Research Journal of Engineering Sciences ISSN 2278 – 9472
Vol. **12(2),** 1-7, May **(2023)** *Res. J. Engineering Sci.*

Microdrone with proximity alert using LiDAR

N.K. Sharma[1*] and Hemant Kumar Varshney[2]
[1]Department of Electronics and Communication Engineering, Baba Sahab Dr. B.R. A. College of Agril. Engg. and Technology, Etawah-206001, UP, India
[2]Department of Electronics and Communication Engineering, National Institute of Technology Delhi, Delhi, India
nagandras5@gmail.com

Available online at: www.isca.in, www.isca.me
Received 28th Novmber 2022, revised 21th March 2023, accepted 16th April 2023

Abstract

Microdrone with LiDAR proximity sensor is a remote-controlled device which can detect obstacle in it's way and alert remote controller by beeping the buzzer and blinking the LED. These light weight Microdrones that can take off from anywhere fly indoors or in forest or gardens and sense obstacles. The distance between the drone and the obstacle is inversely proportional to the frequency of beeping of buzzer and blinking of LED. As the drone reaches near to the obstacle. The frequency of beeping the buzzer and blinking the LED increases and vice-versa. This paper consists of a remote controller and a Microdrone with LiDAR sensor in it's front which uses IR light for obstacle detection. The Microdrone is controlled by using a remote which uses F3 EVO flight controller and the data is processed by Arduino Pro Mini.

Keywords: Remote-Controlled, Proximity sensor, LiDAR sensor, Arduino Pro Mini, F3 EVO Flight Controller.

Introduction

Expense of drones is the main problem with them. Drones are still a relatively uncommon item because they are often expensive to purchase and pose a significant danger of damage while in flight. Moreover, huge drones are noisy and require a vast open place to fly[1, 2]. Drones can't fly inside, in impenetrable forest, in locations with plenty of trees. Hence, in this project, we develop a microdrone with the capacity to identify obstacles using LiDAR[3,4]. This type of drone aids in your understanding of both drone flight and the use of drones for obstacle sensing. Flying in dense woodland or challenging terrain is also less perilous due to its small size and reduced cost. Microdrones are utilized in a variety of applications, including surveying, precision agriculture, land development, infrastructure inspection, environmental monitoring and public safety[5,6].

LiDAR-equipped drones are being used to fly over specific regions, and the resulting maps are being created to highlight, survey and keep an eye on potential locations for towers and wind turbines. LiDAR is being used to provide much more accurate measurements in flood-prone areas, which can help risk assessment outcomes and enhance the ability to create more effective emergency planning processes[7,8]. Vegetation density technology is being used to improve drainage systems that use water more effectively in the region of the world affected by drought.

LiDAR even has the ability to detail when and how dense vegetation would develop on the ground, a capability that was previously unheard of and would require countless man-hours to integrate into planning[9,10]. The degree of accuracy that LiDAR can offer, though, is what really makes it popular[11,12].

Materials and methods

This project contains hardware and software and these are given below: Arduino ProMini (Microcontroller AT mega 328), F3EVO Controller (SPRACINGF3EVO), LiDAR Module (TFMini-SMicro), Buzzer (Electromagnetic), LED (Planar), Drone Motors (Coreless Brush Metal Motor), ESC (Electronic Speed Controller), Propellers (55mm Blade propeller), Battery (LiPo Rechargeable battery), Buttons & Switches (Pushbuttons, tall pushbuttons, SPDT slide switch), Electrical & Wirings (Servo wire–Red, Black,White), xii. Drone Body (Q100 Brushed Quad-copter frame), Connectors (Male and Female JST connectors Lock Type), Screws and Fittings (Pan Headma chines crews), Joystick (Thumb joystick), Oscillator (16MHz Quartz Crystal oscillator), Capacitor (Electrolytic capacitor)

Working Principle of Microdrone with Proximity Alertusing LiDAR: The need of components to make a micro-Droneis an F3 EVO controller, a buzzer four drone motors and propellers, an Arduino Pro Miniand a LiDAR sensor as shown in figure-1. Infrared is used by the LiDAR sensor to identify any obstructions in front of it. When an obstacle is spotted, in order to alert the user of the presence of an obstacle, the controller decodes the LiDAR signal and turns on a buzzer and light. In order to manoeuvre the drone safely and avoid collisions, the operator is continually notified of surrounding objects by changing the frequency of the buzzer and led according to proximity.

