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Implementation of Obstruction Avoiding Robot using Ultrasonic Sensor and Arduino UNO

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Abstract— This project attempts to create an obstruction avoiding robot which can automatically sense the presence of an obstruction in its path and avoid them. It intelligently detects barrier present in its path through the ultrasonic sensors, with the help of the internal code from the Arduino UNO, decisions are made to avoid the barriers. This has been achieved by using an ultrasonic sensor and the development board Arduino UNO. The ultrasonic sensor is mounted on a servo motor at the front of the vehicle for a wider field of view. The ultrasonic sensor acquires data which is processed by the Arduino which then decides the direction of travel for the robot. The robot requires low voltage and minimal maintenance for continued operation. Arduino being an open-source software has gained popularity for the creation of basic prototypes due to its relative simplicity in both design and coding. It also boasts of a large online community of learners and engineers.

Keywords: Arduino UNO, Obstruction avoider, Obstacle detector, Ultrasonic sensor

I. INTRODUCTION

THe Project aims to build a robot which can detect obstructions and avoid collisions with the help of ultrasonic sensors and the Arduino UNO. Arduino being an open-source software has gained popularity for the creation of basic prototypes due to its relative simplicity in both design and coding. It also boasts of a large online community of learners and engineers.

The robot is also highly cost-effective and relatively easy to assemble since it uses basic components like ultrasonic sensors and Arduino UNO.

The advantages of autonomous obstruction avoiders are due to their small size and manoeuvrability. They possess many applications like for surveillance in public areas, used in many search and rescue operations during the time of freak accidents and natural disasters.

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They can also be used to reduce the number of accidents in land vehicles like trains and cars. Gesture controlled motion and mapping of unknown landscapes are the upcoming areas of research in this field. The robot can also be equipped with cameras which results in a wide array of applications like target tracking and also improved surveillance.

The technology can also be used in various warehouses and libraries. In fact, it has been in use at the Oodi Helsinki central library since 2018.

It has also been extensively used in some of the largest sorting facilities of global conglomerates. They save time and improve accuracy compared to their human counterparts.

This technology has also been used in consumer electronics like the Roomba which are a series of autonomous vacuum cleaners.

II. LITERATURE REVIEW

The following papers were studied to understand the current scope of barrier detection:

J. Jesus Garcia and others [1] have suggested a method that utilizes a sensor array to detect obstructions. The IR sensor plays a predominant role in identifying objects, “The IR (Infrared) sensors provide the distance from a particular reference point when the obstacles come in between the sensor and reference point, this distance reduces and thus indicates the presence of an obstacle”.

Miguel A. Olivares-Mendez and Luis Mejias [2] proposed a method of obstacle detection using optimized fuzzy visual surveying system. It presents an optimized visual fuzzy surveying system for obstacle avoidance task using an unmanned aerial vehicle. “Once the optimal controller has obtained a set of real tests were made with a quadcopter to evaluate the behaviour of the controller with excellent results. The visual information of the front camera of the quadrotor was used to complete this task. This image is processed off-board and the information is sent to the Fuzzy Logic controller which sends commands to modify the orientation of the aircraft.”

Another approach using Kalman filters was proposed by Rahul Sharma et al [3]. “The Kalman filter is a set of mathematical equations that provides an efficient computational technique to estimate the states of a process by minimizing the mean of the squared error”. It produces a less noisy output compared to sensors and produces much more accurate output. Surachai Panich and Nitin Afzulpurkar [4] proposed an approach of navigation based on various factors that include sensing, mapping, localization, planning and control.

Krishna R Dixit [5] have proposed an approach that utilizes onboard cameras and reflective markers for barrier detection. Hai-Tian-Xie [6] use boundary information for a much-improved method of obstacle avoidance. The method uses the information about the environment of the robot differently from the Potential Field Method (PFM) algorithm, so it avoids the loss of local details in PFM method.

Lumelsky [7] have proposed a simple algorithm which is easily implementable. The Efficiency is low as expected from a primitive algorithm. “The basic idea is to find the obstacle and walk around the obstacle contour.”

