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Research Article

Outlook of Mobile Robot Navigation in Dynamic Environment

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Abstract

In this paper, we have proposed the technique for navigating mobile robot in dynamic environment having moving obstacle, with optimal path. First we introduced artificial potential field method and the acceleration velocity obstacle. We have assumed that the robot having a disk shape and the workspace is of two dimensions. The artificial potential field method and dijkstra's single source shortest path algorithm is used for producing the optimal path in the environment. And then acceleration velocity obstacle technique is used for navigating mobile robot in dynamic environment to reach the goal. To be navigating it, we proposed the pseudo code for optimal path generation and flow chart for navigating in environment.

Keywords: *mobile robot, artificial potential field, dijkstra's single source shortest path, acceleration velocity obstacle*

Introduction

The navigation behavior of mobile robot can be classified according to the complexity of the task that can be performed by mobile robot. The categories according to (Matthias O. Franz) are:

- Search
- Direction following and path integration
- Aiming
- Guidance
- Recognition-triggered response
- Topological navigation
- Survey navigation

Artificial Potential field method

The artificial potential field method for the mobile robot navigation can be categorized under direction following and path integration class. The artificial potential field can be described as follow:

- The work space is viewed as the grid of rectangular cells and each cell is marked whether there is obstacle on the cell or free cell.
- Then for each free cell the potential value is calculated based on the distance from starting cell, end cell and distance from nearest obstacle.
- Then by applying dijsktra's shortest path algorithm we can find the cells which may be optimal path form start location to goal location.

The potential field method can be used to generate high-level plan for achieving the goal. The potential field generates the optimal path towards the goal. The Artificial Potential Field proposed by (Hossein Adeli, 2011) with dijkstra's algorithm can be used to produce the optimal path in given predefined workspace.

Acceleration velocity obstacle

Suppose the current velocity of the robot at time 't' is V(t). To avoid the obstacle, it should achieve the new velocity that is V'. As the robot should not exceed the acceleration constrain $a(t) <= a_{max}$, there is control parameter d it's dimension is time and it is given as follow:
a(t)= v'-v(t) /□
The set of such acceleration velocity obstacles over time horizon t is given as follow:
$AVO^{d}_{A}{}^{t}_{B}$: acceleration velocity obstacle induced by B for A
□□□Control parameter
□□□Time horizon
D(P, r) = {Q | ||P –Q|| < r}

$$AVO^{\delta,\tau}_{AB} = \bigcup_{0<t\leq\tau} D\left(\frac{\delta(e^{-\frac{t}{\delta}}-1)v_{AB}-p_{AB}}{t+\delta(e^{-\frac{t}{\delta}}-1)}, \frac{r_{AB}}{t+\delta(e^{-\frac{t}{\delta}}-1)}\right)$$

Now CA_A is the set of new velocity that avoid the collision with the other obstacles. It is the complement of set of acceleration velocity obstacle. It is given as follow:

$$CA_A = D(v_A, \delta a_A^{max}) \setminus \bigcup_B (AVO^{\delta,\tau}_{AB} \oplus \{v'_B\})$$

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Than the robot selects the most appropriate velocity from set CA_A, which is preferred velocity of the robot. It is value from set CA_A having the least deviation from the preferred value. It is given as follow:

V'_A: New velocity

$$v'_A = \underset{v \in CA_A}{\arg\min} \| v - v_A^{pref} \|$$

For implementing robot navigation in dynamic environment further we can implement *acceleration velocity obstacle* technique. The path generated by dijkstra's algorithm can be used to track the path. Now the path from start point to end point is available. To navigate robot in dynamic environment; it should avoid the static obstacle as well as moving obstacle. By assuming the only mobile robot in environment with moving obstacles, we can implement acceleration velocity obstacle technique for navigation.

Method for mobile robot navigation

The mobile robot can be viewed as hierarchical architecture. It consists of two layers high-level layer and low-level layer. High-level layer is having the ability to build the map and taking decision to avoid the obstacle. Initially, the algorithm feed with information of workspace it includes the information about cells which are as much of size to accommodate mobile robot. It also includes the information about which cells having obstacle and which are free cells having no obstacle. The number of free cells can be reduced by finding the threshold value. This threshold value of potential value indicates the cell having potential value equal or higher than threshold value forms the path from start point to end point using minimal number of cells. The algorithm for finding this threshold value is depicted below:

```
N: Number of cells to be processed

C: array of cells shorted according to potential
value in descending order

τ: the cell having threshold value

BinarySearch(1, N, C);


BinarySearch (i, j, C)

If(I=j)

        Return(C[i+1])

τ=C[(i+j)/2]

 If(using DFS, Is goal point reachable form start
     point using cells with larger value than τ )

BinarySearch(i, ((i+j)/2)-1, C)

Else

BinarySearch(i, ((i+j)/2)-1, C)
```

Fig 1 pseudo code for finding threshold value

The rest of the cells having potential value less than this threshold value can be ignored and the cells having higher value including threshold point can be used to produce the optimal path form start point to the goal point by using the dijkstra's single source shortest path algorithm.

The workspace can be represented as the connected graph. Each cell could be connected with at most four neighbor cells. The dijkstra's single source shortest path with input parameter start point, goal point, and array of cells having potential value greater than or equal to threshold value will return the array of cells which will lead to the goal location with optimal path. These cells can be called as reference map point.

```
S: start cell

G: goal cell

C': graph of cells having potential value greater
or equal to threshold value τ

C'': array of cells which leads to goal point with
optimal path

Dijkstra(S, G, C')

Return(C'');
```

Fig 2 Dijkstra's algorithm for optimal path

Now these cells can be used as reference map for navigating mobile robot in dynamic environment having unexpected mobbing objects or obstacle in the environment.

The flowchart for navigating mobile robot in dynamic environment is depicted as follow:

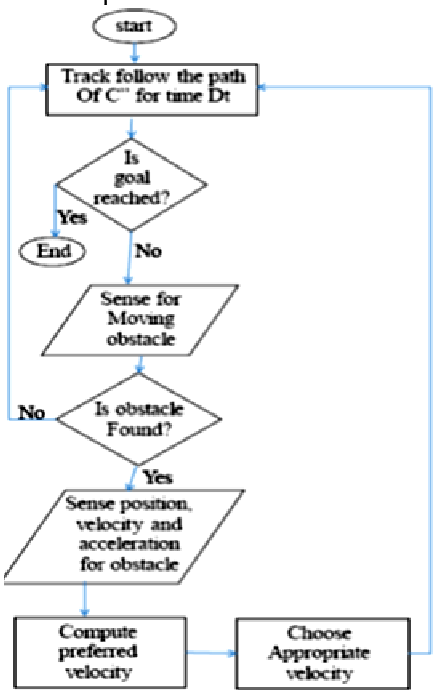

Fig 3 flow chart for navigating mobile robot in dynamic environment

Conclusion and future work

In this paper we have proposed the technique for navigating the mobile robot in dynamic environment. We assumed that there is only one agent in the environment. For producing the optimal path, that exist in the work space, is obtained by the potential field method and dijsktra's single source shortest path algorithm and that path is used as reference map to reach the goal point. While moving towards the goal point moving objects or obstacle are avoided by using acceleration velocity obstacle technique. For that we have presented the flowchart to be followed.

For future work, we are going to simulate this technique in two-dimensional environment. Further if it would give satisfactory result; it could be implemented for three-dimensional environment or for real-time navigation.

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