A Path Planning Algorithm Based on Setting Boot-Point

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Abstract: In some conditions, the application of artificial potential field theory is some limited, such as local minimum and not finding the route between the obstacles nearby and so on. It is quite simple to use the way of guidance to deal with the problem of trap zone of local minimum according to the statement above, which only need to set one or several boot-points and make it run as the setting point when it can't get to the target.

Keywords: artificial potential field; path planning; setting boot-point

1 Introduction

Artificial potential field theory for path planning is presented by Khatib in 1986, the basic concept is to build an artificial potential field, the objective exerts gravity on the car body, the obstacle exerts repulsion on it, and net force decides the way forward. Artificial potential field theory can effectively plan a collisionless route for the cars and the curve is very smooth, which applies to car track, the theory is so simply and practical that it is the mainstream method of obstacle avoidance algorithm for the outdoor intelligent robots.

It is very easy to find a collisionless route using artificial potential field theory in a simple environment. But in some conditions, the application of artificial potential field theory is also limited. In 1991, Y. koren and J. Borenstein pointed out, according to the mathematical analysis and experiment, that there are 4 defects about artificial potential field theory: 1) there is a trap zone caused by local minimum, the so called local minimum is that the robot becomes vibrational or stationary and can't reach the goal because of the repeating gravity and repulsion when the robot enters into some region; 2) it can't find the route between the obstacles nearby; 3) the biggest limitation is that it will vibrates when the obstacles appear, which will lead to unstability;4) it swings through a narrow passage. Artificial potential field theory leaves a lot to be desired in the effective requirement of today's intelligent robots.

2 Improved Artificial Potential Field Theory

2.1 The Reason Why It Fails to Reach the Goal Near by the Obstacles

When there are some obstacles at the target: while the car body moves to target, it also closes to the obstacles. At this time, gravity is far stronger than repulsion, which makes the target point not the smallest point, so that the car could not reach the target point. Build a new artificial potential field function to solve such problem:

$$U_{re(q)}=\begin{cases}\frac{1}{2}h(\frac{1}{r(q,q_{obs})}-\frac{1}{r})^2 r^n(q,q_{goal}) & r^n(q,q_{goal})\le r_0\\ 0 & r^n(q,q_{goal})>r_0\end{cases}$$

While, *n is called a positive constant,* η is a positive scale factor. The whole potential function minimum value 0 if and only if $q=q_{obs}$

When the car body is not at the target point, repulsion is:

Meanwhile: $F_{re1}=h(\frac{1}{r(q,q_{obs})}-\frac{1}{r})\frac{r^n(q,q_{goal})}{r^2(q,q_{goal})}$

$$F_{re2}=\frac{n}{2}h(\frac{1}{r(q,q_{obs})}-\frac{1}{r})^2 r^n(q,q_{goal})$$

n_{or} and n_{rg} are two unit vectors, respectively pointing from the obstacle to the car and from the car to the target.

Through the establishment of the above potential function, we can deal with the situation that the target is unable to arrival when the obstacle is near.

2.2 The Problem of Trap Zone Caused by Local Minimum

Artificial potential field theory compresses all the information into a net force of which direction control the next movement of the robot, so it abandons other valuable information distributed by the local obstacles, which makes the robot wander periodically and not get to the target during the process of obstacle avoidance.

We can deal with the problem of trap zone caused by local minimum by setting boot-point. When the robot runs the number of iterations long enough (for example, three times further than that when the robot runs in

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straight line to the target point) and doesn't get to the target point, we consider the robot enters into the trap zone, at this time, we can set several points out of local minimum zone and force the robot to move to the boot-point so that the robot will move out of the trap zone and then move to the target point.

It is quite simple to use the way of guidance to deal with the problem of trap zone of local minimum according to the statement above, which only need to set one or several boot-points and make it run as the setting point when it can't get to the target. Figure 3-5 shows us the block diagram of the above method.

