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LINE FOLLOWER CARGO-BOT FOR WAREHOUSE AUTOMATION

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Abstract - *This Paper describes the line following algorithm for enhancing the transportation of necessary materials inside the logistics industries, warehouses. Every single activity related to the warehouse would be performed without any human intervention. The proposed system spots the black path and nodes to proceed in a direction of short distance on to the ground . This system eases the work of material conveyance as well as minimizes the manpower. This technology targets on the secured, punctual and constructing transportation of goods. This paper aims to implement controlled movement of robots by tuning control parameters and thus achieve better performance. This robot is predominantly designed to proceed in a predefined path. Robots like this are mainly used in industrial plants consisting of pick and place facilities. This robot carries components from desired source to destination by following a fixed path. Recently a lot of research has been done to empower the automation in industries. This robot is made to supply the essential goods.This paper is divided into hardware and software modules.*

Key Words: Path Planning, V-REP Simulation, *ATmega2560,* IR sensor, Automation, Line Follower

1.INTRODUCTION

A warehouse is a facility that basically deals with a planned space for efficient storage and handling of goods and materials, handling equipment and personnel and management resources. Usually, these flows are not coordinated, and this is one of the reasons why it is important to have storage facilities.
The warehouses around us are human dependent for every operation, from transporting the boxes to maintaining records,there are many tasks like loading heavy or harmful substances. However people get tired or take breaks and leave, thereby affecting its functioning. Also human errors become a plausible parameter for its malfunction. A small mistake in the warehouse inventory would result in huge problems, as finding the particular box in such a large, is close to impossible. A solution to these problems would be an autonomous line follower robot. Autonomous robots are independent of any controller and can act on their own. Obstacle avoidance is implemented as a reactive control law whereas path planning involves the pre-computation of an obstacle free path which a controller will then guide the robot along to respond in a particular way to an outside stimulus. The robot uses sharp sensors to detect obstacles. When the robot is turned on, it moves in a straight direction , and when it hits an obstacle, sharp will give us the distance between objects and obstacles. The robot gives a programming instruction that asks the robot to back up, turn to the right direction and move forward. In this way, the robot can change direction every time it encounters an obstacle. The Dijkstra algorithm is used here to find the shortest path where it can quickly act on the pick and place of materials from one place to another.
This is the era of technology and automation. If automation is brought to Industry then it will be far effective. Automation can be introduced in Industry by the application of line following robots where instead of workers, robots navigate the area, thereby improving upon the speed and efficiency of the warehouse and reducing or rather eliminating possibilities of errors. This kind of robot has advantages such as fast service, available 24x7, more reliable, more efficient. It will also ensure safety of humans.

2.LITERATURE SURVEY

In recent years a great deal of time and effort has been spent on developing systems to enable an autonomous to follow the shortest path. In the past few years, researchers and engineers have applied the two wheels balancing model to various fields, which include walking gait for humanoid robots, personal transport systems and robotic wheelchairs. The robot created a new sensor system and algorithms to make robots more perceptive and smarter. Today robots are able to effectively navigate a variety of environments.

Some mobile robots also use various ultrasound sensors to see obstacles or infrared. These sensors work in a similar fashion to animal echolocation. The

robot sends out a beam of infrared light or a sound signal. It then detects the reflection of the signal. The robot locates this distance to the obstacles depending on how long it takes the signal to bounce back. This kind of robot was earlier designed for automation in healthcare industries. With advancement in technologies, this kind of robot is used in Warehouse management.This paper aims to provide a deep insight about the autonomous line follower robot which is independent of any controller and can act on its own.

3.METHODOLOGY

The research projects are divided into tasks, each recording a chronological step in the process of developing and structuring the bot. This approach was utilized in an attempt to progress the project from one stage to the next as it was undertaken. Each is clear so that it builds on the preceding task thus evolving the robot within the goals and requirements generated. This eventually led to the completion of the bot that met the objectives within the timeframe available.

