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Obstacle Recognition and Collision Avoidance using HC-SR04 Sensor for Quadrotor Micro Air Vehicle Application

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ABSTRACT: VTOL Micro Air Vehicle is an upcoming trend in the recent era as they are applied in many areas. These vehicles travel in critical conditions which are restricted area for a human being. Hence continuous monitoring is not possible. The vehicle can move in an indoor environment or an outdoor environment it comes under many obstacles. Hence these obstacles cannot be avoided manually and through video transmission the processing time increases, therefore ultrasonic sensors are used to detect these obstacles and avoid them. The methodology is developed for obstacle recognition and collision avoidance for VTOL MAV using ultrasonic sensors. The algorithm to implement the collision avoidance is framed in a flow chart. The sensors for object recognition and collision avoidance are identified based on the present project requirement. The software and hardware required for implementing the methodology is identified. For initial studies, one of the Ultrasonic sensor is tested for its effectiveness in sensing objects.

I. INTRODUCTION

The science and industrial community is exploring potential uses of flying robots like UAVs and MAVs for military and civil purposes. This led to a growing popularity of unmanned aerial vehicles (UAVs). They are now primarily used for tracking and inspection activities. Nonetheless, recent advances are opening new horizons about miniaturisation and fields of use for low power embedded processors, miniature sensors and control theory. The VTOL system has many advantages compared to other mobile robots in a more complicated and cluttered environment. It uses vertical taking off and landing (VTOL) principle.

Since the early 1990s, MAVs have been in production and have only recently become economically viable. During the 1980s, MAVs were first conceived of when the first full scale UAVs were made, MAV falls under the category of miniature UAVs that has size limit and it is also autonomous. It can be in the size as small as 15 cm. MAV development is driven by commercial, government, research, and military purposes. The MAVs are classified into three types.

Fixed wing: It is a present technology with which most of the aircrafts are flying. Fixed wing drones are used a wing like normal aeroplane shown in fig 1.1. It is provided the lift rather than vertical lift rotors; the need of this wing is used to move forward of MAV. But not hold them up in the air, so this system is more efficient. There are various types under development existing fixed wing designs with vertical lift motors on. Fixed wing occupied large coverage area and fast flight speed of the MAV. Fixed wing MAV doesn't have vertical take-off and landing. It is the main disadvantage of fixed wing MAV.

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Fig 1.1: Fixed wing [15]

Rotary wing: Rotary wing configuration such as quadruple models and helicopters operates on gear and motor configuration shown in fig 1.2. The rotary wings involved more mechanical complexity, which is generally translate into lower speeds and shorter flight ranges. The vertical take-off and take land is the main advantage of rotary wing aircraft. The rotary wings are well suited applications like facility inspections, which require small spaces and ability to maintain visual on single target for extended period.



Fig 1.2: Rotary wing [15]

Flapping wing: It is an aircraft which flies by flapping its wing shown in fig 1.3. The lot of research is going on flapping wings. Flapping wings are more efficient compare to fixed and rotary wing. This flapping aircraft doesn't take support from forward airspeed but the motion of this wing using only flapping.



Fig 1.3: Flapping wing [15]

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The autopilot is a system used by a human operator to control a vehicle's trajectory without continuous 'hands-on' control being required. Autopilots do not substitute a human operator, but help them control the vehicle, allowing them to concentrate on broader operational aspects such as trajectory, weather and systems monitoring. For planes, ships, spacecraft, missiles, and others, autopilots are used. Over time, autopilots have evolved significantly from early autopilots who merely kept an attitude, modern autopilots are capable of performing automatic landings under pilot supervision. An autopilot is designed to carry out some of the pilot's tasks.

An autopilot is a system that does not need continuous monitoring of MAV. It is possible to avoid human interaction with the MAV by putting the MAV in fully autonomous mode. The control board is pre-programmed and interfaced with the computer in the ground station.

There is no autopilot feature for all passenger aircraft flying today. In addition, older and smaller general aviation airplanes are still hand-flown, and even small airliners with less than twenty seats are without an autopilot as they are used with two pilots on short-duration flights. Autopilots are generally required to be mounted in aircraft with more than twenty seats. Two different aircraft are deemed to be the AAUAV (Autonomous Amphibious Unmanned Aerial Vehicle). Multi-copter is one, Hovercraft and one. Both are flexible when it comes to attachment and detachment.

There are three command levels for smaller aircraft in autopilots. Only an aircraft in the roll direction is powered by a single-axis autopilot; these autopilots are also known as wing levellers, reflecting their limitations. A two-axis autopilot controls an aircraft both on the pitch axis and on the roll, and may be little more than a "wing lever" with minimal pitch oscillation-correcting capability; or it may obtain inputs from on-board radio navigation systems to provide real automatic flight guidance once the aircraft has taken off until shortly before landing; or its capabilities may be somewhere between these two ex-flight navigation systems; A three-axis autopilot adds control to the yaw axis and in many small aircraft it is not needed.

