Research on IGV Mobile Vehicle Robot Path in Dynamic Environment

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Abstract: The evolution of various behavior modes of mobile robots described by non-linear differential equation is used to simulate human path planning. The problem of path planning for mobile robots in dynamic environment is studied by behavioral dynamics method. Firstly, the behavior variables and behavior modes of path planning are determined, the course angle dynamics model and velocity dynamics model of the robot are constructed, and the unstable fixed points are analyzed, and the corresponding solutions are given. Secondly, in order to get a better path planning, the competitive model is used to adjust the weight of the behavior mode adaptively. And the simulation results show that the model is correct. And the weight adjustment is effective.

1. Introduction

Path planning of mobile robots is generally divided into global path planning with fully known environmental information and local path planning with partly known environmental information. Global path planning needs optimization. The complexity of algorithm is proportional to the number of obstacles. Generally, it cannot be directly applied to online path planning with moving obstacles. To some extent, local path planning is incompatible with the accuracy of environmental modelling. Because of the existence of static, moving obstacles and moving targets in dynamic environment, the problem of obstacle avoidance is more complex than that of traditional obstacle avoidance. Human beings and other animals have a strong ability to interact with complex environment. They can deal with various problems in dynamic environment, such as effectively avoiding obstacles and intercepting moving targets. Their intelligence is mainly embodied in the way based on the dynamic evolution of behavior. Mobile robots also exhibit such behaviors in unstructured dynamic environments, such as running towards targets and avoiding obstacles. These behaviors show intelligence in dynamic environments through the dynamic behavior of the interaction between robots and the environment. Behavior dynamics method is based on the basic behavioral model, which synthesizes the evolution of various behaviors through non-linear differential equation, and simulates the human path planning.

2. Path planning behavior model

Path planning requires a robot to plan a path from the starting point to the target point, and it must avoid obstacles in the open environment. Therefore, the overall behavior of mobile robot path planning consists of running to the target and avoiding obstacles. The path planning behavior model of mobile robots is composed of the target-oriented behavior model and obstacle avoidance behavior model. In dynamic environment, the two basic behavior modes change with the change of environment, and they restrict each other. Finally, the task of path planning is realized. These behavioral patterns can be realized by differential equations of motion of behavioral variables.

$$(d\varnothing)/dt=f(\varnothing,env) \quad (1)$$

$$(dv)/dt=f(v,env) \quad (2)$$

Among them, $\varnothing$ and v are called behavior variables, v is the moving speed of the robot, $\varnothing$ is the heading angle of the robot, env represents the environment, and the vector field composed of f and g is determined by the task constraints of the robot. In this way, the path planning of mobile robots

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becomes the time course of these behavior variables, that is, the dynamic evolution of behavior. If the initial value of the robot's behavior variables is known, the trajectory of the robot can be described by the time history of heading angle ∅ and velocity v in each planning cycle.

3. Dynamic modelling of path planning behavior

The construction of behavioral dynamics model mainly considers two aspects: one is that the dynamic system must be dissipative and asymptotically stable fixed point or other limit set; the other is that the behavior must be generated through the solution of attractor to ensure that the system maintains an attractor state in all time courses.

3.1. Running toward target behavioral dynamics model

The behavioral dynamics model of the mobile robot running towards the target is expressed by differential equation as showed below.

$$(d\varnothing)/dt=f(\varnothing,env) \quad (3)$$

$$\varnothing = f_{goal}(\varnothing) = -\lambda_{goal} \sin(\varnothing - \varphi_{goal}) \quad (4)$$

Among them, ∅ denotes the heading angle of the robot, φ_{goal} denotes the orientation of the target point relative to the current position of the robot, and λ_{goal} denotes the attraction intensity. $\varnothing = \varphi_{goal}$ is a fixed point of the nonlinear equation. Linearizing it at the fixed point, get $\varnothing = -\lambda_{goal}\varnothing$ approximate exponential asymptotic convergence in the vicinity of the fixed point. φ_{goal} is a stable fixed point, and the target point forms an attractor.

3.2. Dynamic model of obstacle avoidance behavior

Considering the distance between the robot and two symmetrical obstacles and one target point, the robot can reach the target point smoothly through linear motion. Because the obstacle produces repellent to the robot, the differential equation of the obstacle repellent to the course angle of the robot can be obtained by changing the attractor equation of the target point. Through simple summation, the change of unwanted heading angle is affected by θ, and the distance between robot and obstacle is a factor to be considered.

3.3. Integral dynamic model of heading angle

The path planning behavior of robots is determined by the target-oriented behavior mode and obstacle avoidance behavior mode. Therefore, the overall behavior dynamics model of the robot can be obtained, as showed in figure 1.

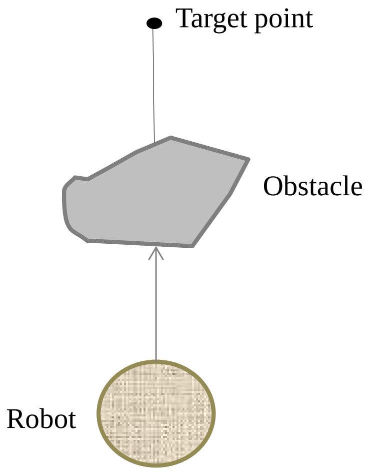

Figure1. Unstable fixed point

From the whole dynamic behavior, it can be seen that the heading angle of the robot does not change any more, and the robot should tend to the target point, but in fact it is not allowed to move to the target point. This corresponds to an unstable fixed point. The robot cannot reach the target point. The unstable fixed point is escaped by adding a random perturbation term to the whole dynamic equation of behavior. Figure 2 shows generalized coordinates of mobile robots.

