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The Research of Genetic Ant Colony Algorithm and Its Application

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Abstract

This paper proposes genetic ant algorithm through the research of the traditional genetic algorithm and ant colony optimization. This algorithm use the results of the genetic algorithm to initialize the pheromone distribution ,use its strong adaptability and rapid global convergence and then get the optimal solution through the colony algorithm that has parallelism、positive feedback system and good solution efficiency. The simulation results of 0-1 knapsack and QoS demonstrate that this algorithm has higher converging speed, stability and global optimization ability.

Keywards: genetic algorithm (GA); ant colony optimization (ACO);optimization problem; 0-1 knapsack Problems；QoS

1. Introduction

Genetic Algorithm (GA) is first proposed by professor John Holland from the United States University of Michigan in 1960s, and Ant Colony Optimization (ACO) is proposed by Italian scholar M.Dorigo etc. GA and ACO both are searching algorithm that is simulating biological group evolution, and they were used extensively in function optimization, vehicle scheduling, image processing .

Both GA and ACO are iterative optimization process that is the foundation of the combination of these two algorithms. GA has the ability of rapid global convergence, but for the feedback information system it is helpless, it will do a lot of redundancy iteration when the solution get in a certain range, so it will reduce the efficiency of the exact solution. ACO will converge on the optimum solution through the

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accumulation and update of information pheromone.Because it has the ability of parallel processing and global searching. But due to the lack of early pheromone, the solution speed is low.

In order to overcome the defects of the two algorithms, on the basis of complementary advantages to propose a kind of genetic ant colony algorithm. First, use the results of GA to initialize the pheromone distribution of the relevant issues. Then, according to the parallel processing and global searching of ACO to get the optimal solution. So form a heuristic method genetic ant algorithm that has higher efficiency of time and solution than ACO and GA.

2. The Determination of Fusion Time of GA and ACO

In order to combine GA and ACO better, genetic ant algorithm need to set up a control function of GA, through calculate the evolution rate of the offspring groups, to control the iterations of GA ,that can ensure GA and ACO fusion at the right time.

Define a control function of GA $c_G^{l+1}=\frac{\overline{C(T)_{l+1}}}{(C(T)_l)^3}$,where $\overline{C(T)_l}$ is the average value of the group after l iteration of GA, $1\le l\le N_G$, N_G is the maximum iterations of GA.Statistics the value of c_G^{l+1} in the iterative process of GA , if c_G^{l+1} are less than 3% for three generations , it will show the optimizing speed of GA is low, so we can terminate GA and get into ACO. Figure 1 is the flow chart of the genetic ant colony algorithm.

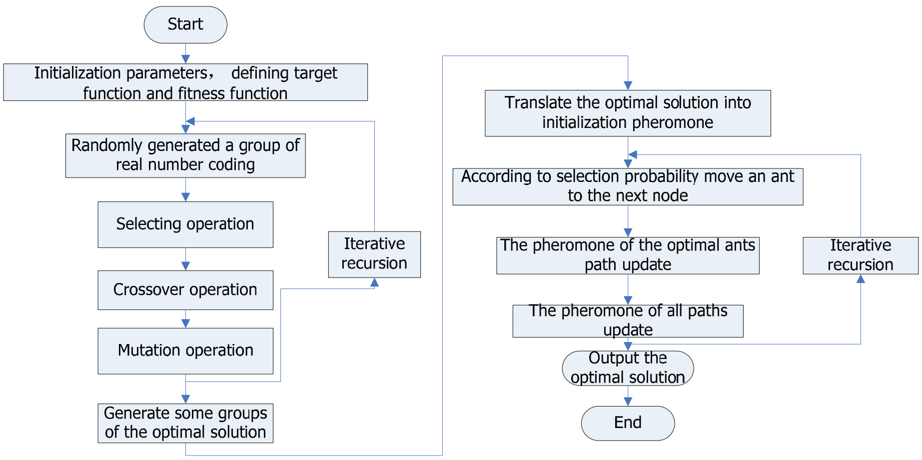

Fig. 1.The flow chart of the genetic ant colony algorithm.

