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Review on Blimp Robot Based on Embedded System and Fuzzy Logic

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Abstract- Blimps have some advantages, for example that they do not need driving forces to float and can move in any direction. In this paper 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. We are trying to use the Fuzzy controller. Mainly to control the navigation of blimp. We are going to facilitates blimp with obstacles avoidance and going to provide more stability to blimp system in air.

Keywords- Airship, Autonomous Aerial Vehicles, Embedded Systems, Fuzzy Control, Software Architecture, Stability.

I. INTRODUCTION

1.1 THE ROBOTIC BLIMP

In today's world, there are many things that go wrong in life. The outcome on arrays of events that occur all the way from terrorism to as simple as traffic accidents can dramatically change if cameras were implemented more in our society. Even though there have been more applications of their usage, the idea of them being mobile would be more idyllic. Introducing the Aerial Blimp Robot, a robotic blimp camera system designed to be an all-in-one observation system. The research behind this project will have the prospective to make important contributions to the advancement of self-directed robotics as well as being enjoyable to us engineering students. Refined machines are able to do crazy tasks that most people cannot even begin to think about much less have people try to complete the inconceivable tasks, which would take extended periods of time to accomplish, and in the end may even led to the overall failure of the tasks in the first place. With that being said, you can pretty much determine that it would be nearly impossible to complete many of the mundane tasks we have today if it weren't for the advancements in technology. For example, if we still did not have cellular phones, communication would be limited to land lines wiping out nearly almost all the data we use in today's world with phones (internet, texting, hot spots, networking, remote controlling, etc.). This productivity in the technological industry has led to a dependency on electronics us humans have. Since the development of aviation, there have also been many advances. We have used aviation in war, civilian transportation, the transportation of goods such as food and items we buy and use, sporting events, all the way down the list to even being an extracurricular activity. Now that we live in a world where everything is controlled by technology and electronics, why not combine several features together in order to have one design to help in a bunch of different ways. The main objective of this project is to design a mobile device that will be able to observe and capture events as they happen while being connected to an aviation envelope. It will have several main functions, which are as follows: video surveillance, camera stabilization system, power directed propellers (on a rotating axis), user control by remote control, user control by inputting coordinates into system, user control by computer ,laptop, and video recognition. This system has the intentions to be just a fancy surveillance system; however, it will also act as a type of revenue for some people by advertising their company's logo on the side, or even sending data to a centralized base such as weather readings, body counts at special events, or simply just recording your favourite football team to watch on television.

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.1.1 is full blimp system.

Fig1.1This 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 runaways, 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.

Recently, the robotics community has shown an increasing interest in small-sized and low-cost unmanned aerial vehicles (UAVs) such as helicopters, quad rotors, or blimps. Especially their low power consumption and safe navigation capabilities make blimps ideally suited for long-term indoor operation tasks. In thesis, we present the design of a robotic blimp for autonomous indoor navigation. The hardware as well as the software system of our blimp is designed in a modular way so that it can be easily adapted for various autonomous navigation experiments. Furthermore, we introduce environment models, the formal state and control definition for miniature blimps, and methods to obtain accurate ground truth state information. We finally present a motion model for miniature indoor airships, which physically simulates the motion based on forces and torques and which enables a probabilistic motion prediction.

1.2 The Blimps System Unit.

A. 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.

B. 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 travelled at any point in time.

C. 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.

D. 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.Fig1.2 is the gondola onboard unit.

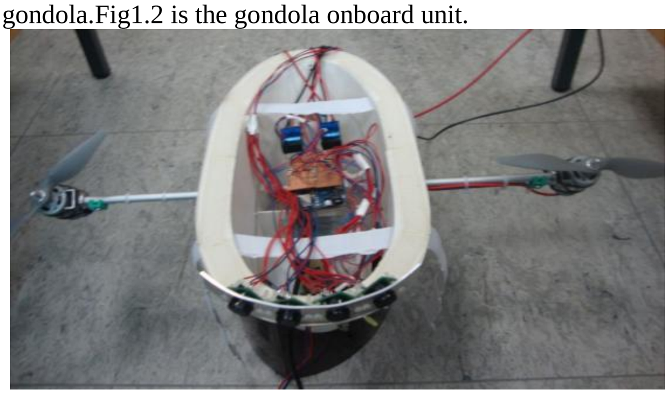

Fig1.2 The Gondola Onboard Unit (GOU)

Scope of This Project

- Search operations
- Advertising
- Disaster relief surveying
- Radio or WIFI repeater for emergency communications
- Public address system platform
- Event photography or recording
- Swarm control station
- Navigational Aid
- Weather or environmental observation
- Alternative energy generation

II. LITERATURE REVIEW

A key challenge in using fuzzy logic controller based UAV blimp system. In this section, the work done on this field by various persons so far in study of this technique is presented.