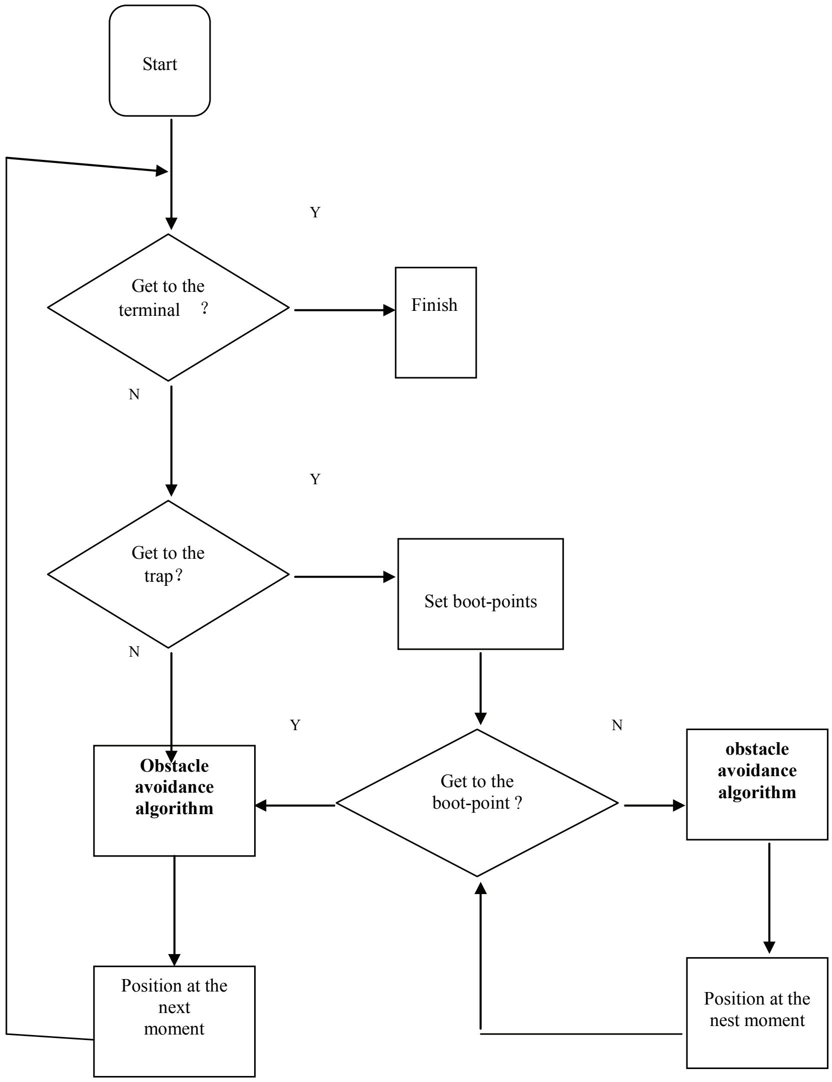

Figure 1. Setting boot-point algorithm

3 The Problem of Vibration near the Obstacles

The problem of vibration near the obstacles for the robot can be improved by adjusting and planning the step of route. We can increase the step appropriately if want the robot to leave the obstacle zone fast; and we can cut the step if want the curve sooth and reduce the width of vibration. However, the increase of step can make the car take the obstacles which will make the built of collisionless route fail; and the reduction of step also make the increase of calculated amount and the difficulty of track and so on. Therefore, the effect is limited to use the way of adjusting the step.

