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A path finding mobile robot for industrial applications

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ABSTRACT

Robots are rapidly developing which replaces factory workhorses, which are physically bound to their manufacturing cells which comprise machines capable of performing challenging tasks in an industry. Mobile robots are most widely used in factories and other environments to execute a number of tasks involving transfer of some item from one point to another. The robot has to avoid various obstacles on its path. The objective of this work is to provide the basic concepts and algorithms required to develop a path finding mobile robots which work autonomously in difficult areas. A simple route tracing algorithm for mobile robot is proposed in this work so as to avoid obstacles on its path. The proposed route tracing algorithm is effective in terms of the shortest path as well as collision-avoidance of mobile robot. The proposed mobile robot may be employed in structured industrial environments and in unstructured environments such as defense, mining and super markets.

Keywords: Mobile robot; Obstacle avoidance; Path finding; route tracing algorithm

1. INTRODUCTION

Mobile robots move from one location to another location so as to perform various industrial tasks. Generally, the mobile robots are autonomous type which is capable of finding path by avoiding obstacles without the need of any direct contact or line following. Other mobile robots like automated guided vehicle (AGV) which uses guide devices that allow them to travel on a pre-defined path to execute planned tasks. There are other industrial robots which work in a fixed location, like pick and place robot consists of a jointed arm and gripper assembly. Similarly, autonomous mobile robots like aerial robot, under water robot, polar robot, floor cleaner robot and military robot are also exist. These robots are compelling not for reasons of mobility but because of their autonomy and their major ability to maintain a sense of position and to navigate without human intervention.

In present scenario robot navigation become a major focus on industrial robotics. Mobile robots are commonly used in factories and other environments to perform various tasks involving transfer of job from one location to another. The robot has to identify several obstacles along its path and avoid those obstacles. Several algorithms have been developed for planning paths for robots [1]. Earlier research on autonomous mobile robot attempted with the usage of ultrasonic sensors. The different echoes from each ultrasonic sensors mounted on the mobile robot detects the obstacles and help in tracing the require route. More the sensor more will be the complication of processing the data received from the sensors [2].

Further, the navigation system built on a mobile robot operating in a warehouse made attention on the sensory system used. A hybrid navigation system that combines the perception and dead reckoning introduced so as to get satisfactory operation. For this purpose a microcontroller system based mobile robot was introduced by earlier researcher to control the path of a robot. An algorithm, an encoder and few ultrasonic

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sensors were employed so as to achieve the desired route [3]. Also an environmental map based detection of the static obstacle positions on working area was used with an algorithm in a research work to guide the vehicle to a given target, an optimal path calculation [4] and few researchers attempted with rough terrain [5-6].

Several algorithms like A-Star algorithm, localization algorithm, mapping algorithm, local path planning algorithm and Enhanced D star lite algorithm have been developed for planning paths for robots [7-11]. Also heuristic-based algorithms for robot path planning which comprises neural network, fuzzy logic, nature inspired algorithms and hybrid algorithms were reviewed by earlier researchers so as to highlight the strengths and drawbacks of each algorithm [12]. These algorithms are attempted for the unknown obstacle shapes in the industrial area. So this work is attempted to develop a mobile robot which works on a simple algorithm to avoid different obstacles on its path.

2. METHODS AND MATERIALS

The mobile robot operates in a static indoor environment. The robot is equipped with three infrared (IR) sensors (one for front and the other two for sides). IR sensors are used since they are simple to construct, and they are relatively inexpensive. Obstacles are assumed to be stable and further, obstacles do not have any openings that may prevent reception of signal by the sensor device. Another assumption in which obstacles are isolated enough otherwise, energy signals may return from multiple surfaces resulting in wrong distance values. The algorithm starts with identifying the goal point and keeping the front side of the mobile robot towards it. When the robot front side is looking towards the goal, the algorithm give a forward motion commands from the ARDUINO UNO and the robot moves along the straight line to the goal until an obstacle is detected. It is assumed that the robot is equipped with a motor whose steps can be 'counted'. The algorithm takes as input the start point O and goal point G. It outputs a path to the goal or declares that the destination cannot be reached.

2.1. Step by Step Procedure of Proposed Route Tracing Algorithm

The specific steps of the proposed algorithm are as follows.

Step 1: Rotate the robot (if needed) to make straight (with front side), its direction towards the goal point.

Step 2: Move towards the goal point G. If the robot reached G then jump to Step 7 of the algorithm; else continue with Step3.

