A Mathematical Method for Obstacle-Avoidance and Path-Planning of Robotics

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Abstract - In this paper, a new method which is based on mathematics is proposed for the obstacle-avoidance and path-planning (OAPP) of robotics in unknown environment. The robot just knows the start point and the goal point. The robot is represented by a circle(not a point) whose radius is one. After being sensed, the obstacles are represented by some mathematic functions and when avoiding the obstacles, the robot path will be generated autonomously. Along this path, the robot can get the goal point at last. The simulation results show that the proposed method works very well.

Key Words : obstacle-avoidance, mathematic functions, circle

1. Introduction

The problem of obstacle-avoidance and path-planning of a mobile robot is very famous in the world. And there are also a lot of methods to solve this problem, such as the path-planning based on grid algorithm[1], the path-planning based on genetic algorithm, the path-planning based on neural network algorithm[2] and the path-planning based on fuzzy algorithm[3]. In this paper, I use the mathematical method to solve it. The robot is represented by a circle(not a point) which radius is one. After the robot sensed the obstacles, these obstacles will be represented by some mathematic function. This model is easy and has high efficiency, and also easy to understand, we can easily realize it in the real world.

2. The Proposed Model

2.1 The model of robot

Here, a circle is used to represent the robot, and then the mathematic function of the robot(circle) can be written as :

$$(x-x_0)^2+(y-y_0)^2=r^2 \quad (1)$$

where, x_0 and y_0 indicates the center of the robot which will be changed every step, r indicates the size of the robot.

2.2 The model of obstacles

After being sensed, obstacles can also be represented by some mathematic functions. For example, these three obstacles can be represented as follows:

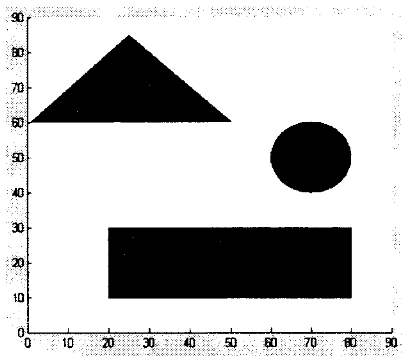

figure 1. the obstacles

$$\text{triangle: } \begin{cases} x-y+59>0 \\ 110-x-y>0 \\ y-60>0 \end{cases} \quad (2)$$

$$\text{rectangle: } \begin{cases} 30-y>0 \\ x-20>0 \\ 80-x>0 \\ y-10>0 \end{cases} \quad (3)$$

$$\text{circle: } 10^2-(x-70)^2-(y-50)^2>0 \quad (4)$$

2.3. The Model Algorithm

The proposed algorithm is expressed in 2D workspace. And the environment is unknown. The robot just knows the start point and the goal point. Because the mathematic function generates strong attractive force from goal point to robot, at first, the robot begin to move from start point to goal point along a straight line. Before every step, in order to avoid obstacles the robot will scan a circle area

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to see whether there are obstacles around it or not. the centre of this circle area is the center of the robot, its radius equals two. If there are no obstacles, it will move to next step along the strait line to the goal point. If there are obstacles around him, it will split the circle area into 16 parts and then the robot will calculate out in which part there are obstacles and in which part there are not obstacles. According to the attraction from goal point and the calculated obstacles(which will generate the repulsive force to robot), the robot will figure out the best direction for next step to move. As to how the obstacles can generate repulsive force and how the goal point can generate attraction to robot, we can know from the picture.

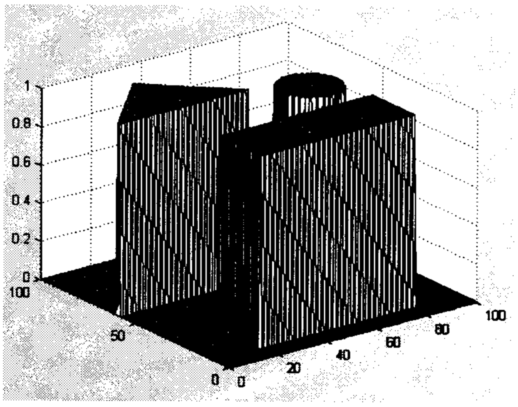

figure 2. the generation of the repulsive force

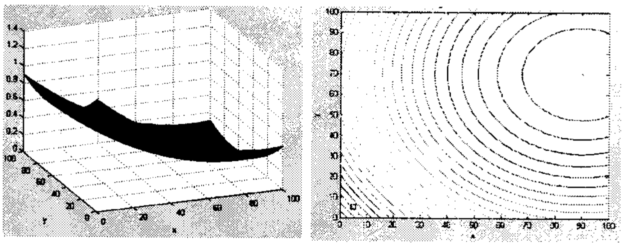

figure 3,4. the generation of the attactive force
the green cross represents the goal point
the blue square represents the start point

This algorithm includes three main parts: preprocess, up and down boundary location, and final location.