The four motors that are used in micro drone for both takeoff and flight control. To achieve the intended flying movement, the RF receiver is interpreted by the flight controller and employed by it. The Micro drone uses an Arduino Pro to detect nearby objects using LiDAR and to control the LED and buzzer as necessary. We have a small and light weighted micro drone that can fly indoors, through forests, or through gardens. LiDAR proximity sensing is used to detect obstructions.

The battery, LiDAR module, F3 EV0 flight controller, ESC, and drone motors are all linked to the Arduino board. First, we turn on the remote control and attach the battery to the Arduino. Now that we've pushed the left throttle upward, the remote's antenna transmits a signal to the drone's antenna, which the Arduino decodes and then passes onto the F3 EV0 flight controller, which in turn provides data to the ESC, which regulates the motor and propeller speeds. The drone is currently in the air, and we can use the remote to modify its orientation.

The complete working of Microdrone is given below: i. We will first turn on our drone by connecting it to a power source, then turn on the remote and position the drone so that it is steady before dragging the left joystick upward. ii. Following the first step, move the left joystick once again in the bottom-center direction. iii. Drag both joysticks (left and right) simultaneously in the bottom-center direction after sliding the left joystick in that direction. The propellers' motion will start up as a result. iv. As the drone is based on LiDAR technology and created for the detection of obstacles, whenever any obstacle came close to the drone it will start beeping loudly by indicating with a red LED bulb, so that we can avoid that obstacle. v. After moving the propellers, drag the left joystick upward to lift the drone and drag the right joystick downward for stability in the air.

Components descriptions: Arduino Pro Mini (Microcontroller ATmega328): The core of the Arduino Pro Mini board is the ATmega328 microprocessor. Six analogue inputs, an on-board resonator, fourteen digital input/output pins—six among which can be used as Pulse Width Modulation Output pin built-in reset button, mounting slots for pin connectors is shown in figure-2 and that's about it. Connect a six-pin header to a Spark fun breakout board or an FTDI cable to send USB data and power to the circuit. The Arduino Pro Mini is designed for short-term installation inside displays or other objects. The board's absence of pre-mounted connectors makes it possible to employ a variety of connector types or wire direct soldering. The pin configuration is usable with the Arduino Mini. There are mainly two different versions of the Pro Mini one for 3.3 V and 8 MHz, and 5V and 16 MHz available[3].

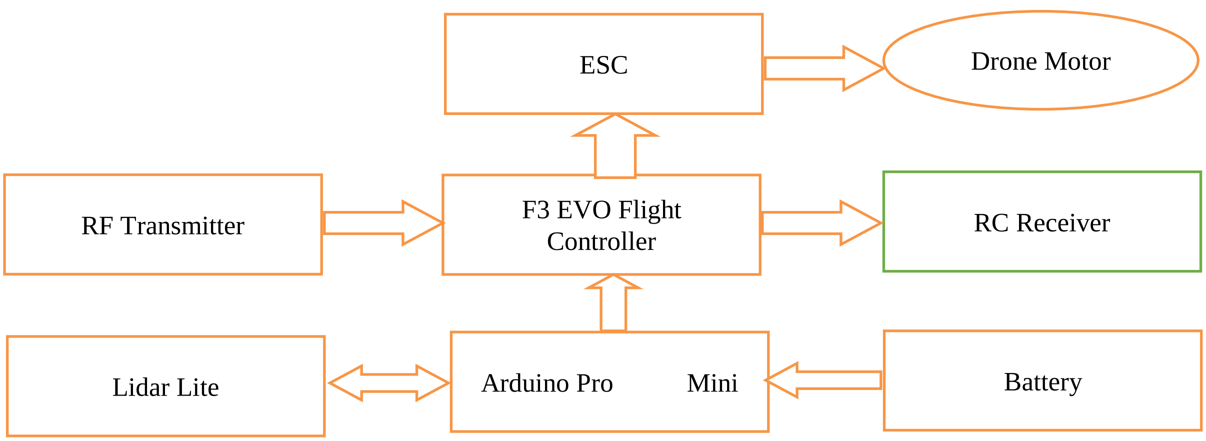

Figure-1: Block Diagram of Microdrone with Proximity alert using LiDAR.

Figure-2: Arduino Pro Mini Board.

F3 EVO Controller (SP Racing F3 EVO): The F3 Racing EVO flight controller includes features that make it the board of choice for your upcoming multirotor (drone) racing build as shown in Figure-3. It has been created to provide amazing flight performance in a stackable, race-ready compact. In conclusion, the F3 EVO employs cutting-edge CPU, sensor, and software technology to make your multirotor (drone) fly like it's on rails. The gyroscope and accelerometer sensors are coupled to the rapid SPI bus, allowing the software to get more information even faster to aid in further stabilizing your craft.

