A Novel Route Planning Scheme Based on Dynamic Time Variables

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Abstract. In this paper, the processing method of dynamic time variables in the route planning node that we designed involves the field of route planning, including determining the route time and stay time, combining the floating reserved time to determine the redundancy; after the entity has visited a node, the current value is calculated redundancy: According to the calculated redundancy value, combined with the preset redundancy threshold, the entity's route and stay time are reminded. By converting the dynamic time variable into a fixed value, the model can complete the search for the optimal path within a limited time. At the same time, the concept of reserved floating time is introduced, thereby retaining the dynamic characteristics of time, so that visitors can have sufficient time stay, and can complete the stay according to the fixed time requirements, can effectively track the stay time and make corresponding processing in the corresponding situation to ensure the stay ability. The proposed scheme has better performance.

Keywords: Dynamic time variables, route planning, route time.

1. Introduction

Route planning is one of the main research contents of motion planning. Motion planning is composed of route planning and trajectory planning (time). The sequence of points or curves connecting the start and end positions is called the path, and the strategy that constitutes the path is called Route planning. The path is a certain sequence of the robot's pose, regardless of the factors that change the robot's pose parameters over time.

Route planning (generally referred to as location planning) is to find a series of path points to be passed. Path points are positions or joint angles in space, while trajectory planning is to give time information to the path. Motion planning (also known as motion interpolation) is to insert a sequence of intermediate points for control between the endpoints of a given path to achieve smooth motion along a given path. Motion control is mainly to solve the problem of how to control the target system to accurately track the command trajectory. That is, for a given command trajectory, select suitable control algorithms and parameters, generate output, and control the target in real time and accurately track the given command trajectory [1-5].

The goal of route planning is to make the distance between the path and obstacles as far as possible and the length of the path as short as possible; the purpose of trajectory planning is to make the robot's running time as short as possible or the energy as small as possible while the robot is moving in the joint space. Trajectory planning adds time series information on the basis of Route planning to plan...
the speed and acceleration of the robot when performing tasks to meet the requirements of smoothness and speed controllability.

With the vigorous development of smart tourism, scenic spots have made certain achievements in the construction of smart management and smart services, but there are still some problems, such as how scenic spots can assist in effective planning of tourist routes and improve service efficiency. In view of the problems of smart scenic tourism, we can make full use of new network technologies such as mobile Internet [6-9], Internet of Things [10, 11], and cloud computing, to solve these issues, and make the entire journey of scenic tourists more intelligent, humanized, specialized and refined.

2. Related Works

In order to solve the Route planning problem, many effective solutions have been explored. They are not mutually exclusive, and often combine to achieve a common path. The typical methods are as follows:

1) Geometric method

The geometric method extracts the geometric characteristics of the environment. Using its combination characteristics to map the environment space to a weighted (weight can make the geometric distance between two points) graph, so that the Route planning problem of avoiding obstacles can be transformed into a simple graph search problem. The Route planning method based on geometric method is generally divided into 3 steps:

- Find the starting point in the search graph;
- Find the target point in the search graph;
- Use these two points as a polyline that does not pass through obstacles in the graph or connect the curves to get a collision-free path.

Geometric methods include:

a. Visibility Graph

This method connects the vertices of all obstacles (set as V0), the starting point s, and the target point g with a straight line combination, and requires that the line between the three cannot pass through the obstacle; That is, the straight line is visible. Assign weights to the edges in the graph to construct the graph G (V, E) [12]. Then use a certain search method to plan the optimal path. This method can be used when the number of obstacles or the shape of the line is not complicated, but when the two are not satisfied, the constructed graph G (V, E) will increase the amount of calculation by hundreds of thousands, so it is somewhat clever. People have made some improvements to it, so that it can complete Route planning without saving so much information. This method is called tangent method.

Advantages: intuitive concept and simple implementation. Disadvantages: lack of flexibility, that is, once the starting point and target point are changed, the visible view must be reconstructed, and the path is not optimal.

b. Voronoi diagram method

This method uses a series of nodes to define; these nodes are equidistant from the edges of two or more obstacles nearby. The Voronoi diagram divides the space into several areas, each area only contains the edge of an obstacle (similar to the brushfram method). Advantages: The path is very safe. Disadvantages [13]: The amount of calculation is very large, and the path is not optimal. A typical Voronoi diagram is shown in Fig. 1.