3.1 Task 1 formed the first step where key points and objectives were established including the idea. Understanding about this project is critical in determining plans for conducting research and performing the design work and after that robot is designed to run in a specific track to check the line follower

3.2 Task 2 provides the second step, choosing path manually. It entailed the software review with a line following algorithm. The line following feature for bot is based on 3 infra-red sensors and the line follower programming algorithm that was designed. This task is done in V-rep(Simulator) to check its working.

3.3 Task 3 is working with the robotic arm. The robotic arm is designed to place the object at different heights without colliding other surfaces.

3.4 Task 4 is combining all components. This also provided the opportunity to calibrate and perform additional fine tuning of the output allowing it to become more effective and efficient in its performance.

The final component comprises a complete assessment of each process undertaken, the choices made and achievements obtained during the project as well as evaluation of the final bot effectiveness.

4. MATERIALS USED

1.WHITE LINE SENSOR- The sensor is used for differentiating between white and black it gives the analog values accordingly.used or line following. It will be placed on the down side of bot. Its output will be given to the microcontroller and based on this the microcontroller will give output to motors.

2. SERVO MOTORS- It will be used in making the arm mechanism to pick and place the construction materials . It can also be used to rotate sharp sensors.

3. MOTORS- The motors with quadrature encoder are used to move the bot to different places and encoder can be used to calculate the distance that how much the bot moved between two points and we can use those values in path following algorithms.

4. LCD - It can be used for user interface so that the person can see whats the present status of bot. By which we can debug it easily.

5. Sharp Sensors- The sensors are used to detect the distance between them and objects. In our theme these are used for wall following so that bot don't collide to wall.

6. Atmega2560 development board- The board is used to take input from sensors and to give outputs to various parts based on the program we have uploaded on it. The board is used in various embedded applications.it has all pins in port wise configuration.

7. L298N Motor Driver- The l298n is a high powered motor driver used for controlling direction and speed of motors based on input it gets from a microcontroller. It will be used to make bot move left ,right , straight, reverse so to follow the line correctly.

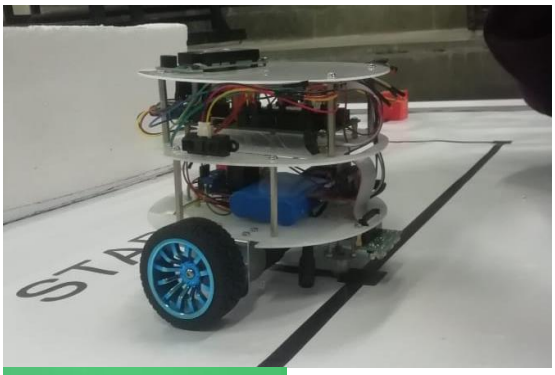
8. Battery- The Li-Ion 2200MAH 11.1V 2C is a light weight , small size, long life ,high current supply, rechargeable battery.it will be used to give power to all components in the bot so that all components function properly.

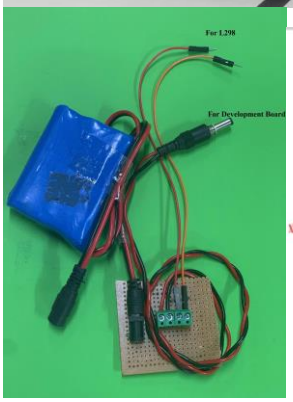
9. Buzzer Module - A buzzer is a device which makes a buzzing or beeping noise.The buzzer is used for indicating the task is completed by beeping for 5 second.

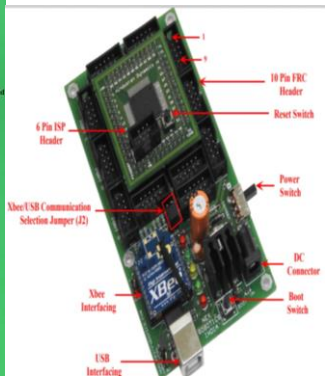
10. Caster wheel - a caster wheel is a type of single wheel which is placed at bottom of object to make that object move easily in any direction.in our design we have used 2 caster wheels one in front side other at back side and 2 wheel in centre.

