Design of Robotic model using white line senor based autonomous carrier robot in Industrial Applications – Task and performances for validation

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Abstract. The Robotic Prototype applies line following algorithm using white line sensor to follow a predefined map. Theme of the performed robotic prototype is to be implemented in production environments to perform repetitive and recurring tasks. In the present work, the robotic prototype designed to follow a line to perform tasks and also to decipher and detect the possibility of any unpredictable non-static obstacles in its path programmed to maneuver the obstacle by finding other possible shortest paths to reach the destination. Some of the tasks performed are pick and place objects at multi-elevation from pre-defined locations. retrofitting and validation were done for the simulation in reality to solve tasks and challenges in industrial applications for the chosen application in production line and mobilization.

Keywords: Autonomous carrier · Industrial application · Robotic prototype · Real model · Validation

1 Introduction

There exits many of the gaps and needs to be fulfilled on the automation of various components and its functions in sectors like health and industrial operations. Primarily, in productional environments, the need for transportation for small parts in large quantities within the premises are tremendous. At present, the problem is solved by the humans and as this task is simple, low-value task and repetitive for humans which leads to lose their concentration while performing tasks which leads further to increased human error. Over 40% of works surveyed at least a quarter of their work week on repetitive tasks. Almost 90% of accidents that occur in workplace are due to human error [1]. According to survey, by introduction of automation for daily work will reduce the number of productivity-killing tasks and reduce wasted time by an appreciable percentage and to eliminate human error and the repetitive work can be automated by 30% by early 2020s to increase efficiency [2].

Automation is essential in other sectors namely health sectors where Healthcare-Associated Infections (HAIs) are the infections, people get while they're receiving heath care for another condition. According to reports from Centres of Disease Control and Prevention (CDC) taken on 2015, 4% of hospitalized patients are infected with one or more HAI [3]. There were an estimated 687,000 HAIs in U.S. acute care hospitals in 2015 [4]. Although significant progress has been made in preventing some HAI types, there is much more work to be done, CDC says. Continuing the efforts to solve the existing Problem, it is evident to sanitize the contaminated environmental surfaces frequently to avoid cross-transmission of pathogens. Herein the introduction of autonomous robot with line following mechanism to sanitize contaminated surface algorithm is beneficiary for the prevention and control of HAIs and also with expected frequent movement in the Hospital area, obstacle detection algorithm is implemented.

2 Methodology

2.1 Problem Definition

Theme of the performed robotic prototype is to be implemented in Industrial Areas or Production environments to perform repetitive and recurring tasks. The robotic protoytpe follows a line to perform tasks and also it is designed with possiblity of any unpredictable non-static obstacles in its path and it is programmed to manoeuvre the obstacle by finding other possible shortest paths to reach the destination. Some of the tasks performed are pick and place objects at multi-elevation from pre-defined locations.

2.2 Constructions Equipments of Industrial Robotic Model

1. *Atmega 2560 Development board* - It is a microcontroller of AVR family .It is the mind of robot .It takes the input from sensors and processes it and control the actuators (DC motor and servo motor).
2. *L298N Motor Driver* - It is used for controlling speed and direction of the motors . The function of this IC is to provide the required amount of current to the DC motors which the development board can not provide as the current provided by the board is too low.
3. *Line following sensor/ white line sensor*- This sensor used to detect black /white line . It consist of 3 pairs of transmitters and receivers.
4. *Sharp/proximity sensor* - This sensor used to detect obstacles placed close to the robot.
5. *Servo motor* - It is a rotary actuator for precise control of angular position , velocity and acceleration.
6. *Geared DC motor with Encoder* - Motor is used for movement of bot . The attached encoder is used for measuring the speed and direction of a rotating shaft and keep track of how far the bot has moved.

2.3 Mechanism and Conf1igured Sensor

The Robotic Prototype applies line following mechanism using white line sensor which has several advantages over 3d modelling the environment using Lidar, Radar or Camera those are reduced robot cost and advanatges of precise well defined Path which is easy to program and reduced Validation Period for the robotic model. Some of the Major Advantage of sharp (proximity) sensor over radar is limited data is processed which led to least processing time, while the disadvantages of sharp (proximity) sensor are unreliability to harsh conditions like natural calamity which is unapplicable to a closed production facility. Some of the advanatage of servo motor over stepper motors is the ability to provide high torque at high speed.

