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Heuristic Rule Base Network Path Analysis and Planning of Wheeled Mobile Robots

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Abstract

Autonomous wheeled mobile robot (WMR) path analysis and planning problem is an area of interest for the entire research community. Many authors have used different techniques to solve these problems. This paper presents an intelligent controller for solving the path analysis and planning problem of WMR in cluttered environment using heuristic rule base network (HRBN) technique. The proposed controller is applicable to plan an optimal path avoiding obstacles and reaching to target. This technique provides a general, robust, safe and optimized path of WMR. Simulation tests have been demonstrated to show the effectiveness of the proposed controller.

Keywords: Wheeled mobile robots; path planning; heuristic rule base network.

1. Introduction

A lot of research is going on around the globe to find a suitable intelligent control to be used for navigation of a mobile robot without human interaction. Navigation problem of an autonomous WMR is a one of the most important issue in the design and development of intelligent controller [1]. Path analysis and planning problem of WMR has found considerable attention over the past few years to improve their operational capabilities. A robotic system is an intelligent agent which is able for autonomous operations in known and unknown environments. Navigation of WMR is a challenging research topic for several reasons. First, a WMR should able to identify features, detect obstacles, patterns and target, learn from experience, find path and build maps, and navigate in environment for achieving the desired objective [2]. It is necessary to plan an optimal or feasible path avoiding obstacles present in its way depending on their task while an autonomous WMR decide to move towards the target.

Path planning and path optimization of WMR is basic area of research in an autonomous mobile robotics system. There are involving many things such as finding route and kind of movements of robot from the initial position of the robot to the target position, avoiding collision, shorter traveling time and more clearance from the obstacles [3-4]. Guzmanet et al. [5] presented interactive tools for facilitating and understanding of several well-known algorithms and techniques for solving WMR path planning problems.

They focused on describing problems in a simple manner in order to be useful for education purposes among different disciplines. Ge and Cui [6] have described the problem of goals non reachable with obstacles nearby when using potential field methods for WMR path planning and new repulsive potential functions. Santiago et al. [7] have presented a sensor-based path planner which results in a fast local or global path planning able to get the information and execute the desired task. For last several years, the scientists and engineers in the field of mobile robotics have extensively given attention for development of various control strategies for path planning problem of WMR [8, 9]. To take the best decision and to react intelligently, artificial intelligent techniques are the wishes to understand principles leading in some manner to the comprehension of the human brain function and to build machines that are able to perform the complex tasks requiring massively parallel computation.

This article has proposed an intelligent controller using heuristic rule base network technique for the solution of the collision free path optimization problem of WMR. HRBN deals with the human perception based ideas which decide to the WMR how to take intelligent decisions for navigation safely in the environment [10]. Useful heuristic rules are developed to build the desired mapping between perception and motion and these rules are embedded into the software to get the simulation results and verifying the effectiveness of this work. In simulation environments the proposed approach is well suited avoiding obstacles and gives the optimized path and obtained the desired goal. The method is simple and fast in execution using human perception based heuristic rule concept.

This paper has been organized into four sections. Following the introduction, perception based heuristic rule base network technique has been described in section 2. The simulation results are discussed in section 3. Finally the conclusions are given in section 4.

2. Heuristic Rule Base Network Technique in Path Planning

The heuristic rules are based on human perception (i.e. the working environment provides a fixed referential frame for the rules). In this technique different sensors devices are attached to the robot and these sensors allow to measures the normal ambient distances, which is strongly influenced by the robot's environment. On the basis of these information, human perception based heuristic rules are formulated and these rules are used to create the control software. This is a general, robust, and safer methodology which provides fast path planning framework for WMR. There are two cases generally considered such as if the target is located right side then the robot will steer clockwise direction i.e. positive steering angle, on the other hand if the target is located left side then the robot will steer counter clock direction i.e. negative. Human perception based some of the heuristic rules based on Fig. 1 depicts the environment to avoid the obstacles and motion control by the WMR. Based on this scenario some formulated heuristic rules are listed in Table 1. For example some rules are given below.

Rule 1: If LOD = 300 mm, ROD = 400 mm, FOD =900 mm and TA = 47˚ Then Change in steering angle = 0˚

Rule 2: If LOD = 200 mm, ROD = 250 mm, FOD =700 mm and TA = 56˚ Then Change in steering angle = -46˚

Rule 3: If LOD ≤ 200 mm, ROD = 150 mm, FOD =1000 mm and TA = 56˚ Then Change in steering angle = -32˚

Rule 4: If LOD ≤ 200 mm, ROD =250 mm, FOD ≤300 mm and TA = 68˚ Then Change in steering angle = 68

