CHAOTIC ANT SYSTEM OPTIMIZATION FOR PATH PLANNING OF THE MOBILE ROBOTS

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ABSTRACT

This paper presents an improved ant system algorithm for path planning of the mobile robot under the complicated environment. To solve the drawback of the traditional ant colony system algorithm (ACS), which usually falls into the local optimum, we propose an improved ant colony system algorithm (IACS) based on chaos. Simulation experiments show that chaotic ant colony algorithm not only enhances the global search capability, but also has more effective than the traditional algorithm.

KEYWORDS

Ant colony system, Chaotic, path planning of the mobile robot

1. INTRODUCTION

The swarm intelligence algorithm (SIA), which is a new evolution algorithm, has increasingly attracted more and more researchers [1-4]. Among the SIA, ant colony system (ACS), which was created from the enlightenment from the nature world, in fact, is a positive feedback method of studying the real swarm ants which look for foods in the nature: the more heuristic is in the road when more ants have got through the road, so the latter ants are more impossible to select the road. The ant can cooperate and communicate with other ants, and in this way the ant system can find the shortest road from their nest to the foods.

ACS, which has the more quick convergence speed and more accurate solution than the simple ant colony optimization algorithm, is one of the best ant colony optimization algorithms [1]. So, this paper is based on the ACS to solve the path planning of the robot.

The rest of the paper is outlined as follows. Sect.2 briefly addresses the concept of ACS and briefly reviews the work of ACS about robot. Sect.3 describes the improved ACS based on chaotic (IACS) for the problems of path planning of robots. Sect.3 presents the experimental results and it shows that IACS is beneficial for ACS algorithm when applied on the path planning of the robot.

2. ACS

In the way of the real ant system in the nature world to look for the food, ant colony system algorithm (ACS) is being used to find the optimum. Artificial ant will not only find the way to the food in oneself, but accumulate with other ants by their means also [5].

Path planning is one of the most important techniques for the mobile robot. As mobile robot is in the way with barriers, we want to find the best path from the start point to the object point according some evaluation criterions, such as the shortest road and the safest road [6]. The traditional ACS algorithm includes state transition and updating pheromones.

When the ant select the next city in the path planning of the ACS algorithm, the ant will select according to the amount of the road's pheromones and generally there are more possibilities to

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select the road of having more pheromones. In particular, the norm with which ant k, currently at city i, chooses to go to city j is

$$j = \begin{cases} \arg max\left\{\left[\tau_{ij}(\mathrm{t})\right]\left[\eta_{ij}(\mathrm{t})\right]^{\beta}\right\}, & q \le q_0 \\ J\left(p_{ij}^{k}\right), & q > q_0 \end{cases} \tag{1}$$

Where the $\tau_{ij}(t)$ is the existing pheromone trail between the city i and city j in the time t, $\eta_{ij}(t)$ is the heuristic information on the path from city i to city j, $q = rand(), q \in (0,1)$, q_0 is a parameter available a prior ($0 \le q_0 \le 1$). While ant k select the next city, there is a random figure q , and if $q \le q_0$, the ant will select the next node according the equation (1), otherwise according the equation (2).

$$p_{ij}^{k} = \frac{\left[\tau_{ij}\right]^{\alpha}\left[\eta_{ij}\right]^{\beta}}{\sum_{l \in N_i^k}\left[\tau_{ij}\right]^{\alpha}[\eta_{ij}]^{\beta}} \tag{2}$$

Where η_{ij} is the heuristic information on the path from city i to city j, which is defined as $1/d_{ij}$, where d_{ij} is the distance between city i and city j. N_i^k denotes the neighborhood of cities of ant k when being on city i. Parameter α determine the relative influence of the pheromone trail and the parameter β determine the relative influence of the heuristic information. In the way of the ACS, the pheromone on the path city i to city j will update after the ant k march up from the city i to city j according above the rule and the process conform to the equation(3).