T. Xu, X. Zhang, and Y. Lu, proposed Onboard controlling system design of unmanned airship, According to author Unmanned airship possesses some advantages, such as long time hovering, much less energy consumed and cost efficiency. It is becoming one of the focus interests in the field of unmanned vehicles.[1]An onboard controlling system was designed in this paper, in which microcontroller and corresponding peripherals are included. With STC12C5A60S2 as the central unit, the onboard microcontroller was designed in detail including MCU, ultrasonic sensor, compass, battery monitor circuit, alarming signal generation and so on.

L. He, W. Huang, and Y. Wang , proposed Study of variable structure control technology on stratospheric airship attitude,[2] In this work Aim at autonomous control of stratosphere airship, the paper addresses one attitude controller design approach based on the small disturbance model of airship. The controller was designed based on the theory of output feedback variable structure control; the variable plane is designed by solving a set of bilinear matrix inequality transformation and a set of linear matrix inequalities iterative. Base on high improved gain method, it availably reduce shake used to adding a little and positive quantization in the denominator of control law. Then the control system made up of output feedback variable structure controller is simulated, the simulation results show that this method has excellent control effect.

Y. Yueneng, Z. Wei, and W. Jie, proposed Sliding mode control for a near space autonomous airship. This paper presents an improved sliding mode control method for autonomous flight, considering the characteristics of nonlinearity, strong coupling and uncertainty of an airship. Firstly, the dimensional motion mathematical model of an airship is derived, including kinematics and dynamics equations. Then the controller for autonomous flight is designed by use of an improved variable structure control method, which adopts the boundary layer sliding mode control approach.[3] F. Dai, W. Gao, N. Kushida, and L.

Shang proposed Fuzzy Control for the Autonomous Airship, This paper is to introduce the fuzzy control for the experimental autonomous airship. The basic technology that includes the hardware of the system and the program to control the airship navigating along the shortest flight path to the target point is developed. Fuzzy control is used because the control for an airship is nonlinear and it is difficult to describe the accurate motional equations of the system**.**[4]

X. Zhang, and Y. Lu, proposed Onboard controlling system design of unmanned airship. This work on Unmanned airship possesses some advantages, such as long time hovering, much less energy consumed and cost efficiency. It is becoming one of the focus interests in the field of unmanned vehicles. An onboard controlling system was designed in this paper, in which microcontroller and corresponding peripherals are included. With STC12C5A60S2 as the central unit, the onboard microcontroller was designed in detail including MCU, ultrasonic sensor, compass, battery monitor circuit, alarming signal generation and so on.[5]

Rami Al-Jarrah and Hubert Roth proposed Design Blimp Robot based on Embedded System & Software Architecture with high level communication & Fuzzy Logic , his work on High level functionality and communication based small size and low weight blimp.[10]

Al-Jarrah, R., Roth, H.: Developed Blimp Robot Based on Ultrasonic Sensors Using Possibilities Distributions and Fuzzy Logic. In this paper, authors present obstacles avoidance and altitude control algorithms based on fuzzy sets and possibilities distributions to control the blimp's complexity and main behaviours of the system. The fuzzy knowledge base is designed empirically to introduce two-layer fuzzy logic controllers which have the ability to reduce the ultrasonic sensor uncertainties and to estimate the shortest distance between the blimp and the objects. Finally, the results of the experiments show the algorithm is improving the performance of the blimp to avoid obstacles safely and maintain at a certain altitude.[11]

Al-Jarrah, R., AitJellal, R., Roth, H , proposed Blimp based on Embedded Computer Vision and Fuzzy Control for Following Ground Vehicles. In this work a ground robot followed by blimp system and seen by a computer system.[12] D. Lee et al. Proposed Semi-autonomous haptic teleoperation control architecture of multiple unmanned aerial vehicles. In this work VP control layer, which modulates each VP's motion according to the teleoperation commands and local artificial potentials (for VP-VP/VP-obstacle collision avoidance and VP-VP connectivity preservation); and teleoperation layer through which a single remote human user can command all (or some) of the VPs' velocity while haptically perceiving the state of all (or some) of the UAVs and obstacles. Master passivity/slave-stability and some asymptotic performance measures are proved.[13] Kirchner and Furukawa [17] present a localization system for indoor UAVs, which utilizes an infrared emitter on the vehicle and three external infrared sensors to localize the robot via triangulation. Although this approach does not have high computational demands, it requires external devices that perceive the infrared signals. In addition, many small-scale blimps have been designed for remote controlled operation or rather simple control tasks such as corridor or line following [18]. Consequently, these airships are usually equipped with severely limited sensing and navigation capabilities. For example, Zufferey et al. [19] developed a miniature blimp, which was controlled on a circular trajectory based on the image of a camera with only a single horizontal line of pixels.Ishida [20] developed a blimp for mapping gas distributions during random flights through the environment. Several approaches were proposed for blimp systems equipped with altitude stabilization and collision avoidance.

