Embedded Control Path Planning System Using IR Array Sensor

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Abstract: This project focuses on the development of the line following robot using a sensor. This line follower robot is an autonomous robot which follows a certain path. Generally, the path for this autonomous robot is either it has to follow the black line on the white surface or white line on the black surface. The robot follows the path using an IR array sensor. Using this sensor, the line can be detected. These sensors sense the line and sends the output of the sensor to the Arduino. The acquired input from the IR sensor to the Arduino is then given as input to the motor driver by which the direction of the robot is controlled. In this paper the components required, software used, implementation testing and results are being discussed.

I. INTRODUCTION
An autonomous line following robot is a category of robot that can perform tasks intelligently depending on themselves, without any human assistance. Autonomous navigation is a way to help achieve the better path planning and path prediction and also optimizing the path. Mobile robot navigation based on lines, landmarks and signs have been broadly implemented around the globe. The main goal of these works is to develop a mobile robot with the capability of navigating through a predefined path or towards a set destination using a line, landmark or sign as a point of reference. This robot is designed in such a way that it is capable of following a black line on the white surface or vice versa. This robot has IR sensor array installed under the front part of the robot, and this robot is also equipped with the Arduino which functions as the brain of the robot. The circuit of the robot performs the necessary operations to drive the robot according to the predefined line. This mobile robot follows either the black line which is on the white surface or the white line on the black surface. The basic operations of the line following robot are, to identify the predefined path or the line by IR sensor which are installed front-beneath the robot and sending those readings to the Arduino. The microcontroller on the Arduino board analyses the readings and performs the required operations. The robot moves with the help of three wheels among which two are connected at the back of the robot with corresponding motors to them. The third wheel is a caster ball which is a universal wheel. This caster wheel is connected in the front-down side of the robot. Whenever the robot detects the black line it moves with high speed comparatively when it moves in the turnings or in the corners. The speed of the robot is relatively low depending on the turning angles.

II. Areas of Application
Line follower robot can be used for various purposes in the industries. The robot can be employed to lift heavy weights and it can also be employed at places where humans are out of reach. The transportation of radio-active materials is risky. So, in such places these robots can be employed. These robots can also be used in the hospitals for assisting the doctors. In restaurants these robots can be utilized in many ways such as serving the food, taking the orders from the customers. If these robots are employed in the restaurants the customers will get attracted.

III. Working of Line Following Robot
The working of the line following robot is quite interesting and simple. The line follower robot senses either the black line or the white line on their respective controversial surfaces by using the IR sensor and then the output obtained that is the readings from the sensors are given as input to the Arduino. The Arduino then performs required operations on the acquired input and sends the output to the motor drivers through which the motors run.

A. Working of IR sensor
The line follower robot uses the IR sensor for detecting the black line and the white lines on their controversial surfaces. This IR sensor has an IR led and an IR photodiode together they are known as photo-coupler or opto-coupler. When light falls on the light surface the light gets fully reflected and if the light falls on the dark surface the light gets completely absorbed and there will be no reflection. This kind of behaviour of light is used for the construction of IR sensor.
In this line following robot we used IR transmitters and IR receivers for sending and receiving the light. IR transmitter transmits the infrared light on to the surfaces. When the infrared light falls on the white surface the infrared light is reflected and will be caught by the photodiodes which generates the potential difference. When the infrared light falls on the black surface then the infrared light gets absorbed by the black surface completely thereby there will be no reflection of light on to the photodiode. Whenever the sensor senses the white surface the output will be 1 and when senses black the output will be 0.

Block Diagram

Circuit Explanation

This complete robot can be divided into three sections: Sensor section, Control Section, Driver Section.

Sensor section
In this sensor section it consists of IR diodes, potentiometer, Comparator and LED’s. The potentiometer here in this is used for setting a reference voltage at one of the terminal of the comparator and at the other terminal of the comparator the voltage provided by detecting the line using IR sensor is given. The comparator then compares both the voltages and generates the digital signal as the output to the Arduino.