$$\tau_{ij}(\mathrm{t}) = (1-\varphi)\,\tau_{ij}(\mathrm{t}) + \varphi\Delta\tau_{ij}(\mathrm{t}) \tag{3}$$

$$\Delta\tau_{ij} = \sum_{k=1}^{n}\Delta\tau_{ij}^{\ k} \tag{4}$$

Where $0 < \rho \le 1$ is the rate of the evaporation. In general, lowering the pheromone values enables the algorithm to forget bad decisions made in previous iterations, $\Delta\tau_{ij}(t)$ is the pheromone produced by the ant k after passing the road from the time t to time t+1. After all of the ant get to the end from the start, only the road (may be not only one) of the best ant will update the pheromone according to the rule, and in one point, the rule is accelerating the convergence speed of algorithm. This process is subjected to rule as follows:

$$\Delta\tau_{ij}^{\ k} = \begin{cases} \frac{1}{L_k}, & arc(\mathrm{i,j})\ \text{belong to best loop} \\ 0, & \text{otherwise} \end{cases} \tag{5}$$

Where Q denotes the intensity of the pheromone, and L_k denotes the length of the best ant in this iteration.

3. IACS FOR PATH PLANNING OF ROBOTS

Recently, the path planning of the mobile robot has attracted a great deal of researchers. Paper 6 has been proposed an ant colony algorithm about rolling planning. An improved ant colony algorithm of differential evolution based on chaotic has been improved in paper 7. The results of their experiments have revealed that the improved algorithm can still find the safe better path even in a very complex environment. With the help of the map created under the start point and the end point, the algorithm add the local path information of the environment to the step of initializing pheromone trails and the step of selecting the next city, and have a operation to select and crossover with adapt the values of α, β and φ , which make the algorithm have more capabilities to flee the local optimum [8]. To improve the performance of the results of the traditional ACS applied in the mobile robots, we investigate improved ACS called IACS algorithm, which is based on the conception of logistic mapping to modify the rule of updating pheromones that it will escape from the local optimum in the early.

3.1 Improvement of the Local Updating Pheromone

The main characteristic of the chaotic is pseudo randomness, ergodic property, sensibility to the condition of the start [9]. In consideration of chaotic characteristic, change the rule of local updating pheromone, which may be improving diversity of the algorithm so as to avoid fall into the local optimum in the early time. We have using the mapping of logistic in this paper, and the rule as follows:

$$x_{k+1} = \mu(1 - x_k), \mathrm{k} = 0,1,2,...; x_0 \in [0,1] \mu \in (3,4] \qquad (6)$$

We will get a series of values of $x_1, x_2, ..., x_k$ while the value k changes. Through testing the value μ , it concludes that the dynamic system is simple displaying a litter change or complicated displaying periodicity chaotic while $0 < \mu \leq 1$ and $3 \leq \mu \leq 4$ respectively. Then we design two simulation experiments by means of mapping logistic on Matlab, and initialize value m as 0.5, the number of iteration as 500, and the value μ as 2,3,3.3 , 3.6. The result of different value μ_k is given in the Fig.1 - Fig.4.

