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Obstacle Detection in Self-Controlled Cars

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Abstract: ***An autonomous car is a vehicle that can guide itself without human command and control. It is also known as a driverless car, self-driving car, unmanned vehicle, or robot car. Autonomous vehicles can perceive their surroundings (obstacles and track) and commute to their destination with the help of a combination of sensors, cameras, and radars. There is a basic need for a system that can detect obstacles and move in a pre-computed path, a system that can detect the obstacles that appear suddenly which may cause accidents.***
Therefore, the automatic obstacle avoidance vehicle is designed for obstacle detection and collision avoidance. The ultrasonic sensor is tuned to enable the real-time obstacle avoidance system for wheeled robots, allowing the robot to continuously sense its environment, avoid obstacles and move to its target area. The design requires an ultrasonic sensor (hcsr04) to detect the obstacle and determine its distance.
This sensor module is placed on the front of the vehicle and mounted on a servo motor rotating in the direction of the sensor. The system includes a motor driving module and four dc wheel motors which are used to move the vehicle forward, reverse, left, right, and stop. The Arduino Uno microcontroller is mainly used to control the vehicle and achieve the desired detection and prevention
Keywords: Arduino Uno, ultrasonic sensor, DC motor, servo motor, motor driver module

I. INTRODUCTION

With the development of automation technology, automation begins to develop from simple system control to complex system control and advanced intelligent control, and that too in various fields.
An intelligent car is based on the automobile as the background, including automatic control, sensor technology, computer, machinery, and other disciplines of design.
An intelligent car integrates a complex integrated system, which can realize environment perception, self-planning, and self-decision functions. It can make full use of computers, sensors, information, communication, artificial intelligence, automatic control technology, and high-tech complex technology.
As demand for autonomous projects increases, the use of the sensor increases. The sensor is a complex device that converts physical parameters (e.g. temperature, pressure, humidity, speed, etc.) to a signal that can be electrically measured. They are very important to robots. It offers robot remote access and decisions about the desired environment.
The project is designed to build an obstacle avoidance robotic vehicle using ultrasonic sensors that will move according to the code assigned and will a free space, navigating from any obstacle on its way.
The so-called obstacle avoidance system is made to use the advanced range finding device in front of the autonomous car. When the car faces an obstacle, it can locate and respond to the location sensor and enter the Arduino through the data transmission starting the core processing.
Ultrasonic sensors are known for their reliability and great versatility in the industry. Ultrasonic sensors can be used to solve the most difficult tasks involving object detection or level measurement with millimeter accuracy because the measuring method works reliably in almost all conditions.
In this project, a robotic vehicle that moves in different directions like forward, backward, left, and right are designed and built to avoid the obstacle when it receives the sensor input that the object is detected.

II. LITERATURE REVIEW

Matthies et al. highlighted the importance of an autonomous navigation scheme for Unmanned Ground Vehicles operating under a complex operational scenario that required obstacle detection. During the detection phase, the relationship between encountered obstacles and the robot's path was inferred [1].

Darms et al. focused their work on path planning together with one of the main issues that were represented by tracking activity. The role of such topics is fundamental in evaluating a collision-free path for self-driving vehicles. The authors formulated the tracking controller as a multiconstrained model predictive control (PC) problem to follow the planned path for maneuvering to avoid obstacles by evaluating the proper steering angle to avoid collisions [2].

Discant et al. instead, underlined the safety issues regarding obstacle avoidance, being an important feature for any kind of vehicle. A lidar sensor was used to detect the obstacles along the route and to optimize the path automatically by using the information about the vehicle's position, the location of the obstacle, the operational capabilities of the vehicle, and environmental restrictions [3].

Matthies et al. presented a method for identifying objects in a dynamic environment by using a 3d light detection and ranging sensor, for high-speed object detection [4].

Borenstein & Koren used a fuzzy-based inference system (FIS) for navigation by using sensor information fusion. Such a system is made of two controllers: the first one uses sensors positioned in the front of the vehicle to detect obstacles, while the second controller evaluates the difference between the heading and the target angle [5,6].

Furthermore, Gibbs et al. used an adaptive neuro-fuzzy inference system for navigation purposes by fusing sensor information. Such a system was made of four controllers: two are used for angular velocity regulation for reaching the target position and the other two are used for obstacle avoidance [7,8,9,10].

