Obstacle Avoidance Trajectory Planning for Robot Motion Based on Probability Theory (Stage One)

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Background

The robot system will deviate from its original trajectory due to the influence of process noise and observation noise, such as the deviation of the control model, external disturbance and inertial sensor error. This kind of trajectory deviation is not obvious in robot sensing and control systems with strong deterministic types, such as industrial robot motion control with grating. But for sure the weaker control system, such as: visual navigation of autonomous mobile trolley, inertial guidance of unmanned aerial vehicle (uav), etc., due to the influence of sensor observation error and error control process, the robot does not guarantee completely accurately track the desired trajectory, but walking along the path of each moment are deviate from the track of probability. When it is assumed that both the system observation errors and the control process errors obey the Gaussian distribution, the deviation from the predetermined trajectory also obeys the Gaussian distribution. This kind of error obeys the gaussian distribution of the robot's nondeterministic motion.

Objectives

The total project will be executed in two stages:
Stage 1 Using the Gaussian distribution in probability theory is to analyze the motion of the robot on the predetermined trajectory, and the motion error distribution in each cycle is analyzed to calculate the collision probability between the robot and the obstacle at different moments

Stage 2 On the basis of the stage 1 experiment, the robot is assigned multiple trajections, and the robot searches for the optimal trajectory according to the collision probability of different trajections.

Particularly, stage one has the following sub-objectives:

1. Define the motion space of the robot and simulate the motion error
2. Priori Estimation of Trajectory Error Distribution
3. Obstacle collision probability calculation
4. Experimental simulation

Preliminary Literature Review

At present, most research on trajectory planning methods of robotic systems are based on the deterministic assumptions of the system, and there are many excellent results[1-3].In the research of robot non-determinism, Bry[4] added system non-determinism to the node generation process of the random expansion tree. Each time a new node is generated, the Monte Carlo method is used to test the variance probability of the new node and carry out trajectory planning. Toit[5] et al. combined LQR control with Kalman filter in the robot control system, and used the rolling time domain method to reduce the movement deviation of the robot system. Sun[6] et al. applied multi-core and multi-threaded programming technology to apply Toit's LQG non-deterministic sampling optimization method to real-time calculations, and simulated the real-time trajectory planning of medical probes and mobile robots.

Methodology

In this project(stage one), use the method of probability theory, based on the linearization of the robot model, and apply the Kalman filter method to a priori estimation of the error probability of the robot moving along the predetermined trajectory. The point on the predefined trajectory is regarded as the probability expectation, and the covariance is used to represent the possible error. Using the Gaussian motion probability ellipse, evaluate the probability of avoiding obstacles on the covariance of each trajectory, and obtain the probability of avoiding obstacles of the trajectory.

Citations

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