Application of Improved Double Ant Colony Algorithm in The Robot Path Planning

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Abstract. Traditional ant colony algorithm is applied to mobile robot path planning, existing to slowly solve, slowly convergence speed, easy to fall into local optimal .A kind of double ant colony optimization based on combined optimization is proposed. Forward ant searched path be combined with backward ant searched path when two groups of ants in current generation completed a path search. Then the new paths were sorted, selecting the better path for global pheromone updating, combining the thought of MAX-MIN ant colony algorithm. Simulation experiment shows the improved ant colony algorithm can well solve the problems of the traditional ant colony.

1. Introduction

The planning of mobile robots is that the robot in an obstructed environment search an optimal path according to one or more rules (such as minimum energy consumption, the shortest path).The optimal obstacle-avoidance path is from the starting point to goal point. Ant colony algorithm has many advantages like information positive feedback effect, excellent parallel computing, strong ability of heuristic searching, etc. But ant colony algorithm has many disadvantages like lack of initial pheromone, solving slowly, easily falling into local optimal solution. Double ant colony optimization based on combined optimization is proposed.

2. The combination optimization of path

When two groups of ants in current generation completed a path search, forward ant searched path be combined optimize with reverse ant searched path to combine into the better paths. Forward ant searched path is defined as $P1$. Reverse ant searched path is defined as $P2$. Combined path is defined as P. The combination optimization can be divided into three categories.

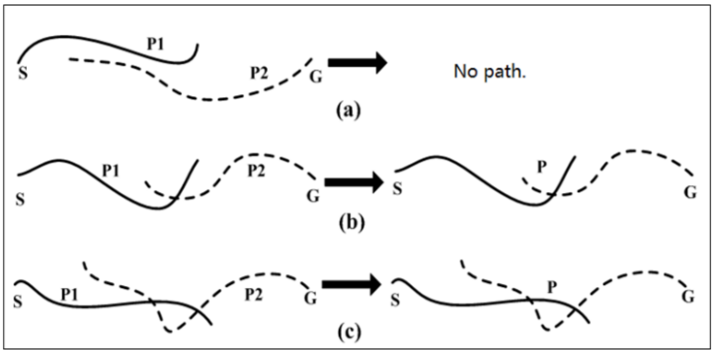


Fig. 1 Two paths are not complete

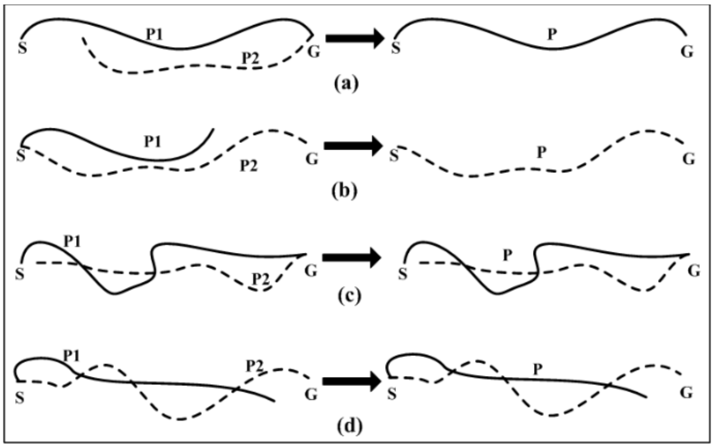


Fig. 2 Only a complete path

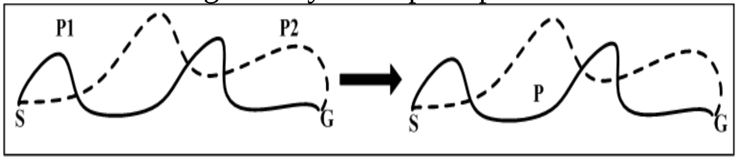


Fig .3 Two paths are complete

As shown in the Fig. 1, two incomplete path can also be combined into a complete path, improving the ability of ant colony algorithm plan path. As shown in the Fig. 3, the incomplete path can optimize the complete path, increasing the diversity of paths. Combination optimization enhance the information interaction between the two groups of ants, accelerating the speed of solution, increasing the diversity of solution.

3. Enhanced Ant Colony Optimization Algorithm

According to the above definitions, the procedure of enhancement ant colony algorithm is implemented as follow.

Step 1: Load the image and preprocess the image.