Rajashekaraiah et al. proposed the MATLAB/Simulink simulation environment as a powerful tool for implementing the item algorithm (probabilistic threat exposure map) to improve the obstacle avoidance capability for moving and stationary obstacles [11].

Simone et al. investigated safety issues for manned vehicles. The authors developed a system capable of evaluating the commands of an operator and, in the case of the detection of obstacles, automatically correcting unsafe operations [12].

Furthermore, Giesbrecht et al. (2017) focused on driving assistance algorithms to reduce low-level tasks for a driver in the presence of cluttered and difficult areas. Such a system shares the burden between the autonomous algorithms and the driver, manages proximity warnings, trajectory control in the case of narrow passages, wall following, etc. [13].

In Mohammadi and khaloozadeh (2016), a nonlinear sub-optimal regulator is proposed for trajectory planning and avoidance of obstacles. The state-dependent Riccati equation (sure) is used to design a sub-optimal nonlinear controller. Such an approach allows one to create an efficient and well-organized method for the control design of a non-linear system [14].

Tee kit et al. used Microsoft robotics developer studio 4 (MRDS) to create autonomous system navigation. The authors implemented an indoor robot navigation system by using multi-sensor fusion, obtaining information by a depth camera, proximity sensors, and an IR marker tracking system. The navigation system implemented this by transforming the data of the three sensors into tendency arrays to fuse them to decide on object-avoiding maneuvers. The algorithm established the appropriate maneuvers according to the short, medium, or long distance from the obstacle to be avoided [15].

III. SYSTEM DESIGN

A. Components

The main components used in this project are presented as follows:

1) Arduino UNO

Arduino Uno Rev3 is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by the tech company Arduino. The board is fitted with sets of digital and analog input/output (I/O) pins that can be interfaced with several expansion boards (shields) and other circuits.

Description of Arduino UNO
Digital I / O digital input / output terminal: 0 to 13.
Analog I / O Analog inputs / outputs: 0 to 5.
Support ISP download function.
Input voltage: No external power supply when connected to the computer USB,
External power supply: 5V ~ 9V DC voltage input.
Output voltage: 5V / 3.3V DC.
Using the Atmega328 microprocessor controller.

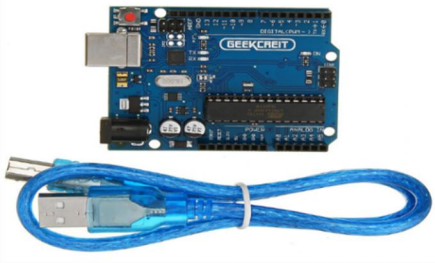

Figure 1. Arduino Uno

2) TT Gear Motors

A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gear head to a motor reduces the speed while increasing the torque output. The most important parameters in regards to gear motors are speed (rpm), torque (lb-in), and efficiency (%).

Description of Gear motor: Type: 1:120
Features: Strong magnetic, Anti-interference
Model: 1A120-1812L (Prefer Torque)
Rated voltage: 3V/6V
Current: ≤180mA/≤250mA
Speed: 45±10%r/min 90±10%r/min
Torque:0.45±10%kgf.cm to 0.85±10% kgf.cm

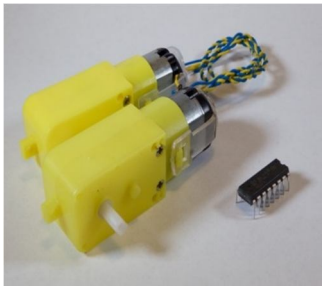

Figure 2. Gear Motor

3) Wheels

- A tire or wheel is a ring-shaped component that surrounds a wheel's rim to transfer a vehicle's load from the axle through the wheel to the ground and to provide traction on the surface over which the wheel travels.
- When it comes to safety, tires are one of the most important components of the vehicle. The brakes stop the wheels, not the car! It's the tires that stop it.
- Tyres provide the contact between the car and the road. They have to transmit drive forces, braking forces, and lateral forces.

Description of tires:
With inner tire dimensions
Diameter: 68mm
Width: 26mm
Centre hole: 5.3 x 3.66mm (two sides are semicircle)
Weight: 50g

Figure 3. Robotic Tires

4) Servo Motor

- A servo motor is a rotary machine that converts electrical energy into mechanical energy. This mechanical energy is the movement of the output shaft. Servomotors are also known as rotary actuators or linear actuators. It is used to control the angular position of an object.
- The output shaft of this motor can be moved to a particular angle, position, and velocity that a regular motor does not have.
- The Servo Motor utilizes a regular motor and couples it with a sensor for positional feedback.

