DEVELOPMENT AND SIMULATION OF HEURISTIC ALGORITHM FOR COOPERATIVE MOBILE ROBOT APPLICATION

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Abstract Robotics is the branch of engineering that involves the conception, design, manufacture and operation of robots. One of the goal of robotics research is to develop team robot that can work among the other mobile robots or even human. Achieving team cooperativeness is desirable one because of in many robotic applications are inherently distributed in space, time, or functionality, thus requiring a distributed a suitable solution. In homogeneous team, all robots are identical in terms of geometry, sensing, control, and mobility. In this research work, the aim is to develop a heuristic algorithm to establish cooperation between two identical mobile robots for an application like warehousing, material distribution in manufacturing environment.The proposed methodology has three modules, first one is design of the environment, the second module is implementation of heuristic algorithm and the third module is simulation of the proposed method through MATLAB coding.

***Keywords**: Cooperative Mobile Robot, Heuristic Algorithm, Path Planning, Homogeneous Robot*

I. INTRODUCTION

Mobile robot cooperation includes like the benefits of communication, cooperation and learning, and whether team members should specialize or be homogeneous etc. The numerous research projects have been undertaken in various forms, such as robot soccer, all-terrain operation, box-pushing problems etc. For a complex adaptive systems, it is very important to coordinate cooperative behavior to solve a given task because that task will not have sufficiently detailed specification to solve it. In this context, the development of suitable heuristic algorithm to carry out the task by two or more mobile robots quickly without much computational effort by single mobile robot is inevitable.

II. RELATED WORKS

Yasuda et al. (2006) introduces a design methodology of a fault tolerant autonomous multi-robot system. Their approach is based on reinforcement learning that adopts the Bayesian discrimination method for segmenting a continuous state space and a continuous action space simultaneously. Here, a computer simulations are conducted to illustrate the fault tolerance of multi robot system is also developed. Ying wang et al. (2008) describes a machine learning approach to the multi-robot coordination problem in an unknown dynamic environment.

A multi-robot object transportation task is taken into consideration. Here, a flexible two layer multi-agent architecture is developed to implement multi-robot coordination. In this architecture, four software agents from a high level coordination subsystem and two heterogeneous robots constitute the low level control subsystem. They use two types of machine learning-reinforcement learning (RL) and genetic algorithm (GA) are integrated to make decisions when the robot cooperatively transport an object to a goal locations. The two decision making mechanisms namely RL and GA, are implemented based on the sequentialQ-learning algorithm. Computer simulations using java language and experimentation using the developed prototype were used to demonstrate the feasibility and effectiveness of the System.

Williams D et al. (2002) have introduced a frame work for reinforcement learning (RL) on mobile robots and described their experiments using it to learn simple tasks. Here, they briefly survey reinforcement learning, a machine learning paradigm that is especially well suited to learning control policies for mobile robots. They discuss some of its shortcomings, and introduce a framework for effectively using reinforcement learning on mobile robots.It allows machines and learning agents to automatically determine the ideal behavior within a specified task. Simple reward feedback is required for the agent to learn its behavior known as the reinforcement signal, representing a measure of how good the last action was performed.

KresimirKovac et al. (2004) have proposed that box-pushing problem based on the pusher-watcher approach, involving two pushers robots that learn the best strategy for cooperatively moving an oversized elongated box to a specified goal and one watcher robot acting as the environment and also presents a solution to the box pushing problem based on reinforcement learning in a multi agent system. They deal with the proportions between the robots and the size of the box. For large sized boxes the robots are forced to cooperate using various techniques. Based on the orientation of the box, the state of the environment is determined by applying heuristic method.

Kiener.J and O.Vonstryk (2010) have presented the cooperation of a strongly heterogeneous autonomous robot team, composed of a highly activated humanoid robot and a wheeled robot with largely complementing and some redundant abilities. By combining heterogeneous robots the diversity of achievable task increases as the variety of sensing and motion abilities of the robot system are extended compared to homogeneous robots. Yang et al. (2004) have introduced multi-robot learning to help the robots to cope with a dynamic or unknown environment, find the optimal cooperation strategy, and make the entire system increasingly flexible and autonomous. Some of the shortcomings in this workarealso explained.