Step 2: Initializing parameters of the ant colony algorithm used in the process of operation. Let $k = 1,\ m = 1$.

Step 3: If $k <= K$, that is not the number of iterations, go to Step 4. If $k > K$, the algorithm is over and go to Step 15.

Step 4: Place the ant *m* on the starting point *S*. The current node number is assigned to i. Put point *S* in the path node number matrix *ROUTE*. *KXW* is the reachable neighbor set, which in the neighborhood of grid i and not on the current path and not belongs to the obstacle grids matrix ZAD.

"$C = setdiff\left(A, B\right)$" denotes that function returns the values in *A* that are not in *B* with no repetitions.

$$KXW = setdiff(LI, [ZAD', ROUTE]) \tag{1}$$

Step 5: If $i \neq E$ and matrix KXW is not empty, continue to look for the next path point *j*, otherwise go to Step 7. State transition probability, the ant *m* choosing node *j*, is calculated by Eq.(2). α is the relative importance of pheromone. β is the relative importance of distance heuristic function. Selecting the next path points by roulette wheel selection, then the node number is assigned to *j*.

$$P_{ij}^{k} = \frac{\tau_{ij}^{\alpha} * \eta_{ij}^{\beta}}{\sum\limits_{s \in KXW} \tau_{is}^{\alpha} * \eta_{is}^{\beta}} \tag{2}$$

Step 6: Add the node *j* to the path matrix *ROUTE*. Let $i = j$. Find out that the next step can choose the reachable set KXW, go to Step 5.

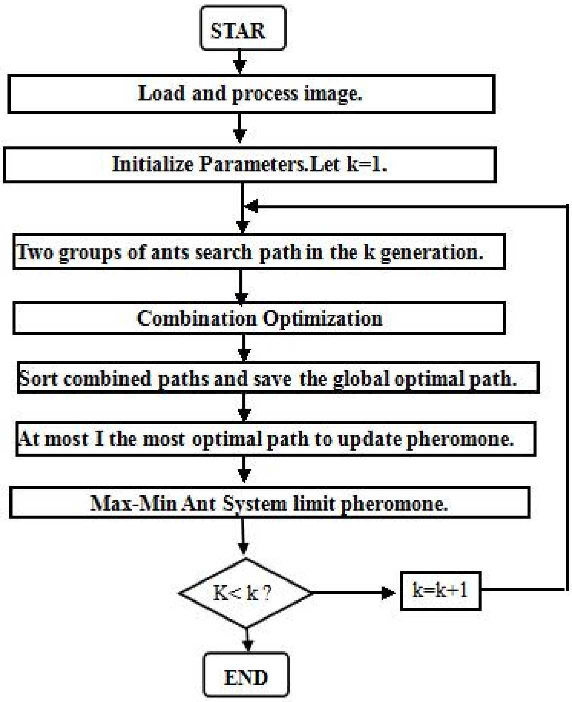


Fig. 4 The algorithm flow chart

Step 7: Save the path matrix *ROUTE* to unit array $ROUTES\{k,\ m\}$.Let $m = m+1$.If $m <= M/2$, then go to Step 4. Otherwise go to Step 8.

Step 8: The backward ants search path according to Step 4-Step 7.

Step 9: Forward ant searched path be combined with backward ant searched path.

Step 10: Sort combined paths and update the global optimal path.

Step 11: The dissipation of pheromone is is calculated by Eq.(3).

$$\begin{cases} \tau_{\mathrm{ij}}(t) = \tau_{\min}, & \text{if} \quad \tau_{\mathrm{ij}}(t) < \tau_{\min} \\ \tau_{\mathrm{ij}}(t) = (1-\rho)\tau_{\mathrm{ij}}(t-1), & else \end{cases} \tag{3}$$

Step 12: Choose at most *I* the most optimal path is used to update global pheromone increment and the global optimal path needs additional compensation.

Step 13: Update global pheromone. Updated formula is as follows.