Description of Servo Motor
Item Name: SG90 Mini Analog Servo
Operating Speed (4.8V no load): 0.12sec/60 degrees
Stall torque: 1.2kg / 42.3oz (4.8V);1.6 kg / 56.4oz (6.0V)
Operating voltage: 3.0-7.2V
Temperature range: -30°C~60°C
Dead band width: 7us
Item size: 3.2 x 3 x 1.2cm
Item weight: about 9g

Figure 4. Servo Motor

5) Ultrasonic Sensor

- An ultrasonic sensor is a sensor that measures the distance of a respective object by sending the sound wave of a specific frequency sound pulse and then times how long it takes for the echo of the sound to reflect back.
- The sensor has two openings on its front.
  - Tiny speaker to transmit opening ultrasonic waves
  - Microphone to receive the ultrasonic waves
- The sound wave is reflected after the collision with the respective object and this wave is received by the ultrasonic receiver. Distance is measured by calculating sending and receiving time of this sound wave.

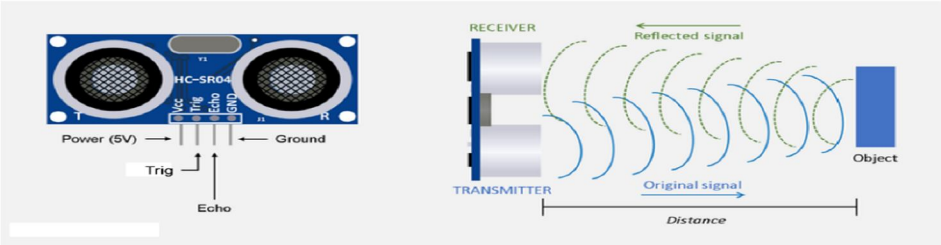

Figure 5. Ultrasonic Sensor

Description of Ultrasonic sensor:
Working Voltage: 5V(DC)
Static Current: Less than 2mA.
Output Signal: Electric frequency signal, high-level 5V, low-level 0V.
Sensor Angle: Not more than 15 degrees.
Detection Distance: 2cm-450cm.
High Precision: Up to 0.3cm
Input Trigger Signal: 10us TTL impulse
Signal: output TTL PWL signal
Mode of connection: VCC trig(T) ech0(R) GND

6) Jumper Wire

- These are simply wires that have connector pins at each end, allowing them to be used to connect two points without soldering. Jumper wires are typically used with breadboards and other prototyping tools to make it easy to change a circuit as needed.

Description of Jumper wires
40pcs 10cm male to female colour breadboard jumper cable Dupont wire for
40pcs chromatic male to female colour jumper cable
High quality and in good working condition
Durable and reusable
Easy to install and use
Length: 10cm
1p-1p pin male to female header
Compatible with 2.54mm spacing pin headers

Figure 6. Jumper Wire

7) 9V Battery

- 9-volt battery, is a common size of battery that was introduced for early transistor radios. The 9V battery is used in many different applications. 9-volt batteries can frequently be seen used in radios, smoke alarms, wall clocks, walkie-talkies, portable electronics, and much more.

Description of 9v battery
Carbon Zinc
Capacity: 600 mAh
Color: Blue

Figure 7. Battery 9Volt

8) DC Power Switch

- The switch plays a role as an on-off switch in the circuit so that it can turn on or turn off different devices in a circuit or the entire circuit itself. It reacts as an Automatic switch to control a large voltage load by using a low voltage signal.

Description of Power switch:
Colour: black
Current Rating: 2.0 amps
Switch Type: SPDT
Terminal Type: SPDT

Figure 8. Switch

9) Motor Driver

- Motor Driver Shield L293D Duemilanove Mega UN0 Geekcreit for Arduino - products that work with official Arduino boards. L293D use 16 pin DIP package, its internal integration is a bipolar H - bridge circuit. This kind of bipolar pulse width method has many advantages, such as the current continuous, or micro current vibration when the motor stops, which is a lubrication effect. It can eliminate the dead zone of static friction when positive and negative.

