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Design Blimp Robot Based On Embedded System and Fuzzy Logic

Sunil K. Suman , Prof. Saniya M. Ansari

Abstract - Blimps robot with helium gas have main advantages, there will be no need of driving force. In this project we are going to present a low weight , embedded system based blimp unmanned Airship. Advantages of this project could be less energy consumption low noise and cost efficiency which could made them ideal for exploration of areas without Disturbing environment. In this project we are going to implement high resolution and advanced facilities with low weight camera for capturing the video or images depending on need basis. We are trying to use the Fuzzy controller for automatic control in air. We are going to facilitates blimp with obstacles avoidance. We are going to provide the stability of blimp system in air. We are providing the facilities for tracking the object on ground from the Aerial blimp system.

Keywords:- Autonomous Aerial Vehicles, Embedded Systems, Fuzzy Control, Software Architecture, Stability, Tracking the Object.

1. INTRODUCTION

The development of small size autonomous flying vehicles represents one of the current frontiers of research in mobile robotics. In this context, aerial blimps have the advantage that they operate at low speed, do not spend energy to keep their position, and are not overly sensitive to control errors compared to other flying vehicles. On the other hand, they are sensible to outside influences like air flow and are subject to a three dimensional motion model with translations and Rotations.

Therefore, they are a common platform to evaluate robotic algorithms for autonomous flight and navigation. In this project, we describe how such a blimp system including an embedded micro system and software framework can be build up. In this regard, we aim to keep the system as small and agile as possible in order to operate indoors. This size constraint also limits the possible weight of the blimp. Due to these characteristics, blimps are not only interesting for robotics but also for micro system technology as the attached devices should be both small and efficient. Such performance aspects are evaluated in the experiments. Fig.1. is full blimp system.

- *Sunil K.Suman is currently pursuing masters degree program in electronic and telecommunication engineering in SP Pune University,Pune, India. E-mail: sumans69@yahoo.com*
- *Saniya M. Ansari is currently Assistant Professor of Department of E&tc DR.D.Y.Patil school of Engineering, SP Pune,University Pune,India,. E-mail:ansari.saniya6@gmail.com*

Fig.1.This images shows the completely build blimp

Recently, the unmanned airships become focus interest increasingly because of their advantages such as long time hovering, much less energy consumed, very low noise and cost efficiency which made them ideal for exploration of areas without disturbing environment. Also they can take off and land vertically without run aways, Airship could also reach anywhere so that remote or difficult to access regions could be monitored. However, an important navigation problem is automatic control of altitude and horizontal movement. A second important navigation problem for the blimps is obstacle detection and collision avoidance.

2. ARCHITECTURE OF A SYSTEM

2.1 THE BLIMP SYSTEM

The blimps system contains following unit.

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2.1.1. The Main Unit (MU)

The processing control unit is the core of the system and it is distributed among At mega microcontroller which handles stability control and maintaining blimp attitude set points. Our chosen for this microcontroller depends on its ability to interface with other components in the system.

2.1.2. Inertial Measurement Unit (IMU)

As a flying robot the Bryan angles (roll, pitch, and yaw) are required and to obtain these angles an inertial measurement unit (IMU) was used. The accelerometer data along with the gyroscope data about all three axes will be taken into contexts, allowing the blimp to know its attitude along with its distance traveled at any point in time.

2.1.3. Motor Drivers

They are necessary to control the speed of each motor. The drivers are based on discrete MOSFET H-bridge motor driver enables bidirectional control of one high-power DC brushed motor. It supports a wide 5.5 to 30 V voltage range and is efficient enough to deliver a continuous 15 A without a heat sink. The pulse-width modulation (PWM) is directly controlled by the microcontroller.

2.1.4. Sensors

We mounted a quarter ring with four ultrasonic sensors to gondola in (x, y) plane to be used for avoidance obstacles. The altitude distance during the flight was verification and controlled via the fifth ultrasonic sensor that is downward-facing mounted at the bottom of the gondola.fig.2 is the gondola onboard unit.

