The Ant Algorithm for Solving Robot Path Planning Problem

Gengqian Liu Tiejun Li Yuqing Peng Xiangdan Hou
Hebei University of Technology,Tianjin,P.R.China, 300130
Email: pyq1969@163.com

Abstract

Using ant algorithm, robot path planning in two-dimension environment is studied. It introduces the intelligent finding optimum mechanism of ant colony. It solves the drawback of local optimization and expedites searching speed. The mathematical model is established and the algorithm is achieved with VB language, the result shows it is valid with the capability of robust and extensibility.

1. Introduction

Robot path planning means in the working space, a path is found with the robot starting from a point , rounding barriers and arriving to the destination. Commonly, there are many paths for robot to accomplish the task, but in fact the best path is selected according to some guide line. These guide lines are : shortest path, least energy consuming or shortest time. So, the robot path planning is a constrained optimization problem.

Robot path planning is a NP problem, traditional optimization methods are not very effective to it, which are easy to plunge into local minimum. The ant algorithm is a simulated evolution algorithm based on population and ant colony behaviors , it was first used in the traveling salesman problem (TSP)[1-3]. Ant algorithm absorbs the behavior characteristic of real ants, as we know, real ants are capable of finding the shortest path from a food source to the nest without using visual cues. Also, they are capable of adapting to changes in the environment, for example finding a new shortest path once the old one is no longer feasible due to a new obstacle. That is because ant release own secretion which called pheromone on its path road, and the pheromone influences other ants path selecting, when a path is selected by many ants, the pheromone on the path becomes more and more, and more ants select it, of course the pheromone will weaken with time running. In this paper, a new method for robot path planning is proposed based on ant algorithm, and the mathematical model is established. With the experiments, the results show the method is effective.

2. Theory of ant algorithm

We describe the model of ant algorithm through the problem of N-TSP[4]. In order to simulate real ants, there are some earmarks, m is the count of ants, d_{ij} ($i, j = 1,2,\cdots,\mathrm{n}$) expresses the distance from city i to city j, $b_i(t)$ expresses the count of ant at city i at t, $m = \sum_{i=1}^{n} b_i(t)$ • $\tau_{ij}(t)$ expresses pheromone intensity of path (i,j) at t. At preliminary, the pheromone on each path is equal, set $\tau_{ij}(0) = C$ (C is a constant) .The k -th ant ($k = 1,2,\cdots,\mathrm{m}$) selects transfer direction according to pheromone on path, $p_{ij}^{k}(t)$ expresses the probability from i to j at t.

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]*[\eta_{ij}]^{\beta}}{\sum_{u\in allowed_k}[\tau_{iu}(t)]*[\eta_{iu}]^{\beta}} & \text{if } j \in allowed_k \\ 0 & \text{others} \end{cases} \quad (1)$$

therein , $allowed_k$ ={0 , 1 , … , n-1}- $tabu_k$ represents the node that the k-th ant can select in the next step. $tabu_k$ ($k = 1,2,\cdots,\mathrm{m}$) records the cities visited by the k-th ant in the current route, it is adjusted with the time and the pheromone disappears little by little, $1-\rho$ represents evaporation rate. When ants accomplish one circulation, the pheromone is adjusted according to the follow formula:

$$\tau_{ij}(t+n) = \rho \times \tau_{ij}(t) + \Delta\tau_{ij} \quad (2)$$

Proceedings of the Third International Conference on Information Technology and Applications (ICITA'05)
0-7695-2316-1/05 $20.00 © 2005 **IEEE**

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}^{k} \qquad (3)$$

$\Delta\tau_{ij}^{k}$ represents the pheromone amount left by the k-the ant at path (i, j) in this circulation, $\Delta\tau_{ij}$ represents sum of pheromone amount left at path (i, j) in this loop.

$$\Delta\tau_{ij}^{k} = \begin{cases} \dfrac{Q}{L_k} & \text{if (i, j)} \in \text{tabu}_k \\ 0 & \text{others} \end{cases} \qquad (4)$$

Q is constant, L_k represents the route length of the k-th ant this circulation. At the time of preliminary, $\tau_{ij}(0) = C$, $\Delta\tau_{ij} = 0$ ($i, j = 1, 2, \cdots, \text{n - 1}$) , α , β denote the information accumulated during the movement of ants and the different effects of factors in the path selection. η_{ij} denotes expectation transfer from city i to j.

3. Robot path planning based on ant algorithm

3.1. Model constitution

Let the working space is 2-dimension board, the location and size of barriers are known and they are not change. The working space is partitioned with equal grid, and a m*n board is gotten. If there is no obstacle in a grid, the grid is called free, otherwise called obstacle grid. The partitioned space is shown as fig.1, shadow area is obstacle.

