microcomputer board by the serial port after doing the processing of sensor information and the calculation concerning the decision of the control output, and six propellers (ch0~ch5) are driven. Thrust was able to be generated axially each for a direct movement in the direction of the desire and the propeller was arranged. Propeller motor ch4 and ch5 that intersected, united the midair carbon pipe, arranged the propeller motor of ch0~ch3 that generated thrust x axis and y axis, and generated thrust z axis were arranged.

The variables manipulated for translation and rotational motion in our PID controller were decided by deviations based on the relative distance from the x, y, and z axes and the relative yaw angle. The relative distances e_x, e_y, and e_z [cm] are from the blimp to the target. The relative angle e_θ [rad] is the angle from the yaw angle of the blimp to that of the target. The manipulated variables $m_x(t)$, $m_y(t)$, and $m_z(t)$ [g] for translational motion, and $m_\theta(t)$ [g] for rotational motion at time t, are calculated as

$$m_x(t) = K_{px}e_x(t) + K_{Ix}\sum e_x(t)\Delta T + K_{Dx}\frac{e_x(t) - e_x(t-\Delta T)}{\Delta T} \quad (1)$$

$$m_y(t) = K_{py}e_y(t) + K_{Iy}\sum e_y(t)\Delta T + K_{Dy}\frac{e_y(t) - e_y(t-\Delta T)}{\Delta T} \quad (2)$$

$$m_z(t) = K_{pz}e_z(t) + K_{Iz}\sum e_z(t)\Delta T + K_{Dz}\frac{e_z(t) - e_z(t-\Delta T)}{\Delta T} \quad (3)$$

$$m_\theta(t) = K_{p\theta}e_\theta(t) + K_{I\theta}\sum e_\theta(t)\Delta T + K_{D\theta}\frac{e_\theta(t) - e_\theta(t-\Delta T)}{\Delta T} \quad (4)$$

where KP is the proportional gain, KI, is the integral gain, and KD is the derivative gain. The parameters are adjusted for each basic motion.

$m_x(t)$–$m_\theta(t)$ generated for propellers ch0–ch5 are determined by using m, m_y, m_x, and m_0 as follows:

$$m_0(t) = m_y(t) + m_\theta(t) \quad (5)$$

$$m_1(t) = m_x(t) + m_\theta(t) \quad (6)$$

$$m_2(t) = m_y(t) - m_\theta(t) \quad (7)$$

$$m_3(t) = m_x(t) - m_\theta(t) \quad (8)$$

$$m_4(t) = m_z(t) \quad (9)$$

$$m_5(t) = m_z(t) \quad (10)$$

m0(t)–m5(t) are continuation values that are calculated by equations (5) through (10). However, the motor drive developed by this research cannot control a continuous rotational speed. As for the drive of the motor, only a binary control of ON-OFF is possible. The drive of the motor is adjusted and thrust is adjusted according to the time width for that. As for the motor, a positive rotation and the reverse rotation are individually possible. By these devices, controlling such a propeller motor, it becomes possible to generate an independent thrust and blimp robot is freely movable to x, y, and z axis.

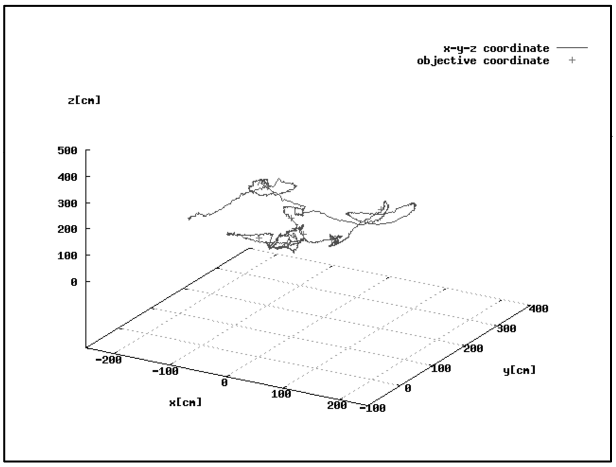


Fig.4 Three-dimensional orbit result of blimp

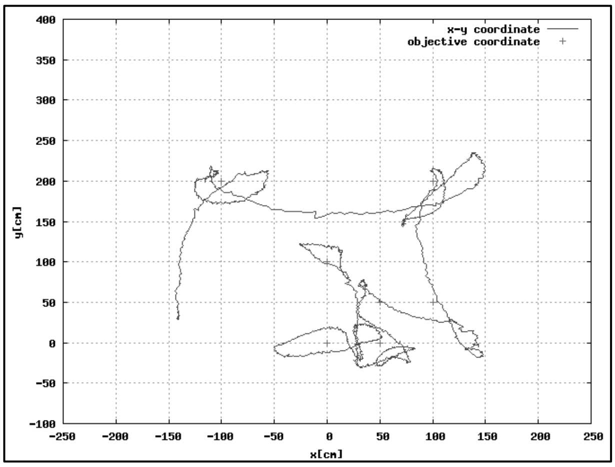


Fig.5 The orbit of X-Y plane of blimp

Figure 4 showed three dimension orbit of blimp robot. The orbit of X-Y plane was shown for Figure 5.