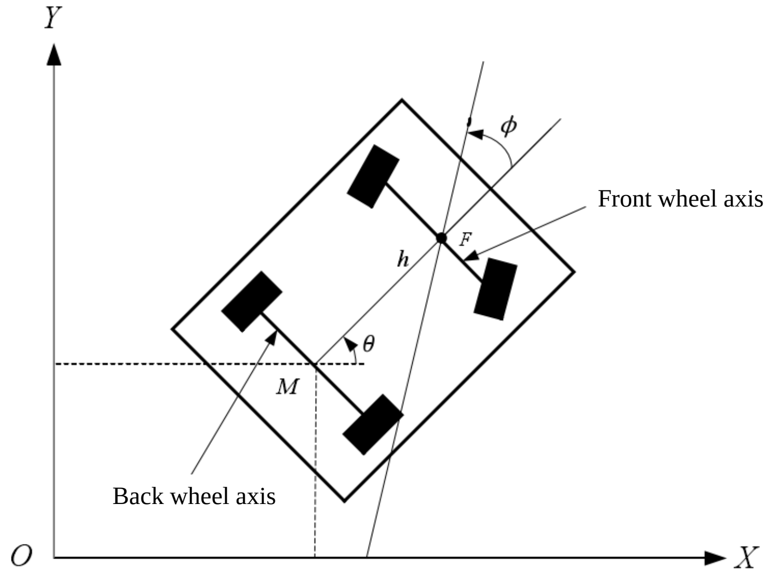

Figure2. Generalized coordinates of the mobile robots

3.4. Velocity dynamics model

In the course of path planning, the mobile robot assumes that the velocity is constant. When there is a moving target, v_{mgoal} becomes an attractor. Therefore, the following equation is used for the velocity.

$$v=-c_v(v - v_{mgoal}) \qquad (5)$$

Among them, v_{mgoal} is the speed of moving target, and c_v reflects the influence intensity of target speed.

3.5. Competition in behavior modes

Robot path planning is the result of the joint action of the goal-oriented behavior mode and obstacle avoidance behavior mode. The weight coefficients between them determine the contribution of a certain behavior to the overall behavior. Because the environment in which the robot is located is complex and dynamic, if the weight coefficients are fixed and unchanged, the path planning is sometimes unsatisfactory. Therefore, it is necessary to control the weight coefficients of both sides in the process of robot navigation in order to plan a better path. Such weight coefficients reflect the role of two kinds of behavior in the overall behavior in different local environments, and they are reflected as a competitive relationship.

4. Simulation analyses

Based on the above model and analysis, the simulation software is used to simulate the path planning under the dynamic and static environment. Simulation parameters: A = 2, A. λ= 60, do: 0.1, σ= 0.6, C = 1, d 0 = 0.05, K1 = 0.3, 2 = 1,d = 0.1, k = 0.1; the speed of moving obstacles are 0.4 m/s and 0.25 m/s respectively, and they all move in a straight line; the planning period is 0.5 S, and the equation of motion of moving target is:

$$x=0.3\cos(\pi t/6) \qquad (6)$$

$$y=0.3\sin(\pi t/6) \qquad (7)$$

From the simulation results of mobile robot path planning in dynamic and static environment, it can be seen that the robot can complete the planning task well and reach the goal. The weight coefficients of the target and obstacle avoidance behavior patterns change with time. Initially affected by fewer obstacles, the two coefficients change from the initial value of 0.5 to the first stable mode, and after 3.5 seconds of stable state, the robot passes through two nearly symmetrical obstacles. The two coefficients remain relatively stable in the dense area of obstacles for a period of time until they meet the emergence of moving targets and gradually move away from obstacles, and quickly switch to the dominant state of running towards the target behavior, thus forming the final stable mode.

5. Conclusions

For the path planning problem of mobile robot in dynamic environment, while giving the behavior mode of path planning, the course angle and speed of the robot are determined as the behavior variables. Their non-linear dynamic models are constructed through analysis, and the stability of the fixed point of the model is analyzed by using the stability analysis method of dynamic system. Meanwhile, the solution to the unstable fixed point is given. Competition model is used to automatically adjust the weight of path planning behavior model. The validity of path planning model is verified by simulation results.

References

[1] Xu De, Tan Min. Robot Vision Measurement and Control [M]. Beijing: National Defense Industry Press, 2011:285-289.

[2] Wang Dingwei, Wang Junwei, Wang Hongfeng, et al. Intelligent optimization method [M]. Beijing: Higher Education Press, 2017:167-170.

[3] Alberto Ceselli, Giovanni Righini, Matteo Salani. A column generation algorithm for a rich vehicle-routing problem [J].Transportation Science, 2009, 43(1):56-69.