Obstacle Avoidance For Autonomous Drone Using Ultrasonic Sensor And ARM Cortex

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I. AIM

To control the speed of BLDC motor based on distance of obstacle from the robot measured using ultrasonic sensor.

II. COMPONENTS REQUIRED

1.Ultrasonic sensor 2.BLDC motor 3.Electronic Speed Controller (ESC) 4.STM32 Nucleo Board 5.ConnectingWires

III. WORKING OF COMPONENTS

A. Ultrasonic sensor Working

Ultrasonic sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. There are mainly two essential elements which are the transmitter and receiver. Using the piezoelectric crystals, the transmitter generates sound, and from there it travels to the target and gets back to the receiver component. To know the distance between the target and the sensor, the sensor calculates the amount of time required for sound emission to travel from transmitter to receiver. The calculation is done as follows:

Fig. 1. Ultrasonic Sensor

$$\text{distance} = \frac{\text{speed of sound} \times \text{time}}{2} \tag{1}$$

Where 'T' corresponds to time measured in seconds. 'C' is sound speed = 343 m/sec. Ultrasonic sensor produces high-frequency sound waves and analyse the echo which is received from the sensor. The sensors measure the time interval between transmitted and received echoes so that the distance to the target is known.

B. BLDC sensor Working

A BLDC (Brushless DC) motor is a type of synchronous electric motor that operates based on the principles of electromagnetism. Unlike traditional DC motors, BLDC motors use electronic commutation instead of mechanical commutation. This makes them more reliable, efficient, and have a longer lifespan. The basic working of a BLDC motor involves the interaction between the stator and rotor components. The stator is the stationary part of the motor that contains the electromagnets, while the rotor is the rotating part that contains the permanent magnets. When an electrical current is applied to the stator windings, a magnetic field is created that interacts with the magnetic field of the permanent magnets in the rotor. This interaction causes the rotor to rotate, which generates mechanical power. The speed of the rotor is controlled by adjusting the frequency and magnitude of the electrical current supplied to the stator. To maintain the proper alignment between the magnetic fields of the stator and rotor, BLDC motors use sensors such as Hall Effect sensors to detect the position of the rotor. This information is used to trigger the electronic commutation of the stator windings to ensure that the magnetic fields are always aligned correctly.

Fig. 2. Brushless DC Motor

C. Electronic Speed Control

Electronic speed control (ESC) is a device used to control the speed of an electric motor, typically a brushless DC motor (BLDC), in response to user inputs. ESCs are widely used in applications such as drones, RC cars, and electric bicycles.The basic working principle of an ESC involves three main components: the input signal processor, the motor driver, and the power management circuitry. 1.Input Signal Processor: The input signal processor is responsible for receiving and interpreting the user input, which can be in the form of a pulse width modulation (PWM) signal from a remote control or a command signal from a microcontroller. 2.Motor Driver: The motor driver is the heart of the ESC, which generates the required electric signals to drive the motor. It takes the processed input signal from the input signal processor and converts it into a set of electric pulses that are sent to the motor. The motor driver must control the current, voltage, and timing of the electric pulses to ensure that the motor runs smoothly and efficiently. 3.Power Management Circuitry: The power management circuitry is responsible for controlling the flow of power from the battery to the motor. It includes a voltage regulator, which regulates the input voltage from the battery, and a battery protection circuit, which protects the battery from overcharging or over-discharging. When the user inputs a command to increase or decrease the speed of the motor, the input signal processor processes the signal and sends it to the motor driver. The motor driver adjusts the current, voltage, and timing of the electric pulses sent to the motor to increase or decrease the motor speed.

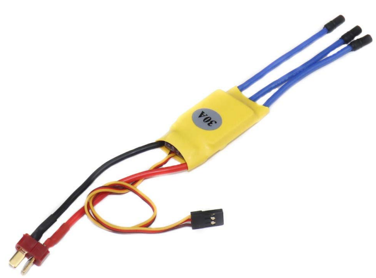

Fig. 3. Electronic Speed Controller

D. STM32 Board

The STM32F412Zx is a microcontroller from STMicroelectronics, based on the Arm Cortex-M4 core, that is designed for use in a wide range of applications such as industrial control, medical devices, and consumer electronics. Some of the features are given below: **Core:** The STM32F412Zx is built around the Arm Cortex-M4 core, which provides high-performance processing capabilities and a range of advanced features, such as a floating-point unit, digital signal processing instructions, and support for single-cycle multiply and accumulate operations.

Memory: The STM32F412Zx has 1MB of flash memory for program storage and 256KB of RAM for data storage. It also includes a variety of memory management features, such as a memory protection unit, cache, and instruction and data prefetch.

Peripherals: The STM32F412Zx includes a wide range of peripherals, including USB, Ethernet, CAN, I2C, SPI, USART, and a range of timers and analog-to-digital converters. It also includes an LCD controller and support for external memory interfaces.

Power: The STM32F412Zx includes a range of power management features, including multiple power-saving modes, low-power peripherals, and support for dynamic voltage scaling.

