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Image registration based on improved Ant Colony algorithm

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Abstract. Image registration is an important technology in image processing and computer vision, ant colony algorithm search for the optimal registration parameters in image registration has a strong global optimization ability, but the final search to the accuracy of the registration parameters and search for a very long time. in this paper an improved ant colony algorithm is presented to improve the registration accuracy by the original ant colony algorithm and simplex algorithm has a strong local optimization, improved ant colony algorithm heuristic function in order to improve the convergence speed; Finally, the improved ant colony algorithm combined with multi-resolution registration strategy to reduce the time of image registration. The experimental results show that compared with the original ant colony algorithm, an improved ant colony algorithm can effectively improve the image registration accuracy, and can reduce the number of convergence of the algorithm.

Introduction

Image registration method based on mutual information is calculated by matching the image and reference image entropy and entropy between two images, and then to implement mutual information as a similarity of image registration. Using mutual information as the similarity of image registration not required for image segmentation and feature extraction preprocessing, so as to avoid a loss of accuracy of registration, registration requires only reliance on image gray value, without human intervention so as to realize the automated image registration[1-2].

At present, mutual information registration uses most optimized algorithm including the simplex method, the Powell, the genetic algorithm, the simulation annealing algorithm and Particle Swarm Optimization algorithms and so on. Ant colony algorithm is the latest development of a bionic optimization algorithm, by the Italian scholar Domingo M[3-4] in 1991, is a population-based global search strategy, no special requirements for the objective function in the form of simple parameter setting, has fine distributed computing, the strong robustness, to be easy with other method unions and other merits, has demonstrated its good performance and huge potential in solution complex optimization. However the ant colony algorithm searches finally may also is only a solution of close globally optimal solution. The entire search process is simultaneously long; the convergence rate is quite slow.

To make the ant colony algorithm to search the global optimal solution and can improve the convergence rate, we improved the ant colony algorithm. First, introduce improved inspired by current global optimal path function in order to improve the rate of convergence of the algorithm, secondly, using simplex algorithm of fast and powerful local search ability, at last in the ant colony algorithm, the registration for the optimal path for each loop parameters as a starting point for local optimization for simplex, in order to obtain the global optimal solution.

Ant Colony Algorithm

The process of ant colony algorithm search best matching parameter: m ants are the starting point S transfer standards to a certain layer through the intermediate layers of nodes at the same time transferred to the last layer of nodes, and finally simultaneously arrives an end point E, m ant to form m way, each path parameter according to the following formula you can generate a set of registration of Δx, Δy and θ values:

$$\Delta x = V(i,1)\times 10 + V(i,2) + V(i,3)\times 0.1 + V(i,4)\times 0.01 - 50 \quad (1)$$

$$\Delta y = V(i,5)\times 10 + V(i,6) + V(i,7)\times 0.1 + V(i,8)\times 0.01 - 50 \quad (2)$$

$$\theta = V(i,9)\times 10 + V(i,10) + V(i,11)\times 0.1 + V(i,12)\times 0.01 - 50 \quad (3)$$

In the search process of ant colony algorithm, ant inspired by the amount of information on each path and the path to calculate the probability of the transfer layer from the current node to the next layer node, it is assumed that the ant k at time t in the node (q, j-1), ant k in the t time (q, j-1) on moves from the current node to node (i, j) the state transition probability for $p_{ij}^k(t)$ [6]:

$$p_{ij}^k(t) = \frac{[\tau_{ij}(t)]^\alpha \times [\eta_{ij}(t)]^\beta}{\sum_{s=0}^{9} [\tau_{sj}(t)]^\alpha \times [\eta_{sj}(t)]^\beta} \quad (4)$$

In (4) $\tau_{ij}(t)$ is information element value of node (i, j), the information element of each node is equal in initial time, if α is bigger, this ant chooses other ants to pass through the way the probability to be bigger, between ant's cooperation is stronger; β is the expectation inspiration factor, had reflected the ant inspires information in the rate process in the ant choice way value degree, β is bigger then the condition transition probability is closer the greedy rule; $\eta_{ij}(t)$ is the inspiration function, expression is as follows:

$$\eta_{ij}(t) = \frac{10 - \left|i - i^*\right|}{10} \quad (5)$$

i^* is a turn circulation produces the optimal choice passes through j strata time node value.

Improved ant colony algorithm step

According to above introduction to the primitive ant colony algorithm two improvements, the ant group algorithm basic step which this article improves is as follows: 1) initialization: t=0, loop N=0, set the value for maximum number of loops m value of the $N_{\max}$ and ants, setting the boundaries of the simplex algorithm begins local optimization m value, set the relevant parameters of the simplex algorithm, the starting time for each node pheromone $\tau_{ij}(0) = 1$, pheromone on each node increase $\Delta\tau_{ij}(0) = 0$.

2) Define a two-dimensional array Tabu used to store the m ants go in the n wheel cycle path, m ants as for the starting point S.

3) cycle-index N=N+1.

4) Layer j=1.

5) According to equation (5) and improved heuristic function ants choose the j-layer probability of each node; use the roulette wheel to determine m ants in the j layer of the selected node, and then the node value stored in the array Tabu.

6) j=j+1, j>12 turn to step 7), otherwise, turn to step 5).