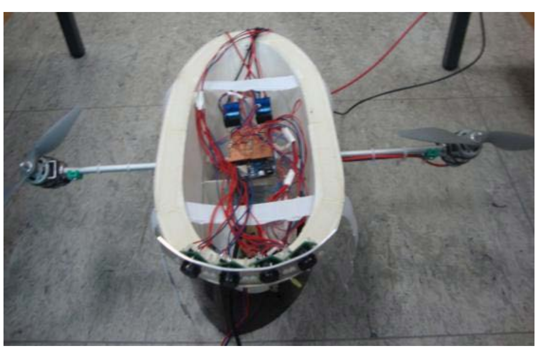

Fig.2. The gondola onboard unit (GOU)

2.2 AERIAL BLIMP SYSTEM

The system can control various activities where man cannot stand .But with the help of electronics and computer technology we can control and operates the devices and we can take the decision from the remote area. Fig.3. shows the full architecture of the system and Fig.4.shows the ground station.

- The following are the blimp Hardware
- 1 non-rigid envelope filled with helium;
- 2 dual blade main propellers
- 1 dual blade tail propeller
- 1 shaft for adjustment of the angle of the main propellers; wireless Camera;
- 2 Graupner Speed motors for the main propellers;
- 1 Multiplex Permax motor for the tail propeller;
- One motor and encoder for the main propellers' shaft;
- PWM controllers for the motors;
- 1 Reedy Black Label 2, Ni-MH battery ;
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- 2 Flight Power EVO 25, Li-Po batteries.
- Servo motor
- 5 Ultrasonic sensors
- ATMega 328 microcontroller
- Wireless TX-RX(Xbee)

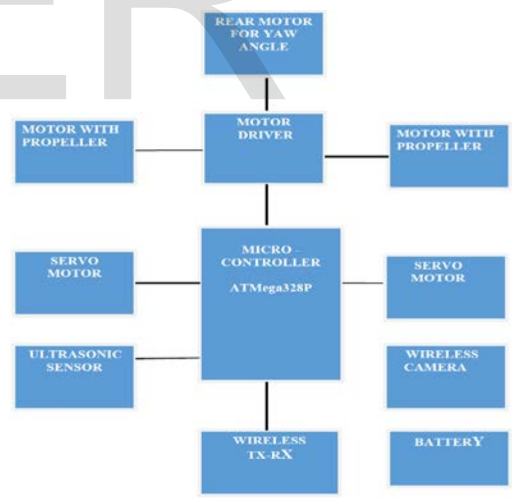

Fig.3. block diagram of blimp robot

2.3 GROUND STATION

In our project there are two stations one is blimp robot in air and other is the computer and remote control on the ground. Blimp robot is controlled by ground station in the range. In the Blimp robot camera interfacing for capturing image or video. Wireless camera sends the data on the ground station. Movement of the blimp controlled by the user on the ground station. Main computer send the instruction to the wireless module which is attached with the ground computer. The Atmega generates the pulse width module (PWM) to control the motors. Finally, Xbee client will send the flight data to the ground control center and receive commands. Ultrasonic sensors were mounted on front of gondola to be used for avoidance obstacles. Atmega328 µcontroller to handle the stability control and maintaining blimp attitude set points. The choice of Atmega328 µcontroller depends on its ability to interface with other components in the system which handles simple string commands from the system unit and controls the power of the motors and the setting of the servo.

2.3 GROUND STATION

In the ground station there are pc with Matlab,TV Tuner,controller. Remote control etc.if blimp system is out of automatic control then we can use the remote controller.on the pc we can see the object image and tracking the ground object.from the blimp system data is coming on the pc through Xbee.