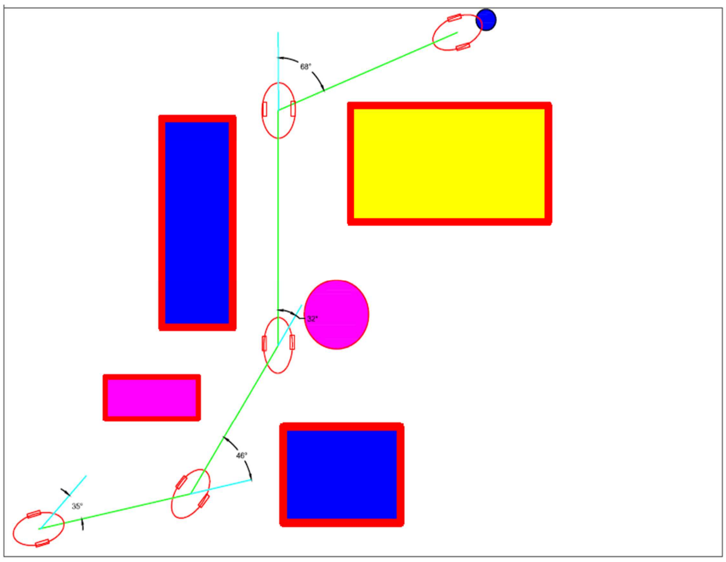

Figure 1: Human perception based rule formation for WMR

Table 1 Human Perception Based Heuristic Rules.

Rule No.	LOD (mm)	ROD(mm)	FOD (mm)	TA (Degree)	SA (Degree)
1	300	400	900	47	0
2	200	250	700	56	-46
3	200	150	1000	56	-32
4	200	250	300	68	68

These rules are used for designing an intelligent controller for path planning and obstacles avoidance problems of WMR, approximately four hundred rules are fed into the proposed control software, using MATLAB software package and simulation results are demonstrated.

3. Simulation results and discussion

The simulation results have been demonstrated for WMR using proposed controller, which has been developed in MATLAB software package.

The first priority of the robot is to avoid obstacles present in the environment. When sensors attached in the robot receive the information about the object which is too close to the robot, it avoids a collision by moving away from it in the opposite direction. Collision avoidance has the highest priority for mobile robot. Therefore, it can override other behaviors; in this case, the obstacle avoidance behaviour is activated when the readings from sensors are less than the minimum threshold values. Fig. 2 shows the simulation result in static environment in which different size of obstacles are present and also shows the minimum path followed by WMR using the heuristic rule base network.

Figure 3 shows the intelligent decisions taken by WMR to follow minimum path, avoiding the static obstacles present in the environment. Depending on the location of the obstacles (on the left or right) it moves in the opposite direction avoiding the obstacle, and then moves towards the target point.

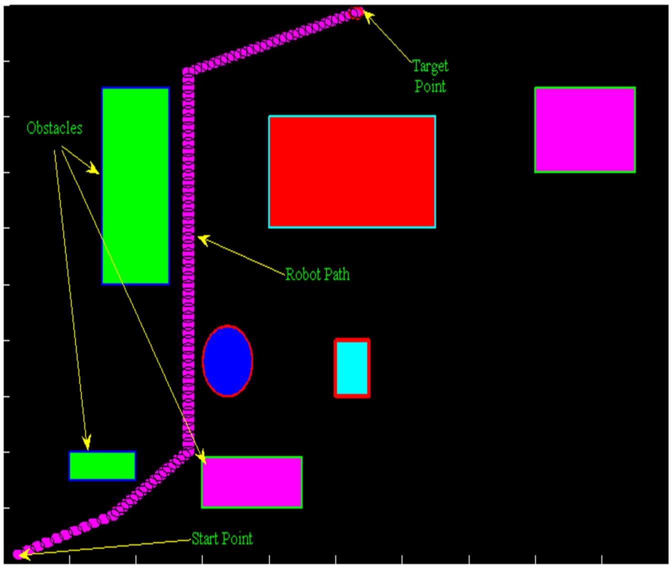

Figure 2: Simulation result of obstacle avoidance.

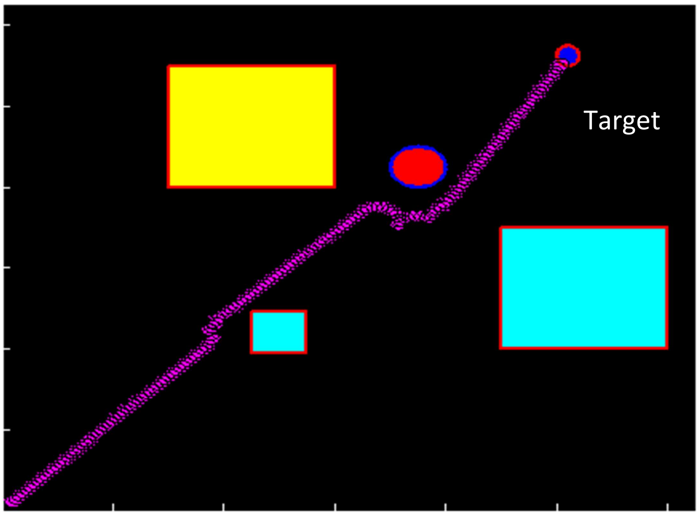

Figure 3: Minimum path travelled by WMR.

4. Conclusions

From the theoretical and simulation analyses the proposed methodology is a general, robust method which provides fast path planning framework for WMR using human perception based heuristic rule base network controller. The method is simple but efficient tool for mobile robot navigation, especially in obstacles avoidance. The proposed methodology is successfully applied for path optimization and obstacles avoidance problem. The WMR rapidly recognizes their surroundings which provide sufficient information for path optimization during navigation.

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