International Journal of Scientific Research in Multidisciplinary Studies
Vol.6, Issue.1, pp.43-45, January (2020)
Research Paper
E-ISSN: 2454-9312
P-ISSN: 2454-6143

Light Detection and Ranging based Collision Avoidance for Micro Aerial Vehicle

P. Sakthivel[1], B. Anbarasu[2*], G. Anitha[3]

[1,2,3]Dept. of Aerospace Engineering, MIT Campus, Anna University, Chennai, India

Corresponding Author: avianbu@gmail.com, Tel.: +91-97899-40684

Available online at: www.isroset.org

Received: 23/Dec/2019, Accepted: 20/Jan/2020, Online: 31/Jan/2020

Abstract—Obstacle detection and collision avoidance algorithm are proposed to detect and avoid static and dynamic obstacles in the indoor environment. The range of the obstacle from the Micro Aerial Vehicle using Light Detection and Ranging sensor. Based on the principle of Time of Flight obstacle detection algorithm is implemented on Raspberry Pi Zero W, a single board computer. When the computed range between the Micro Aerial Vehicle and the obstacle is less than threshold range value of 1.5 m, pulse width modulated signal can be applied to the pitch channel to pitch the Micro Aerial Vehicle backwards to avoid collision with an obstacle.

Keywords—LIDAR, Time of Flight, Micro Aerial Vehicle, Obstacle detection, Collision Avoidance

I. INTRODUCTION

Air vehicles which are remotely piloted or having an autopilot are generally defined as Unmanned Aerial Vehicles (UAV). They could have different missions according to their civil or military usage such as ground surveillance, payload or cargo carriers, and geological surveying, reconnaissance and armament carrier applications. Unmanned air vehicles may be considered as the future of aviation. Technological advances in aviation electronics, avionics, seem to enable the air vehicles to fly themselves with small help of the human pilot. Nowadays, all over the world, a lot of UAV concepts have emerged and most of them have been made operational successfully. To maintain the flight path, avoid the obstacle in the course of flying by remotely sensing the range of the obstacles before it leads to an accident. These can be applied in the future UAV Air Traffic Control System as the flight path doesn't change frequently in the place of a crowded drone. Unless the emergency condition. System integration of the Micro Aerial Vehicle (MAV) was a little complex because of less weight and size. And also, the selection of microcontroller and sensor must be optimum.

The rest of the paper is organized as follows Section II contains the Related work, Section III contains the proposed Methodology, Section IV contains the Results and Discussion, Section V contains the Conclusion and Future Scope.

II. RELATED WORK

The distance of the obstacle must be detected before the MAV collide with it. There are many remote sensing sensors to measure the range of obstacles, which means that the sensors find the distance of obstacle without disturbing the obstacle. The light travels faster and hence the sensor gives instantaneous values. The Light Detection and Ranging (LIDAR) sensor play more advantages such as long-range determination and resistance to high noise environment than other sensors [1]. The Raspberry Pi Zero W is a single board smaller computer. So that we can be able to integrate different things under the common controller. The Raspberry Pi Zero W has inbuilt Wi-Fi and Python idle. Also, its size and weight were satisfying the requirement of MAV. The Python is an open-source programming language to access the Microcontrollers and also the Flight Simulator. To check the process, the simulation was made by using the XPlane Flight Simulator. In this work, the real-time value was computed, processed and simulated in the digital form. Thus, the simulation reduces the cost of invention, increases the study of MAV behavior. The TCP internet protocol was used to make the connection reliable.

III. METHODOLOGY

It is a Time of Flight (TOF) principle. The source sends the signal periodically, which wave will reflect after contacting the object [2]. The source obtains time of flight by measuring the round-trip phase difference and then calculates relative range between the source and the detection object.

$$d = s \times t. \quad (1)$$

Where, d denotes the distance travelled by the signal (meter), s denotes the speed of the signal (meter/second), t denotes the time taken by the signal (second).

$$s = \lambda \times f. \quad (2)$$

Where, λ denotes the Wavelength of the signal (nanometer), f denotes the Frequency of the signal (Hertz).

$$t = \Delta\phi / 2\pi f. \quad (3)$$

Where, $\Delta\phi$ denotes the Phase shift between the transmitted and received signals (radian).

$$r = d / 2. \quad (4)$$

Where, r denotes the Range of the object from the source (meter).