Step 3: If the ultrasonic sensor located in front side detects an object/obstacle (distance $< d$ cm, a preset value), turn the robot by 90° right side and move along the boundary of the obstacle keeping a safe distance from the obstacle using information from the second ultrasonic sensor located in other side. Start recording number of counts from motor.

Step 4: Follow the obstacle boundary until the robot meets the straight route to the goal G (from starting point O) again. If the straight route cannot be reached (assume other objects are present in the route), continue with Step 5. Else, robot track through a movable area towards the goal G. If the necessary goal G is reached then jump to Step 7 of the algorithm; else go back to Step 3 and repeat until required track is achieved.

Step 5: Suppose an object is detected (such that the robot cannot be reached the goal point G), stop the motor count and trace back (until robot reaches the first right turn by ninety degree) by decrementing the recorded motor count. Then proceed in the other direction (opposite side).

Step 6: Follow the obstacle boundary until the robot traces the straight route to G (from O). If the straight route cannot be reached (assume other objects are present on the robot route), conclude no route can be found and exit; else robot trace towards the goal. If the goal is reached, continue with Step 7. Else jump back to Step 3 of the algorithm and repeat until required route is achieved.

Step 7: Report the shortest path/route found and STOP.

The algorithm presented is similar to the well known M-line algorithm where the robot follows an object detected on its track and bound with free movable space until the robot reaches the M-line (equivalent to the shortest route to the goal). It is worth noting that recording of motor counts and using it to backtrack facilitates a hardware-efficient realization. Indeed the motor counts can also be used to follow the M-line even after an obstacle is encountered. No explicit calculation of coordinates of those points reached by the robot is necessary.

The proposed simple route tracing algorithm is illustrated for a mobile robot in Fig. 1. An initial assumption is made such that the robot front side is kept towards the goal point for simplicity. The starting (reference) point is *O* while the destination/goal is labeled as *G*. At *I*, the robot takes a right turn and reaches the point *J*. Thereafter, the mobile robot turns are at point *K*, *L*, *M*, *N*, *P*, *Q* as shown in Fig. 1. Three ultrasonic sensors on the mobile robot are labeled as *S*1, *S*2 and *S*3.