Amin [8] have also proposed that “use Ultrasonic (US) sensors and CV systems on a smartphone to detect and alarm the user of any obstacle in the path..”. This uses the smartphone which has become a necessity in today’s world and helps visually impaired individuals sense obstacles thus replacing the cane.

Jin [9] have proposed a method of obstacle avoidance that utilizes a rotating ultrasonic sensor to measure distance. This helps the device find the distance to the obstacle in all directions dynamically. “An omnidirectional intelligent obstacle avoidance system was designed to control the ultrasonic sensor rotating for measuring distance”. “ PWM drive servo actuators were used in this system to control the rotation measurement of the ultrasonic sensor.” The data is then filtered with which the optimal path of the robot is determined. “ The experimental results show that the designed system can effectively improve the speed, sensitivity and obstacle avoidance success rate of autonomous obstacle avoidance.”

Xinchi [10] have proposed a method of obstacle avoidance in the marine environment which can achieve both static and dynamic obstacle avoidance. It utilizes the ant colony algorithm for achieving static avoidance whereas the COLREGS model is used for dynamic avoidance.

III CONSTRUCTION

A. HC-SR04 Ultrasonic Sensor:

The ultrasonic sensor is used to determine the distance of the obstruction using SONAR. Ultrasonic waves are transmitted by the ultrasonic sensor which, when hits an obstruction bounces back. These reflected waves are detected by the sensor and it returns the time taken by the wave to go back and forth. The distance between the sensor and the obstruction can be calculated by multiplying the time by the speed of sound ($343ms^{-1}$) divided by 2.

The HC-SR04 module consists of four pins namely Ground, Vcc, Trigger and Echo. These pins are connected to ground, 5 volts, digital I/O pins on the Arduino respectively. The Trig is set on High state for a few microseconds, which will set out a sonic burst travelling at the speed of sound. The time in milliseconds is received as the output in the Echo pin.

Figure [1] Ultrasonic Sensor

B. L298D Motor Drive Module:

L298D Motor Drive IC is used to control DC Motor to drive in any given direction. It consists of 16 pins and a single IC can control two DC Motors. Its working is based on H-bridge, which is a circuit designed to allow voltages in any direction. A single L293D consists of H-Bridge circuit which can rotate two DC Motors independently.

There are four input pins which are responsible for regulating the rotation of the connected motor. The input pin is provided with either Logic 0 or Logic 1 to change the direction.