Tsalatsanis. A et al. (2009) presents a novel task allocation methodology based on supervisory control theory applicable to cooperative robot teams. A team of heterogeneous robots with different sensory capabilities is considered.AmitaLanjewar et al. (2002) have proposed clustering method and Ant Colony Optimization for mobile robot. It deals with the analysis and design of a new class of mobile robots. These small robots are intended to be simple and inexpensive, and will all be physically identical, thus constituting a homogeneous team of robots. They derive their usefulness from their group actions, performing physical tasks and making cooperative decisions as a coordinated team. Stefano carpin et al. (2002) have introduced the cooperative leader following task for multi-robot teams. They described the design and implementation of a distributed technique to coordinate team level and robot level behaviors for this task.Their proposed approach has been run and validated on a team of robots performing both indoor and outdoor environments.

III. METHODOLOGY

The objective of proposed work is completed with the following three modules of work namely, a) Design of working environmentb) Develop and implementation of heuristic algorithm and c) Simulation of the algorithm.

3.1 Design of the environment

The effeteness of any heuristic algorithm is mostly based on the environment in which the algorithm is going to implement. Here, an automated warehouse consists of many predefined locations for material storage in same floor level is considered. The proposed layout of an assumed warehouse environment is shown in figure 3.1 with two mobile robots forcreating the cooperativeness among them to complete the given task. During transportation they have to negotiate the cooperation strategy and decide to an optimal locations and amplitude of the individual forces applied by them so that the object is transported quickly and effectively. The dimension of the environment is fixed as 100x100m.

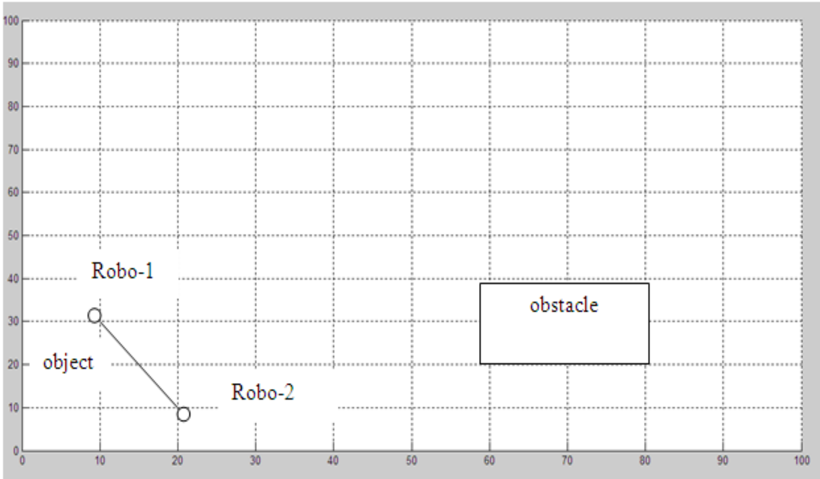


Figure 3.1: Layout of Simulation

3.2 Implementation of heuristic algorithm

The obstacle location was predefined and fixed on the working environment as plane rectangular surface. The path does not depend upon the shape of the obstacle. Some of the assumptions are followed foe simulation purpose like, Initial position and initial velocity of the robot-1 and robot-2 are known at each instant, Position and velocity at the goal are known at each instant, robots are equipped with all necessary sensors for finding the obstacle, each robot begins with the knowledge of its location in a user-defined cartesian coordinate system, and all motion takes place in a two-dimensional plane.

3.3 Modelling the environment obstacles

Here, three classes of obstacles are considered, which may be added to the workspace using a configuration filedassignedfunction in the following way: *Spheres: (x,y,z, sphere radius), Parallelograms: (x,y,z, length,width,height), Cylinders: (x,y,z, radius,height).* The collision detection is implemented using sphere covering technique.