Figure-3: F3 EVO Flight Controller

LiDAR Module (TFMini-S Micro): The Time of Flight (TOF) LiDAR sensor as shown in Figure-4 used in the TFMini-S Micro LiDAR Module can measure an object's distance from as close as 10 centimeters and as far away as 12 meters. The reflectivity of your target item and lighting circumstances will affect your effective detection distance, as they do with all LiDAR sensors, but what sets this sensor apart is its size. The TFMini-S, which is only 42x15x16mm in size, enables you to incorporate LiDAR into applications that have historically been reserved for smaller sensors. Being a single-point micro ranging module, the TFMini LiDAR distance sensor can be integrated into a wide range of robots, UAVs, drones, and other commercial and industrial pieces of equipment. The 4.5V to 6V voltage supply and 4° FOV of this LiDAR distance sensor are both available. Based on the TFmini update, the TFMini-S is a single-point ranging LiDAR. The blind zone is reduced to 10 cm, and outdoor performance and accuracy of various reflectivities are increased. This allows for steady, accurate, sensitive, and high frequency range detection[5].

Figure-4: LiDAR Module.

Buzzer (Electromagnetic): A buzzer, which produces sound, may convert audio signals into sound signals as shown in figure 5. It is powered by standard DC volts. Several electrical devices use it as a sound device, such as printers, laptops, and alarm clocks. The two buzzer kinds, identified in the circuit by the letters "H" or "HA," are piezoelectric buzzers and electromagnetic buzzers. Depending on how it is built and what it is intended to do, a buzzer can make a range of sounds, such as electric bells, alarms, sirens and music.

Figure-5: Buzzer.

An electromagnetic buzzer consists of a housing, magnet, solenoid coil, oscillator, and vibration diaphragm, among other parts. When the power supply is activated by the oscillator's current conveying the audio signal, the solenoid coil generates a strong magnetic field. The solenoid coil and magnet induce the vibration diaphragm to vibrate and produce sound on a regular basis. Between 2 and 4 kHz is where the standard electromagnetic buzzer functions[6].

LED (Planar): An LED is a light emitting diode which is used to produce light as shown in figure- 6 when current passes through it. There are two type of terminal edge. One is bigger that indicate positive terminal and another indicate negative terminal. Positive terminal indicates anode and negative terminal indicate cathode. The advantages of LED are as follows. It has faster switching time, smaller size and longer lifespan[7].

Figure-6: LED.

Drone Motor (Coreless Brush Metal Motor): Micro Coreless Motor are micro motors used in Drones and Quadcopters, these 720 coreless motors are coreless, meaning they do not have metal core in the rotor. These motors can achieve higher RPM with less load. This property makes them suitable for use in flying objects such as Drones, Quadcopters, Helicoptersetc. they are very small in size and have an RPM range of 6000 (with load) to 48000(no load). These 720 coreless motors operate on a voltage of 3-5 volts as shown in figure -7 and peak current consumption of 2A. These motors are suitable for micro drones, quadcopters[8].

Figure-7: Drone Motor.

ESC (Electronic speed controller): There is an electronic circuit which is known as electronic speed controller, which is used to control and regulates the speed of an electric motor. It might also offer dynamic braking and motor reversing. In electrically driven radio-controlled models, tiny electronic speed controls are very helpful. An electric motor's power can be throttled from 0% to 100% with the use of an ESC Controller as shown in Figure-8. Electronic speed controllers come in brush and brushless varieties. 30A STANDARD ESC Motors that require up to 30A of current can be driven by an electronic speed controller. LiPo batteries in the 2S to 3S range are used to power it. The flight controller and other onboard modules are powered by regulated 5V (maximum demand of 2A) from the onboard BEC[9].

Figure-8: Electronic Speed Controller.

Joystick (Thumb Joystick): An input device characterized as a joystick, sometimes referred as a control stick. Video game controllers, or joysticks, often have one or many pushbuttons whose positions can be read by a computer as shown in Figure -9. The analogue stick is a common alternative to the joystick used on contemporary video game systems. Thumb joysticks are joysticks that match the "analogue" remote controller on PS2 (PlayStation 2) controls so much. Just two potentiometers—one for each rotation utilized upper limbs[10].

Figure-9: Thumb Joystick.

Button and switches: A switch is an element that regulates whether an electric circuit is open or closed. They enable a circuit's current flow to be managed (without having to actually get in there and manually cut or splice the wires). In any circuit that calls for user input or control, switches are essential elements. A switch can only be in one of two states: open or closed. A switch appears to be an open gap in the circuit while it is in the off state. This effectively creates the appearance of an open circuit and stops current flow.

