Alternate Trajectory Determination Using Multimode Automated Robotic Vehicle with Line Following and Object Following Mode

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Abstract - In this paper the authors have explained the development of robotic vehicle prepared by them, which operates autonomously and is not controlled by the users, except for selection of modes. The different modes of the automated vehicle are line following, object following and object avoidance with alternate trajectory determination. The complete robotic assembly is mounted on a chassis comprising of Arduino Uno, Servo motors, HC-SRO4 (Ultrasonic sensor), DC motors (Geared), L293D Motor Driver, IR proximity sensors, Voltage Regulator along with castor wheel and two normal wheels.

Keywords— Components, Robotics, Arduino, Mobile robots, Vehicles, Computational efficiency, Mobile vehicular movement, Sonar navigation, Robotics and automation, outdoor mobile robot, Object following, Obstacle avoidance, collision avoidance.

I. INTRODUCTION
An autonomous car or an unmanned vehicle is a vehicle that has the ability of sensing its environment and navigating without any human intervention. These cars use different techniques, such as sonar, GPS, laser light, radar and computer vision to detect their surroundings. Specially designed control systems translate the information received from sensors to recognize suitable navigation paths, obstacles and relevant signs. These cars are equipped with specially designed control systems that can interpret data received from sensors to differentiate between different objects on the road, which is very helpful in planning the desired path. The authors have developed a robotic vehicle which simulates an automated vehicle and even can behave as an autonomous robot in the object avoidance mode. Basically, the robot operates in three different modes which are object following mode, object avoidance and lastly, line following mode. In the object following mode, the robotic vehicle moves forward while maintaining a distance of 15 cm form the object. If the object stops, then the vehicle detects that and automatically stops at this specified distance. And if the object moves backwards, then the object moves backwards while simultaneously maintaining this pace of 15 cm. In the object avoidance mode, the robotic vehicle detects any obstacle in its path and stops. Then it scans its surroundings, to form an alternated trajectory in which there is no obstacle and proceeds in that direction subsequently. In the line following mode, the robotic vehicle traces the white colour and rejects it, to only move at black stripe of line.

II. METHODOLOGY
MARV (Multimode automated robotic vehicle): The robotic vehicle involves the chassis on which the rest of the components are mounted. It consists of Arduino UNO which is programmed in such a way that it processes the input data from the proximity sensors and ultrasonic sensor and processes it to transfer it to the motor driver. The driver takes in this information and then accordingly the trajectory of the vehicle is changed.

A. Line Following Mode:
The IR proximity sensors are interfaced with the Arduino module as is ultrasonic sensor. When the IR sensor detects the black line, it traces this colour and sends this information to the Arduino module which in turn sends the signal to the dc motor driver to follow this line and not the white colour. The DC motor driver in turn, directs the DC motors to turn and rotate accordingly. Hence, the vehicle moves over the black line and follows this black colour line only.

B. Obstacle Avoidance Mode:
Similarly, the ultrasonic sensor detects the obstacle in the object avoidance and object following mode. In the former mode, it sends the signal to the Arduino module which directs it to stop and loop in another direction for clear path
without obstacles. The ultrasonic sensor is rotated by the servo motor on which the sensor is mounted and charts an alternate trajectory free of any obstacles. This information is then sent to the Arduino module which in turn forwards it to the L293D motor driver. The driver directs the dc motor to rotate and the castor wheel changes the direction according to information and trajectory decide to move in that specific direction.

C. Object Following Mode:
In this mode, the Arduino module sends the information about the obstacle to L293D driver to stop if the distance is less than 15 cm or to move forward along with the moving object while maintaining this distance of 15 cm. In case, the object starts moving towards the vehicle, the sensor detects this decreasing distance between the robotic vehicle and the object and forwards it to the Arduino module which directs the L293D driver to stop the DC motors and start rotating in the reverse direction so that the vehicle will move in the reverse direction while simultaneously maintaining the distance of 15 cm even when moving backwards.

D. Constructional Details:
The robotic vehicle consists of following parts:
1) Major components:
   - Arduino Uno
   - Servo motor SG90 - 1
   - HC-SR04 (Ultrasonic sensor) - 1
   - DC motors (Geared) - 2
   - L293D Motor Driver
   - IR proximity sensors
   - Voltage Regulator

2) Minor components:
   - Resistors (1K ohm)
   - Jumpers (male to male and male to female)
   - Chassis
   - Wheels - 2
   - Castor wheel
   - LED
   - Pushbuttons

The construction is explained in various steps as follows:

A. Step 1-Board:
The microcontroller board taken as per the requirement for the project:

1) Arduino Uno: The Arduino Uno is a board that contains ATmega328 which is a single chip microcontroller. It contains 6 analog inputs, 14 digital Input /Output pins (6 of those can be employed as PWM outputs), USB connection, a 16MHz ceramic oscillator, a power jack and a reset button. It can be powered from a battery, a USB cable connected to a computer or a wall power supply. The code on this board is loaded using a USB cable.