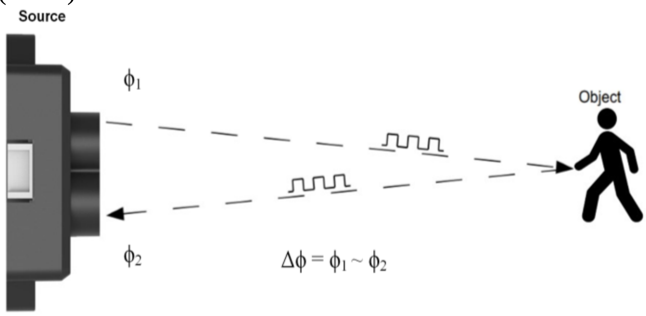

Figure 1. Schematics of TOF Principle

A. Rapsberry Pi Zero W:

The Microcontroller was used to control the input and output signals of the sensors and actuators. The Raspberry Pi Zero W was a remotely accessible microcontroller through VNC software even without the internet connection. The Pi was booted headless and the serial port interfacing option should be enabled to interact with the LIDAR sensor.

B. Benewake TFMini LIDAR:

The sensor converts the physical property to the analog signal. The Light Emitting Diode as a source and the Photodiode as a detector. Inbuilt microcontroller STM32F030C8T6 processing the signal and convert into the digital signal. The sensor interface with the microcontroller via UART communication (Four Channel). The phase shift was calculated by the Lock-in Amplifier, a homodyne detector which operated under the single frequency [3]. The frequency and the wavelength of the signal from the TFMini LIDAR sensor are 100 Hz and 850 nm as given in the datasheet. There will be checksum and limited strength value verification, to maintain the error-free output.

C. XPlane Flight Simulator:

The simulation is the process of conversion of a mathematical model into the computer model. Under the various conditions, we can simulate a system and check the responses of the system. Using the xpc library in Python, the MAV can be simulated to required operations.

D. Python:

It is a high-level programming language flexible to read and write the functional algorithm. Using the socket library in Python, the communication between two or more computers can be made.