3. Optimization Testing of the Genetic Ant Colony Algorithm

3.1. Description of 0-1 knapsack Problems(KPs)

We are given a set of n items, each item i having an integer profit p_i and an integer weight w_i $(i=1,2,\cdots,n)$ .The problem is to choose a subset of the items such that their overall profit is maximized, while the overall weight should not exceed a given capacity of C. If the subset contains item i, then $x_i = 1$,else $x_i = 0$.

We may formulate the model as following integer programming model(1):

$$\begin{cases} \max \sum_{i=1}^{n} p_i x_i \\ s.t. \sum_{i=1}^{n} w_i x_i \le C, x_i \in \{0,1\}, (i = 1, 2, \cdots, n) \end{cases} \tag{1}$$

3.2 Algorithm Design

1) Coding and parameter selection . Take the binary coding rule , chromosome length $length$ equals to the number of items, population scale $popsize = 100$, crossover rate $p_c = 0.5$,mutation rate $p_c = 0.5$, Randomly generate initial population pop , maximum iterations is 300 .

2) Initilization population and fitness function. Use random function to generate a certain number of binary code. Fitness function is the corresponding value of the selection scheme.

3) Crossover operation. Choosing two adjacent individuals from the population to proceed with single point crossover operation until new population produce .

4) Mutation operation. Use the reversal mutation method. For example, the chromosome (1-2-3-4-5-6) is split at 2-3 and at 5-6 , the fragments be inserted with the reverse direction,so the chromosome become (1-2-5-4-3-6). After reversed, if the adaptive value is improve, the chromosome will be accepted, or the reverse is invalid.

5) The parameter selection of ACO. The number of ants m equals to the number of items. Maximum iterations $\max GEN = 100$, the pheromone constant $\tau_C = 60$.

6)Setting the initial value of pheromone. The formula of the initial value of pheromone is $\tau_S = \tau_C + \tau_G$, τ_C is a const , τ_G is the value of pheromone that converted from the top 10% of the highest value from the adaptive value which is from the optimal solution that GA produced ,thereinto, $\tau_G(i) = C(T) \cdot C(i) / N$, $C(T)$ is the all value of the subset , $C(i)$ is the value of item i. $N = 1000$,When the subset contained i item, $\tau_G(i)$ is to stack.

7) Path selection rule. Make use of the probability formula(2), calculation the choosen probability of the items. According to p_i^k ,the ant k choose the next item i ,At this time, if the all value less than C ,then put i into the subset , $solutions(k,i) = 1$, $tabu(i) = 1$,else the item i will not add into the subset, $solutions(k,i) = 0$, $tabu(i) = 1$,until the ant k test all items. In (2), $\tau_i(t)$ is the amount of pheromone that i item get in t iterations, $\eta_i(t)$ is the unit mass value of the items . $\eta_i = v_i / w_i$, where , v_i is the value of the i item, w_i is the weight of the i item, α, β respectively express the value of the pheromone and element information weight and unit weight of the item. Here, $\alpha = 1$， $\beta = 1$.

$$p_i^k = \begin{cases} \dfrac{[\tau_i(t)]^\alpha [\eta_i(t)]^\beta}{\sum_s [\tau_s(t)]^\alpha [\eta_s(t)]^\beta} & , \ s \in J(k) \\ 0 & , \ \text{other} \end{cases} \tag{2}$$

8) The pheromone updating model. All the track of the path will use the update equation (3). where, $\Delta\tau_i(k)$ is the pheromone that ant k left in the item i, $\Delta\tau_i(k) = \dfrac{Q * v_i}{lmb}$, Q is random positive integer that more than 10 and less than 100, lmb is the total value in this iteration.

$$\tau_i(t+1) = \rho\tau_i(t) + \Delta\tau_i(i) \tag{3}$$

3.3 The experimental results

Table 1. Comparation of the experimental results of three algorithms

Item number / algorithm	10		20		50		100	
	The optimal solution	Iterations	The optimal solution	Iterations	The optimal solution	Iterations	The optimal solution	Iterations
Genetic ant colony algorithm	431	1	1042	5	3103	40	2852	32
GA	431	6	1042	100	2304	140	2029	141
ACO	431	10	1042	155	2538	105	2508	198

In the case of the same number of items in the knapsack, the optimal solution of genetic ant colony is better than the traditional GA and ACO. when the number of items is 10 or 20, three algorithms can convergence to the same optimal solution, but the genetic ant colony algorithm have better convergence speed. When the number of items is 50 or 100, genetic ant colony algorithm not only have better convergence speed, but also not get into the local optimal solution and avoid the premature convergence.