Description of Motor driver
Height: 3 cm
EAN: 0695626478670
Item Weight : 60.0 gm

Length: 4 cm
Width : 2 cm

Figure 9. L293D Motor Driver Shield

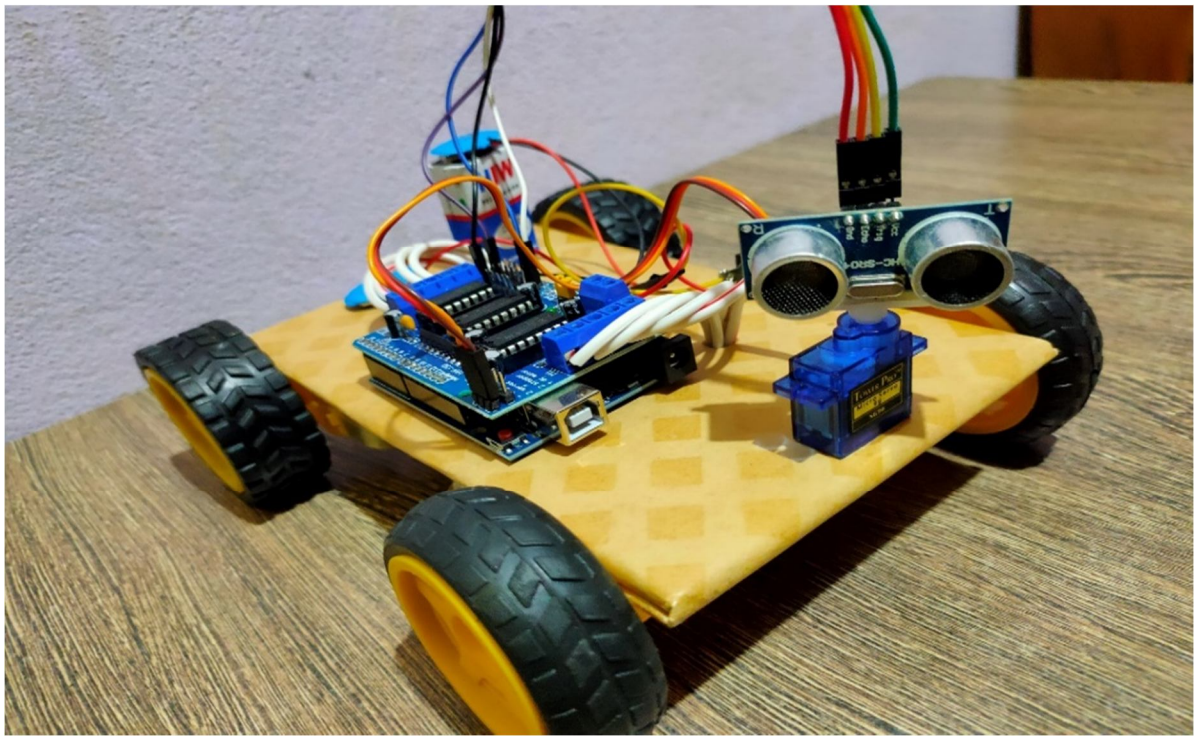

Figure 10. Our Model

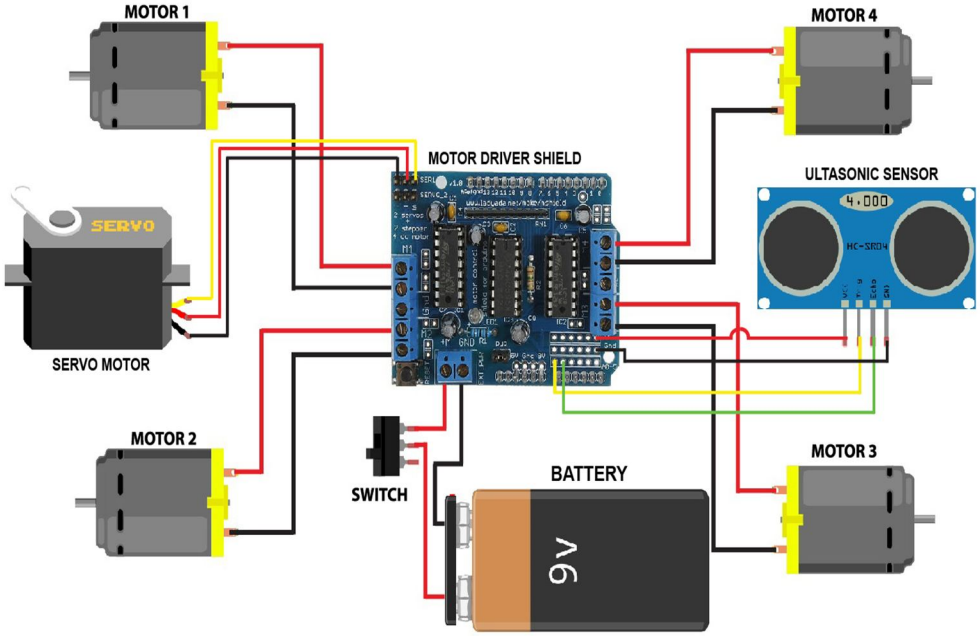

Figure 11. Circuit Diagram

IV. WORKING

1) The car moved along a specific distance; it counts the distance while it is moving on the track.
2) If the sensor can detect any obstacle, then Arduino will give instructions to stop instantly.
3) The Left side and Right-side distance values will be determined by the sensor with the help of a rotating SG90 servo motor.
4) If the left side distance value is more than the right side distance value, then the car turns 900 to the left. Otherwise, it turns 900 to the right.
5) After the obstacle disappears the car starts to move again.
6) After this the car will start to move forward until the obstacle comes in front of it.

V. OBSTACLE DETECTION

On detection of the obstacle, the braking force to be applied depends upon the distance. If the obstacle appears on the Path, the host vehicle will detect it and determines the distance of the obstacle from the host. The speed is then, decreased automatically. If the distance exceeds the critical distance (not a safe distance