2.4 Configuration and Working Scheme

The practically-deisgned field applicable model described is an autonoumous decision making robot can detect obstacle and has a capability to manuer the obstacle by itself. And the following model is designed to folow a line with a white line sensor (Fig. 2) which has the capability to distinguish between white and black color. The model is modeled as an low-cost robot, for which minimum of 2 motors are required and a castor wheel. The all the sensors and the motor driver are connected to a Atmega Development Board. The purpose of the board is to take input from all the sensors of any current scenario and process the data to provide command to the DC motors (Fig. 1) and it is a microcontroller of AVR family. The motors are not connected to the Atmega Development Board because of the lack of ability to provide sufficient amount of current to DC motor to change speed, so motors are connected to the motor driver for controlling speed and direction of the motors. The sharp/proximity sensor (Fig. 3) is placed in the rear end and front end of the robot to detect obstacle during any of its operation.

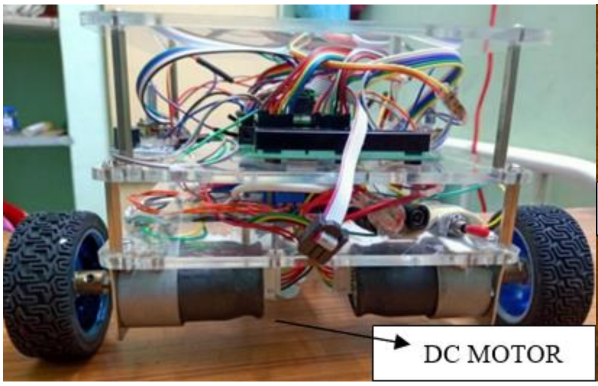

Fig.1. Rear View of the Robot

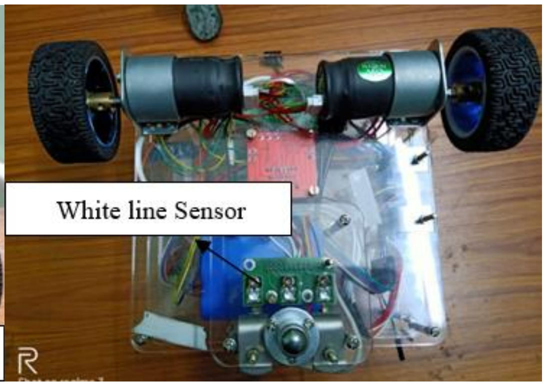

Fig. 2. Bottom View of the Robot

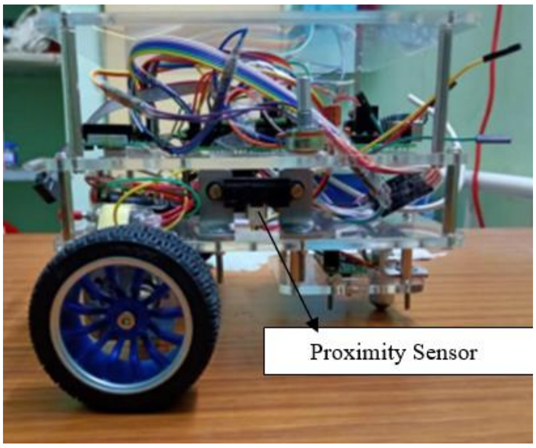

Fig. 3. Side View of the Robot

2.5 Configuration of Accessory and its Applications

The model then is connected to an accessory depending on the purpose of the robot, primarily for the purpose of robots to pick and place materials (M, as referred in functional layout) in Productional line, a robotic arm is introduced in system. Secondarily for the purpose of sanitization in health care facilities an accessory is attached consisting of a sprinkler connected with a sanitizer container, which sprinkles sanitizer in surrounding of the robot when the bot is in motion along its path.