Project Planner is the Pixhawk autopilot's full-featured ground station software. Project Planner is an aircraft, copter and rover ground control station. It's only Windows compliant. Pixhawk is the device used in this project for the flight controller. It integrates on the ground station with two advanced processor and mission planner software. The mission planner is used through the telemetry to collect data from the flight controller panel.

Onboard sensors such as IR sensors, laser sensors, and stereo cameras are now being introduced on the MAV. In alternative GPS system, which is suitable for indoor and outdoor environments, these sensors are required. In the indoor environment, MAV is used for survey, supervision and video graphic entertainment purposes in areas such as homes and offices.

II. LITERATURE SURVEY

[1] Jeffery B. Saunders, Brandon Call, Andrew Curtis, Randal W. Beard, Timothy W. McLain “**Static and Dynamic Obstacle Avoidance in Miniature Air Vehicles**”. This paper uses a laser range finder to present a low-power, low-weight detection method. However, a rapidly exploring random tree algorithm is introduced to generate waypoint paths around obstacles known a priori, and a dynamic geometric algorithm is derived to generate paths around observed obstacles. The algorithms were demonstrated on a fixed-wing miniature air vehicle (MAV) in simulation and flight testing.

[2] Kirill E. Shilov, Vladimir V. Afanasyev and Pavel A. Samsonov “**Vision-Based Navigation Solution for Autonomous Indoor Obstacle Avoidance Flight**”. This paper describes scientific and technical methods as well as the results obtained during research and flight tests to enhance MAV autonomy by computer vision sensing. The task of autonomously overcoming the distance in a corridor containing randomly placed obstacles was given an impetus

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for researching and developing the video-based navigation system. The width of the corridor is slightly more than a vehicle size because it is situated indoors in GPS-denied space. As an airframe, medium-sized hexacopter was picked. To follow the desirable direction created by the video processing system, the flight control module guides the MAV. Implementation and mathematical technical details

[3] Stephen Griffiths, Jeff Saunders, Andrew Curtis, Tim McLain, *Senior Member, IEEE*, and Randy Beard “**Obstacle and Terrain Avoidance for Miniature Aerial Vehicles**”. The smaller fixed-wing miniature aerial vehicles (MAVs), ranging in size from 1/4 to 2 m in wingspan, are studied in this journal. As recent conflicts have shown, there are various military uses for MAVs, including identification, monitoring, battle damage assessment, and communications relays. Such applications are of current and urgent importance, and significant resources are directed at their growth. For many of these applications to mature, the performance of MAVs will have to be enhanced, their functionality will have to be further expanded, their user-friendliness will have to be improved and their costs will have to be reduced.

[4] Choon-Young Lee, Ho-Gun Choi, Jun-Sik Park, Keun-Young Park, Sang-Ryong Lee “Collision Avoidance by the Fusion of Different Beam-width Ultrasonic Sensors” Several ultrasonic sensors with a fixed bandwidth were implemented in this paper and were used for robot navigation. For mobile robot communication each ultrasonic sensor consists of different bandwidths. To differentiate environmental conditions, small beam width is applied and wide beam width is applied to use only a few sensors. It is possible to obtain more effective collision avoidance system when two types of beam widths are used. A sensor with enormous beam width provides knowledge of the possible obstacles in robot movement and can maneuver in a complex environment. This paper created an original module and an advanced algorithm to avoid obstacles in the mobile robot. Better precise map,

Several literary works have recently stressed the mechanical design and development of control strategies in miniVTOL for maneuvers such as take-off, hovering and landing. Kroo et al. (2000) presented interesting results in the design and analysis of quadrotor of centimeters scale. The soil-effect experiment using a free-vortex wake model (Griffiths and Leishman, 2002) and the flapping theory introduced in Deng et al. (2003) were other interesting research. Hoffmann et al. (2004) outlined the design of an autonomous miniature flight control system and the creation of a multi-vehicle framework for multi-agent control algorithms testing and validation.

Several approaches in the field of obstacle avoidance in mobile robotics have already been developed. Most of these approaches, however, do not apply to mini-VTOLs due to their typical small available payload, embedded processing power, and problems of auto-location. There is a lack of publications on obstacle avoidance procedures for miniVTOLs for these reasons

From the literature survey it is clear that the implemented algorithms took large processing time, and to implement these algorithms the equipments/ systems required were more which will increase the weight of VTOL MAV. Hence in the current project ultrasonic sensors which are lighter weight are to be used for identifying the obstacle and avoid collision .

III. CONCLUSIONS

In Phase 1 of the project, the problem description is made, and the literature survey is carried in the collision avoidance of unmanned micro aerial vehicles domain. The algorithm to implement the collision avoidance is framed in a flow chart. The sensors for object recognition and collision avoidance are selected based on the present project requirement. All the software and hardware required for carrying out project is identified. For trail studies one of the Ultrasonic sensor is tested for its effectiveness in sensing objects.

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