Al-Jarrah and Roth [11] controlled their blimp using an on-board microcontroller processing sonar measurements in fuzzy logic without considering their measurement uncertainty. Berm´udez i Badia et al. [21] applied a wireless camera and operated the blimp from a base station using neural network controllers. In contrast to all small-scale blimp concepts described above, our blimp is equipped with various sensors and a full-fledged computer for autonomous navigation in complex environments, and its sensor setup can be easily adapted to different navigation tasks.

Rami Al-Jarrah, Hubert Roth proposed "Visual Fuzzy Control for Blimp Robot to Follow 3D Aerial Object". This works presents a novel visual servoing system in order to follow a 3D aerial moving object by blimp robot and to estimate the metric distances between both of them. To realize the autonomous aerial target following, an efficient vision-based object detection and localization algorithm is proposed by using Speeded Up Robust Features technique and Inverse Perspective Mapping which allows the blimp robot to obtain a bird's eye view. The fuzzy control system is relies on the visual information given by the computer vision algorithm. The fuzzy sets model were introduced imperially based on possibilities distributions and frequency analysis of the empirical data. The system is focused on continuously following the aerial target and maintaining it within a fixed safe distance. The algorithm showing robustness against illumination changes, rotation invariance as well as size invariance. The results indicate that the proposed algorithm is suitable for complex control missions [22]

Guoqing Xia, Benkun Yang Flying over the reality gap: From simulated to real indoor airships.In this paper author proposed an efficient physical dynamic modelling and parameter identification procedure, which are complicated to develop and usually rely on costly facilities such as wind tunnels. In this paper, author present a simple and efficient physics-based dynamic modelling of indoor airships including a pragmatic methodology for parameter identification without the need for complex or costly test facilities project approach is tested with an existing blimp in a vision-based navigation task. Neuronal controllers are evolved in simulation to map visual input into motor commands in order to steer the flying robot forward as fast as possible while avoiding collisions. After evolution, the best individuals are successfully transferred to the physical blimp, which experimentally demonstrates the efficiency of the proposed approach.[23]

Thomas Lemaire, Cyrille Berger, Kyun Jung, Simon Lacroix [2007] "Vision-Based SLAM: Stereo and Monocular Approaches". Proposed Building a spatially consistent model is a key functionality to endow a mobile robot with autonomy. Without an initial map or an absolute localization means, it requires to concurrently solve the localization and mapping problems. For this purpose, vision is a powerful sensor, because it provides data from which stable features can be extracted and matched as the robot moves. But it does not directly provide 3D information, which is a difficulty for estimating the geometry of the environment. In this article author proposed two approaches to the SLAM problem using vision: one with stereovision, and one with monocular images. Both approaches rely on a robust interest point matching algorithm that works in very diverse environments. The stereovision based approach is a classic SLAM implementation, whereas the monocular approach introduces a new way to initialize landmarks. Both approaches are analyzed and compared with extensive experimental results, with a rover and a blimp.[24]

Jonathan Ko, Dieter Fox."Learning GP-Bayes Filters via Gaussian process latent variable models" author proposed GP-Bayes Filters are a general framework for integrating Gaussian process prediction and observation models into Bayesian filtering techniques, including particle filters and extended and unscented Kalman filters. GP-Bayes Filters have been shown to be extremely well suited for systems for which accurate parametric models are difficult to obtain. GP-Bayes Filters learn non-parametric models from training data containing sequences of control inputs, observations, and ground truth states. The need for ground truth states limits the applicability of GP-Bayes Filters to systems for which the ground truth can be estimated without significant overhead. In this paper we introduce GPBF-Learn, a framework for training GP-Bayes Filters without ground truth states. Our approach extends Gaussian Process Latent Variable Models to the setting of dynamical robotics systems. We show how weak labels for the ground truth states can be incorporated into the GPBF-Learn framework. The approach is evaluated using a difficult tracking task, namely tracking a slot car based on inertial measurement unit (IMU) observations only. We also show some special features enabled by this framework, including time alignment, and control replay for both the slot car, and a robotic arm.[25]

