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Implementing a self Driven Edge Avoiding Robot ------------ Using Arduino

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ABSTRACT

Robot navigation requires the guidance of a mobile robot through the desired path to the desired goal avoiding obstacles and hazards encountered in an unknown environment. Detection and avoidance of obstacles, collisions and hazardous situations are in the first place. However, path planning and arrival at the desired goal is also an essential part of the reliable and secure navigation of mobile robots. Planning the optimal path requires optimization of specific navigation performance, such as the minimum time until the robot reaches desired goal with a minimum of control, but also requires to comply with certain restrictions in robot motion, such as avoiding obstacles with the maximum speed of the robot.

Now, the requirement for avoiding the collision with obstacles in the environment, the robots should be equipped with a sensor system that will enable the detection of these obstacles. Information obtained from sensors is used in obstacle avoidance strategies or in strategies for finding the best solution in case of the robot's emergency stop before the collision.

In this research paper authors have tried to develop an edge avoiding robot and explained clearly the usefulness of the newly developed robot.

Keywords: Arduino,computer vision,Particle Swam optimization, Microcontroller

I. INTRODUCTION

To find the optimal path [1–4] the path planning process is used,which is an essential part of mobile robotic systems. As the critical values of velocity, acceleration and deceleration of a mobile robot (MR) are defined as closed mathematical forms over the spatial path. For any MR model [1] these values can be calculated through offline. An approach has been proposed to generate a time-optimal velocity profile for any path in static or dynamic environments[2]. The proposed algorithms are not time-consuming if the way is planned as smooth curves. A real-time robot path planning approach based on the utilization of inequality and optimization technique has been presented in [3]. The problem of finding a path has been transformed into finding a collision-free way without calculating the configuration space obstacles. In addition, many heuristic algorithms have been developed recently to be used for path planning in real world. The fundamental similarities between these algorithms and the motivation behind each one have been introduced in [4]. However, these algorithms can be grouped in many categories such as static algorithms, anytime algorithms, and preplanning algorithms [4].

However, computer vision (CV) has become an important tool in modern robot systems since it provides a useful tool for detection and decision-making during robotic navigation missions. In this context, many studies have applied CV for path planning tasks [5–9]. The object detection has been proposed for MRs to perform their missions in the environment [5]. The proposed algorithm in [5] is based on collecting data images from the surrounding environment during the training phase. Whilst the algorithm is measuring the errors in the data image, it updates the classifier. As a result, it provides the means of classifying and more reliable object detection. The work in [6] addressed the problem of how making a robot learns natural terrain selectively and exploits its knowledge to estimate the terrain for optimal path planning. The author proposed a scheme that combines vision learning and interaction to give the robot the ability to understand the complex environment. In addition, a particle swarm optimization (PSO) algorithm was applied to search for the optimal path. In [7], a combination between CV and robot path planning has been presented aiming to program free robot applications. Image processing and path planning tools was presented using the Wise-Shop floor framework. The authors in [9] developed a CV system for autonomous MR navigation. A vision sensor was placed on system onboard to detect and localize another robot in the simulated environment. This proposed approach used algorithm to determine the path in order to find the best solution.

II. Background of the Work

The authors have reviewed some previous research works. Based on the reports, similar types of research works were performed by various researchers and scientists. The authors below depicted a few of them in these sections. One type of line follower and obstacle avoidance bot using Arduino has been designed and developed by Aamir attar et al. to create an autonomous robot that intelligently detects the obstacle in its path and navigates according to the actions that the user set for it[1]. This system provides an alternate way to the existing system by replacing skilled labour with robotic machinery, which can handle more patients in less time with better accuracy and a lower per capita cost [1]. Aniket D. Adhvaryu et al. has developed an "Obstacle-avoiding robot with IR and PIR motion Sensors". They proposed that the developed robot platform was not intended for a specific task but as a general wheeled autonomous platform. Research on obstacle avoidance robots at the polytechnic level can help students develop communication, technical skills and teamwork. The design of such a robot is very flexible, and various methods can be adapted for another implementation. It shows that PIR sensors are more sensitive than IR sensors while detecting human beings [2]. "Obstacle Avoidance Robotic Vehicle Using Ultrasonic Sensor, Android and Bluetooth for Obstacle Detection" has been designed and developed by Vaghela et al. has mentioned that an enormous amount of work has been done on wireless gesture controlling of robots. Various methodologies have been analyzed and reviewed with their merits and demerits under different operational and functional strategies. Thus, it can be concluded that features like user-friendly interface, lightweight and portability of android OS based smartphone has overtaken the sophistication of technologies like a programmable glove, static cameras etc., making them obsolete. Although recent research has made wireless gesture controlling a ubiquitous phenomenon, it needs to acquire more focus in relevant areas of applications like home appliances, wheelchairs, artificial nurses, tabletop screens etc., in a collaborative manner [3]. "Obstacle Avoidance Robot" has been designed and developed by Paul Kinsky. Quan Zhou mentioned that a robot with a few mechanical components adds two more functions to the main body, namely the laptop holder and the camera holder. The AT89S52 development board is designed, developed and tested on a large scale, which was used to control the motors smoothly. The cameras with relatively low cost are fixed and adjusted on the camera holder for good calibration of the computer vision. Users establish the serial communication method between the upper laptop and the lower development board with a USB port. The computer will send out a signal of the motor condition to the development board [4]. "obstacle avoidance car" has been designed and developed by FaizaTabassum, et al. has mentioned that Obstacle Avoidance Car successfully detects and avoids obstacles. Simple algorithms used to steer and reduce the turning radius successfully navigated the vehicle. In conclusion, the group successfully interfaced with every component that was initially planned. Then, the timer interrupts for IR pulse generation obstacle detection using IR transceiver and Servo mechanism using PWM-Steering system using Lego and Servo is clearly explained in the paper [5].

