TOPOLOGICAL INDOOR LOCALIZATION AND NAVIGATION USING ANT COLONY ALGORITHM

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Abstract— Path planning is an essential task for the navigation and motion control for autonomous mobile robots. This Path planning problem is difficult to solve, especially in dynamic environment where optimal path detected is not accurate when new obstacle appears, Henceforth the method of Meta heuristic Ant Colony algorithm is proposed to solve the difficulty of path planning.

Keywords— Path planning, Ant colony optimization

1. INTRODUCTION

AN autonomous mobile robot should be able to acquire the following information, the current position/where the robot (Localization) and the destination/ where to go (task assignment) and the guidance/how to go (Navigation). Mobile robots can move around to different locations and interact with large scale environment. Meanwhile, they can also be equipped with different sensors, tools or manipulators (even industrial robot, named industrial mobile manipulator) to afford various tasks like supervising, exploring, manipulating, etc. Therefore, the mobile robot can be applied to a variety of scenarios like industrial, military, and home care. In this paper, we will focus on the problem of localization and navigation in the typical indoor environment. The robot has to learn how to localize and navigate itself without prior information. Indoor environments like office or residential buildings generally consists of many rooms which are connected by corridors. To go across the corridors and find the target places, the robot has to obtain a map or guide information from the environment. The maps can be classified into three types: obstacle-based grid maps, feature-based metric maps, and topological maps. As a highly abstracted knowledge expression form, compared to the other maps, the topological map is simple, effective, and compatible with human knowledge. A topological map is a graph-based representation of the environment. Each node corresponds to a characteristic feature or zone of the environment, and can be associated with an action, such as turning, crossing a door, stopping, or going straight ahead. This kind of map is suitable for long distance qualitative navigation, and specially for path planning. In general, they do not explicitly represent free space so that obstacles must be detected and avoided online by other means. Topological maps are simple and compact, take up less computer memory, and consequently speed up computational navigation processes. Path planning is an important issue for the navigation and motion control of autonomous robot manipulators.

II. PROBLEM FORMLATION

First, the algorithm we are using to find the object recognition is ant colony algorithm. It is used to detect the edges of the obstacle. By finding the edge values, before that comparing the image value with morphological operations like dilation and erosion etc., and using the edge values, the area of the object can be found out. And the object detection in the path planning is discussed. After the detection of obstacles, the path can be found by the robot. Efficient navigation of mobile robot means generation of collision free path and design of control flow, which provides desirable path planning. Many efforts have been taken to consider the effects of robot path planning. Such a complex problem can be divided into several simpler problems. The First is generation of collision free path in presence of obstacles. Solution of the problem is given with the NP hard algorithm. There are two different approaches for mobile robot planning: classic and heuristic. The classical approach suffers from many drawbacks such as high time complexity and trapping which makes them inefficient to use in practice. In this paper, A Meta heuristic Ant colony technique which is a probabilistic technique searching for optimal path based on the behavior of ants seeking a path between their colony and source of food.

III.BASIC THEORETICAL CONCEPTS

A. Ant Colony Algorithm

The studies of path planning started in late 60’s and many different algorithms have been proposed, including the roadmap approach, cell decomposition, potential fields and mathematical programming, etc. It has been found that the above methods are either inefficient, due to the high computational cost; or inaccurate, due to the trapping in local minima. To overcome these limitations, many heuristic approaches have been developed, such as the application of artificial neural networks. One of the major advantages of heuristic algorithms is that it can produce an acceptable solution very quickly, which is especially suitable for solving NP-complete problems.

The ant colony optimization (ACO) algorithm is a meta-heuristic approach inspired by the behavior of the biological

ants in real world. It is well known that the biological ants in the real world are able to utilize swarm intelligence to find the shortest route to nutrients. Ant Colony Optimization (ACO) algorithms have been developed to mimic the behavior of real ants to provide heuristic solutions for optimization problems.