This course will be continued until the robot reach the final point.

3. The Simulation Results

In this paper, Matlab is adopted to simulate this algorithm. The following simulation results show that based on this algorithm, the robot can arrive the goal point successfully.

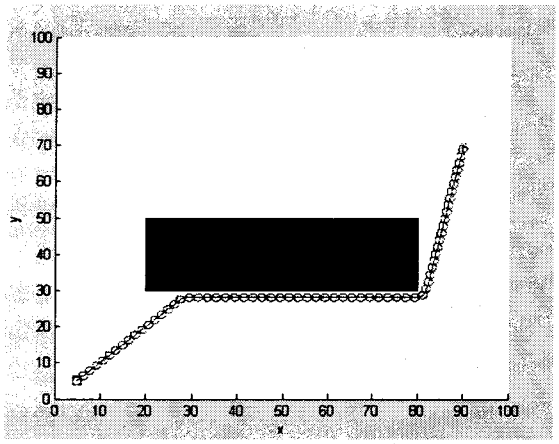

figure 5. when the obstacle is rectangle

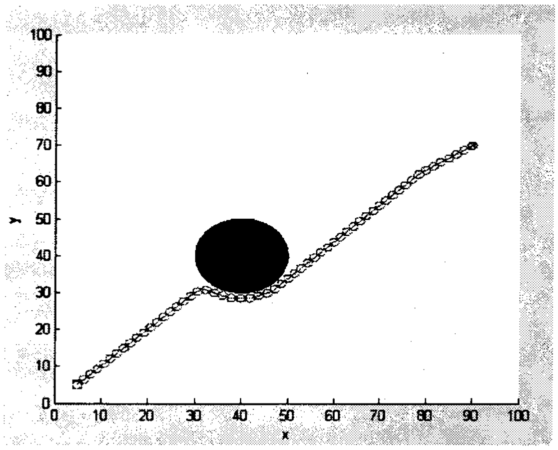

figure 6. when the obstacle is circle

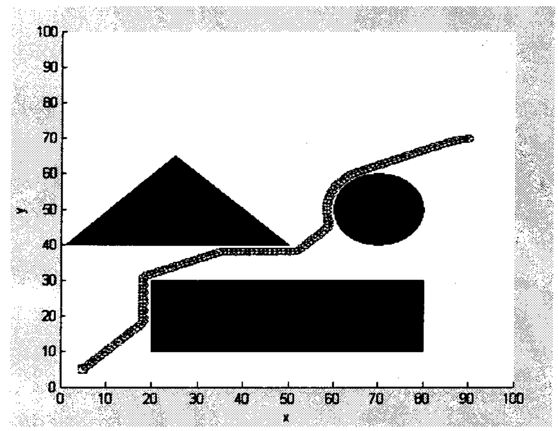

figure 7. when there are all kinds of obstacles
the continuos circles are the track of the robot

4. Conclusion

.The proposed mathematic method enable the robot to avoid the obstacles and reach the goal point in an unknown environment. Based on the method, the goal point can generate attractive force to robot and the obstacle can generate repulsive force to robot. This algorithm is easy to understand and easier to realize.

5. Acknowledgment

The authors would like to thank the Korea Ministry of Science and Technology and the Korea Science and Engineering Foundation for their support through the ERC program.

Reference

[1] Zhao Feng, Cui Ping-yuan, "Approach to Collision Avidance Plan for Robot in Dynamic Environment", Vol.28, No.1, Feb 2003.

[2] "Real-time collision-free path planning of robot manipulators using neural network approaches," Auton. Robots, vol. 9, no. 1, pp. 27-39, 2000.

[3] Li, W.,Ma, C., and Wahl, F.m.: A neuro-fuzzy system architecture for behavior-based control of a mobile robot in unknown environment, Fuzzy Sets Systems 87(1997), 133-140.