11. STK 500 - it is used to burn the hex file in a microcontroller.

12. 6 to 10 ISP converter - It is used to make connection between STK 500 and microcontroller

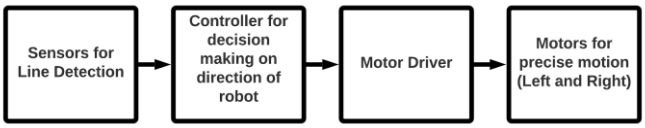




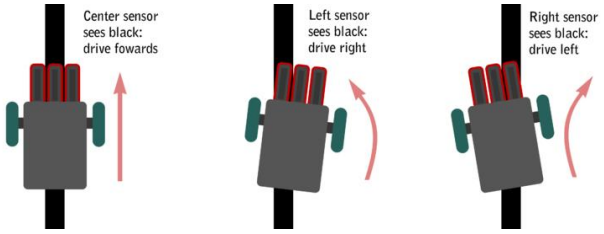


5 BLOCK DIAGRAM AND ITS EXPLANATION

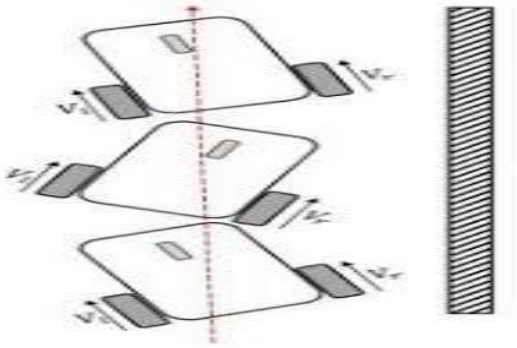
5.1 LINE FOLLOWING



The Robot gets sensor data reading in analog values based on white surface or black surface. Then according to the readings given by sensors the atmega 2560 microcontroller controls motors speed and direction. There are basically three IR Sensors namely Left Sensor,Middle Sensor,Right Sensor.As a black line follower ,the robot will move forward when the middle sensor is on black and other two on white, the robot will move left when the left sensor or middle sensor is on black and right sensor on white,it will move right when the right or middle sensor is on black and left sensor on white . when all three are on black it detects the nodes.
The bot can also follow the WHITE line just all the conditions are reversed for the same.

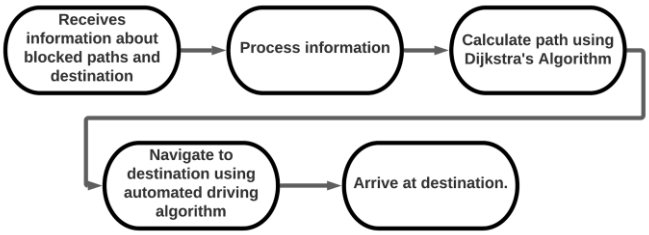


5.2 WALL FOLLOWING



The robot will detect distance from both left and right wall using SHARP sensors and the microcontroller will try to give the speed to the motors accordingly to keep the robot in the middle and make it move forward at the same time . if the distance from left wall is less the bot will try to move to right and if the distance from right wall is less the bot will try to move to left .

