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Trajectory planning method based on expected redundancy

Chong Zhao, Lihong Du, Tingkai Li, Qi Dai

Rocket Army Engineering University, 710038

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Abstract: The problem background of this question is that the aircraft cannot ideally correct the error at some calibration points, that is, it cannot correct a certain error to 0, but correct it to a certain unit with a certain probability, and there will be residual errors after the correction. In fact, compared with Question 1, this question weakens the correction capabilities of some nodes, leading to stricter error constraints, and the actual reachable set of nodes becomes smaller. On the whole, it strengthens the error constraints in trajectory planning. In this way, for the trajectory that has been planned in question 1, in the context of this question, whether the aircraft can successfully reach point B from point A has become an uncertain probability problem. The title requires that the trajectory in question 1 should be re-examined in this context, and a trajectory with the greatest possible probability of reaching the destination can be planned.

1. Introduction

If the idea of solving problem 1 can still be used, not only the error constraint between the two nodes must be considered, but also the uncertainty factor of the probability correction of each node. In order to reflect the randomness of the state of the nodes in the search process, two methods are usually used. One is to add a random variable at all nodes, and then obtain the probability of the track successfully reaching the destination through a large number of simulation statistics. Another method is to only add random variables to a single node and then simulate the corresponding probability. Both of these methods increase the complexity of the calculation and the probability obtained does not have practical reference significance.

In order to reflect the randomness in the search process without increasing the complexity of the algorithm, this question considers the use of a statistic that can represent the characteristics of random variables and has a definite value-expectation. We consider the expected correction error of the node. Since the value of the corrected error of the correction point obeys the probability distribution, the expected error after correction can be calculated as the value of the corrected error at this point, and the probability problem of uncertainty is transformed Solve the problem for deterministic expectations, and then use the model and method of problem 1 for trajectory planning

2. RRT trajectory planning method based on expected value of correction capability

2.1 Basic definition and symbol description

If a node can 100% accurately correct an error to 0, it is called a stable node, otherwise it is called an unstable node, which is represented by.

For unstable nodes, the definition of the expected correction capability of the node is given.

If, according to the problem setting, after the aircraft performs vertical error correction at this node, the vertical residual error obeys the probability distribution.

$$\begin{cases} P(\delta_i^{\perp} = 0) = 80\% \\ P(\delta_i^{\perp} = \min(\delta_{i0}^{\perp}, \lambda)) = 20\% \end{cases}$$

For unstable nodes, the definition of the expected correction capability of the node is given. If, according to the problem setting, after the aircraft performs vertical error correction at this node, the vertical residual error obeys the probability distribution.

Through the above discussion, it can be concluded that the smaller the value, the stronger the correction ability of the node, and the larger the corresponding expected value. In order to facilitate the description below, it is stipulated here that, without causing ambiguity, the concepts of “error” related to the unstable node's pre-correction error, residual error, and residual error expectation mentioned later refer to the concept of “error”. The value corresponding to the point correction type is no longer discussed and distinguished for the specific type. The sum is collectively referred to as the residual error after the correction of the unstable node, and the sum is collectively referred to as the correction capability expectation. You can also find.

2.2 Correction ability expected value solution

In order to calculate each unstable node, first assume that there are all stable nodes in the node set U, and then generate K sample tracks with 100% probability of reaching the destination according to the model and method of question 1, and then according to the unstable node given in this question Node number, count the number of times that all the above-mentioned tracks have passed the unstable node, and record it as. The following takes the point as an example to introduce the method of calculating this node. As shown in the figure, each trajectory has passed the unstable node, and the error when the aircraft reaches the point via the first trajectory (that is, the error before correction) is recorded as, then the correction capability of this point is expected to be

$$\varepsilon_i = -\sum_{c=1}^{C_i} \frac{1}{C_i} 0.2 \min(\delta_{c0}, \lambda) = -\frac{0.2}{C_i} \sum_{c=1}^{C_i} \min(\delta_{c0}, \lambda)$$

2.3 Constraints and Comprehensive Objective Function

After obtaining the correction capability expectation, we use the expected inverse number as the corrected error value. In this way, reconsidering the correction error formula in question 1, we can see that the horizontal error and vertical error of the unstable node after correction become

$$\begin{cases} \delta_i^{\perp} = \left|\varepsilon_i^{\perp}\right|, \delta_i^{\parallel} = \delta_{i0}^{\parallel}, if\,(\tilde{N}_i \in U^{\perp}) \\ \delta_i^{\parallel} = \left|\varepsilon_i^{\parallel}\right|, \delta_i^{\perp} = \delta_{i0}^{\perp}, if\,(\tilde{N}_i \in U^{\parallel}) \end{cases}$$

$$\begin{cases} \delta_{j0}{}^{\perp} \le \min(\alpha_1,\theta), \delta_{j0}{}^{\parallel} \le \min(\alpha_2,\theta), if\,(N_j \in \mathrm{U}^{\perp}) \\ \delta_{j0}{}^{\perp} \le \min(\beta_1,\theta), \delta_{j0}{}^{\parallel} \le \min(\beta_2,\theta), if\,(N_j \in \mathrm{U}^{\parallel}) \end{cases}$$