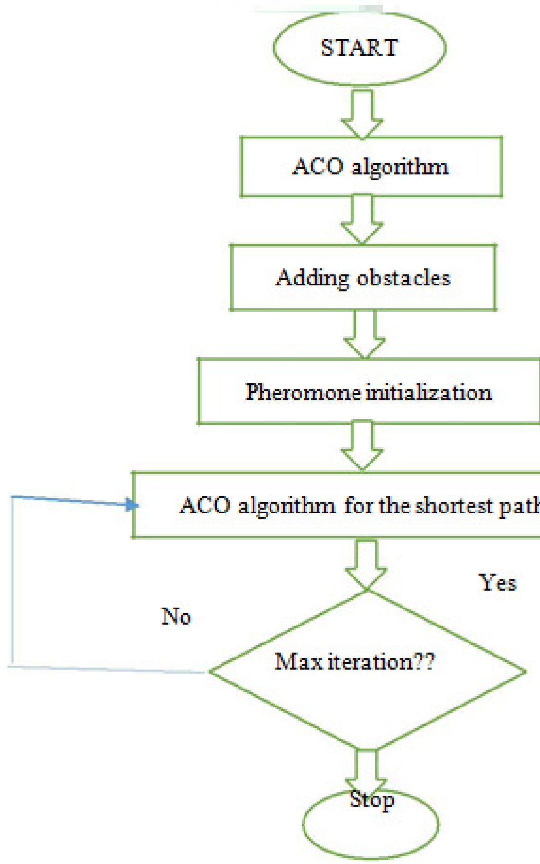


Figure 1. Flowchart of ACO

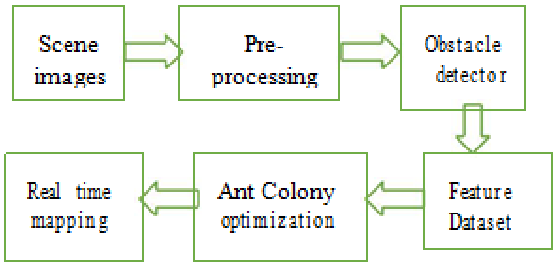
It was first proposed by M. Dorigo in 1992 in his Ph. D. dissertation. When searching for food, biological ants exhibit complex social behavior based on the hormones they deposited (called pheromones). Pheromones attract other ants and outlines a path to the food source that other ants can follow. As more ants walk along the path, more pheromone is laid, and the chance that more ants will take the path increases. The shortest path to the food builds up the most pheromones because more ants can travel it in less amount of time.

IV. OBJECT DETECTION

Edge detection aims to localize the boundaries of objects in an image and is a basis for many image analysis and machine vision applications. Conventional approaches to edge detection are computationally expensive because each set of operations is conducted for each pixel. In conventional approaches, the computation time quickly increases with the size of the image. An ACO based approach has the potential of overcoming the limitations of conventional methods. Furthermore, it can be readily be parallelized, which makes the algorithm easily adoptable for distributed systems.

A. ACO based Image Edge Detection

Image Edge detection refers to the extraction of edges in a digital image. It is a process whose aim is to identify points in an image where discontinuities or sharp changes in intensity occur. This process is crucial to understanding the content of an image and has its applications in image analysis and machine vision. It is usually applied in initial stages of computer vision applications. An ACO based approach has the potential of overcoming the limitations of conventional methods and it can be readily parallelized. ACO is a probabilistic technique for finding the optimal paths in fully connected graphs through a guided search, by making use of the pheromone information. This technique can be used to solve any computational problems that can be reduced to finding good paths on a weighted , the graph which consists of nodes and edges. The movements of ants is ansition probability reflects the likelihood that the ant will move from a information and the pheromone information. The heuristic information is ues are used and updated during the search.



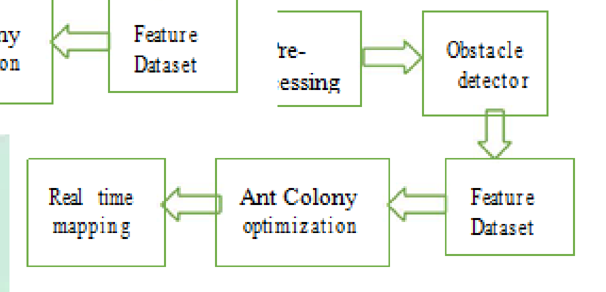


Figure 2. Block Diagram of the ACO system

B. Steps involved in ACO based detection

The initialization step is performed at the beginning. In this step, the necessary initialization procedures, such as setting the parameters and assigning the initial pheromone values, are performed. Then in construction process, a set of artificial ants construct solutions from a finite set of solution components from a fully connected graph. Once solutions have been constructed, there might be a need to perform additional actions before updating the pheromone values. Such actions are those that cannot be performed by a single ant. Normally, these are centralized actions to improve the solution or search process. After construction process, the pheromone values are updated. The goal of the pheromone update is to increase the pheromone values associated with good solutions and decrease those associated with bad ones. This is normally done by decreasing all the pheromone values (evaporation) and increasing the pheromone values associated with the good solutions (deposit). Ants traverse the path by moving from one pixel to another, through their connections. An ant cannot move to a pixel if it's not connected to the pixel where the ant is currently located. This means that an ant can move only to an adjacent pixel.