5.3 PATH PLANNING

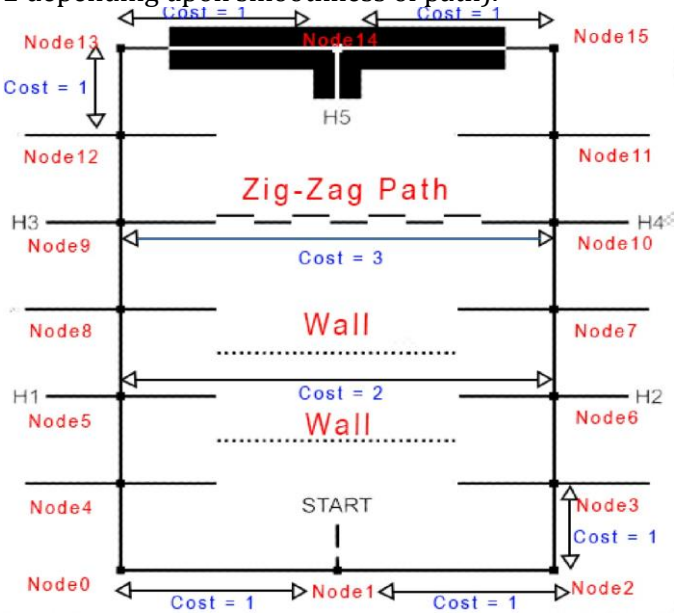


For path planning, we are using Dijkstra's shortest path algorithm by dividing the whole frame into the Nodes. We have divided the whole frame as graph nodes. For going one node to another node , we are giving the address/ indexing of that node to the Dijkstra algorithm and it is returning us shortest path between those nodes ,so that overall cost will be less and less time will be taken to reach the goal.

6. WORKING:

In V-REP Simulation ,We have given an arena with paths between the nodes.

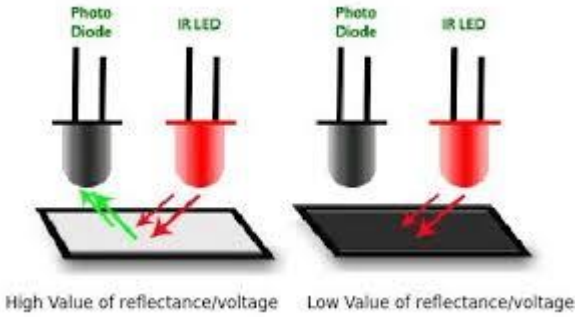
As depicted in the image , we have divided the whole arena into 16 Nodes (Counting from 0 to 15) and stored their cost with each other in 2D array. (eg: for node 0 to 1 cost is 1 unit and for node 9 to 10 cost is 2 depending upon smoothness of path).



For the current direction of the bot , we are using the Four variables i.e left, right , down , up. If left is 1 and rest all are 0 , it means the front face of Bot is in the left direction.

As we have given start and ending node position. We will use the Dijkstra algorithm for finding the shortest path with minimum cost and with the help of Traversal function(Move left by 90, Move right by 90 , Move forward etc.) We will give instructions to bot for travelling on the path given by our algorithm. Basically the path between any two nodes may be black line,white line , zig-zag path, two walls or empty. For following the path , we have implemented the line and wall following algorithm.which is defined below:

Line Follow: IR Sensors are used to identify the line. For line identification logic, three IR Sensors with IR LED and photodiode are mounted.The light emitted by IR LED will be detected by photo diode, whenever they come near to a reflective surface.



As the reflecting percentage of the light color surface is high, the infrared light emitted by IR LED will be maximum reflected and will be recognized by the Photodiode. The light gets completely stopped up by the dark black surface and finds it difficult to reach at photodiode due to low reflectance. By the identical mechanism, we set up the IR Sensors on the Line Follower Robot such that the three IR Sensors are on either side of the black line on the floor. When the robot moves forward, both the sensors wait for the line to be detected. Consider this, if the IR Sensor RM identifies the black line, it signals that there is a right curve (or turn) ahead. .The robot turns left, if the motor on the left side of the robot is slowed down (or can be stopped completely or can be rotated in the opposite direction) and the motor on the right side is run at original speed, this same is applicable for right turn. Likewise, when the IR Sensor RM or LM identifies the black line first, it indicates that there is a right curve or left curve ahead and the robot has to turn right or left respectively.

