

Robot Navigation in Dynamic Environment

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Abstract: Navigation is one of the most challenging competences required of a mobile robot. Success in navigation requires success in perception, localization, cognition, and motion control. Path planning for mobile robot is not only guarantees a collision free path with minimum travelling distance but also requires smoothness and clearances. In this project, mathematical modeling for the robot was done; path planning was done using an algorithm, than using this mathematical model it was simulated in the MOBOTSIM software in the dynamic environment. Experimental results and real environment working model show that the proposed algorithm has effective and efficient in achieving the goal position in dynamic environment.

Keywords: Cognition, Localization MOBOTSIM, Motion Control, Path Clearance, Path Smoothness, Perception.

I. INTRODUCTION

Navigation is a critical ability for robot that claims to be mobile. It encompasses the ability of the robot to act based on its knowledge and sensor values so that it could reach its goal position as efficiently and reliably as possible. Navigation involves sensing, acting, planning, architecture, hardware, computational and power efficiencies; etc. Planning is one obvious aspect of navigation that answers the question: what is the best way there? Given a map and a goal location, path planning involves identifying a trajectory that will cause the robot to reach the goal location when executed [1]. Path planning is a strategic problem-solving competence, as the robot must decide what to do over the long term to achieve its goals. Path planning is one of the important tasks in intelligent robotic systems such as autonomous mobile robots. There are two types of path planning problems:

- (1) Static path planning, which allows a mobile robot to move through stationary obstacles
- (2) Dynamic path planning, which allows a mobile robot to generate a new path in response to a changing environment.

II. METHODOLOGY

Objective of the project is to find the shortest path and avoid the obstacles which are either moving or stationary. For achieving this objective the function of algorithm is divided into three sub functions. Function should be consist short path between goals and start point, and some clearance in between robot and obstacle to avoid hitting, and the Bezier curve is used to recover the sharp turning as a smoothness function [2,3]

Now the overall function is divided into three parts: -

- 1) *Sub-function of path length*
- 2) *Sub-function of path clearance*
- 3) *Sub-function of smoothness*

1) *Sub-function of path length*: If there is no obstacle in the environment that time the shortest path will be the diagonal of in the given environment. Directly calculating the distance between starting point to the goal point of the robot, the shortest path can be obtained. Figure1 shows the distance between two points.

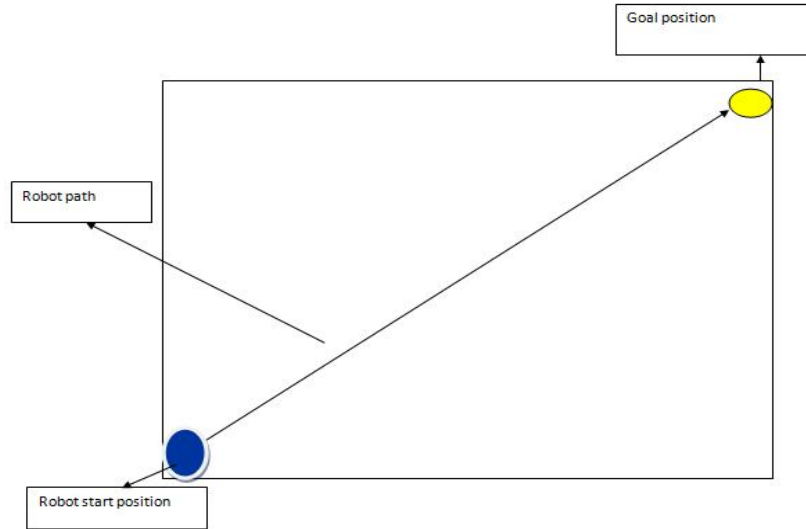


Fig.1 shortest path

Consider the above area with starting point P1 and P2, P3, P4 are via point of robot path and goal point P5, and if there is no obstacles at that time the shortest path will be the diagonal of square. Means, The distance between point P1 to P2 and P2 to P3, P3 to P4, and P4 to P5. Figure1 shows the shortest path of area.

Now the equation will be

$$\text{Fit 1} = \text{dist}(P1, P2) + \text{dist}(P2, P3) + \text{dist}(P3, P4) + \text{dist}(P4, P5) \quad (1)$$

If there is 'n' point in the environment, the shortest path will be the distance between every via point of the robot.