We come up with an idea for it. The problem of vibration of robot near the obstacles manifests in the path fluctuation after adjusted. We can emulate the way of line to make the fluctuation line straight, which only need require there is no obstacles near the line to ensure no collisions while trapping. The detail correcting me-

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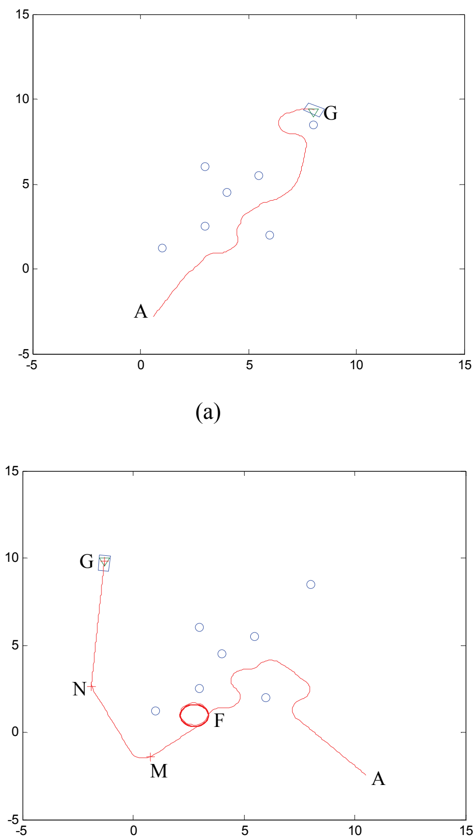
thod is as follows (assume there is an direct collisionless route to the target point): take one point to be coordinate connecting the point of the car a line, then ,get the distance to this line for each obstacles. If any distance to this line for all the obstacles is longer than that that the car can be passed, the car can walk directly in this scale to avoid the possible vibrations. Long route. Cutting the long route into short ones is quite wise.

4 Simulating Effects and Conclusion

Figure 2 shows the car tracking of artificial potential field, the method is to avoid the obstacles in time, namely, to copy the process of people driving: the setting of car route is synchronized with the tracking control, and the car can detect the position of obstacles. Such real-time process can improve the possibility of obstacle avoidance, which suits the changeable environment. A is the position of the car, G is the target point, F means the car is entering into the trap zone, M, N are boot-points after the car drop into local minimum.



(a)

(b)

Figure 2. Simulating effects of improved obstacle avoidance algorithm based on the artificial potential field

Figure 3 shows the planned route in original artificial potential field, so we can judge the advantages and disadvantages obviously. First of all, we can see the movement of the route is obvious between E and F. Besides, in the zone without vibration, even though the route is quite smooth, but the all is the shape of curve which will make the length of route increase. These two shortages makes artificial potential field can't get a route that is short and suitable for tracking in the complicated route rules. Figure 4 deals with the vibration problem. While, A is the beginning of the route plan, G is the target point, A B is the part that is corrected straight. We can see the basic idea from the figure: using the first way of these three ways cuts the route into three parts: AB, BC and CG. Three parties are connected by fold, but it can be solved by using suitable tracking method.

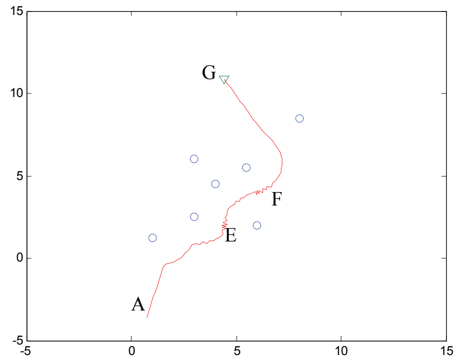


Figure 3. The path planning based on artificial potential field theory

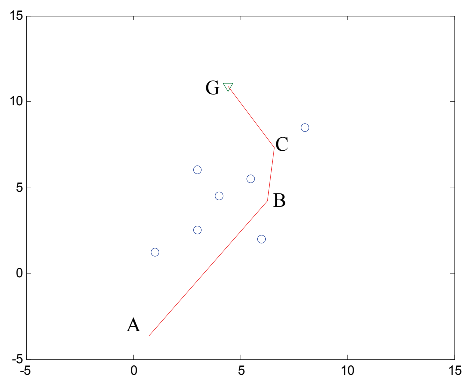


Figure 4. The path planning based on line theory

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