Overall, the STM32F412Zx is a powerful and versatile microcontroller that is well-suited to a wide range of applications. Its advanced features and extensive peripheral set make it an excellent choice for applications requiring high-performance processing and connectivity, while its power management and security features make it suitable for use in battery-powered and security-critical applications.

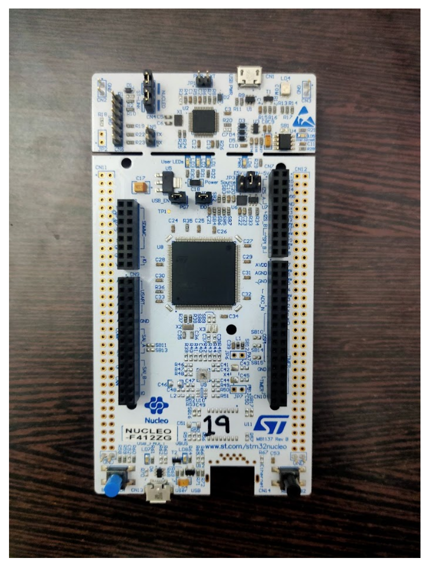

Fig. 4. STM32 Micro Controller

IV. Procedure

Here are the steps to implement this system:

1.Connect the ultrasonic sensor to the micro controller. The ultrasonic sensor typically has Four pins: VCC, GND, TRIG and ECHO. Connect the VCC and GND pins to the corresponding pins on the micro controller, and the TRIG pin to a GPIOE pin(PB7) and ECHO pin to GPIOC pin(PC6) on the micro controller .

2.Next,Connect the BLDC motor to the micro controller through Electronic speed controller(ESC).ESC has 3 pins GND,VCC,PWM pins.PWM pin is connected to connected to GPIOB PB5 pin.Connect the system as shown in circuit diagram below.

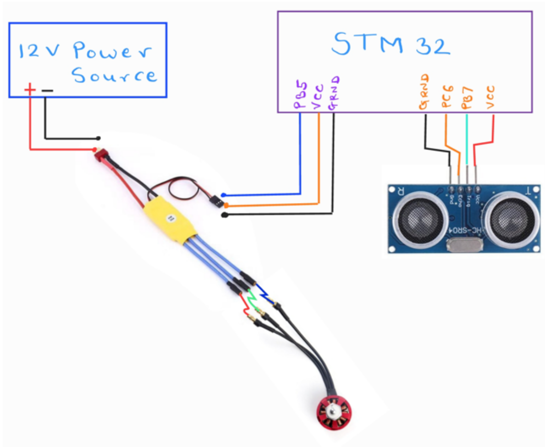

Fig. 5. Circuit Diagram

3.we have written a program that reads the distance measurements from the ultrasonic sensor and controls the speed of the BLDC motor based on the distance measurements. **4.**In the program, we have defined ultrasonic function to read the distance measurements from the ultrasonic sensor that measures the duration of a pulse on a digital input pin, which can be used to calculate the distance.

$$\text{distance} = \frac{\text{speed of sound} \times \text{time}}{2} \tag{2}$$

where duration is the duration of the pulse in microseconds. **5.**we have mapped the distance from ultrasonic sensor to bldc motor speed.As the distance between object and the drone decreases the speed of motor increases and if distance between object and the drone increases the motor works in its normal phase.The physical setup diagram us shown below.

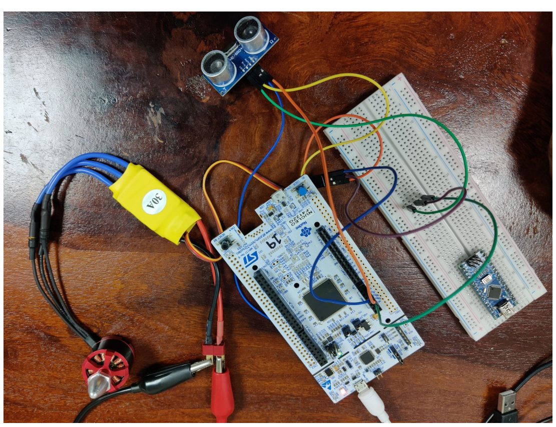

Fig. 6. Physically Connected Diagram

V. CONCLUSION

In conclusion, interfacing an ultrasonic sensor with a BLDC motor controller based on distance was done. By choosing a suitable ultrasonic sensor, connecting it to the micro controller, determining how to use the distance data to control the motor speed, ensuring that the motor controller can receive commands, and programming the micro controller to read the distance data and send commands, it is possible to achieve accurate and reliable control of the motor based on distance.

VI. FUTURE WORK

Future goals include to fuse zigbiee or WiFi module with STM32 and collect battery voltage,speed data from drone and transfer it to the Ground station for Real time analysis of the system.

VII. REFERENCES

1.https://www.watelectronics.com/ultrasonic-sensor/
2.https://www.tytorobotics.com/blogs/articles/how-brushless-motors-work