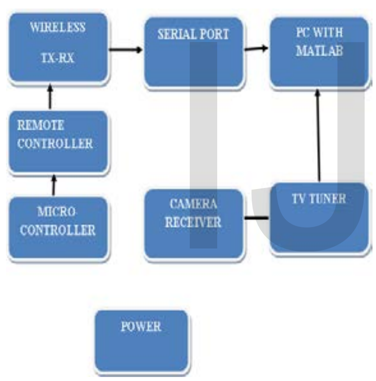

Fig.4. block diagram of ground station

2.4 Algorithm of servo motors and ultrasonic sensors given below:

Algorithm:

- Create two servo objects to control two servo motors.
- Initialize input and output pins for motors and sensors.
- Assign pins to servo motors.
- Set baud rate at 9600.
- Give 20us high pulse to trigger pin of ultrasonic sensor.
- Start reading the echo pin of ultrasonic sensor.
- If the pin reads high, increment the count.
- Send count serially out.
- Also, check if any data is received serially.
- If received data is '1', give the first motor rotation at 0 degree and second motor at 180 degree.
- If received data is '2', give the first motor rotation at 90 degree and second motor at 90 degree.
- If received data is '3', give the first motor rotation at 180 degree and second motor at 0 degree.

3. FUZZY LOGIC

FUZZY logic provides a mathematical framework to deal with the uncertainty and the imprecision typical of the human reasoning system. One of its main characteristics is the capability to describe the behaviour of a complex system in a linguistic way by means of IF–THEN rules similar to those employed in natural language. The facility of fuzzy logic controllers (FLCs) to capture the knowledge of human experts and translate it into robust control strategies without the need of a mathematical model of the system under control has led to a significant increase in the number of control applications using fuzzy inference techniques in the last 25 years. .[14]

3.1 STRUCTURE OF THE 2LFC.

The mostly used controller for the nonlinear system is the fuzzy controller. The fuzzy system is able to have robust control of the robot and it has low sensitivity to a variation of parameters or noise levels. The two-layer fuzzy controllers 2LFC have been designed and implemented in the previous work. During the navigation of the blimp, the control system could have three main characteristics. First, the ability to change the vectorization angle in case the blimp detects an.

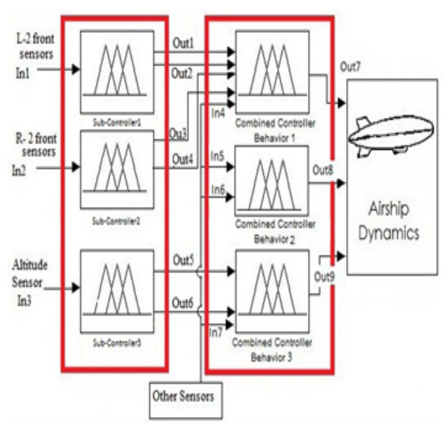

Fig.5.Structure of the 2LFC.

Obstacle in the path. The ability to keep the blimp flies at a certain altitude. Finally, the blimp is able to control the stability around z-axis during the navigation. Hence, we updated the controller to have another combined controller (Combined controller behavior 2) which deals with this issue. Figure 5 shows the structure of the 2LFC which has three sub-controllers in the first layer and three combined controllers in the second layer. The 2LFC is similar to shape to the neural network. However, the 2LFC does not involve a network having fuzzy controller while neuro-fuzzy systems are likely to form the layered structure of an artificial neural network which is known as nodes. Also, there are three modules in the final layer of 2LFC which deal with three outputs

3.2 SUB-CONTROLLERS

The first and second sub-controllers are using the fuzzy sets to find the shortest distance between the blimp and the obstacles in the horizontal path. The third sub-controllers could find the shortest altitude during the flight. The fuzzy knowledge base for these sub-controllers was designed experimentally by testing the sensor's behaviours and studied the effect of the blimp's incidence angle and the distance between the blimp and the detected objects. Therefore, the sensors were divided into three input groups for the sub-controllers. The data from these sensors are directly input to sub-controllers (In1, In2 and In3). The outputs of the sub-controllers are divided into two groups, the shortest distances outputs (Out1, Out3 and Out5) and velocities outputs (Out2, Out4 and Out6). Out1 is the shortest distance obtained from L-2sensors, Out3 is the shortest distances obtained from R-2sensors and Out5 is the estimated shortest altitude. On the other hand, the Out2 is the smallest horizontal velocity 1, Out4 is the horizontal velocity 2 and Out6 is the vertical velocity. The second layer uses the outputs of the sub-controllers and other sensors (IMU) as inputs (In4, In5, In6 and In7) to generate the main behaviours of the blimp (obstacles avoidance and the altitude). We should note that the empirical inputs and outputs linguistic values with membership functions are defined for the combined controllers after simulation studies.