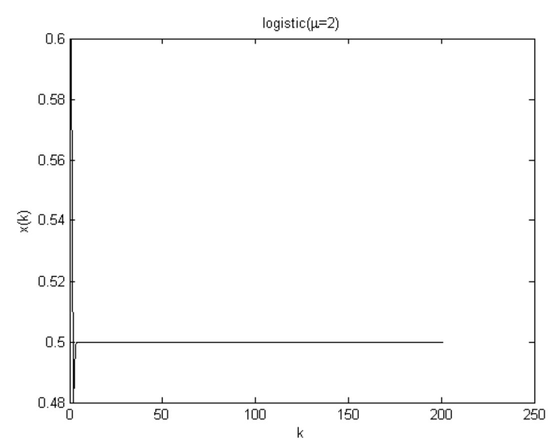

Fig.1 Chaos While $\mu = 2$

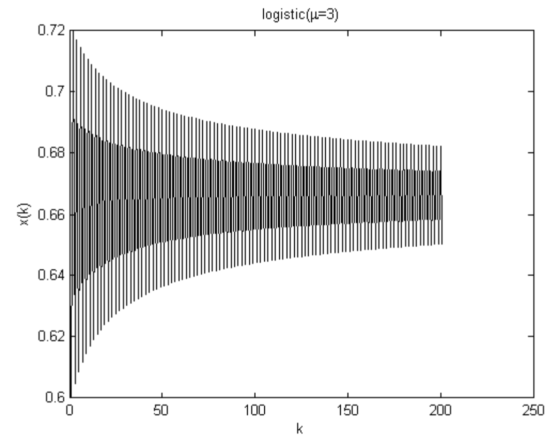

Fig.2 Chaos While $\mu = 3$

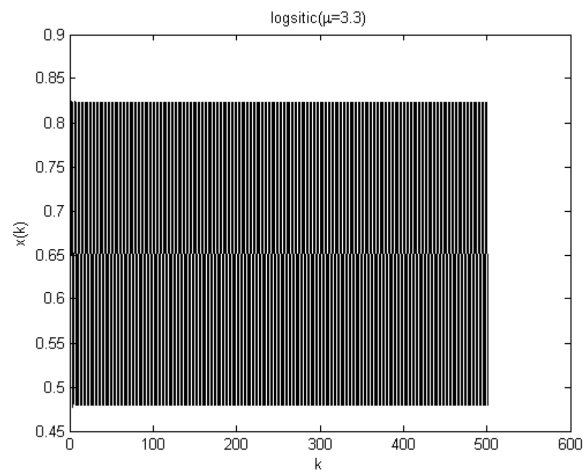

Fig.3 Chaos While $u = 3.3$

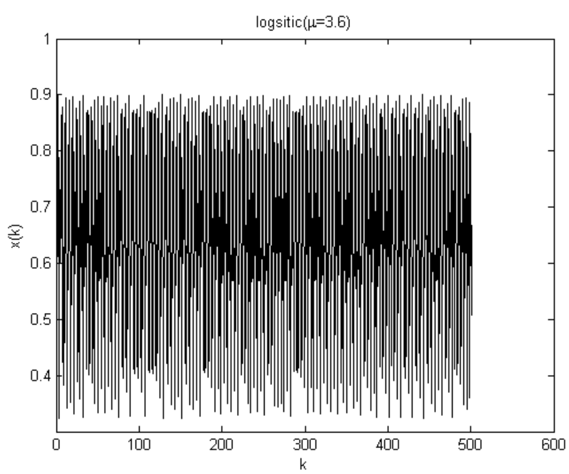

Fig.4 Chaos While $\mu = 3.6$

The parameter μ is changeable. There is the situation of complete chaotic for the mapping logistic when $\mu = 4, 0 \le x_0 \le 1$. To avoid the algorithm drop early into a local premium and improve its diversity, this paper propose a algorithm called IACS which change the rule of updating the local pheromone based on the chaotic performance and different from the formula (3) it do as follows:

$$\tau_{ij}(t+1) = (1-\varphi)\tau_{ij}(t) + \varphi\Delta\tau_{ij}(t) + qx_{ij} \qquad (7)$$

Where chaotic variable x_{ij} is produced from the formula (6) and q is a rate.

3.2 The Framework of the IACS

The IACS algorithm and its path planning experiment of the robot as follows:

Step1: initialize parameters and set the data structure for saving the results, generate chaotic values from formula (6) and put it to $(\tau_{ij})_{N*N}$, initialize the matrix of pheromone;

Step2: ant k $k = 1, 2, ..., m$ set out from the point g_{start}, and write g_{start} into the ant memory $tabu_k$ which contains the cities already visited, and find the available next cities;

Step3: select a path from the start to the end according to the pheromones of the available road and heuristic information;

Step4: after every period of searching process, count and compare every ant road's path. Create a series of chaotic values according to the formula (6) and update the pheromone according to the formula (7). $n = n + 1$ and continues the next loop;

Step5: clear up the ant memory when $n > N_{\max}$ and back to the Step2.

4. Simulation Experiments

In order to investigate the performance of improved ant colony system algorithms for the path planning of the robot, we have had several simulation experiments. In this paper, the simulations are based on a map of 20*20. The parameter $\alpha = 1$, $\varphi = 0.1$, $Q = 3$, $q_0 = 0.15$.