for driving); the braking mechanism is activated and the horn is pressed. If the obstacle is a living creature, it might move out of the path by the horn. But in case the obstacle is not moving, the speed is kept on decreasing in such a way that the host is brought to a stop at a fixed pre-set value before the obstacle.

VI. SPEED MEASUREMENT

For measuring speed with an ultrasonic sensor, a microcontroller or any controller such as Arduino is necessary to connect with this sensor. The ultrasonic sensor consists of two transducers one is act as a speaker which converts the electrical pulses into sound pulses and then emits them with a high frequency of almost 40khz.similarly, the other one acts as a microphone for receiving the sound pulses which are reflected after the collision of a specific object. Because a microcontroller or any controller is attached to an ultrasonic sensor, therefore, the timer of the controller starts to count the pulses when it is transmitted and is stop when sound waves are received by the microphone. Based on sending and receiving the sound pulses the microcontroller or any controller determined to speed of that specific object.

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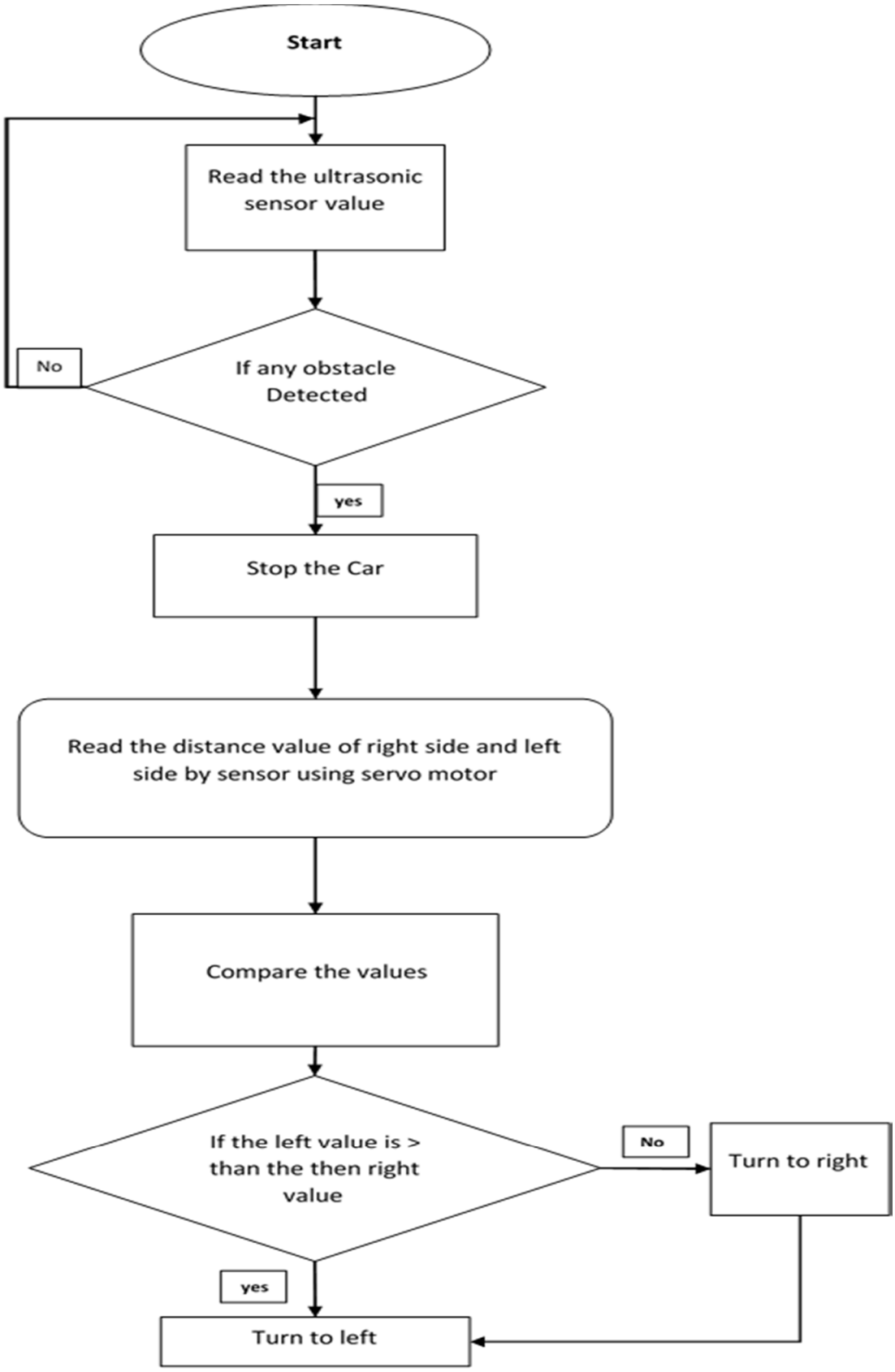