Wall Follow: In order to follow walls, we need at least two sensors to handle the four potential situations the robot could be in. Sensor has to be on the left or right side of the robot. The more sensors we use, the more information we have, so we can make better judgements about what is going on. For this example, I just used two. The robot cannot find the wall, so we have to place the robot next to the wall. If we placed it in the middle of the small room, it would just drive in circles.

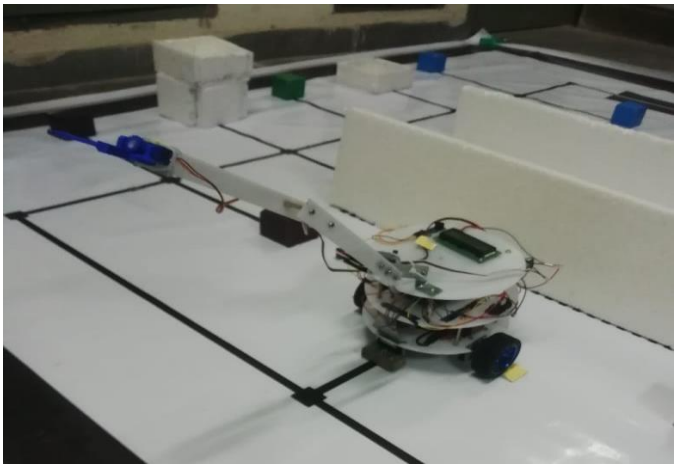
GP2Y0A21YK0F is an Infrared distance measuring sensor unit capable of measuring distance from 10 to 80cm.

It is composed of an integrated combination of PSD (position sensitive detector), IRED (infrared emitting diode) and signal processing circuit. The variety of the reflectivity of the object, the environmental temperature and the operating duration are not

influenced easily by distance detection because of adopting the triangulation method.

Left Sensor	Right Sensor	Situation	Action
Off	Off	Robot is driving away from the wall.	Move Forward
On	Off	There is a wall on the left side of the robot.	Turn hard right to get back parallel with the wall.
Off	On	There is a wall on the right side of the robot.	Turn hard left to get back parallel with the wall.
On	On	The robot is in between the walls .	Move forward.

Pick Place: It is usually mounted on the top of the robot to achieve maximum height for pick and place. Here is the pic of our actual robot with a robotic arm mounted on it. It is consisting of 3 servo motors.
Servo motors are part of a closed-loop system and consist of several parts namely a control circuit, servo motor, shaft, potentiometer, drive gears, amplifier and either an encoder or resolver.
A servo motor is a self-contained electrical device that rotates parts of a machine with high efficiency and with great precision.
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.
The controller is the most important part of the Servo Motor designed and used specifically for this purpose.



6. ALGORITHM

6.1 LINE FOLLOWING ALGORITHM

For Black line following	For White line following
1. START 2. Read LM,MM and RM For Black Line following 3. If LM and RM are both on white surface and MM on black . 4. Move forward (rotate both motor on full speed) 5. Go to step-2 6. If LM or MM on black line 7. Move left (reduce left motor speed to half) 8. Go to step 2 9. If RM or MM on black line 10. Move right (reduce right motor speed to half) 11. Go to step 2 12. If LM and RM on black line 13. Node detected 14.Go to step 2	1. START 2. Read LM,MM and RM For Black Line following 3. If LM and RM are both on Black surface and MM on white . 4. Move forward (rotate both motor on full speed) 5. Go to step-2 6. If LM or MM on black line 7. Move right (reduce right motor speed to half) 8. Go to step 2 9. If RM or MM on black line 10. Move left (reduce left motor speed to half) 11. Go to step 2 12. If LM and RM on white line 13. Node detected 14.Go to step 2

6.2 Dijkstra's shortest path algorithm:

We are using this algorithm to find the shortest path from a single source vertex to all other vertices in the given graph.

Steps for Finding are :

1) Create a set S (shortest path tree set) that keeps track of nodes included in the shortest path tree, i.e., whose minimum distance from source is calculated and finalized. Initially, this set is empty(no element in set).