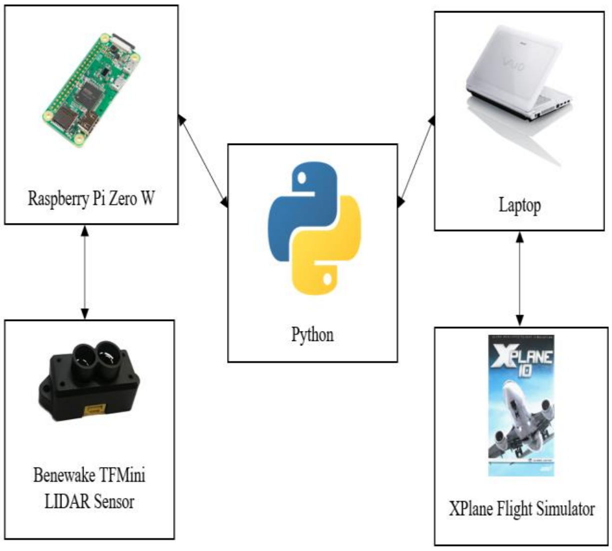

Figure 2. Systematic Connection and Flow Diagram

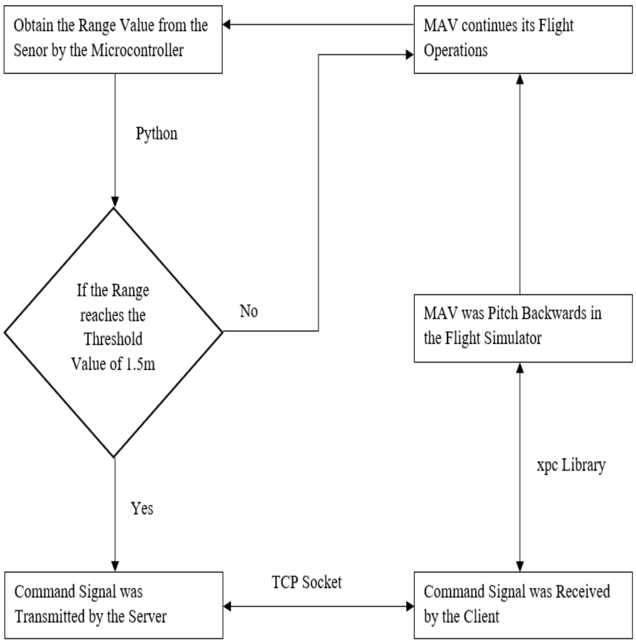

Figure 3. Algorithm for Obstacle Avoidance

IV. RESULTS AND DISCUSSION

When the range value computed by the LIDAR sensor reaches the threshold value (less than or equal to 1.5 m) [4]. The signal was sent from the Raspberry Pi Zero W which acts as a server to the XPlane Flight Simulator which acts as a client through the Python under Transmission Control Protocol (TCP) communication. The signal was checked once again by the client python code and then execute the pitching command to make MAV pitch backwards [5]. When the MAV flying at a speed of 2.8 m/s, the threshold value of 1.5 m is enough to pitch backwards quickly.

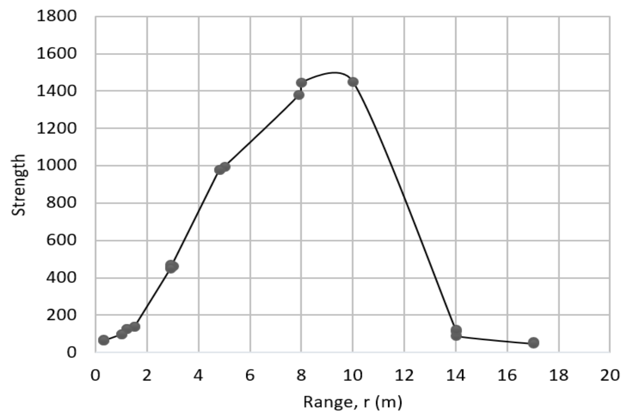

Figure 4. Graph between the Range, r (m) vs Strength

Figure 4. Shows the graphical relationship between the range and strength value which are obtained from the LIDAR sensor. The graph explains that the strength value was less than 200 at the range was either below 2 m or above 12 m. As the distance travelled by the signal increases the strength of the signal got reduced. The addition of Byte 2 and Byte 3 give the range value while the addition of Byte 4 and Byte 5 give the strength value. These are given in the Datasheet of TFMini LIDAR sensor.

V. CONCLUSION AND FUTURE SCOPE

Light Detection and Ranging based obstacle detection and collision avoidance algorithm were proposed for the Micro Aerial Vehicle. The range between the Micro Aerial Vehicle and the obstacle was computed using the Light Detection and Ranging sensor based on the principle of the Time of Flight. Estimated range value can be used to avoid the static and dynamic obstacles in the indoor environment [6]. In future work, Compare the frequency of the signal emitted from the source with the reflected frequency. Using the Doppler Effect, compute the wind speed and real-time implementation of obstacle detection and collision avoidance algorithm onboard the Micro Aerial Vehicle.

ACKNOWLEDGMENT

I would like to extend my regard to our faculty members for their constant support during coursework. Also, the countless researchers and scientific personnel who shared their work in the various forms of publications on the internet deserve huge respect and a note of gratitude, without whom, it would have been much more difficult to grasp the knowledge required for this work. Nevertheless, I express my gratitude to my family and friends for their kind co-operation and encouragement which help us in completion of this project.