Alberto Elfes, Samuel S. Bueno, Josué J. G. Ramos, Ely C. de Paiva, Marcel Bergerman, José R. H. Carvalho, Silvio M. Maeta, Luiz G. B. Mirisola, Bruno G. Faria, José R. Azinheira "Modelling, Control and Perception for an Autonomous Robotic Airship" In this paper author proposed Robotic unmanned aerial vehicles have an enormous potential as observation and data-gathering platforms for a wide variety of applications. These applications include environmental and biodiversity research and monitoring, urban planning and traffic control, inspection of man-made structures, mineral and archaeological prospecting, surveillance and law enforcement, communications, and many others. Robotic airships, in particular, are of great interest as observation platforms, due to their potential for extended mission times, low platform vibration characteristics, and hovering capability. In this paper provide an overview of Project

AURORA (Autonomous Unmanned Remote Monitoring Robotic Airship), a research effort that focuses on the development of the technologies required for substantially autonomous robotic airships. Discussion on airship modelling and control, autonomous navigation, and sensor-based flight control. This also present the hardware and software architectures developed for the airship. [26]

Renzo De Nardi, Owen Holland, "UltraSwarm:A Further Step Towards a Flock of Miniature Helicopters".Describe further progress towards the development of a MAV (micro aerial vehicle) designed as an enabling tool to investigate aerial flocking. This research focuses on the use of low cost off the shelf vehicles and sensors to enable fast prototyping and to reduce development costs. Details on the design of the embedded electronics and the modification of the chosen toy helicopter are presented, and the technique used for state estimation is described. The fusion of inertial data through an unscented Kalman filter is used to estimate the helicopter's state, and this forms the main input to the control system. Since no detailed dynamic model of the helicopter in use is available, a method is proposed for automated system identification, and for subsequent controller design based on artificial evolution. Preliminary results obtained with a dynamic simulator of a helicopter are reported, along with some encouraging results for tackling the problem of flocking.[27]

Naoyuki Kubota."Multi-Objective Design of Neuro-Fuzzy Controllers for Robot Behaviour Coordination"[2006] Discusses the behavioural learning of robots from the viewpoint of multi objective design. Various coordination methods for multiple behaviours have been proposed to improve the control performance and to manage conflicting objectives. This proposed various learning methods for neuro-fuzzy controllers based on evolutionary computation and reinforcement learning. This introduces the supervised learning method and evolutionary learning method for multi objective design of robot behaviours. Then, the multi objective design of fuzzy spiking neural networks for robot behaviours is presented. The key point behind these methods is to realize the adaptability and reusability of behaviours through interactions with the environment. [28]

J. Serres, D. Dray, F. Ruffier, N. Franceschini. "A vision-based autopilot for a miniature air vehicle: joint speed control and lateral obstacle avoidance".Proposed on the autonomous guidance of Micro-Air Vehicles (MAVs) in confined indoor and outdoor environments, developed a vision based autopilot, with which a miniature hovercraft travels along a corridor by automatically controlling both its speed and its clearance from the walls. A hovercraft is an air vehicle endowed with natural roll and pitch stabilization characteristics, in which planar flight control systems can be developed conveniently. Hovercraft is fully actuated by two rear and two lateral thrusters. It travels at a constant altitude (~2 mm) and senses the environment by means of two lateral eyes that measure the right and left optic flows (OFs). The visuo-motor control system, which is called LORA III (Lateral Optic flow Regulation Autopilot, Mark III), is a **dual OF regulator** consisting of two intertwined feedback loops, each of which has its own OF set-point and controls the vehicle's translation in one degree of freedom (surge or sway). Computer-simulated experiments show that the hovercraft can navigate along a straight or tapered corridor at a relatively high speed (up to 1 m/s). It also reacts to any major step perturbations in the lateral OF (provided by a moving wall) and to any disturbances caused by a tapered corridor. The minimalistic visual system (comprised of only 4 pixels) suffices for the hovercraft to be able to control both its clearance from the walls and its forward speed jointly, without ever measuring speed and distance. The non-emissive visual sensors and the simple control system developed here are suitable for use on MAVs with a permissible avionic payload of only a few grams. This study also accounts quantitatively for previous ethological findings on honeybees flying freely in a straight or tapered corridor.[29]

