Robot Path Planning In Static Environment Using Ant Colony Optimization

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Abstract: When a machine or robot moves from one source point to a destination point it is important that it takes an efficient and optimized path. To achieve this goal path planning is done to find an optimized path for a robot which is moving from one point to another. For this, artificial intelligence is used which has various techniques for finding an optimized path. ACO is one of the various techniques from AI which is based on the foraging behavior of the ants. The main motive of path planning is to select an optimized path while moving from source to destination and avoid collision with obstacles (if any) in the path in a static or dynamic environment.

Keywords: Ant Colony Optimization (ACO), Robot Path Planning (RPP).

I. INTRODUCTION

Machines are the building blocks of automation. They are operated by human beings having a control over the machinery systems. But, what if machines can operate and work by themselves. Artificial intelligence made it possible by making machines intelligent that can take decisions by themselves and work even in hazardous and dangerous environment where human intervention is strictly prohibited. So, machines could be an effective option to do work in such kind of environment.

Artificial intelligence made the machines intelligent by implementing some programming in them. The programmed machines can work like the machines used to work under the control of a human. Now, in a working environment a robot has to move from one point to another for any reason for e.g. to transfer material from one point to other etc. So, there are some points necessary for a robot while navigating the route:

1. Direction: in which direction the robot is moving, towards the target or away from it.
2. Path planning: to choose the optimized and efficient path
3. Control over its motion: how the robot is moving towards the destination.
4. Congestion control: to remember what path it has followed and from where it has started.

For the purpose of path planning, ACO is used to develop an algorithm which can be used to find an optimized path for a robot while navigating and to avoid collisions with the obstacles in the path.

ANT COLONY OPTIMIZATION

ACO is a heuristic technique which is used to find an optimized path. It is inspired by the real ants behavior while searching for food. All ants of a same anthill move along the same path by following one another. This is because every ant releases a substance called “Pheromone” while moving. The other ants sense the intensity of pheromone and follow the path having a higher concentration of pheromone. This is their way to find an optimized path.

Initially the ants wander randomly to find their own way to the destination. Every ant releases pheromone along the path. On their return trip ant senses the pheromone intensity and choose the path having higher intensity of pheromone. The pheromone evaporates with time and hence the concentration of pheromone would be higher along the shortest path as the time taken to cover the shortest path would be minimum as compared to other paths. Hence, almost every ant would be attracted by the higher intensity of pheromone along the shortest path and select the optimized path. This technique can also be applied on the robots to find an optimized path while navigating in an environment.

WORKING ENVIRONMENT

There are mainly two types of environment in which a mobile robot can work:

1. Static environment in which the object does not move with time i.e. they are static or fixed.
2. Dynamic environment in which the position of object changes with time i.e. they can move.

If the robot has some prior knowledge about its environment, it is called global path planning and the path can be planned in offline mode even before the robot starts moving.

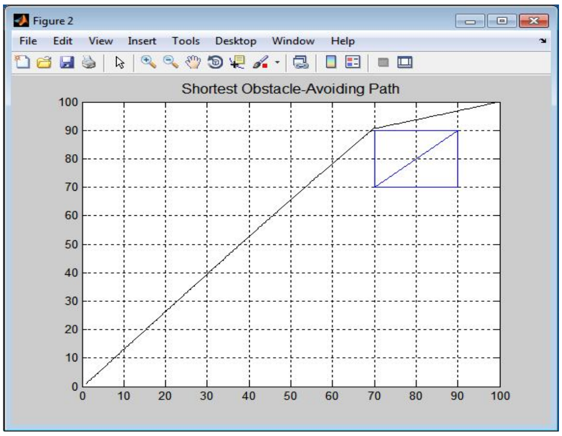
And if the robot has no prior knowledge about its environment, it is called local path planning. It is done in online mode in which robot has to move in a real world like environment.

ARTIFICIAL ANTS

Artificial ants are the mobile robots that are inspired from the real ants. The movements of the artificial agents are governed by a probabilistic function that depends on heuristic and trail functions. They move in a search space having all possible solutions and generate optimal solutions. Artificial ants prefer paths having higher pheromone concentration. The position of ants and quality of solution is recorded so that better solutions can be obtained in later simulation iterations.