III. Experimental Setup and Result Analysis

The concept of the 'Edge Avoider robot' is the same as a line follower. In these types of robots, we generally use the behaviour of light on a black and white surface. When light fall on a white surface it will almost full reflects and in case of black surface light is absorbed by the black surface. This behaviour of light is used in a line follower robot as well as an edge avoider robot.

Here we have used IR transmitter, and receiver also called photodiodes, are used for sending and receiving light. IR transmits infrared lights. When infrared rays fall on any surface except black or many dark surfaces, it's reflected back and catched by photodiode and generates some voltage changes. When IR light falls on black cover, light is absorbed by the black surface, and no rays reflect back. Resultantly the photodiode doesn't receive any light or rays. Here in this Edge Avoider robot, when the sensor senses white surface, the microcontroller gets 0 as input and when senses black line controller gets 1 as input.

A. Circuit Diagram and Working Explanation

We can devide the Edge Avoider Robot project into three different sections that are sensor section, control section and driver section.

Sensor section

This section contains IR diodes, potentiometer, Comparator (Op-Amp) and LEDs. Potentiometer is used for setting reference voltage at comparator's one terminal, and IR sensors are used to sense the line and provide a change in voltage at the comparator's second terminal. Then comparator compares both voltages and generates a digital signal at the output. Here in this circuit, we use two comparators for two sensors. LM 358 is used as a comparator. LM358 has inbuilt two low noise Op-amp. Control Section: 8051 microcontrollers are used for controlling whole the process of the line follower robot. The outputs of comparators are connected to PIN P0.0 and P0.1 of 8051. 8051 reads these signals and send commands to the driver circuit to driveline follower.

Driver section

The driver section consists motor driver and two DC motors. The motor driver is used for driving motors because the microcontroller does not supply enough voltage and current to drive the motor. So we add a motor driver circuit to get enough voltage and current for the engine. The microcontroller sends commands to this motor driver, and then it drives motors.

A. Working

Working of this edge avoider robot is quite exciting and the same as line follower but the difference in the operations after sensing inputs. In this robot, when it senses a white surface, it goes forward, and when any one of the sensors or both sensors sense no signal or black surface, it gets to stop and move backwards and change its direction and if again, it senses a white surface, then go forward.

The circuit diagram is shown for this edge avoider robot. The output of comparators is directly connected to PIN P0.0 and P0.1 of the microcontroller. And motor driver's input pin 2, 7, 10 and 15 are connected at PIN P2.3, P2.2, P2.1 and P2.4, respectively. And one motor is connected at the output pin of motor driver 3 and 6, and another motor is connected at 11 and 14.

In programming, first of all, we have defined input and output pins. And then, in the primary function, we checked inputs and sends output accordingly to output pins for the driving motor. There are four conditions in this edge avoider that we read by using the 8051 microcontroller. We have used two sensors namely left sensor and right sensor.In table 1 the sensor list clearly mentioned.

Table 1: List of Sensors

Input		Output				Movement Of Robot
Left Sensor	Right Sensor	Left Motor		Right Motor		
LS	RS	LM1	LM2	RM1	RM2	
0	0	1	0	1	0	Forward
0	1	1	0	0	0	Stop/back/Turn Right
1	0	0	0	1	0	Stop/back/Turn Left
1	1	0	0	0	0	STOP/back/turn left