4. The application of genetic ant colony algorithm in QoS

4.1. The mathematical model of Quality of Service(QoS)

Hypothesis P_b represents bandwidth constraints, P_d represents delay constraint, P_{pl} represents package loss rate constraint, then QoS contented with bandwidth constraints , delay constraint , package loss rate can be expressed as: $R = (s, M, P_b, P_d, P_{pl})$, the goal is find a multicast tree T_j for the given source node s and destination node set M , make transmission path $p(s, d_i)$ from source node s to any destination node $d_i \in M$ meet the following constraints:

1) Bandwidth constraints: $B(p(s, d_i)) \geq P_b$,

2) Time delay constraint: $D(p(s,d_i)) \geq P_d$,

3) Packet loss rate constraint: $L(p(s,d_i)) \leq P_{pl}$,

4) Cost constraint: In the all multicast trees, $C(T_j(s,M))$ is minimum and content with 1) to 3).

4.2. The analysis of experimental results

Simulation experiment by MATLAB7.0, randomly generated network topology. Figure 1(a) is the network topology after pretreatment, it have the 25 nodes. Among them: 1 is the source node; 4,13,20 are the destination nodes. Set population scale $N = 20$; Delay constraint $P_d = 200$,bandwidth constraints $P_b = 50$, packet loss rate constraint $P_{pl} = 80$. GA related parameters: crossover probability $p_c = 0.8$, mutation probability $p_m = 0.04$, $N_{G_{\max}} = 40$. Fusion part related parameters: $\tau_{(i,j)}^C = 60$, $N = 1000$. ACO related parameters: heuristic factor $\alpha = \beta = 1$, pheromones volatile rate $\rho = 0.2$, constant $Q = 1000$, $N_{A_{\max}} = 20$, the number of ants equal to the number of nodes in the network topology.

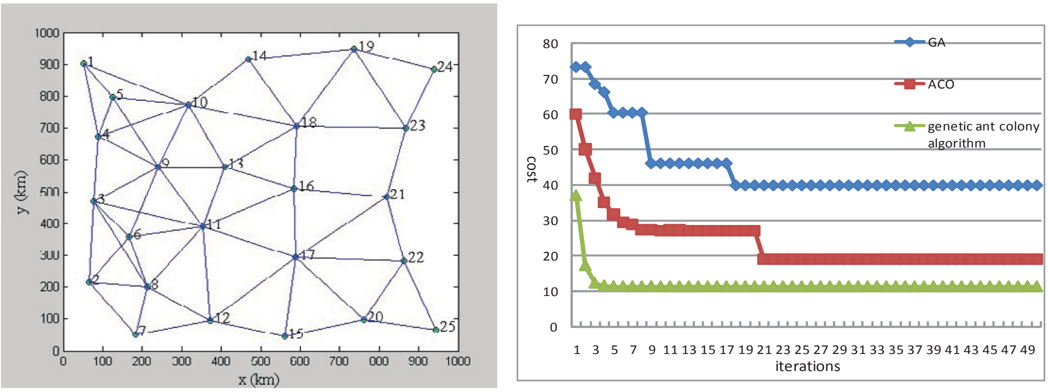

Fig.1.(a)network topology after pretreatment ;(b)cost comparison of three algorithms

From figure 1(b), we can see the value of the optimal solution GA generated is 39.8 in 18th, the value of the optimal solution ACO generated is 19 in 21, the value of the optimal solution genetic ant colony algorithm generated is 11.3 in 10. Comparation of three algorithms, we can find genetic ant colony algorithm has increased about complexity, but due to GA generated some optimization solutions, turn to the initialization pheromone of ACO, make ACO can rapidly approach to optimal solution, and overcome ACO for lack of initialization pheromone slowly solve rate, just need less iterations can find optimal solution, obviously improving the efficiency of convergence.

5. Conclusion

Based on genetic ant colony algorithm, through the testing of 0-1 knapsack problems, the correctness and effectiveness of this algorithm was verified. Then this algorithm is applied to QoS. The experimental results show that this algorithm can improve the calculation efficiency, has good stability, and can get the optimal solution of the problem.

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