SPDT Slide switch: Three terminals make up an SPDT: one common pin, two pins that can be connected to the common, and a third pin. When two circuits are attempting to travel in the same direction, SPDTs are excellent for switching between two power sources, switching inputs, and other related tasks. The SPDT variant makes up the majority of basic slide switches. Typically, SPDT switches should have three connections is shown in Figure-10.

Figure-10: SPDT Slide Switch.

Push button: A basic switch mechanism used to control a machine or process is called a push-button, sometimes known as a pushbutton or just a button. Plastic or metal are the most typical materials utilized to create buttons. It is often flat or curved to accommodate a human finger or hand, making it simple to press against or push against. Buttons frequently act as biased switches is shown in Figure-11.

Figure-11: Push Button.

Connectors (Male and Female JST connectors Lock Type): Devices that link electronic circuits are called electronic connectors. These tools are used to assemble, install, and power electrical gadgets. The housing and the terminals are the two primary parts of an electrical connector. A male (plug) and a female (jack) component make up electronic connectors is shown in Figure-12.

Figure-12: Male and Female JST Connector Lock Type.

Results and discussion

Our Microdrone is based on the LiDAR (Light Detection and Ranging) Technology which is used to detect the obstacle in its way by giving proximity alert. This Microdrone alerts the controller by beeping the buzzer and blinking the LED with increasing frequency as the proximity between the drone and the obstacle increases. This increased beeping and blinking helps the controller to change the direction of the drone so that the collision can be avoided.

First we will switch 'ON' our drone by connecting it through battery, then we wills witch 'ON' there mote and put our drone in a stable manner, after this we will first drag the left joystick in upward direction as shown in Figure-14.

Now a gain drag the left joystick in bottom direction as shown in Figure-15.

After dragging the left joystick towards bottom direction, drag both the joystick (left as well a sright) towards bottom centre direction simultaneously as shown in Figure-16.

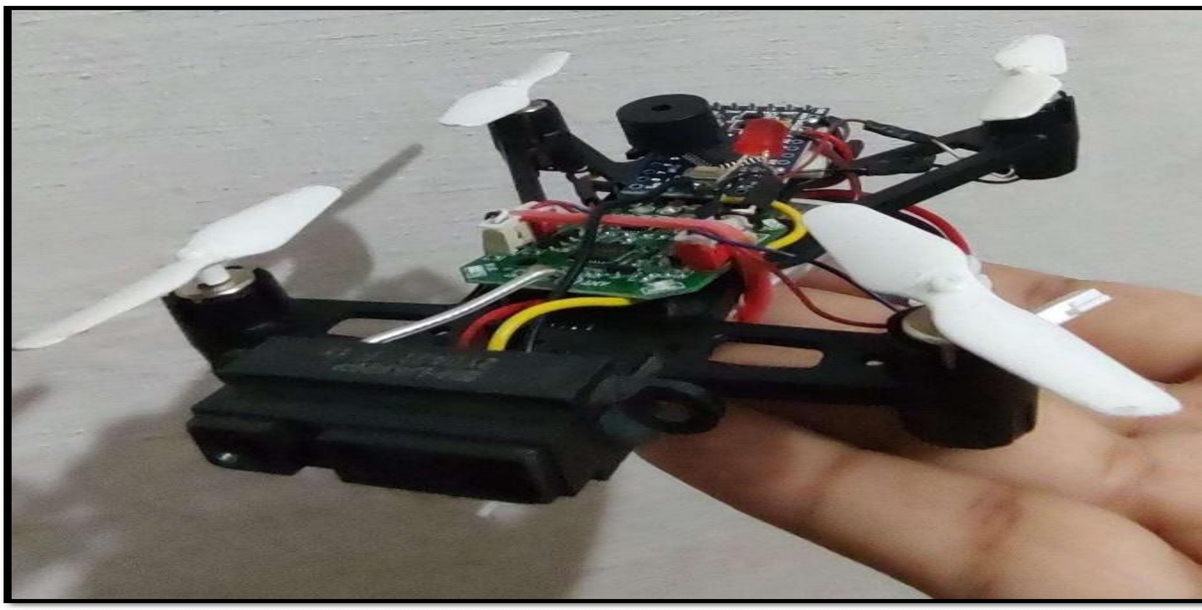

Figure-13: Complete Diagram of Microdrone with Proximity Alert using LiDAR.

Figure-14: When wedrag left throtelin Upward Direction.