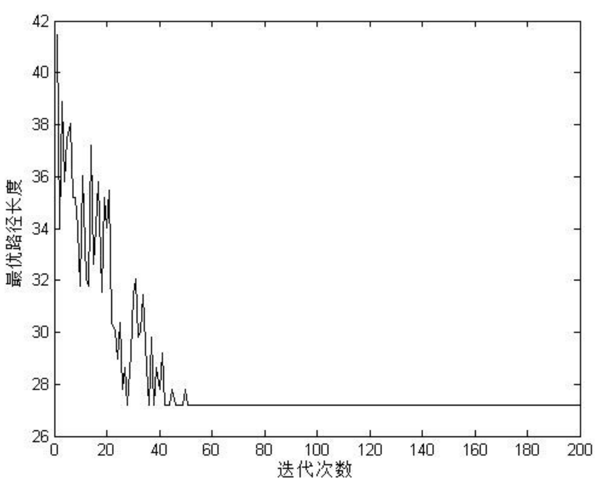

Fig.5 Diversity of Results and the Convergence of the Algorithm

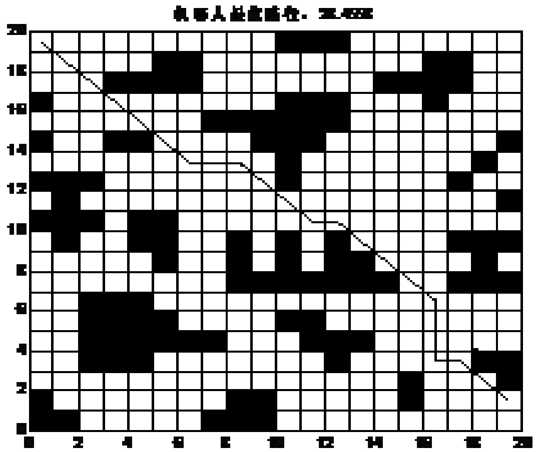

Fig.6 The Best Road of our Algorithm Under the Complicated Environment1

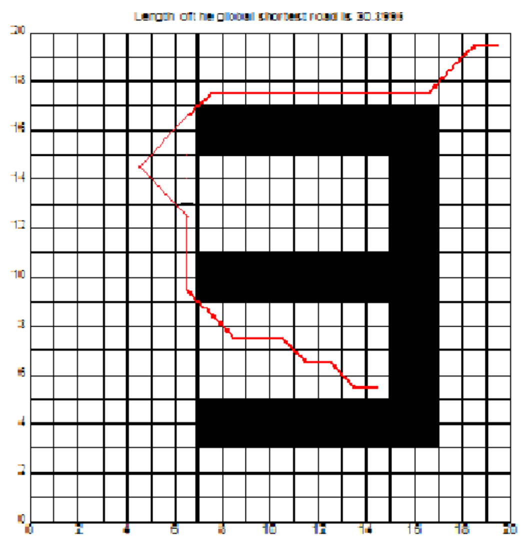

Fig.7 The Best Road of Our Algorithm Under the Complicated Environment2

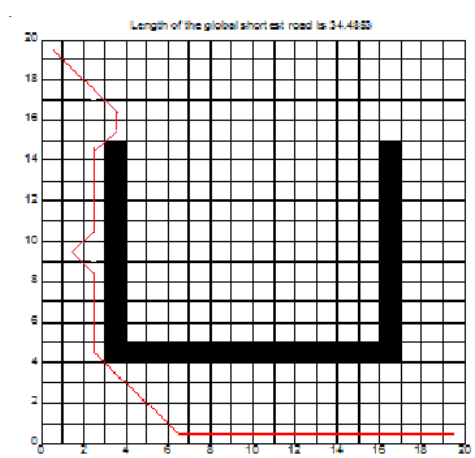

Fig.8 The Best Road of Our Algorithm Under the Complicated Environment3

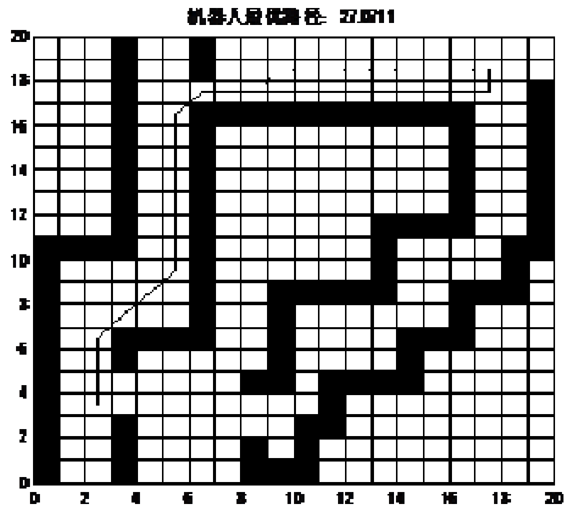

Fig.9 The Best Road of Our Algorithm Under the Complicated Environment4

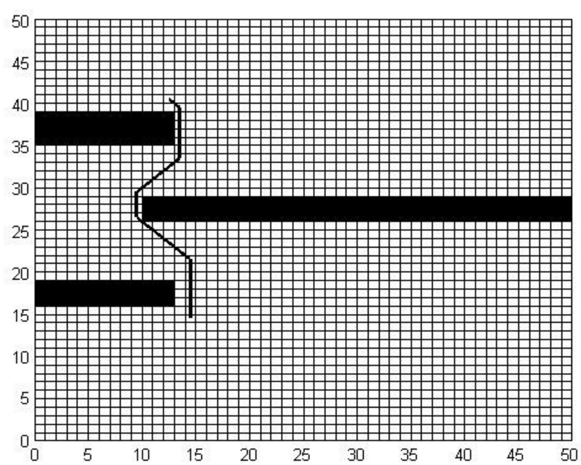

Fig.10 The Best Road of Our Algorithm Under the Complicated Environment5

Fig.5 shows the diversity of the results and the convergence of the algorithm. The line in Fig.6-Fig.10 is the best road of our IACS algorithm under the complicated environment. The experiment has proved that our IACS algorithm can find the best path with a quicker convergence speed.

5. Conclusions and Future Work

This paper has proposed an improved ant colony algorithm based on chaotic which improve the algorithm diversity by changing the updating local pheromone for path planning of robots, so it has improved the accuracy of the best road. Simulation experiments show that the IACS is better to solve the path planning of the robot under the complicated environment.

In future, we should research the impact of the parameter in our algorithm to improve the algorithm performance.

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REFERENCES