If point p1, p2, p3, p4, p5, p6, p7, p8..... in search space then the function as below

$$\text{Fun 1} = \sum_{i=1}^n (P_i, P_{i+1}) \quad (2)$$

In Eq.2, Where (Pi, Pi+1) is the distance between Pi=P (Xi, Yi) and Pi+1=P (Xi+1, Yi+1)

2) *Sub-function of path clearance*: But this shortest path may not be feasible path, there may be some obstacle as in fig.4.2. Due to this obstacle the path length will varies. For the obstacle avoidance the function should be as below:

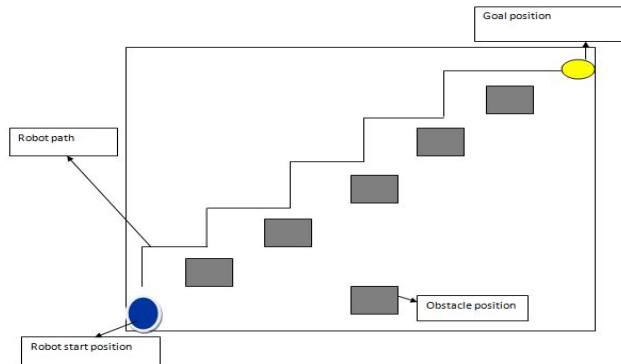


Fig.2 collision free path

As the above fig.2.shows, if the obstacle comes into the path, the path length will increase. If the path via point p1, p2, p3.... And obstacle position s1, s2, s3..., then the condition of collision avoidance is stated as follows: if the distance between every via point of the path and obstacle is $|P_i S_j|$ for any path then the Eq.3,

$$\text{Fun 2} = \begin{cases} \sum_{i=1}^n \sum_{j=1}^m (|P_i S_j|) / S_d \\ 0 \end{cases} \quad (3)$$

If $|P_i S_j| > S_d$.

Where the $S_d = R_r + O_r$

S_d =distance between robot radius and obstacle radius.

R_r = robot radius

O_r =obstacle radius distance

$P_i = (X_i, Y_i)$ is the position of via point. $i=1, 2, 3, 4, \dots, n$.

$S_j = (X_j, Y_j)$ position of obstacle. $j=1, 2, 3, 4, \dots, m$.

The above Eq.3 is clearance function of the path to avoid the hitting with obstacle.

3)Sub-function of smoothness

During the path planning, when the robot will move from one point P_i to another point P_{i+1} , the path should be smooth. For this smoothness, Bezier curve method is used as a steering angle for smooth curve.

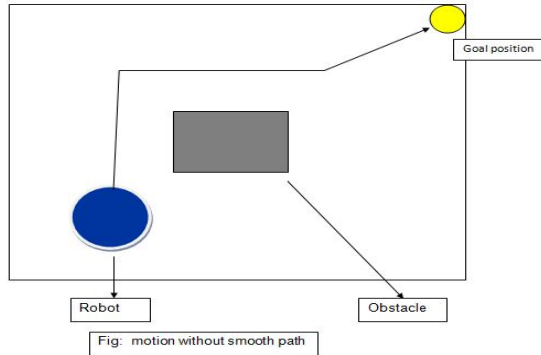


Fig.3 Motion without smooth path

In Figure3 path of robot is not smooth but below figure 4.4 shows the smooth path of robot

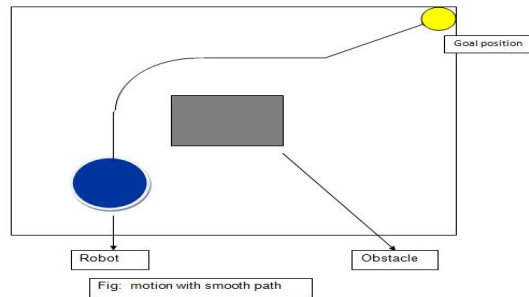


Fig.4 Smooth curve motion

Bezier curve: suppose we have $n+1$ control point positions: $P_i = (X_i, Y_i)$.

where i varying from 0 to n . $P(u)$ position vector, which described the path of an Bezier polynomial function P_0 and P_n .

$$P(u) = \sum_{k=0}^n P_k \text{BEZ}_{k,n}(u) \quad 0 \leq u \leq 1 \quad (4)$$

In Eq.4, Bezier blending function $\text{BEZ}_{k,n}(u)$ are the Bernstein polynomials:

$$\text{BEZ}_{k,n}(u) = C(n, k) u^k (1-u)^{n-k} \quad (5)$$

In Eq.5 Where $C(n, k)$ are the binomial coefficients:

$$C(n, k) = \frac{n!}{k!(n-k)!} \quad (6)$$

This above Eq.4 Bezier curve is used for next function which is fun3.