Figure-15: When wedrag left joystick in Bottom Direction.

Figure-16: When wedrag both the joy stick in Bottom Centre Direction.

Figure-17: Movement of Propeller.

This will turn on the movement of propellers after the movement of propellers as shown in Figure-17, drag left joystick in upward direction to lift the drone and drag right joystick in downward direction for stability in the air, so that dronecanfly.

As the drone is based on LiDAR technology and created for the detection of obstacles, so whenever any obstacle came near to drone it will start beeping loudly by indicating with a red LED bulb, so that we can avoid that obstacle.

Conclusion

The project "Microdrone with Proximity alert using LiDAR" has been successfully designed and tested. All the hardware components used are working properly and we finally conclude that our Microdrone with Proximity Alert using LiDAR can detect obstacle and will alert the controller about the collision by beeping the buzzer and blinking the LED continuously so that the collision can be avoided by changing the direction the drone. The frequency of buzzer and LED increases as the distance between the object and the Microdrone decreases.

Future Aspects: To conduct forest surveys and investigate the UAV's potential for use in the forest industry more thoroughly. to evaluate the UAV as a tool for making judgements about thinning and pruning schedules, for keeping track of defoliation and health, and for enhancing the accuracy of allometric forest growth models. To fully analyze the impact of the decreased flying heights and increased point densities in compared to full-scale LiDAR on the derivation of metrics necessary to make these assessments, more research is needed.

The current technology has been demonstrated to be capable of flying numerous transects across a single forest plot in a single flight, even though future enhancements of this system will extend flight endurance.

References

1. Aguilar, W., Casaliglla, V., & Pólit, J. (2017). Obstacle Avoidance Based-Visual Navigation for Micro Aerial Vehicles. *Electronics*, *6*(1), 10. https://doi.org/10.3390/electronics6010010.
2. Bürkle, A., Segor, F., and Kollmann, M. (2011). Towards autonomous micro-UAV swarms. *J. Intell. Rob. Syst*. 61(1), 339–353. doi: 10.1007/s10846-010-9492-x.
3. Duan, H., & Li, P. (2014). Bio-inspired computation in unmanned aerial vehicles (p. 124). *Berlin, Germany: Springer Berlin Heidelberg*. DOI 10.1007/978-3-642-41196-0.
4. Floreano, D., & Wood, R. J. (2015). Science, technology and the future of small autonomous drones. *Nature*, *521*(7553), 460–466. https://doi.org/10.1038/nature14542.
5. Hambling, D. (2015). Swarm Troopers: How small drones will conquer the World. Publishing services provided by Archangel Ink.
6. Iida, F. (2003). Biologically inspired visual odometer for navigation of a flying robot. *Robotics and autonomous systems*, 44(3-4), 201-208.
7. Meier, L., Tanskanen, P., Heng, L., Lee, G. H., Fraundorfer, F., &Pollefeys, M. (2012). PIXHAWK: A micro aerial vehicle design for autonomous flight using onboard computer vision. *Autonomous Robots*, 33, 21-39 https://doi.org/10.1007/s10514-012-9281-4.
8. Quaritsch, M., Stojanovski, E., Bettstetter, C., Friedrich, G., Hellwagner, H., Rinner, B., & Shah, M. (2008). Collaborative microdrones: Applications and research challenges. In *Proceedings of the 2nd International Conference on Autonomic Computing and Communication Systems* (pp. 1-7).
9. Ruffier, F., Viollet, S., Amic, S., & Franceschini, N. (2003). Bio-inspired optical flow circuits for the visual guidance of micro air vehicles. In *Proceedings of the 2003 International Symposium on Circuits and Systems, 2003. ISCAS'03.* Vol. 3, pp. III-III). IEEE doi: 10.1109/ISCAS.2003.1205152.
10. Sheikh, Y. A., & Shah, M. (2007). Trajectory association across multiple airborne cameras. *IEEE transactions on pattern analysis and machine intelligence*, 30(2), pp.361-367 doi: 10.1109/TPAMI.2007.70750.
11. Vincent, P., & Rubin, I. (2004). A framework and analysis for cooperative search using UAV swarms. In *Proceedings of the 2004 ACM symposium on Applied computing* pp. 79-86 https://doi.org/ 10.1145/967900. 967919.
12. Wu, X., Ehehalt, R., Razinskas, G., Feichtner, T., Qin, J., & Hecht, B. (2022). Light-driven microdrones. *Nature Nanotechnology*, 17(5), pp.477-484 https://doi.org/10.1038/s41565-022-01099-z.