The most common decision rule used is the one used in the original AS. On the ^{h}construction process, the ^{h} ant moves from node i to node j according to the transition probability $p_{i,j}^{(n)}$

$$p_{i,j}^{(n)} = (\tau_{i,j}^{n-1})^{\alpha}(n_{i,j})^{\beta} / \sum j \in (\tau_{i,j}^{n-1})^{\alpha}(n_{i,j})^{\beta} \qquad (1)$$

the probability that the ant will move from node I to node j. The AS decision rule is based on the transition probability given by, where $(\tau_{i,j}^{n-1})^{\alpha}$ is the quantity of pheromone on the edge from node i to node j ; $(n_{i,j})^{\beta}$ is the heuristic information of the edge from node i to node j; and are the constants that control the influence of the pheromone and heuristic information respectively, to the transition probability. $\sum j \in (\tau_{i,j}^{n-1})^{\alpha}(n_{i,j})^{\beta}$ is a normalization factor, which limits the value of $p_{i,j}^{(n)}$within [0,1]. Initially all the nodes are assigned with same pheromone values. So the heuristic function plays the primary factor that determines the probability. Nodes that are closer to the robot have a higher probability of being selected. In this way, the robot moves in the search space till it encounters an obstacle. When the succeeding node for the robot is coincident with the obstacle boundary, it is not considered as a feasible node and the procedure continues till it reaches the target. Let us consider the obstacle be a basket, by the ant colony algorithm the edge detection of the obstacle is shown in the following figure. In the above figure, artificial ants are distributed over the image and move from one pixel to another. The movement of the ants is steered by the local variation of the pixel intensity values. The goal of the ant's movements is to construct a final pheromone matrix that reflects the edge information. Each element in the pheromone matrix corresponds to a pixel in the image and indicates whether a pixel is an edge or not. The collective iteration of the ants produce a pheromone matrix, which can then be used to extract a complete edge trace. With this, it is not appropriate to select a best far solution during the construction process. Therefore, all edges have been visited by at least one ant undergoes a pheromone update.

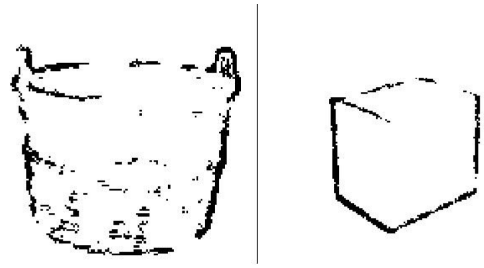


Figure 4. Image edge detection using ACO

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V. RESULTS AND DISCUSSION

The ants initially travel in different directions on each successive iterations. With update in pheromone intensity, after each complete tour to target station, a new path is obtained. When we increase the number of iterations it is seen that all the ants travel in common path that gives the optimal solution. Simulation is done using Mat lab. Experimental details are shown in fig.5. It travels diagonally along the shortest path towards the target and at the edge of the obstacle it deviates and changes its path.

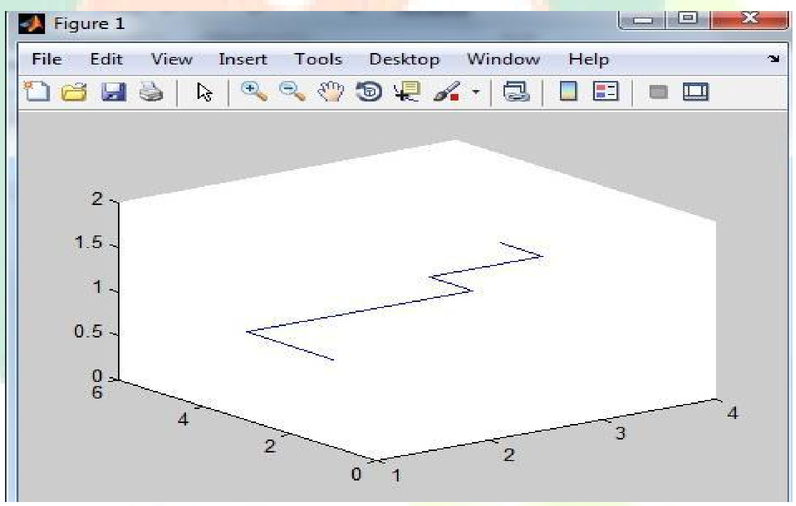

Figure 5. Path planning using ACO

VI. CONCLUSION

An ACO based image edge detection that takes the advantage of feasibility approach in identifying edges in an image. To find the navigational path of robot is currently among the most intensively studied and promising area of research which has a significant role in robotics. It has varied application in different field of works, especially where human presence is dangerous to avoid human error or economically not viable. In this paper, ACO is used to find the navigational path of autonomous mobile robot avoiding obstacles to reach the target from the source. The output is found to be optimal and satisfying for the navigation of mobile robots. With increase in complexity of the problem, i.e. with increase in obstacles or in dynamic environment, it can be effectively applied.

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