The difference between the optimization objective of this question and Question 1 is that not only the total number of error correction points passed through is the smallest, and the total length of the trajectory is the smallest, but also the probability P of the aircraft to reach the end through the trajectory is as large as possible, then there is.

3. Simulation results and analysis Simulation results and analysis

3.1 Simulation results and analysis Simulation results and analysis

From the table, we can see that the corrected optimal trajectory of data set 1 accounts for a relatively high number of unstable correction points, which leads to a significant decrease in the probability of reaching point B smoothly compared to the optimal trajectory of its voyage. Data set 2 The probability of reaching point B on the optimal trajectory is as low as 10.69%. The expected redundancy RRT algorithm proposed in this paper is used to re-plan data set 1 and data set 2. The results of the re-planning of data set 1 are shown in Figure 29 (detailed track information is recorded in Table 9). 9 calibration points, the track length is 104370.9255m, and the probability of reaching point B is 80.40%. Compared with the optimal trajectory of problem 1, the probability of reaching point B is increased at the expense of only about 100m of voyage length. 1.26%, compared with the optimal trajectory correction, the probability of reaching point B is increased by 39.59% under the condition that one more correction point is passed.

The result of the re-planning of data set 2 is shown in Figure 1. The trajectory has undergone 20 correction points in total, the length of the trajectory is 173563.6610m, and the probability of reaching point B is 80.40%. Contrast problem 1 the optimal trajectory of the voyage, at the expense of only about 100m of voyage length, the probability of reaching point B is increased by 1.26%. Compared with the optimal trajectory of the correction, it arrives smoothly after passing through one more correction point. The probability of point B increased by 39.59%.

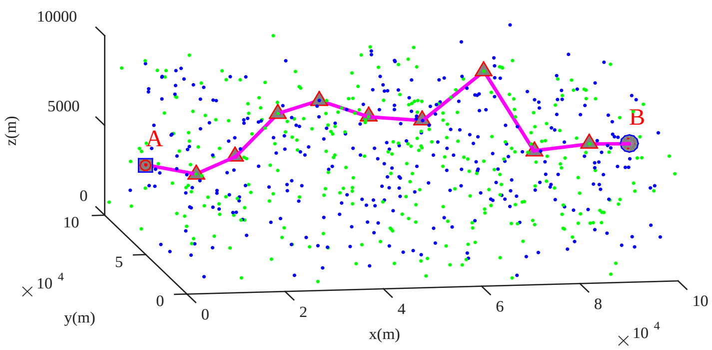

Figure 1: Optimal track of data

3.2 Result analysis

In order to further analyze the total length of the optimized track, the number of correction points passed and the probability of successfully reaching point B, we conducted 104 Monte Carlo simulations for data set 1, and performed statistics on the data.

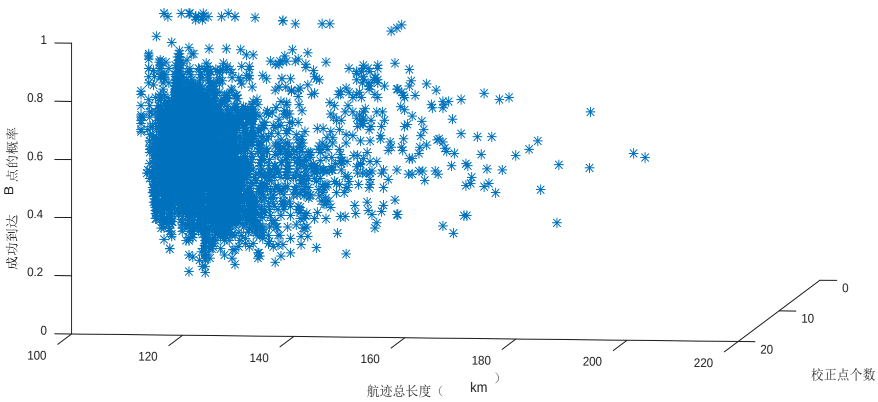

Figure 2: Sub Monte Carlo simulation

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