A straight line orbit lacks stability because it has received the influence of inertia. The control that moves between the target points is done by the PID control now. However, the appearance in which the orbit is corrected is shown toward the target point. Especially, it is shown that it is operation to which adjacent to the target point is done as it is a setting.

Figure 6.7.8 showed the transition of the time of the orbit in x, y, and z each axis. In each axis, blimp independently corrects the orbit, and does the movement operation to the target point. And, an individual axis and the orbit result shows, it is understood that the influence of inertia is large.

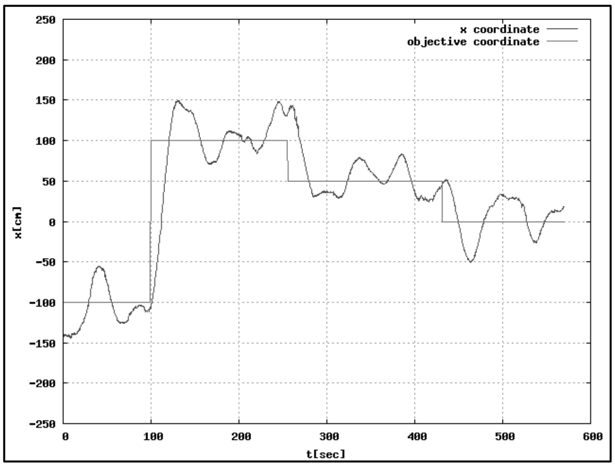


Fig.6 Transition at time in x axis

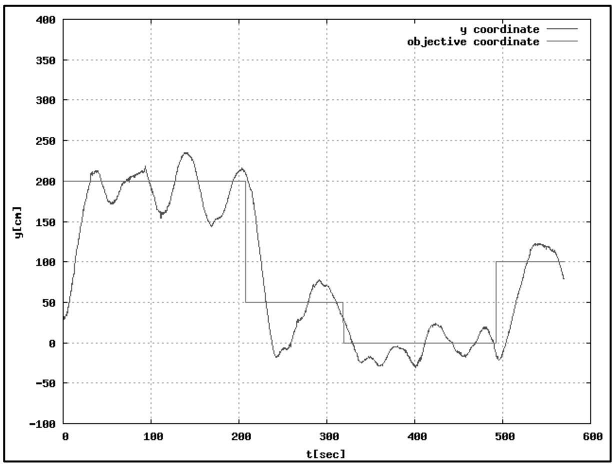


Fig.7 Transition at time in y axis

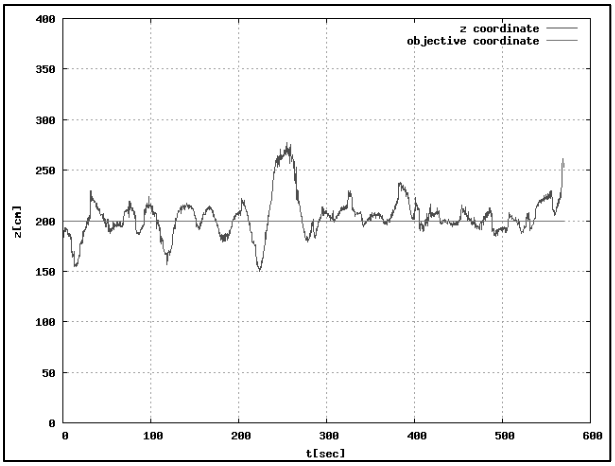


Fig.8 Transition at time in z axis

4 Conclusion

The rotation operation in the PID control and the surveillance point (each target point) was able to be achieved. However, there is a problem that the disorder of the orbit by the influence of inertia is caused in other side. And, the error margin of keeping position in the surveillance point is large.

The orbit is stabilized and it will be necessary to improve keeping position with surveillance point in the future. It is scheduled to change the PID control from a positional control to the speed control and to try to this improvement.

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