In Fig.1, we record the grid from left to right , from up to down and get the serial number, when ant searching path, the serial number is used ,but when computing object functions, coordinate is computed.

Robot path planning is a problem of finding the shortest path, the restriction is not intersected with obstacle. The object function is defined as:

$$f = \sum_{i=1}^{N-1} d(m_i, m_{i+1}) \qquad (5)$$

therein , $d(m_i, m_{i+1})$ expresses distance of adjacent node.

3.2.Algorithm of path planning

We put ants into the m*n grid, each ant leaves from

0	1	2		4	5	6	7	8	
	11			14	15		17	18	19
20	21	22	23	24	25		27	28	29
30			33	34	35	36	37	38	39
40			43	44	45	46	47		49
50	51	52	53	54	55		57	58	59
60	61	62		64	65	66	67	68	
70	71	72	73	74	75			78	79
80		82	83	84	85		87	88	89
90		92	93		95	96	97	98	99

Figure 1. 10*10 grid

the prescriptive start node, searching adjacent free grid, and reaching the intention node based on pheromone on grid. Here, we set:

m is count of ants;

η_{ij} is visibility of grid（i, j）, viz. 1 / d_{ij};

τ_{ij} is pheromone intensity of grid（i, j）;

$\Delta\tau_{ij}$ is pheromone increment of the k-th ant at grid（i, j）;

f_k is objective function;

P_{ij}^{k} is transform probability of the k-th ant, it is direct proportion with $\tau_{ij}^{\alpha} \bullet \eta_{ij}^{\beta}$,update equation of intensity of pheromone is:

$$\tau_{ij}^{new} = \rho \cdot \tau_{ij}^{old} + \sum_{k} \Delta\tau_{ij}^{k} \qquad (6)$$

here,each paremeters is:

α expreses relative importanceof pheromone ($\alpha \geq 0$);

β expreses relative importance of visibility ($\beta \geq 0$);

ρ expreses permanence of pheromone ($0 \leq \rho \leq 1$) , $1 - \rho$ espresses evaporation;

Q is a constant.

The algorithm is described as follows:

step1 nc=0(nc is a loop counter.)

initialize each τ_{ij} and $\Delta\tau_{ij}^{o}$

put m ants to start point or intention node.

step2 set all start node into current $tabu_k$

for each ant ($k = 1,2,\cdots,m$) move to next j according to P_{ij}^k

$$p_{ij}^k(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^\alpha * [\eta_{ij}]^\beta}{\sum_{u \in allowed_k} [\tau_{iu}(t)]^\alpha * [\eta_{iu}]^\beta} & \text{if } j \in allowed_k \\ 0 & \text{others} \end{cases}$$

$allowed_k$ is free grids adjacent to i and not in $tabu_k$,put j into $tabu_k$

step3 computer f_k ($k = 1,2,\cdots,m$)

record the current best answer

step4 update equation of intensity of pheromone

step5 for each grid(i, j), set $\Delta\tau_{ij} \leftarrow 0$

$nc \leftarrow nc + 1$

step6 if $nc < nc_{max}$, goto step 2

step7 output the best answer

4. Experiments and conclusion

We simulated robot path planning with computer, the algorithm generated obstacles randomly. Fig 2 is the program result, left corner is start node and right corner is intention node, the optimum path is shown with wide line.

In this paper, an algorithm based on ant colony is proposed to solve robot path planning problems. The proposed ant algorithm has the following characteristics: (1) it hurdles the abuse of local optimization and expedite searching speed, with the experiments, the method is proved effective. (2) The algorithm has good scalability. This is because that the ant algorithm leaves information on the path for the sake of next routing during the search process. The information can be kept when more nodes are added. In the future, we would like to study multi-robot path planning problem and obstacles are added dynamically, at that time ant can use foregoing knowledge, and more characteristics would be discovered.

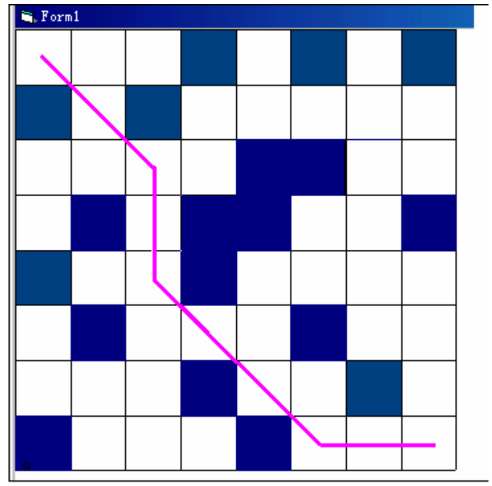

Figure 2. Result of experiments

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