Pin Diagram

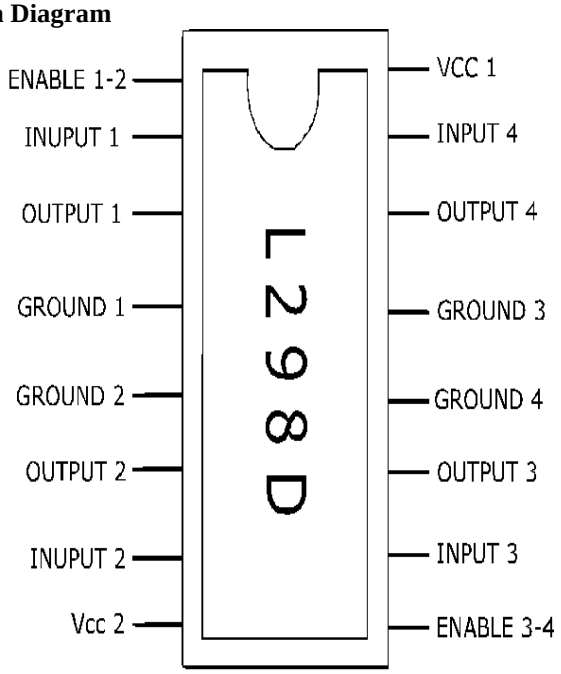


Figure [2] Pin Diagram of L298D Motor Driver

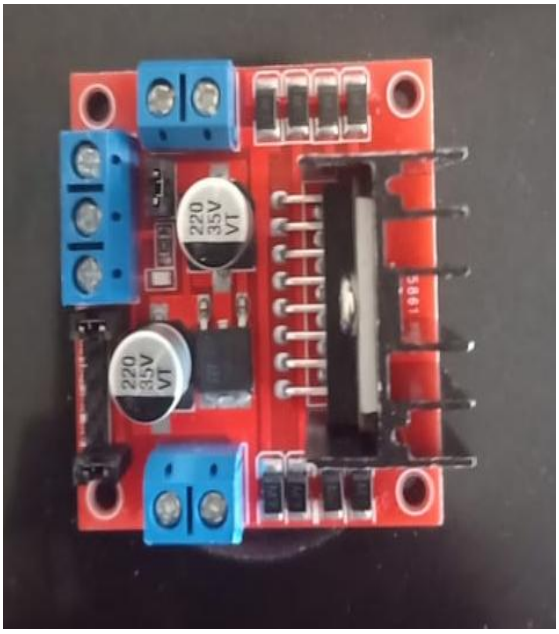


Figure [3] L298D Motor Drive Module

C. Servo motor:

The servo motor is used to rotate the wheels by a certain angle up to a high degree of accuracy. The final position of the object, the servo motor is fitted to, is given back to the motor as positive feedback. Depending on this feedback, the current position of the robot is altered in order to achieve the desired position.

D. Arduino UNO:

Arduino UNO is an open-source - microcontroller board which houses the ATmega328P microcontroller. The board consists of 2 KB of RAM, 1 KB of ROM, flash memory of 32 KB and can be programmed with the software Arduino IDE.

They also include 14 digital I/O pins for both reading and writing data, and 6 analog pins for reading input:

The different components on the Arduino are as explained as follows:

- GND (3): Abbreviation for 'Ground'. These 3 pins are used as the negative terminal of any sensor or circuit connected to the Arduino.
- 5V & 3.3V: Easy to guess, 5V and the 3.3V pin supply 5volts and 3.3 volts of power to the circuit respectively. Most of the sensors used are designed to be compatible with these 2 voltages.
- Power: All Arduino boards require a power source to run on. There are two ways to power the board. The first is by using a USB cable connected to a computer. Alternatively, the board can be powered by connecting it directly to a wall power supply using the barrel jack given. Also, it's through the USB that one uploads the code on the ATmega328 microchip**. NOTE**: the voltage of the power source must be in the range of 6-12V.
- Analog: Analog pins are represented under 'Analog In' label and consist of pins A0 to A5. These pins can read signals from analog sensors (for example, temperature sensors) and convert it to binary data for the processor to read.
- Digital: The Digital pins are numbered from 0 to 13 on the Arduino UNO. They are used for both digital inputs like accepting data from a digital sensor and also as digital outputs like powering an LED. The tilde operator (~) is located next to some digital pins (3,5,6,9,10) and can be used for PWM (Pulse width modulation along with their regular function as digital I/O.
- Reset button: Pushing this button restarts the code uploaded to the board.
- Main IC: The black cuboid with metal legs is the brains of the Arduino board, known as an Integrated Chip or IC. In the model used in our project, Arduino UNO, the IC is the microprocessor ATmega328P. The microprocessor is explained in further detail in the next part.

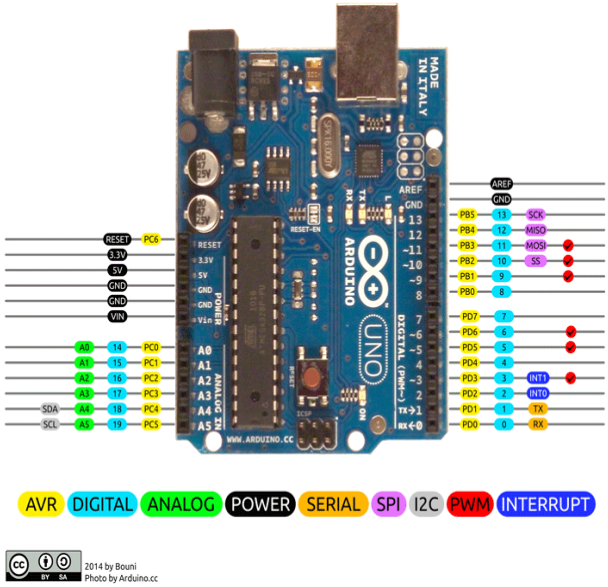


Figure [4] Arduino UNO

ATMEGA 328P-PU:

ATmega328 is a single-chip microcontroller and its key specifications are given below:

PARAMETERS	VALUE
CPU Type	8-bit AVR
Performance	20 MIPS at 20 MHZ
Flash memory	32 kB
SRAM	2 kB
EEPROM	1Kb
Pin Count	28-pin PDIP, MLF,32pin TQFP, ML
Maximum operating frequency	20 MHZ
Number of touch channel	16
Hardware Q Touch Acquisition	No
Maximum I/O pins	23
External interrupts	2
USB Interface	No
USB Speed	-

Figure [5] Specifications of ATmega328

IV METHODOLOGY

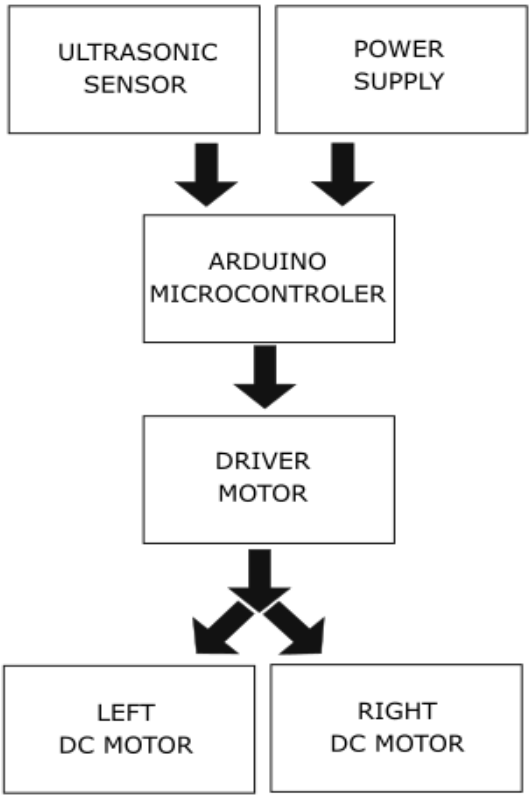
At first, the robot is given a forward direction to move and the input is set to low for Trigger pin as well as the Echo pin of the ultrasonic sensor.

When the ultrasonic sensor detects the reflected waves, the object is said to be in front of the robot and the echo pin goes high. Instantly after the echo pin goes high the timer starts and will stop when the echo pin goes low. The sensor will give the output in milliseconds and the distance between the barrier and the robot is calculated.

Depending on the distance, the direction of the motor is determined. If the distance is not too small, then the robot will turn left as default if there is no barrier or obstruction in the left direction. If the distance is small the speed of the robot will decrease, eventually, it moves in the backward direction and turns left/right depending on whether the barrier or obstruction is present on the left.

Actuators are responsible for changing the direction of the robot, to which the power is given by the driver module through Arduino microcontroller using different combinations of input for each direction into a set of four pins.

Block Diagram



V APPLICATIONS

The bot designed can be

1. Used as a robot capable of autonomous navigation.
2. Used as a maze solving robot.
3. Used as a rescue vehicle in dangerous environments.
4. Used to reduce accidents due to human error.
5. Used for militarized to reduce the risk of human casualties.
6. Used for mapping unknown landscapes.
7. Used during search and rescue operations.
8. Used in various warehouses and libraries.

VI RESULT

The barrier avoiding robot designed can detect obstructions like obstacles and barriers using the ultrasonic sensor and change its path to avoid them. The servo motor helps in providing a wider field of view for the robot.

VII CONCLUSION AND FUTURE SCOPE

The obstruction avoiding robot has the ability to detect obstructions and avoid obstacles and barriers. The robot is built using the Arduino UNO development board and its IDE which helped communicate with the robot. The obstruction avoider uses an ultrasonic sensor seated on a servo motor to get a wider field of view. The Arduino helps achieve the autonomous navigation of the robot.

This project can be enhanced with the use of a more specialized development board. A camera can replace the ultrasonic sensor for better accuracy and precision. Even the structure can be replaced to further improve mobility.

The basic principles of the project can also be applied to Unmanned Aerial Vehicles which can then be used for surveillance and military applications.

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