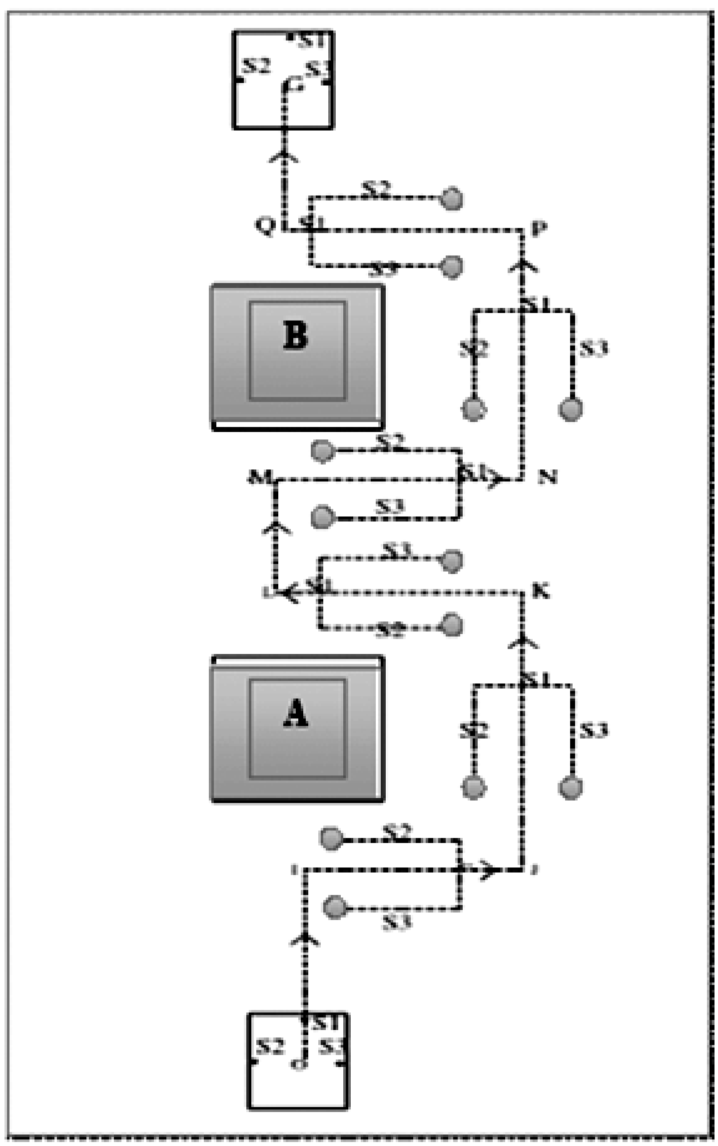

Figure 1: Robot route tracing diagram

2.2. Proposed Path Finding Mobile Robot

The route tracing algorithm is implemented through an ARDUINO UNO (micro controller) ATMEGA328 which requires electronics circuits for sensing, tracing and for motor actuation. The other key components are motor driver (L293D), voltage regulator, Battery (12V/7Ah), DC motor (150rpm) and IR sensors. The direction of motor is controlled by voltage change which rotate the motor shaft in clockwise (or) anticlockwise and gives the mobile robot direction.

In this work, the route tracing system built on a mobile robot is considered. Three ultrasonic transducers are used to measure and detect distances from objects/obstacles that are flexible to target materials, surface and color. These sensors have virtually unlimited maintenance-free lifespan due to that they are not affected by dust, dirt or high-moisture environment. The mobile robot resulted with a change of its path while it detects an obstacle [13]. The obstacle avoidance by the mobile robot controlled by route tracing algorithm is shown in the Fig. 2-5.

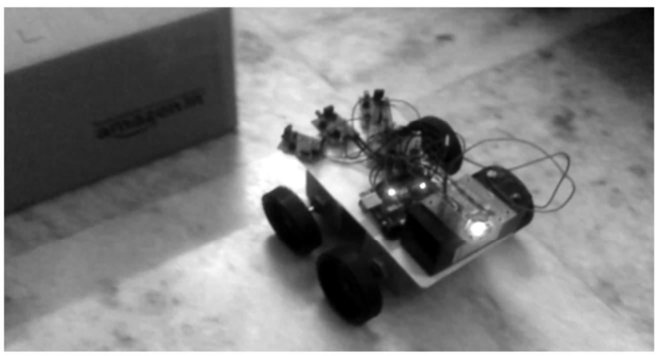

Figure 2: Initial position of the robot

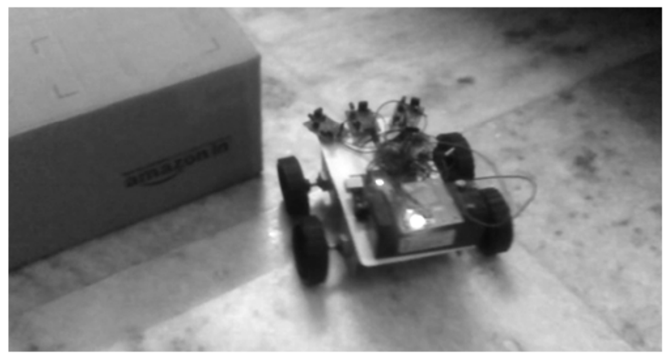

Figure 3: Robot taking right turn near obstacle

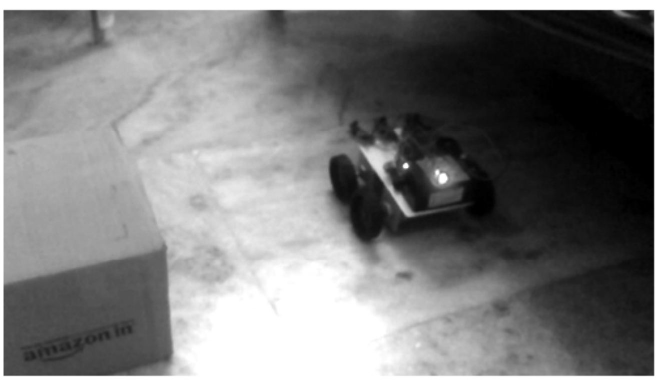

Figure 4: Robot moving forward after turn

Figure 5: Robot near the goal

3. CONCLUSION

In present industrial scenario, efficient path planning algorithms are required for the mobile robot parameters like path length or travel time, computation time required to find a collision-free route. The proposed route tracing algorithm is simple, effective and gives the shortest path as well as collision-avoidance of mobile robot. This type of mobile robots may be employed in structured industrial environments and in unstructured environments such as defense, mining and super markets.

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