![Figure 1. A typical Voronoi diagram.](image-url)
c. Free space law
The environment is divided into two parts, namely obstacle space and free space. Use a certain search strategy to find a path in free space. According to the different methods of dividing free space, it can be divided into convex area method, triangle method, and generalized cone method. Advantages: The path has no collision and is more flexible [14]. The change of the starting point and the target point will not cause the reconstruction of the connected graph. Disadvantages: In some cases, the path deviates too far from the foreground target, and the shape of the planned path is more complicated and the accuracy is not high.

2) Unit division method
The typical feature of unit division is that the division of space and the search are cross-processed. This method divides the free space into a set of simple units, and the adjacency of the lines between the units is also calculated at the same time. First identify the unit where the starting point and the target point are located, and then connect the consecutive cells between the two points to obtain a safe path. The pollen of the unit can be dependent on obstacles or independent of obstacles. For the former, the boundary of the obstacle is used to generate the boundary of the cell, and the resulting set of free cells accurately defines the free space [15]. Its advantage is: the obstacle is effectively expressed, and the resulting cell is less, which is independent of obstacle cell division method searches for fewer nodes. The disadvantage is that the adjacency relationship between the unit decomposition and the calculation unit is expensive. For the unit decomposition independent of obstacles, the environment space is divided into some regular-shaped units, and the algorithm is simple. In all units, if there are no obstacles, it is called an empty unit: if it is full of obstacles, it is a full unit, and if part of it contains obstacles, it is called a mixed unit. Eight-segment elements are regarded as nodes, and the adjacent relations between them are connected by arcs to obtain a network connected graph, so the problem of finding a safe path becomes a graph search. Its advantages are: simple division and easy implementation. The disadvantages are: Obstacles are not necessarily represented accurately, and the way to improve is to increase the number of units to increase the accuracy of the points exchange.

3) Mathematical analysis method
This method transforms the problem of finding the optimal path from the start point to the end point into a problem of seeking a set of extreme values of objective functions with constraints, and transforms the problem of Route planning into a problem of function optimization. Because this kind of optimization is non-linear and has many kinds of restriction conditions, discretization methods are often used to find the optimal solution.

3. Route Planning Scheme Based on Dynamic Time Variables
In this section, after abstracting the route planning of scenic spots, we propose a route planning scheme based on dynamic time variables. It is described as follows:
According to the travel mode of the entities, we determine the route time $t_1$ spent by the entities on the journey, the stay time $t_2$ spent by the entities staying in the nodes according to the travel mode of the entities, and determine the floating reserved time $t = t_1 + t_2$ according to the route time and stay time; Then, we determine the actual floating reserve time $t'$, combined with the floating reserve time $t$ to determine the redundancy $\eta$.

The moment when the entity finishes visiting a node is recorded as a critical moment node, and the calculation step of calculating the redundancy $\eta$ corresponding to the critical moment node is triggered at each critical moment node to obtain the redundancy corresponding to each critical moment node; According to the calculated redundancy value, combined with the preset redundancy threshold, the entity's tour route and stay time are reminded.

By converting the dynamic time variable into a fixed value, the model can complete the search for the optimal path within a limited time. At the same time, the concept of reserved floating time is introduced, thereby retaining the dynamic characteristics of time, so that visitors can have sufficient time stay, and can complete the stay according to a fixed time requirement. In order to ensure the completion of the route, we introduced the concept of time redundancy, which can effectively track
the stay time and make corresponding processing in the corresponding situation to ensure the stay ability.
Specifically, according to the difference in the route time of entities in each node, the redundancy corresponding to the actual route time is determined, and it is stipulated that the redundancy corresponding to the current moment is obtained every time the entity finishes visiting a node. Values, and then remind visitors of the way of sightseeing based on redundancy, to achieve effective tracking of visitors’ stay time, to remind the actual stay time, to effectively plan the visitor’s stay time, and to avoid uneven distribution of stay time. As a result, the sights are missed.
In the actual implementation process, according to the different estimated time spent by entities at each attraction, the actual redundancy changes, and the dynamic time variables are converted into quantitative processing, which reduces the complexity of the model and facilitates the optimization. The search of the path, and the setting of time redundancy and key time nodes, allows us to monitor the whole process to ensure the smooth progress of the game.