[1] Dorigo M.,Stutzle T. Ant Colony Optimization. The MIT Press. Cambridge, Massachusetts. London, England. 2004.
[2] Zhai Yahong,Xu Longyan. Ant colony algorithm based on distribution on estimation of quantum pheromone control research[J]. Computer Engineering and Design.2014,35(4):1414-1418.
[3] Liu Chang-an,Yan Xiao-hu, LiuChun-yang,WU Hua. Dynamic Path Planning for Mobile Robot Based on Improved Ant Colony Optimization Algorithm [J]. ACTA ELECTRONICA SINICA,2011,39(5): 1220-1224.
[4] Ye Shitong, Wan Zhiping. An ant colony algorithm based on improving global pheromone update efficiency and its simulation[J]. Computer Applications and Software, 2014,(1):176-179.
[5] Hai-Bin Duan. Ant colony algorithms: THEORY AND APPLICATIONS[M].Beijing: Science Press, 2006.
[6] CHEN Xiong, ZHAO Yi-lu, HAN Jian-da. An improved ant colony optimization algorithm for robotic path planning.2010, 27(6): 821-825.
[7] Xu Hong-li, Qian Xu, Yue Xun. New ant colony optimization algorithm based on logistic chaotic image to resolve VRP problem [J]. Application Research of Computers,2012,29 (6): 2058-2060.
[8] Kong Li-fang, Zhang Hong. Asynchronous parallel particle swarm optimizer for feature subset selection [J]. Control and Decision,2012,27 (7): 967-974.
[9] Li Lixiang, Peng Haipeng, Yang Yixian. Chaos ant colony algorithm and its application [M]. China Science and Technology Press,2013,1.
[10] Liu Xu-xun, Cao Yang, Chen Xiao-wei. Mouse colony optimization algorithm for mobile robot path planning [J]. Control and Decision,2008, 23(9): 1060-1063.