METHODOLOGY:

By taking the simplest approach we are solving RPP problems.



By selecting a 2D grid model ,we are representing here an environment in which robot has to move from source to destination. It is a map consists of a 100x100 square dimension. The X-axis is divided into 100 equal parts and the Y-axis is also divided into 100 equal parts. Each side of a cell is of unit length. The origin or the source point of the robot is at the coordinate (0, 0) and the target point at coordinate (100,100). An obstacle of rectangular shape is placed at the coordinates (70,70) and (90,90) as diagonal. The mobile robot has to reach the target from the source point by avoiding any collision with the obstacle along the optimized path using Ant Colony Optimization algorithm.

SELECTING A NODE-

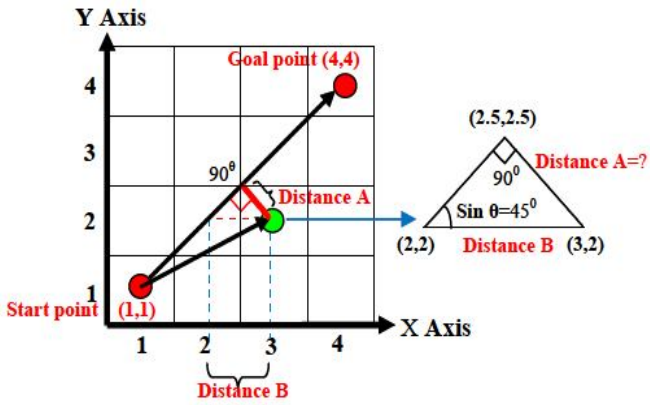
Initially the robot is at source point and has to move towards the destination. The robot has to select its proceeding node to move towards the target. The node will be chosen on the basis of a probability formula. The formula includes heuristic equation and pheromone intensity equation.

The heuristic equation:

Heuristic= [1/distance between next node and the intersection point at reference line]*β …(1)

where, β= heuristic coefficient

The heuristic equation or visibility equation represents the distance between selected adjacent nodes with intersect point at reference line and the line from that intersection point must be perpendicular to the node i.e. Distance A. A perpendicular is a shortest distance between two points and hence minimum the distance A, the path will get more closer to the reference line and would be the optimized one. For example, let's take start point (1,1) and goal point(4, 4).the green node(3,2) is a candidate node for which distance has to be calculated.



Distance A=Sin θ*Distance B

=Sin θ* sqrt[(y2-y1) ^2+(x2-x1) ^2]

= Sin 45* sqrt[(2-2) ^2+(3-2) ^2]

= 0.7071*1

= 0.7071

Visibility = [1/0.7071]1 =1.4142

Pheromone or trail equation:

Trail= [trail//Σ trail] α …..(2)

Where, α=trail coefficient

From equations (1) and (2)

Probability ij (t) =

Heuristic ij(t)*Pheromone ij (t)

= (1 / distance between next node and the intersection point at reference line)β * (trail / Σ trail)α …..(3)

where, the ij is the location of the node under investigation at time t.

LOCAL UPDATING

The pheromone gets evaporated with time. Hence, the pheromone amount will be reduced at all the nodes locally by the given evaporation rate using the formula of update local rules

t_{ij}(new trail) ←(1-ρ)* t_{ij} (old trail)

where, ρ=evaporation rate

Local updating is important because it prevents the unlimited accumulation of pheromone on the map and to avoid confusion while selecting a node by sensing the pheromone intensity which could lead to a wrong decision taken by the robot.

GLOBAL UPDATING

When an ant reaches the destination, it carries the information like path cost ant takes to traverse from source to destination, address of the nodes passed while moving. The information carried by the ant is fetched and the intensity of pheromone is updated or increased only on the nodes passed by the ant.

tij ← tij + Σ Δ tijk

where, Δ tijk is the amount of pheromone deposited by an ant on the path it has visited.

Hence, the intensity of pheromone is increased only along the path travelled by the ant .Which is then used to choose the optimized path from all the available traversed paths by sensing the pheromone intensity.