3.3 AVOIDANCE OF OBSTACLES CONTROLLER

The first combined controller in Fig.6. is the most important behaviour of the blimp which is the avoidance of obstacles. The goal of this controller was to keep the blimp at a safe distance from frontal obstacles. The collision avoidance system should cause the blimp to change the direction of main propellers motors (the vectorization angle) when the front sensors detect an obstacle in a certain distance. This combined controller has the ability to decide which input has the smallest distance (Out1 or Out3) and which input is the accurate velocity (Out2 or Out 4). Hence, this controller has two inputs: first, the error which describes the difference between the required avoidance distance and the shortest distance. The second input is the horizontal speed and the output of this controller is the vectorization angle (Out7).

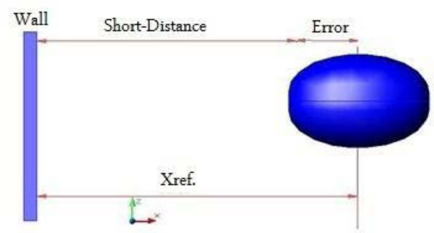

Fig. 6. Avoidance of obstacles controller

3.4 ALTITUDE CONTROLLER

Third combined controller is the altitude controller in fig.7. which has two inputs: error in the altitude distance and error in vertical velocity. The altitude error was the difference between the desired altitude and current shortest altitude. The change in altitude error indicates whether the blimp is approaching the reference altitude or moving away from altitude. The controller output is the voltage of main propellers motors (Out9).

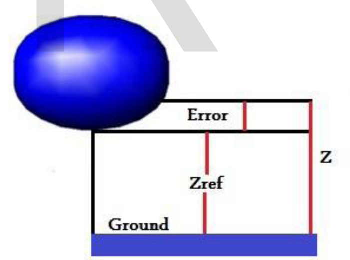

Fig.7.Altitude Controller

3.5 YAW ANGLE CONTROLLER

The second combined controller as illustrated in fig.8. is the Yaw angle controller. This controller was introduced in order to control the Yaw angle to get stabilization in the blimp by using the motor mounted at the blimp tail.

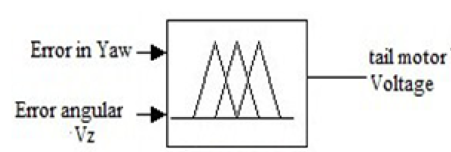

Fig. 8. Fuzzy controller for Yaw angle.

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A fuzzy controller was used to control this behaviour as shown in fig.9. The first input is the error in yaw angle (In5) with 5 linguistic variables (NH: negative high, NL: negative low, Z: zero, PL: positive low, PH: positive high). The second input is the yaw angular velocity around z axis (In6) with 5 linguistic variables (NH: negative high, NL: negative low, Z: zero, PL: positive low, PH: positive high), the output is the voltage of the tail motor (Out8). The 25 fuzzy rules for Yaw controller which describe the controller behaviour in terms of relationships between input and control variables are summarized in Table 1. The membership functions for inputs and outputs are shown in fig.9.