The Flow Chart

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VII. ADVANTAGES

1) The ultrasonic sensor has high frequency, high sensitivity, and high penetrating power therefore it can easily detect external or deep objects.
2) It can be used as a movable Surveillance System.
3) It can be controlled remotely.
4) It does not require Man Power.
5) It can be used for critical applications like a flood, bomb disposal, Fire, Terrorist attack, earthquakes, and Spying.
6) These sensors easily interface with a microcontroller or any type of controller
7) These sensors have greater accuracy than other methods for measuring the thickness and depth of parallel surfaces.
8) These sensors could easily sense the nature, shape, and orientation of that specific objects which is within the area of these sensors.
9) These sensors are easy to use, not dangerous during operation for nearby objects, persons, equipment, or material

VIII. DISADVANTAGES

1) It is used for short distances only
2) It is not in human control.
3) During the use of an ultrasonic tester for testing it is very important to know the operational manual, in other words, it required careful attention from an experienced technician.
4) When these sensors are used for inspection purposes they should be water-resistive otherwise they could be damaged.
5) When these sensors are interfaced with a microcontroller or any controller then an experienced person or programmer is required.

IX. APPLICATIONS

1) By doing extra things, it can be used in army applications.
2) Intruder alarm system.
3) This can be used in the robotic industry for robot sensing.
4) This can be used in a car parking system where car entry is controlled through a barrier system, the barrier must not be lowered when there is beneath a vehicle. This whole process is controlled through the ultrasonic sensor.
5) This sensor is used for detecting the speed of the motor or generator.
6) This sensor is also used in the presence detection system.

X. CONCLUSION

This project is very simple but very effective and useful. The automatic detection and avoidance technology is also popular and is required in the unmanned vehicle.

For detecting obstacles one single sensor was used along with a servo motor. The percentage of accuracy and minimum probability of failure was obtained.

The system shows that it can avoid obstacles, able to avoid a collision, and change its position. It can be said that with the design, more functions can be added to perform various work to lessen human stress

The obstacle avoidance system of intelligent cars has the advantages of simple design, stable performance, low cost, and measurement accuracy to meet the requirements of the obstacle avoidance system. The measuring precision of the ultrasonic distance module can reach 0.3 cm, the minimum measuring distance is 2 cm, and the maximum measuring distance is 400 cm. The ultrasonic obstacle avoidance system can set the specific distance of obstacle avoidance, and the range of obstacle avoidance is wide, so it is widely used.