7) We will calculates m group of transformation parameter with preserved in Tabu m ant way with (1)~(3), according to each group of transformation parameter Δx, Δy, θ value will calculate its corresponding mutual information, definite epicycle optimal choice.

8) if the $N \geq N_{end}$, with this optimal path corresponds to the transformation parameters Δx, Δy, θ starting $X^{(0)}$ is initialized with the value of the simplex algorithm, and then using local optimization by simplex algorithm, to decode the results of local optimization, optimal path replace this round with the decoded results. Otherwise, turn to step 9).

9) Determines the current best path.

10) t=t+13; renews each node using formula (6)~(8) the information element, and array Tabu clear spatial;

$$\tau_{ij}(t+13) = (1-\rho)\cdot\tau_{ij}(t) + \Delta\tau_{ij}(t) \quad (6)$$

$$\Delta\tau_{ij}(t)=\sum_{k=1}^{m}\Delta\tau_{ij}^{k}(t) \tag{7}$$

$$\Delta\tau_{ij}^{k}(t)=Q\cdot I_{\mathrm{k}}(A,B) \tag{8}$$

11) If all the ants converge to the same path or $N \geq N_{\max}$, the loop ends, the optimal registration parameters Δx^*, Δy^*, θ^* and maximum mutual information Hi^* output. Otherwise *m* ants back the starting point *s* and go to step 3).

Experimental results and analysis

1) Convergence performance analysis

In order to analyze the improvement ant colony algorithm the restraining performance, this article by figure 1(a) took the reference image, treats the matching image by the 1(b) achievement, uses the ant colony algorithm and the improvement ant colony algorithm separately carries on 20 times the matching, establishes each algorithm to circulate 150 times, records two algorithms in each matching each turn circulation optimal choice mutual information value.

The ant colony algorithm needs to circulate 121 times can restrain to the close overall situation most greatly mutually information value, but improved algorithm to circulate 90 times can restrain to the superior greatly mutually information. Therefore, improved ant colony algorithm for cyclic and less frequently improves convergence. At the same time, as can be seen later in the cycle, improvement of convergence of ant colony algorithm to more convergence than the original algorithm of curve to the curve close to the ideal maximum mutual information line, indicating improved mutual information algorithm to obtain the value to be greater than the original value of mutual information algorithm, with higher accuracy.

(a) reference image (b) registration of image (c) after registration image

Figure 1 Image registration example

2) Comparison of the image registration accuracy

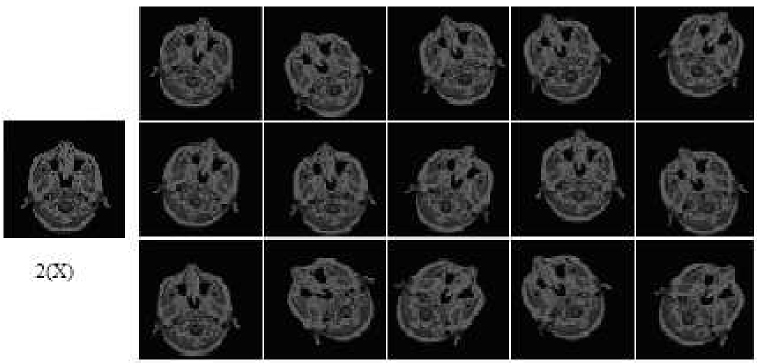

Figure 2 Image registration examples

In order to analyze the registration accuracy of the improved algorithm, we have chosen the particle swarm algorithm, the original ant colony algorithm and the improved ant colony algorithm with prospective effect of contrast. In Figure 2(X) took the reference image, carries on 15 transformations to the reference image, obtains 15 test chart achievement which shown in Figure 2 to treat the matching image, separately uses the above these three algorithms carries on the matching for these 15 images and the reference image.

In order to compare more intuitive improved ant colony algorithm, original ant colony algorithm and particle swarm optimization registration accuracy, Table 1 gives the three algorithms registration parameters obtained with respect to the real parameters of the maximum error, the smallest error and the average error.

TABLE 1 Three registration error comparisons of algorithm

Agorithm	Maximum error	Minimum error	Average error
Improved Ant Colony Algorithm	0.6542	0.0245	0.1896
Ant Colony Algorithm	1.2854	0.4017	0.9891
Particle Swarm Optimization algorithm	1.4239	0.5418	1.0753

Table 1 shows the improved ant colony algorithm obtained mutual information than the original ant colony algorithm and particle swarm algorithm obtained mutual information, the bigger the mutual information registration accuracy is higher, so the improved ant colony algorithm for registration accuracy is higher than the original ant colony algorithm and particle swarm optimization, improved ant colony algorithm registration error is much smaller than the other two algorithms.

Conclusions

In order to overcome the convergence rate slow question of primitive ant colony algorithm in the registration process, this paper an improved ant colony algorithm is proposed, through joins the current optimal choice to make the improved ant colony algorithm inspiration function, simultaneously aims at the result that the ant colony algorithm searches each time is only approaches in the superior solution of globally optimal solution, but is not the optimal solution, will unify the ant colony algorithm and simplex algorithm, later in the search of ant colony algorithm, each time circulation optimal solution which arrives to the ant search carries on the partial optimization through the fast simplex algorithm, receives searches the overall situation most superior registration parameter. The experimental results show that compared with the original algorithm, improved algorithm can effectively improve the image registration accuracy, and can reduce the number of convergence of the algorithm.

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