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An Enhanced Approach 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. This paper describes the design of a fuzzy logic based navigation system for a mobile robot. The advantage of using fuzzy logic for navigation is that it allows for the easy combination of various behaviors outputs through a command fusion process. The navigation system in this case consists of two behaviors - an obstacle avoidance behavior and a goal seeking behavior. The inputs to the fuzzy controller are the desired direction of motion and the readings from the sensor array. The outputs from each behavior's rule base are integrated using the command fusion process and made crisp using a modified defuzzification technique. The end result is very smooth motion control of the robot.

Key Words: 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 traditional artificial intelligence approach to building a control system for an autonomous robot is to break the task into a number of subsystems. These subsystems typically include perception, world modelling, planning, task execution and motor control. The subsystems can be thought of as a series of vertical slices with sensor inputs on the left and actuator outputs on the right. The disadvantage of this approach, however, is that all of these subsystems must work correctly for the robot to function at all.

1. ARTIFICIAL POTENTIAL FIELD METHOD

In subsumption, all of the behaviors run concurrently. Since many of the behaviors may produce outputs which are intended to be used by the same device, a motor for example, some sort of arbitration scheme must be provided to overcome the problem of conflicting outputs. If two behaviors both produce an output intended for the same device, the two behaviors will compete with each other for control. In subsumption, this arbitration scheme is achieved by arranging the behaviors into a hierarchy, in which a higher level behavior can subsume control from a lower level behavior.

2. LIMITATIONS OF SUBSUMPTION:

One of the problems associated with subsumption is that the arbitration technique employed only allows a single behavior to be active at any one time. While this is satisfactory in many situations, there are times when a combination of two behaviors is required. Take, for example, navigating towards a target and avoiding obstacles. Each of these could be implemented as a single behavior each. So long as no obstacles are detected, the robot will gracefully head towards its target location. If an obstacle is detected, however, the obstacle avoidance behavior becomes active and steers the robot away from the obstacle. The problem with this is that the obstacle avoidance behavior has no knowledge about the target location, thus it could steer the robot in any direction to avoid the obstacle. In many situations, this may work perfectly well, but there are times when it may be desirable for the robot to steer in a direction which takes it closer to its desired path. This can be achieved by combining the output of the two behaviors, referred to as command fusion. The output from the path following behavior and the obstacle avoidance behavior are combined to produce a heading which takes it towards its target location while avoiding obstacles.

3. 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) <= amax, there is control parameter d it's dimension is time and it is given as follow:

$a(t)= v'-v(t) /\delta$

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

δ: Control parameter

τ: Time horizon

D(P, r) = {Q | ||P –Q|| < r}

Now CAA is the set of new velocity that avoid the collision with the other obstacles. It is the complement of set of acceleration velocity obstacle.

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

V'_{A}: New velocity

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.

4. 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:

- ***Pseudo code for finding threshold value***

```
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)
```

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.

- ***Pseudo code Dijkstra's algorithm for optimal path***

```
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'');
```

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:

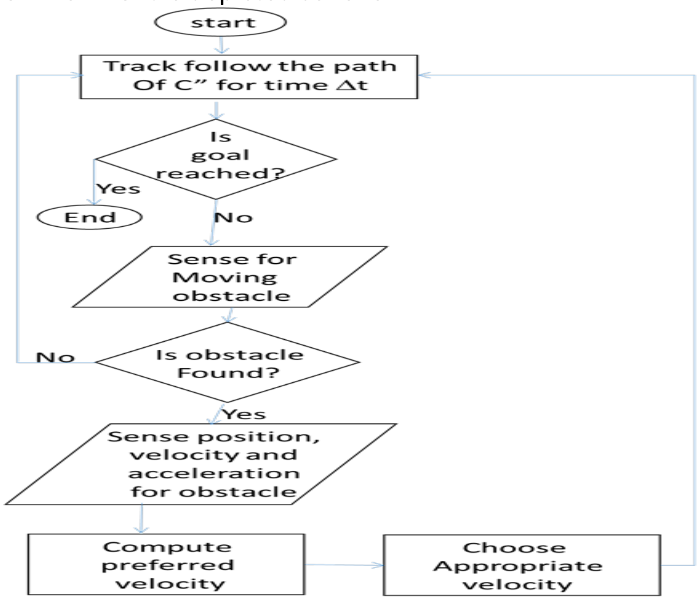

Figure 1: flow chart for navigating mobile robot in dynamic environment

5. 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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