Elaborating further about the Production line model, the robotic arm consists of 2 servo motors. One Servo motor is used for gripper where it is directly connected to one of the gears (Fig. 4) and controls the rotation of gears thus controlling the opening and closing of the gripper. Second Servo motor (Fig. 5) is for arm movement where the servo motor controls the angle which the arm makes with the horizontal. The arm is mounted in front of the robot (Fig. 6).

Reasons of Mounting Locations of the Arm in the Bot

- Placing the arm at the front reduces the arm length and reduced quantity of construction material required because of which cost is reduced.
- For better stability of the robot placing, the robotic arm is placed at front as it acts as a counterweight to the two heavy DC motors at the back to avoid toppling.

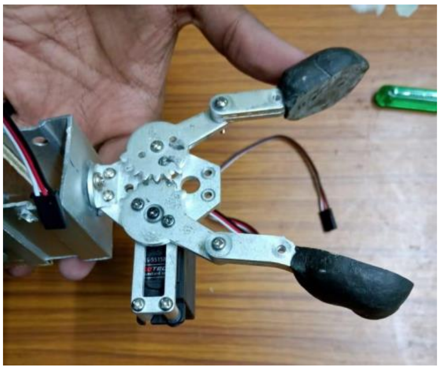

Fig. 4. Gripper Model

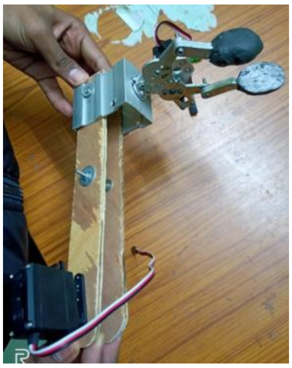

Fig. 5. Robotic Arm

Fig. 6. Robot in the Field

3 Industrial prototype maps

The map is a prototype for this problem statement and this prototype (Fig. 7) is designed to mimic of Industrial environment to pick and place objects from different locations with multiple junctions is the map. Also, the considering the necessity to pick and place the Materials (M) at different elevation.