2) Assign a distance value to all vertices in the input graph. Initialize all distance values as INFINITE(or any higher value). Assign distance value as 0 for the source node so that it is picked first.

3) While S doesn't include all nodes

a) Pick a node 'u' which is not there in S and has minimum distance value.

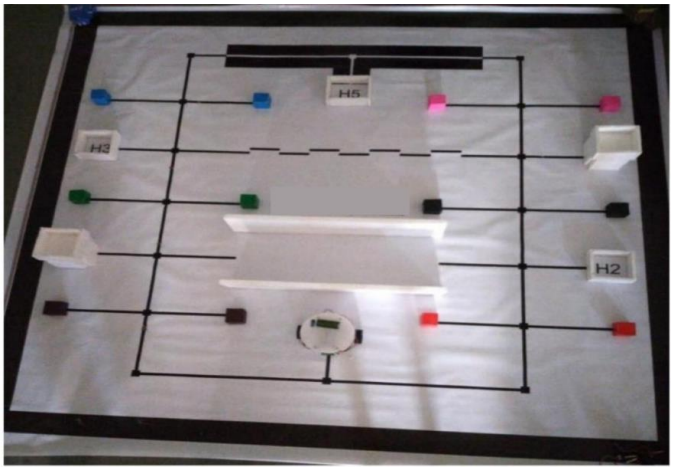
b) Include 'u' to S.

c) Update distance value of all adjacent nodes of 'u'. To update the distance values, iterate through all adjacent nodes. For every adjacent node 'v', if the sum of distance value of 'u' (from source/initial) and weight of edge "u-v", is less than the distance value of 'v', then update the distance value of 'v'.

7. RESULT

The final result of our project is to traverse the arena and perform pick and place of two Construction.
Materials (CMs) to the designated Houses as per the Configuration Table and
Configuration Image.
Procedure:
1. Setup the arena as shown in Figure.
2. Keep the robot at the START position.
3. Program the robot to perform the specific task.
4. Beep the buzzer with the starting and ending of the task.
5. The end will be at the beginning position.

House		Construction Materials	Required
H4	high-rise	Brick	
H2	low-rise	Cement	



SR NO.	TYPE OF PATH	Behaviour
1.	Straight Line	Works fast at maximum speed possible easily detects node
2.	White line follow	Speed reduced upto 75% detects node correctly and follows line effectively
3.	Zig-Zag	Speed is very very slow but follows line correctly and difficulty in node detection
4.	No line only wall follow	Speed reduced to 50%, No node detection until a black or white line is identified before node. Easily avoids the wall.

8. FUTURE WORK

Construction Industry- Automation Technologies can be used in a better way at construction sites that will improve the quality of work, safety improvement, time saving and high productivity of work.

Better power management System : The current power management system with 11.1 v can be replaced by a rechargeable battery for working long hours without breaks.

Loading and Unloading of materials: Here, the idea is to form an efficient automated warehouse system, if the robot fails to load or unload the desired carton.It is important to design a perfect mechanism, such that every carton is loaded and unloaded with precision and no carton gets destroyed in the process. All these operations have to be interfaced together forming the project with a fully automated warehouse system.

Application for requirement: An automated app has to be developed to check how much and which type of material is required by the destination place as we are doing this manually for now.

9. CONCLUSION

This proposed system when practically implemented allows us to find the shortest path from source to destination by calculating minimum cost between each node, the system also avoids obstacles if any, also picks the material from the given destination and drops to the destination where the material is required. Since it is a prototype, The current speed of the robot covers around 1m in 10 seconds and can pick a load not more than 100g and can work upto 30-45 mins continuously. Obstacle avoidance is implemented as a reactive control law whereas path planning involves the pre-computation of an obstacle free path which a controller will then guide the robot along to respond in a particular way to an outside stimulus. When it will be actually implemented in real time, there will be less practical errors and can be solved with better components and more time .Once it is fixed it will be a helpful application for automated warehouses and can also work for construction sites for delivering goods from one place to another.

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