Control Section
In this, the controller used is Arduino UNO which acts as the brain of the robot and performs the required tasks. This Arduino UNO is used for controlling the whole process of the Line following robot. The outputs of the comparator are given as input to the Arduino. The Arduino then reads the signals and sends the commands to the motor drivers. In this way the Arduino Controls the whole circuit of the line following robot.

Driver Section
In the driver section the line following robot consists of a motor driver and two dc motors. The motor driver is used for driving the motors. The supply form the Arduino is not sufficient to run the dc motors so in order to run the motors without any interruption the dc motors are connected with the motor driver which provides the enough voltage and current to the dc motors to run. In this way the Arduino sends the commands to the motor driver and then it drives the two dc motors.

Arduino
In this project the use of microcontroller is for controlling the whole process and the microcontroller use is Arduino UNO. Arduino can be used as an open source software and also as hardware for the development of various projects. Arduino family consists of different types of modules they are UNO, MEG, LILYPAD, DIECIMILA, NANO, and DUEMILANOVE. Arduino UNO has a microcontroller of ATMega328P and it has 14 digital input/output pins in which 6 pins can be used as PWM outputs, 6 analog input/output pins, a 16MHz quartz crystal, a USB connection, a power supply jack, reset button, crystal oscillator. A simple USB cable is enough to connect the Arduino board with the computer and can be used for programming. It supports 5V DC to 12V DC.

Arduino UNO Board

The program code can be written in the Arduino IDE and the program code can be dumped into the Arduino board with the help of USB cable which connects the Arduino with the computer.
Algorithm (Wall Following Algorithm)

In this project the algorithm that we used is the Wall following algorithm. This wall following algorithm is the most commonly used algorithm for solving the maze follower robot or a line following robot. Whenever the robot reaches the intersection the robot checks for the path to proceed according to the priority. The robot makes the decisions whenever it happens to get through an intersection.

This left hand on wall algorithm can be simplified into these simple conditions:

- If you can turn left then go ahead and turn left,
- else if you can continue driving straight then drive straight,
- else if you can turn right then turn right.
- If you are at a dead end then turn around.

Some of the notations that we use in solving the path are

- L = left turn
- R = right turn
- S = going straight past a turn
- B = turning around

The robot need not travel the complete path instead it can follow the shortcuts which ultimately leads to the final destination with less travelling. Using the following substitution, the path can be optimized.

- LBL = S
- LBR = B
- LBS = R
- RBL = B
- SBL = R
- SBS = B

Following is the example which shows using wall following algorithm optimizes the path.
The actual path the Robot has to follow is the LBLLBSR and using the wall following algorithm the path got optimized to SRS. In this way using this wall following algorithm we can reduce the travel path of the robot. The disadvantage of this wall following algorithm is that it is not applicable to the closed loop paths.

Result

The program was developed and was dumped into the Arduino for the bot to run. Finally with the help of the IR sensors the robot could identify the black line and the white surface and could move along the path laid. The perturbations occurred while the movement of robot and these perturbations are because of not using the PID controller and if the PID controller is used the jiggling movement of the robot can be reduced. In this way the bot can be run and this bot can be further implemented and can be included with the other features like avoiding the obstacles using the sensors like ultrasonic sensors. These robots can be implemented in the industrial purposes if they are further added with additional features like obstacle avoidance.
Conclusion

Robotics has outstanding role in the global economy and in our everyday life which led in the demand of robotic technologies and these technologies are spreading in wide range of applications and human activities especially in the fields of manufacturing, medical, defense. The designed robot has sensor Arduino microcontroller board, motor driver. This line following robot is a prototype of the robots that are to be used in the industries. This project gives a basic information about the robot that can be employed in the real world for the industrial application. By using the better-quality material and sensors the performance can be improved. The jiggling movement of the motor can be reduced by employing the PID controllers. If the sensing capability is more than the movement of the robot will be more accurate. This robot can be used as an alternate to the existing system. These robots will be able to handle heavy loads in manufacturing units in less time with high accuracy at low cost.
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