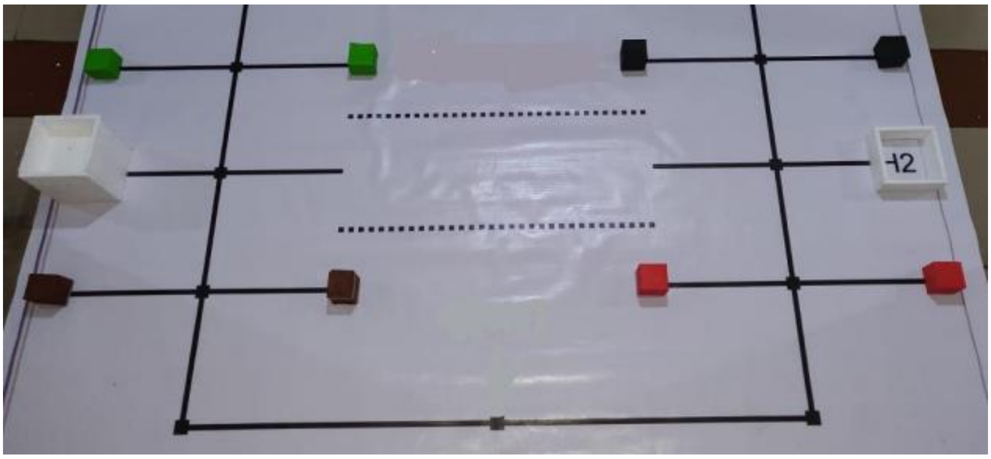

Fig. 7. Industrial Prototype Map captured in reality

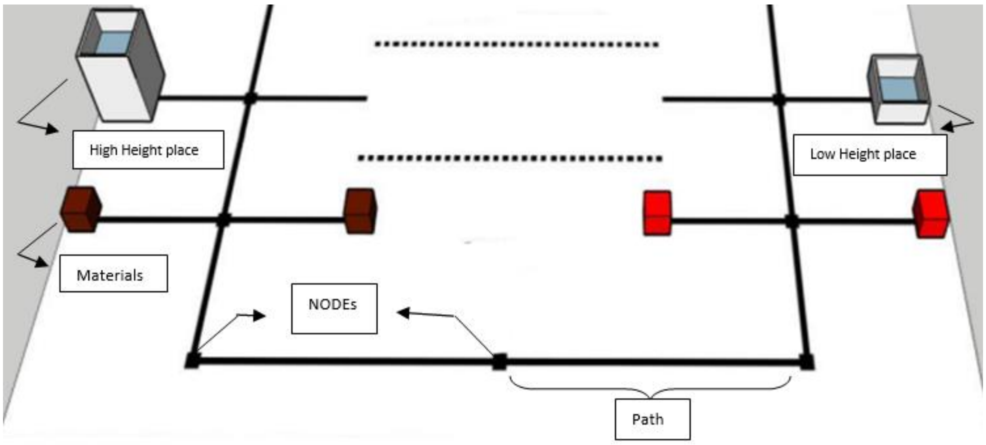

Fig. 8. Prototype Map (Animated model)

3.1 Typical Functional Layout of the Prototype Map and its Target (Fig. 8)

Materials (M). These are the objects that needs to be transported. These are cubic shaped boxes.
Place. The place where the Materials (Ms) are delivered. There are 2 types of Places: low height place (LHP) and high height place (HHP) consisting of different heights for Delivery for the materials (Ms).
Path. Paths are the one way path for the robot to travel. Here the Black line is very thin so that the white line sensor detects only one Black line in any one of the receiver among 3 receivers.
Node. They are Junctions on the map where Robot can change directions to reach destiny. The Node is 3 times thicker than the Path, so the notable change in sensor reading is that white line sensor detects black line on all 3 recievers.

3.2 Retrofitting problems faced

During the simulation in reality there were several challenges faced those are,
Challenge 1. Due to increased vibration and shivering of robot during fast movement, misorientation of the gripper before picking the material (M) is possible, so there is possibility that gripper won't pick the material (M) during simulation in reality.
Solution 1. By Increasing the contact-surface area of the of gripper. (Fig. 5 & 6)

Challenge 2. Our robot is of 15cm height and in order to pick up the material (M) from 3cm height
Solution 2. The problem requires an L-Shaped arm or 2 Movable links which consists of 2 servos for arm and 1 servo for gripper, an L-shaped arm was chosen considering cost-effectiveness with better problem-solving with limited time. (Fig. 5)

Challenge 3. During the process of Placing the material (M) in High-height place (HHP), following challenge is to differentiate the elevation of place where the material (M) is to be placed.
Solution 3. As a Map of the Industrial place is assumed to be fixed, the solution is to save the elevation of House it has near that NODE in the Map of the algorithm.

Challenge 4. Initially, The LCD display was used to display the all-sensor readings to calibrate the algorithm of the robot, the major requirement was to extract maximum number of sensor data as possible to simulate the model smoothly, which was not possible with LCD display used in the model because the LCD display took extra milli seconds to display the sensor data. So, the limited amount of sensor data was feed-ed to the algorithm which led to improper line following and improper rotation of the robot at the Junction/Node of the map.

Solution 4. In order to solve lag time provided by LCD display, it is evident to exclude the display. Thereby to display the sensor data for calibration for algorithm, serial communication was established using Tera-Term to log data via serial port which provided negligible lag issues resulting in extraction of maximum number of sensor data.

Challenge 5. Some of the issues were found with Sharp line sensor, when sensor detects black coloured line then the extracted sensor data is dependant of the battery charge. So different set of data were noticed with maximum and minimum battery level of the robot which led to calibrating issues

Solution 5. The challenge is then solved with 3 set of calibrated values dependant of battery level of the model after various simulation by trial-and-error methods.

4 Conclusions

The following are the conclusions derived out of the present study as under

1. The Robotic Prototype, machanised with white line sensor based automative carrier was framed and applied for perfoming the chosen task in industry 4.0 application
2. Robotic arm tracing functional layout of the map to reach the target destiny was achieved through simulations fitted for its ultimate target.
3. An inbuild algorithm with simulation realising the obstacles and finding its shortest way to reach the destiny was demonstrated.
4. Retrofitting and validation were done for the simulation in reality to solve tasks and challenges in industrial applications for the chosen application in production line and mobilisation.

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