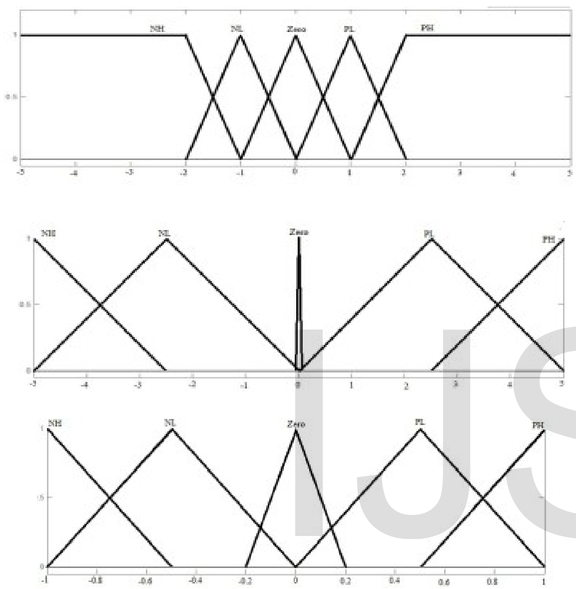

Fig.9. Membership functions: error in yaw angle, error in angular velocity around Z-axis,voltage of tail motor

Table 1: Fuzzy Rules for Yaw Controller

Yaw error	Angular velocity error				
	NH	NL	Z	PL	PH
NH	PH	PH	PH	PL	Z
NL	PH	PL	Z	Z	Z
Z	Z	Z	Z	Z	Z
PL	Z	Z	Z	NL	NH
PII	Z	NL	NII	NII	NII

fig.10.represent the reasult of ultrasonic sensor when infront ultrasonic sensors detect the obstacle then on the computer screen then we can see the graphs, graphs changes as like distance between sensors and obstacle changes

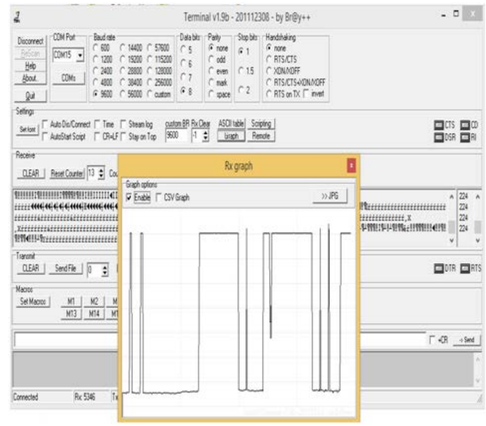

Fig.10.Experiment result of ultrasonic sensors

4.Tracking the Ground Object from Blimp System

We mounted the wireless camera on the bottom of the blimp system which is used for tracking the ground object. This concept is based on image matching. Object image is store in my data base if there will be matching then total number of matching is displayed on the scene. We are using shift algorithm for tracking the ground object from Aerial blimp robot. My idea is based on Image matching. We provide a basis for object and scene recognition. This approach has been named the Scale Invariant Feature Transform **(SIFT),** as it transforms image data into scale-invariant.

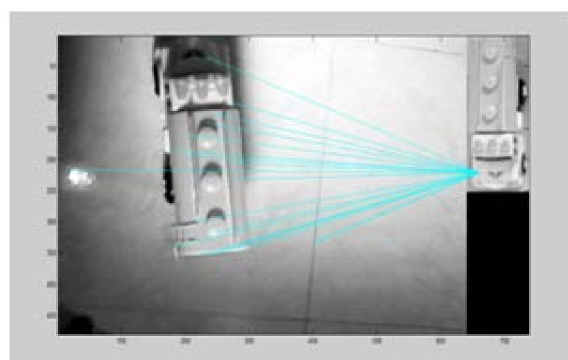

Fig. 11. Result for tracking of ground vehicle from aerial blimp

5. CONCLUSION

We presented a powerful, low-weight, and embedded system which is applicable for autonomous blimp robot. We designed an embedded hardware and software system on the blimp. The experiments results showed that the system achieved the requirements of the project. This system ensures the stability and reliability to accomplish actual explorations missions. Also, the flight control and navigation system for the indoor blimp robot was presented. The architecture of the two layers fuzzy control system is presented to generate the main behaviours of the blimp, the altitude and obstacles avoidance. In addition, a fuzzy control was used to control the Yaw angle during the flight. The experimental results showed good experimental performance of the blimp.

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