REFERENCES

[1] Omid Esrafilian, "Autonomous Flight and Obstacle Avoidance of a Quadrotor by Monocular SLAM," In the Proceedings of the *2016 IEEE International Conference on Robotics and Mechatronics*, pp.**240-245**, **2016.**

[2] A. Sharmila, "Obstacle Detection using Ultrasonic sensor", *International Research Journal of Engineering and Technology*, Vol.**5,** Issue.**4**, pp.**1964-1966**, **2018**.

[3] Arun K. Ghosh, "Introduction to Measurements and Instrumentation", *PHI Learning Private Limited*, India, pp. **200-203**, **2012**.

[4] Paolo Tripicchio, "Confined Spaces Industrial Inspection with Micro Aerial Vehicles and Laser Range Finder Localization", *International Journal of Micro Aerial Vehicle*, Vol.**10,** Issue.**2**, pp.**207-224**, **2018**.

[5] K. Manimala, "Implementation of Collision Detection and Avoidance Algorithm for Point Mass Model UAV", *International Journal of Scientific Research in Mathematical and Statistical Sciences*, Vol.**6**, Issue.**1**, pp.**203-208**, **2019**.

[6] M. Faiz Bin Ramli, "Object Detection Technique for small Unmanned Aerial Vehicle", In the Proceedings of the *2017 IOP Conference series of Materials Science and Engineering on International Conference on Mechatronics*, Kula Lumpur, Malaysia**,** pp.**160-164**, **2017**.

[7] Jeffery Saunders, "Static and Dynamic Obstalce Avoidance in Miniature Air Vehicles", In the Proceedings of the *Aerospace Reasearch Central on the AIAA Meeting Paper*, Arlington, Virginia**,** pp.**26-29**, **2005.**

[8] Matthias Nieuwenhuisen, "Multimodal Obstacle Detection and Collision Avoidance fro Micro Aerial Vehicle", In the Proceedings of the *2013 IEEE International Conference on European Conference on Mobile Robots*, Barcelona, Spain, pp.**9-12**, **2013.**

[9] Simin Zingg, "MAV Navigation through Indoor Corridors using Optical Flow", In the Proceedings of the *2010 IEEE International Conference on Robotics and Automation*, Alaska, USA, pp.**3361-3368**, **2010**.

[10] Jean-Christophe, "Autonomous Flight at Low Altitude using Light Sensors and Little Computational Power", *International Journal of Micro Aerial Vehicle*, Vol.**2,** Issue.**2**, pp.**107-117**, **2010.**

[11] David Droeschel, "OmniDirectional Preception for Light Weight UAVS using a Continuously Rotating 3D Laser Scanner", *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol.**1**, Issue.**2**, pp.**107-112**, **2013**.

AUTHORS PROFILE

Mr P. Sakthivel has obtained his B.E (Aeronautical Engineering) from Anna University and currently pursuing M.E (Avionics) from Anna University. His areas of interest are Avionics and Sensors.
E-mail: sakthi95sagittarius@gmail.com

Dr B. Anbarasu received his B.E (ECE) from Madurai Kamaraj University and M.E (Avionics) from Anna University. Currently, he is working as Teaching Fellow in the Department of Aerospace Engineering at MIT Campus, Anna University, Chennai and pursuing his research in indoor navigation. His research interest includes Avionics, UAV systems and Image processing. E-mail: avianbu@gmail.com

Dr G. Anitha obtained her BE (EEE) from ACCET, Karaikudi and MTech (Control & Instrumentation) from IITM, Chennai and PhD in Avionics from Anna University, Chennai. She is working with the Division of Avionics, Department of Aerospace Engineering, MIT, Anna University, Chennai. Her research interest includes Avionics, Aircraft Navigation, guidance, and control systems and Image processing. E-mail: anitha_g@annauniv.edu