IV. PROPOSED SOLUTION

A new approach to guide the robot when avoiding obstacles is now proposed, whose essence is to choose a escape path that is tangent to the obstacle boundary. The control system based on this approach uses the same position error controller as the impedance-based control system, which corresponds to the inner loop in Figure 3 (see Figure 8). The difference is that the rotation angle φ in (8) is 0not calculated using the repulsion force anymore. Instead, it is calculated by using the angular position of the obstacle relative to the robot, which is determined by the position of the sensor that gives the least range measurement, regarding a set of sensors able to perform range measurement, as a laser scanner, for example. The rotation angle is now determined so that after maneuvering the vehicle takes the direction of the tangent to the boundary of the obstacle in that point. The advantage is that the robot performs smoother movements when navigating, as it is shown in the sequence. Therefore, whenever an obstacle is detected inside the repulsion zone defined by the distance dobs (see Figure 7), the angle β is determined from the range measurements provided by the onboard sensing system. Such an angle is defined by the direction in which it was gotten the minimum range measurement and is related to the characteristics of the sensing system. For example, if the sensing system is a ring of ultrasonic sensors, such an angle is obtained from the disposition of the sensors in the ring concerning the axis of movement of the robot. Knowing the robot orientation relative to the actual target (the angle α) and estimating the angle β, the angle φ that allows the tangential escape is obtained as

$$\varphi = sign(\beta)\frac{\pi}{2} - (\beta - \alpha), \qquad (10)$$

where α > 0 when the obstacle is at the right of the axis of movement of the robot and β > 0 when the block is detected at the right side of the robot. In this configuration, which is depicted in Figure 7, the angle φ is positive, meaning that the real goal is rotated to the left side, regarding the axis of movement of the robot.

The angle φ is then used in the rotation matrix in (9), and the real goal is rotated to a new position (the virtual purpose). The position error controller starts using the coordinates of the virtual target, causing the robot to take the tangent to the obstacle boundary. Notice that in the absence of obstacles, there is no change in the position of the real goal, and the robot continues seeking it. A control system implementing the tangential escape approach is sketched in Figure 8, where u, ω and the vector c have the same meaning as in Section 3. This way, regarding the asymptotic stability of the position error controller, it is straightforward to conclude that the control system implementing the tangential escape is also asymptotically stable, which guarantees that after escaping all obstacles, the robot always reaches its goal (supposed to be reachable).

The evaluation process means how the control system based on the divergent escape approach performs; a simulated example explained in this paper. The objective is to take the robot from the starting point (0 mm, 0 mm) (with orientation Ψ = 0 degrees) to the goal point (9000 mm, 5000 mm) once more, avoiding any obstacle in its path. Notice that this is the same example simulated using the impedance-based control in Section 3, and the walls of the three corridors are the obstacles to be avoided. Figure 9 shows the path the robot travelled over to reach the goal. Whenever an obstacle (a wall of a corridor the robot entered in) is detected, the robot turns around in order to follow a line parallel to it. The distance dobs that defines the repulsion zone was defined as 70 cm once more. Complementing the simulated example, Figure 1 shows the linear velocity developed by the robot along its path, while Figure 2 shows its angular velocity.

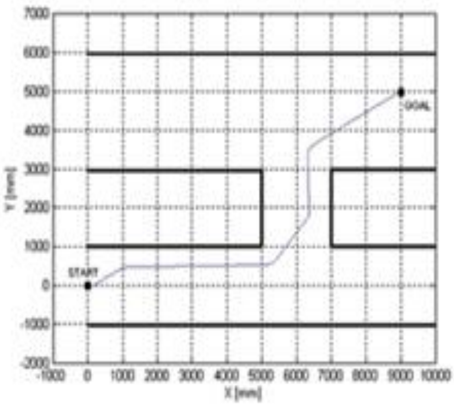

Figure 1: The linear path the Robot travels in tangential approach

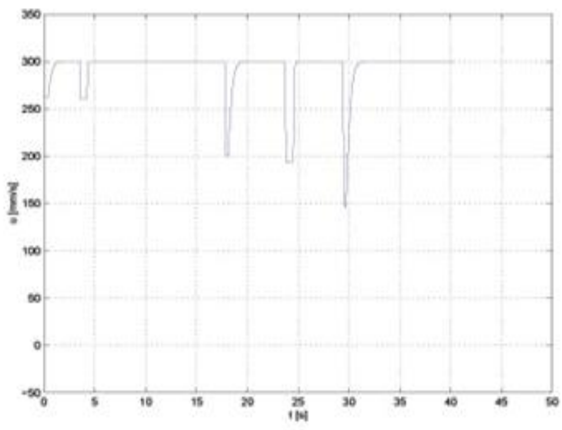

Figure 2: Angular Velocity based Robot Escape path

V. CONCLUSION AND FUTURE SCOPE

In this research paper, an obstacle avoiding robot is developed by the authors. The robot is capable of detecting and avoiding obstacles in its path. The Arduino platform is used for data processing, and the related software counterpart helped communicate with the robot to send parameters for guiding movement in the developed robot. Three ultrasonic distance sensors were used for obstacle detection. These sensors also provided a wider field of detection. In this way, the authors have developed a fully autonomous robot, and it is capable of performing all the operations without user intervention. When placed in an unknown environment with obstacles, it moved while avoiding all obstacles with considerable accuracy. As future work, authors have planned to install cameras to detect the block. Another way we can get clear and fast pictures from the CCD or industrial use ones. Even the ones we mentioned in the camera holder part will be better because of the particular software.

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