For detecting obstacles one single sensor was used along with a servo motor. The percentage of accuracy and minimum probability of failure was obtained. The system shows that it can avoid obstacles, able to avoid a collision, and change its position. It can be said that with the design, more functions can be added to perform various work to lessen human stress.

This project can be extended to line following and object avoidance robot vehicles. It also can be modified by adding various types of sensors such as flame sensor modules, and camera modules for various applications. Finally, the project will be helpful for the environment, defence, and security sectors of the country.

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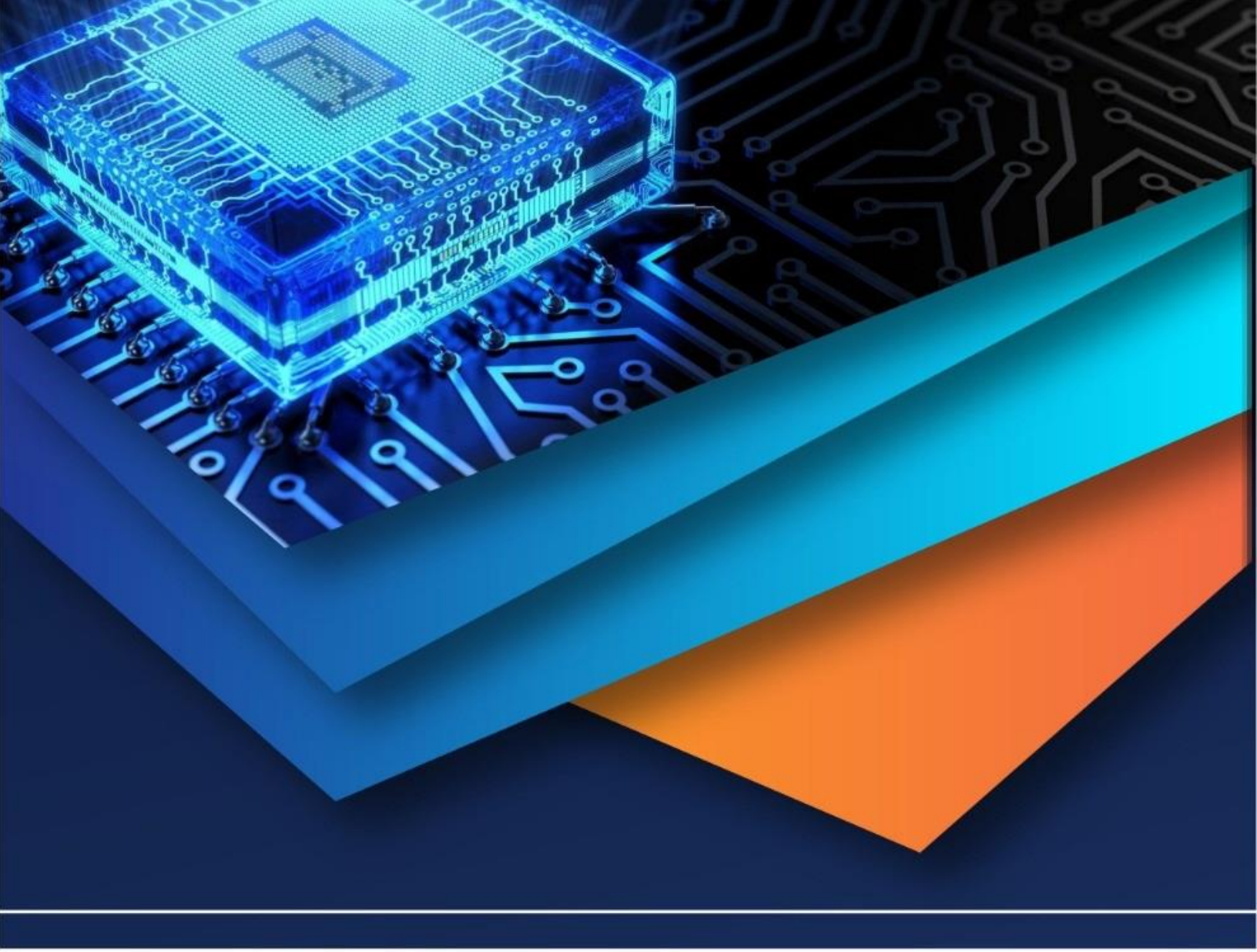

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