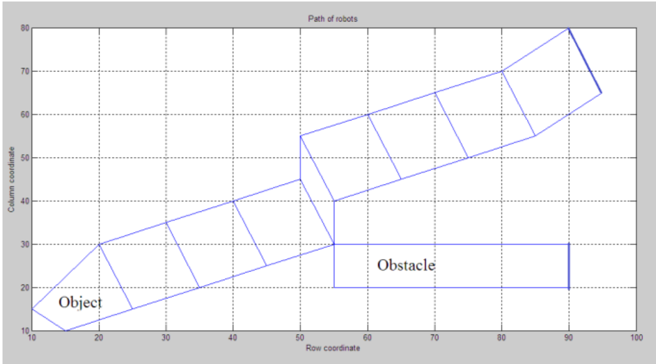
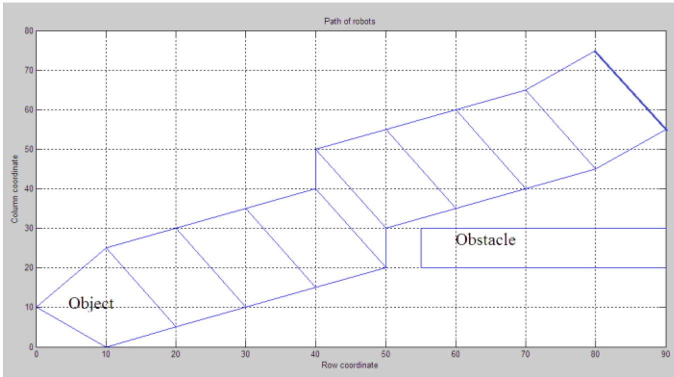
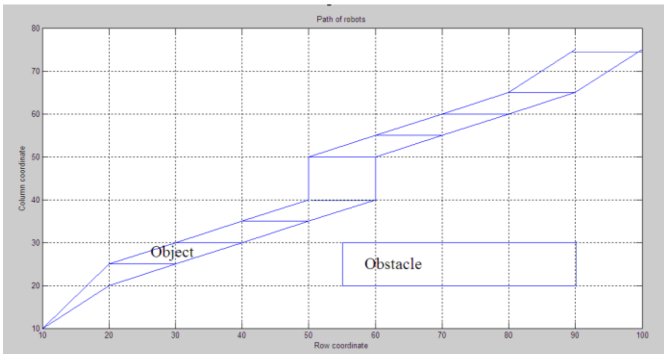
Algorithm Steps:

1. *Initial and final coordinates of robots are get from the user*
2. *Locate the coordinates of object*
3. *Create map grid for splitting the environment into defined locations*
4. *Locate the obstacle inside the environment*
5. *The distance between the robots and various positions are calculated as,*
   a) *Distance (Dt)=* $\sqrt{[(x_2-x_1)^2+(y_2-y_1)^2]}$
   b) *Slope (m) =*$(y_2-y_1)/(x_2-x_1)$
   c) *Equation of the path computed is* $y = mx+c$
6. *Compute the path of the robots by shortest path method*
7. *Create map colour and plot initial and final points*
8. *Using shortest path algorithm goal location is reached*
9. *The path is computed using finite element diffusion*

IV. RESULT AND DISCUSSION

MATLAB coding was writtenfor moving the object and for various shapes of obstacles available within the working environment. Here, three different sets of input values are used to test the algorithm and the corresponding simulation output is given in Table 4.1.

Table 4.1: Simulation Output for different runs

Simulation Run	Input Values	Simulated Path output by MATLAB code
1.	Initial coordinate of robot-1 = [0, 10] Initial coordinate of robot-2 = [10, 0] Final coordinate of robot-1 = [80, 75] Final coordinate of robot-2 = [90, 55]	
2.	Initial coordinate of robot-1 = [0, 15] Initial coordinate of robot-2 = [15, 0] Final coordinate of robot-1 = [90, 80] Final coordinate of robot-2 = [95 65]	
3.	Initial coordinate of robot-1 = [10, 10] Initial coordinate of robot-2 = [10, 10] Final coordinate of robot-1 = [90, 75] Final coordinate of robot-2 = [100, 75]	

V. CONCLUSION

The heuristic algorithm along with simulation using MATLAB code has been developed for obtaining the path planning applications like material storage in a warehouse. The effectiveness of the algorithm is tested with different shapes of obstacles. For all the three cases, it is found that the optimal path has been generated.

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