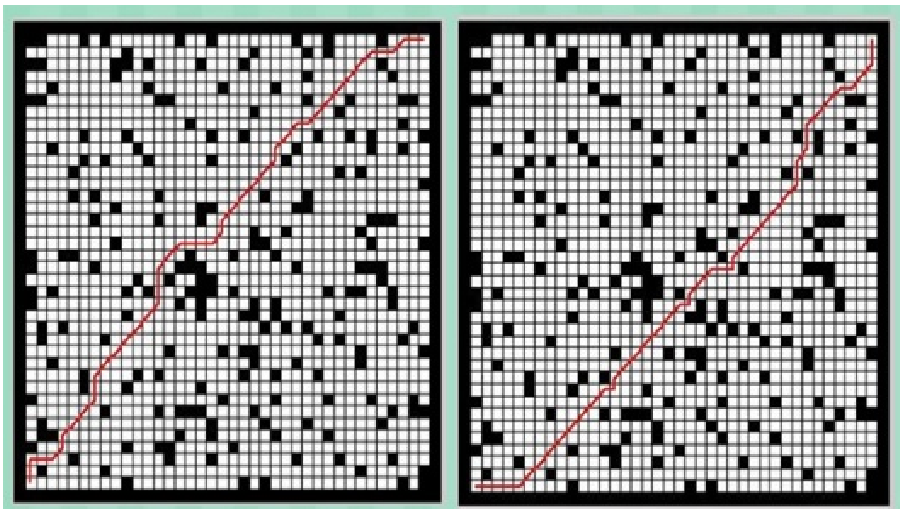
$$\begin{cases} \tau_{\mathrm{ij}}(t) = \tau_{\max}, & \text{if} \quad \tau_{\mathrm{ij}}(t) > \tau_{\max} \\ \tau_{\mathrm{ij}}(t) = \tau_{\mathrm{ij}}(t) + \Delta\tau_{ij}(t) & \text{else} \end{cases} \tag{4}$$

Step 14: Let $k = k+1, m = 1$. Go to Step 3.

Step 15: Output the best path.

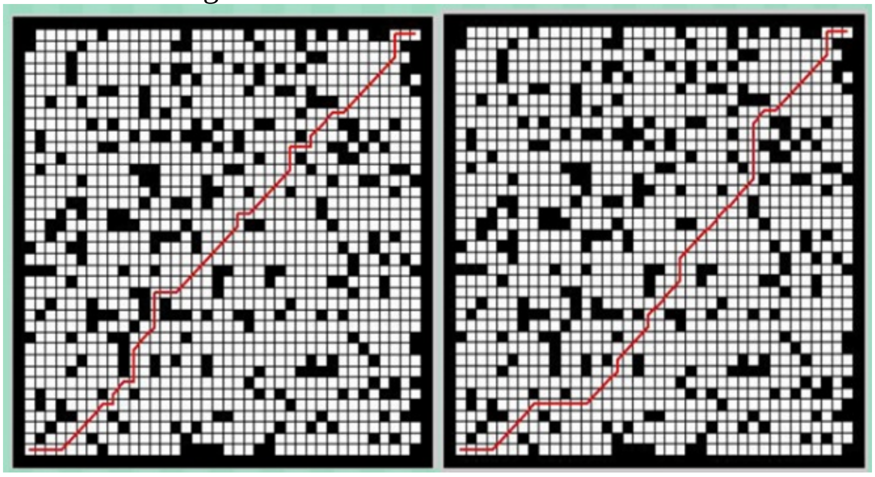
4. The Simulation Test And Performance Analysis

Under two complex environments, the algorithm (CCDACA) in literature [4] and the improved ant colony algorithm (IDACA) dose the contrast experiment. Fig. 5 and Fig. 6 show the simulation results respectively.



(a) CCDACA (b) IDACA

Fig. 5 Result under the environment a



(a) CCDACA (b) IDACA

Fig. 6 Result under the environment b

To eliminate the effects of accidental factors, each algorithm does 20 simulation experiments in each environment. Record the length of the path optimal, the number of its knee and the time of path planning every time, then average its. The simulation result is as table 1.

Table 1 Two algorithms' performance comparison

Environment	Algorithm	Length	Knee	Time
a	CCDACA	58.5976	19	8.203 s
	IDACA	57.2345	17	6.302 s
b	CCDACA	58.1834	21	9.804 s
	IDACA	57.7692	15	7.080 s

We can see from the above table that IDACA generates the shorter path than CCDACA, taking less time, having less knees. The improved algorithm is correct and effective.

5. Summary

Double ant colony algorithm strengthen the information interaction between the two groups of ants through combination optimization of the path. This accelerate the solving speed and increase the diversity of path. Sorting combined path, the better path and the global optimal path is used to update global pheromone, improving the convergence speed. The algorithm does not easily fall into local optimum, because Max-Min Ant System's idea is used. Simulation results show that the improved algorithm accelerate the solving speed and convergence speed.

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