ANT COLONY OPTIMISATION ALGORITHM:

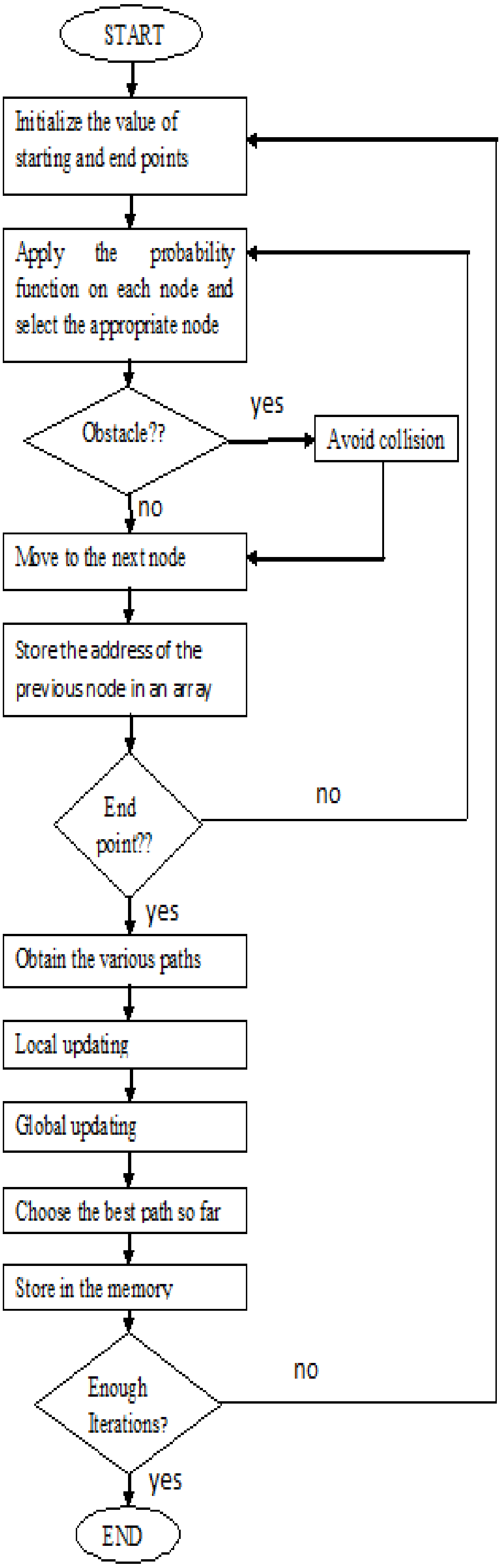
There are so many algorithms which have being proposed to solve RPP problems since the evolution of path planning in 1980. Here, an algorithm is proposed for robot path planning using the concept of ACO. This algorithm would used to find an optimized path in a static environment while avoiding any collision with the obstacles encountered in the path.

The process is divided in the following steps:

1. Initialize the value of starting and target points. The robot must know from where to start and where to reach.
2. On the basis of probability function given by eq.(3) select an appropriate node.
3. Now, check if an obstacle has encountered. If yes then select another node to avoid collision. And move to the selected node. Else simply move to the node selected in step 2.
4. The robot must know what path it is taking. For that it has to store the address of every node the robot has gone through in an array.
5. Now, the information about path taken etc by him must be fetched out every time it reaches the goal.
6. Local updating will be done. In local updating the pheromone evaporation will be done as described earlier.
7. Global updating will be done to update the pheromone concentration on the path traversed by the robot.
8. By selecting the best path so far, we can get an optimized path after sufficient iterations

Algorithm pseudo code

Do For iteration=1, 2, ….. N
Do For ant=1,2, …. K
Do For step=1,2, …. M
Compute the probability of the kth ant's next node.
Move to a next node by the computed probability
Store the history of past node locations in an array
If the current location is equal to the end point
End
End
Obtain the path passed
Update the pheromone evaporated on the entire map
Compute and update the pheromone amount generated by the kth ant on the path traversed
If there are sufficient iterations has done to get an optimized path
End



IMPLEMENTATION

The pseudo code will be converted into the MATLAB code implemented by using available functions in MATLAB.

II. CONCLUSION

After performing a sufficient number of iterations the optimized path is obtained which is effective for path cost reduction, consumes less power and shorten computation time. Hence contribute to the total cost reduction for a robot to work in an environment.ACO comes out to be the most effective technique to find an optimized and effective path without colliding with the obstacles comes into the path.

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