Zenon Mathews, Sergi Bermúdez i Badia, Paul F. M. J. Verschure "Action-Planning and Execution from Multimodal Cues: An Integrated Cognitive Model for Artificial Autonomous Systems" Proposed multimodal sensors to perceive the environment and subsequently performing intelligent sensor/motor allocation is of crucial interest for building autonomous systems. Such a capability should allow autonomous entities to (re)allocate their resources for solving their most critical tasks depending on their current state, sensory input and knowledge about the world. Architectures of artificial real-world systems with internal representation of the world and such dynamic motor allocation capabilities are invaluable for systems with limited resources. Based upon recent advances in attention research and psychophysiology we propose a general purpose selective attention mechanism that supports the construction of a world model and subsequent intelligent motor control. This implements and tests this architecture including its selective attention mechanism, to build a probabilistic world model. The constructed world-model is used to select actions by means of a Bayesian inference method. This method is tested in a multi-robot task, both in simulation and in the real world, including a coordination mission involving aerial and ground vehicles[30]

Jonathan Strahl, Timo Honkela, Paul Wagner. "A Gaussian Process Reinforcement Learning Algorithm with Adaptability and Minimal Tuning Requirements". present a novel Bayesian reinforcement learning algorithm that addresses model bias and exploration overhead issues. The algorithm combines different aspects of several state-of-the-art reinforcement learning methods that use Gaussian Processes model-based approaches to increase the use of the online data samples. The algorithm uses a smooth reward function requiring the reward value to be derived from the environment state. It works with continuous states and actions in a coherent way with a minimized need for expert knowledge in parameter tuning. Analysis and discussion on the practical benefits of the selected approach in comparison to more traditional methodological choices, and illustrate the use of the algorithm in a motor control problem involving a two-link simulated arm.[31]

Andrea Cesetti, Adriano Mancini, Emanuele Frontoni, Primo Zingaretti, Sauro Longhi. "From Simulated to Real Scenarios: A Framework for Multi-UAVs". In this paper a framework for simulation of Unmanned Aerial Vehicles (UAVs), oriented to rotary wings aerial vehicles, is presented. It allows UAV simulations for stand-alone agents or multi-agents exchanging data in cooperative scenarios. The framework, based on modularity and stratification in different specialized layers, allows an easy switching from simulated to real environments, thus reducing testing and debugging times. CAD modelling supports the framework mainly with respect to extraction of geometrical parameters and virtualization. Useful applications of the framework include pilot training, testing and validation of UAVs control strategies, especially in an educational context, and simulation of complex missions.[32]

Hichem Maaref, Kadda Meguenni Zemalache, Lotfi Beji. "Self-tunable Fuzzy Inference System: A Comparative Study for a Drone" The work describes an automatically on-line Self-Tunable Fuzzy Inference System (STFIS) of a mini-flying called XSF drone. A Fuzzy controller based on an on-line optimization of a zero order Takagi-Sugeno fuzzy inference system (FIS) by a back propagation-like algorithm is successfully applied. It is used to minimize a cost function that is made up of a quadratic error term and a weight decay term that prevents an excessive growth of parameters. Simulation results and a comparison with a Static Feedback Linearization controller (SFL) are presented and discussed. A path-like flying road, described as straight-lines with rounded corners permits to prove the effectiveness of the proposed control law.[33]

J. R. Martínez-de-Dios, Luis Merino, Aníbal Ollero, Luis M. Ribeiro, Xavier Viegas. "Multi-UAV Experiments: Application to Forest Fires" . This presents the application of a multi-UAV system to forest fires. Particularly the experiments carried out with the COMETS system will be presented. After the introduction and motivation, the UAVs, sensors and basic methods are presented. The third section deals with the general description of the fire detection, localization and monitoring. The next sections are devoted to the multi-UAV surveillance and fire alarm detection, fire observation and monitoring, and cooperative fire monitoring.[34]

Maryam Falahpour, Hassan Moradi, Hazem H. Refai, Mohammed Atiquzzaman, "Performance comparison of classic and fuzzy logic controllers for communication airships".This paper compares two different airship control methods, namely fuzzy logic and classic controllers, to navigate the balloon while hovering over a region in order to re-establish communication. A dynamical model of the airship in the presence of air friction is shown, and simulations are done using MATLAB Simulator.[35]

III. CONCLUSIONS

In this paper different types of Unmanned Aerial Vehicle are compared and different types of control algorithms discussed. Also different techniques for designing of low weight of UAV are studied. We learn the fuzzy logic and fuzzy logic controller for controlling the aerial robot. We learn the hardware and software used in the aerial robot.

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