1. Determining the route time spent by the entities on the journey according to the transportation mode of the entities, including:
   Leave \( t^i_k \), \( k = 1, 2, \ldots, n \), mark \( t = \sum_{k=1}^{n} t^i_k \), \( t_i \) is the time that the entity will spend on the journey.
   In the implementation, the journey to the node will be divided into several sections during the actual travel of the entities. Here, the time spent on each section of the journey is recorded as \( t^i_k \), and the time spent by the entities during the journey is recorded as \( t_i \). The latter is the cumulative sum of the former, in this way, the time spent by entities in the course of the journey is determined by the cumulative sum.

2. According to the transportation mode of the entities, the staying time \( t^i_k \) spent by the entities staying in the nodes includes:
   Set \( t^i_k \), \( k = 1, 2, \ldots, n \), mark \( t^i_k = \sum_{k=1}^{n} t^i_k \), as the time that entities will spend in the node.
   Similar to the previous step, the time spent by entities in each node is recorded as \( t^i_k \), and the time spent by entities during the journey is recorded as \( t^i_k \), and the latter is the cumulative sum of the former. In this way, the sum is summed by accumulation. The way is determined the time spent by entities in the process of staying in the node.

3. Determine the actual floating reserve time \( t_h \), combined with the floating reserve time \( t \) to determine the redundancy \( \eta \), including:
   The floating reserve time used is \( t_h \), \( n = 1 \) or \( 2 \), and time redundancy \( \eta \) is introduced. \( \eta = 1 - \frac{t_h}{t} \) indicates the actual route's utilization of floating time. Among them, set \( t \) as the floating reserved time.

4. Determine the floating reserved time \( t_h \) according to the \( t_i \) and \( t^i_k \) obtained in the first two steps, and then determine the utilization degree of the floating time that represents the actual route time of the entities in the node according to the floating reserved time.
   The greater the redundancy, the higher the time utilization rate of the entity’s current stay route, the less time spent on the road or other things unrelated to stay, and the more adequate stay; on the contrary, if the redundancy is less, Which shows that the time utilization rate of the entity's single-money stay route is low, and the time spent on the road or other things unrelated to the entity is more, and the stay is not sufficient.

5. According to the calculated redundancy \( \eta \) value, combined with the preset redundancy threshold, the entity's tour route and stay time will be reminded.
   In order to be able to remind visitors of the entity’s stay time based on the calculated redundancy value, redundancy thresholds \( \eta_0 \), \( \eta_1 \), and \( \eta_2 \), are set, and the relationship among the three is in order of \( 0 < \eta_0 < \eta_1 < \eta_2 \leq 1 \); when the actual calculated redundancy is close to 1. It shows that the current entity's stay time is basically used for the sightseeing of nodes in the node, and basically no time is spent on irrelevant things.
\( \eta \) is the warning line, if \( \eta_1 < \eta < \eta_2 \) will trigger a warning, remind visitors that they must pay attention to the stay time, control the stay season to ensure the smooth completion of the pre-selected route; \( \eta_3 \) is the termination line. When \( \eta_0 < \eta < \eta_1 \), a reminder "reserved time has been exhausted" will be issued. You must stay according to the set time to ensure the completion of the scheduled route; When the time redundancy is lower than \( \eta_4 \), it shows that the current route cannot be completed in the remaining time, and the route search must be performed again so that the entities can complete the game within the limited time.

4. Conclusion

When entities are currently visiting the node, it may be due to unreasonable route planning and excessive traffic at a certain node that the actual stay time may not match the expected stay time, or even vary greatly, which may cause the planned node to not be visited, which affects stay experience. In this article, we aim to provide the concept of time redundancy, so as to effectively track the stay time and make corresponding processing in the corresponding situation to ensure the processing method of dynamic time variables in the route planning.

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