Mathematical Function: overall function is the addition of all three functions as

$$M F = \text{fun1} + \text{fun2} + \text{fun3}$$

III. RESULT AND DISCUSSION

All the math function is used to get the short path in the environment, For the simulation of “robot navigation in dynamic environment” MOBOTSIM software are used. MOBOTSIM is software for 2D simulation of mobile robots. It provides a graphical interface that represents an environment in which you can easily create, set and edit robots and objects. In order to set these robots in motion MOBOTSIM has a Basic Editor in which the we can write macros making use of specific functions to get information about robots coordinates and sensor data and to set speed

and driving data for them, as well as making use of all the power and ease of Basic language to program navigation techniques [4].

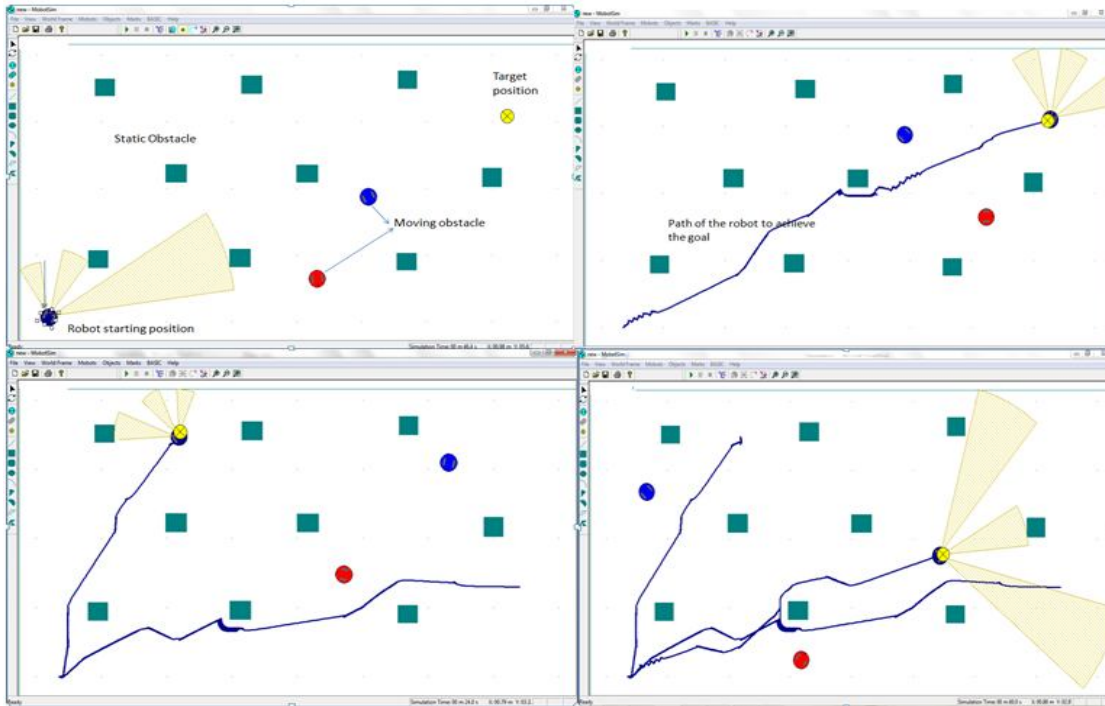


Fig.5 Path Achieved By Robot

This simulation is done by the real environment experimental setup and mobile robot is able to find the goal position by avoiding the static and dynamic obstacle. All the programming is done in embedded C. Simulation results and real environment working model show that the proposed algorithm is effective and efficient in achieving the goal position in dynamic environment.

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