B. Step 2-Sensors:
To have proper mechanism and response from the robot, proper readings have to be taken for it. In this, we have used 2 sensors:

1) HC SR04: Ultrasonic sensors are transducers that work on the same principle as the sonar or radar which evaluate characteristics of a target by translating the reflections from radio or sound waves respectively. These sensors produce and emit high frequency sound waves of the order of more than 20 KHz. The speed of these waves is same as that of the speed of sound, which is 330m/s. These waves then strike the object that is in its range and then reflect back to the receiver of ultrasonic sensor. The sensor calculates the time interval between sending the wave and receiving the signal to determine the distance of the object.

2) IR Proximity Sensors: A proximity sensor is a sensor that is employed to detect the presence of objects in close proximity without any physical contact with those objects. IR sensor also acts as a colour detector. IR
sensor emits IR waves from its LED and then these waves strike the object and reflect back to the IR receiver, i.e. the IR photodiode which produces a voltage proportional to the amount of received light. The amount or magnitude of reflected light depends upon the colour of surface from which it is being reflected. Black is known as a perfect absorber and white

C. Step 3-Communication and Movement

1) Servo motors: A servomotor is a variable speed drive used in industrial production and automation of processes. It is a rotational actuator that can be used for precisely controlling the angular position, velocity and acceleration of the object mounted on its shaft. Its operating principle is not different as compared to generic motors, rather, it uses servomechanism to establish closed loop control with a basic open loop motor.

2) DC motors: A geared DC motor is defined as an enhanced version of a basic DC motor. It is formed by attaching a gear assembly to a DC motor. Its speed is measured in terms of rotations of shaft per minute and is called as RPM. The gear assembly assists in decreasing the speed and increasing the torque.

3) L293D Motor Driver: L293D is an integrated circuit that is used for driving the motors. It is a dual H-bridge IC. It works as a current amplifier which takes a low value current signal and provides a high value current signal. This high value current signal is utilized in driving the motors. Since it contains two H-bridge driver circuits, it can be used drive two DC motors simultaneously, in both forward and reverse directions. The two motors can be controlled by supplying input logic at pins 2 and 7 and 10 and 15. The logic 00 or 11 will stop the corresponding motor and the logic 01 and 10 will rotate it in clockwise and anticlockwise directions respectively.

4) Voltage Regulator: A voltage regulator is a device that is used for electrical regulation. It is designed for automatically maintaining a steady voltage level that is generally lower than the voltage supplied to it. It works as a buffer for safeguarding circuit components that could get damaged by high voltages.

Figure 1: Assembly of components on chassis

Figure 2: Actual Model of the Project
III. VARIOUS APPLICATIONS IN INTELLIGENT TRANSPORTATION

Such types of autonomous robotic vehicles can be used in various types of applications such as:

- Cruise Control with autonomous feature which automates the control of speed according to the proximity of the vehicle from other vehicles. It automatically increases and decreases the speed depending on whether the vehicle ahead is far-off or close-by.

- A warning system for alerting the user if the vehicle is deviating from his lane and changing lanes.

- A system which clearly lets the vehicle driver know that he has enough distance to speed up or break.

- Notification to emergency services in case of a vehicular collision automatically with the help of advanced autonomous evidence based protocols. Ex: OnStar

- System which is based on artificial intelligence and assist the driver in the parking of vehicle in the most efficient manner.

- Night vision integrated into a system which automatically detects the presence of any pedestrian and alerts the driver and stops the vehicle if it is in close proximity of the pedestrian.

- System which monitors the condition of the driver if he is in a fit state to drive or not i.e. drunk or injured or asleep or drowsy, and automatically alerts the driver and brings the speed of the vehicle down.

- A sign recognition system which automatically detects the colour of the street light ad accordingly controls the response of the car.

IV. CONCLUSIONS

Autonomous vehicles have made rapid progress in recent years, and can now be seen on the roads in several smart cities around the world. These cars will play an important role in the future of smart cities and will change the world, just as cars did before them. In this paper we tried to explain the development and working of a basic automated robotic vehicle. It is our belief that this paper can provide a wider view on the world of autonomous and automated vehicles and their understanding.

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