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Application of Improved Ant Colony Algorithm in Intelligent Medical System: from The Perspective of Big Data

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With the development of technology and information science, big data becomes a buzzword on everyone's tongue and changed the style of study and work. Using the advanced internet of things technology in big data context, intelligent medical can build regional information platform of health archive. Then, the purpose of intelligent medical is to achieve interaction among patients, doctors, medical services and medical organizations so as to gradually reach complete information construction. Here, the selection and construction of intelligent medical system is the important task. Then, the improved ant colony algorithm is developed in this paper to cluster and assess corresponding information provided by intelligent medical system in order to improve intelligent medical system. Finally, the example is introduced by using the proposed method and demonstrates the scientific of the proposed method.

1. Introduction

With the development of technology and information science, big data has gradually appeared in the academic and practical fields and changed the style of study and work (Kshetri, 2016; Liu et al., 2016). Kshetri emphasized the importance of big data's role in expanding access to financial services in China which can help the next development of financial services in China. Liu et al., reviewed the data quality and usage issues from the perspectives of big data and encouraged people to rethink the influence of big data.

Lots of research organizations and companies have devoted themselves to this research topic and most of them focus on social industry such as medical industry (Lee et al., 2014). Base on the effect of big data and cloud computing, intelligent medical has appeared in our society. Using the advanced internet of things technology, intelligent medical can build regional information platform of health archive. Then, the purpose of intelligent medical is to achieve interaction among patients, doctors, medical services and medical organizations so as to gradually reach complete information construction. Conduction a safe and successful major event highly depends on the effective provision of intelligent medical services that are often offered by different public and private agencies. Poor communication and coordination between these agencies and doctors or patients may result in delays in decision making and duplication of efforts.

Based on digitalization and visualization model, the technology related to Internet of Thing can be applied in intelligent medical field in order to make more people share the limited resources of medical (Yang et al., 2015). From the existing development of medical information, the trend of introducing health care into community becomes apparent. In this process, radio frequency instrument and related devices are applied to real-time trace and monitor life characteristics in the family. By using Internet of Thing, the medical organization can realize real-time diagnosis and health awareness for patients and sub-health patients so as to effectively decrease and control the occurrence and deterioration of patients. (Diaz et al., 2016)

Ant colony algorithm provided by Dorigo (1991; 1996), has been attracted much attention. The aim of the ant colony algorithm is to search for an optimal path according to the behavior of ants seeking a path between their colony and a source of food. It is widely accepted that in the natural world, ants initially wander randomly and upon finding food return to their colony while laying down pheromone trails. Ji et al., (2013) proposed a new ant colony clustering algorithm with fitness perception and pheromone diffusion for community detection in complex networks. Based on clustering methodology, Inkaya et al., (2015) developed an ant optimization algorithm with no a priori information. Moradi and Rostami (2015) introduced ant colony optimization to

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integrate graph clustering for feature selection in the field related to machine learning. The genetic algorithm (GA) is a kind of self-adapting heuristic global search algorithm which was derived from imitating the thought of natural biological evolution. Ding and Fu (2016) proposed kernel-based fuzzy c-means clustering algorithm by using genetic algorithm.

Cluster analysis is the organization of a collection of data points into clusters based on similarity. Clustering is usually regarded as an unsupervised classification task. (Jain et al., 1999; Matake et al., 2007). In this paper, we firstly construct a framework of intelligent medical decision support system from the five attributes including the risk, the information security, the services, the stability and the economy benefits, which can be applied to evaluate different systems related to intelligent medical and help clustering information. Based on this framework, the ant colony algorithm is introduced to cluster the information of intelligent medical system. However, the traditional ant colony algorithm has many parameters which are difficult to be obtained. Then, by using the genetic algorithm, these parameters in the ant colony algorithm can be easy to be acquired. The genetic algorithm can optimize these parameters in the ant colony algorithm and decrease the number of setting parameters when the ant colony algorithm reaches the global optimization. In addition, this improved method can avoid local optimization, increase the speed and improve the performance of clustering information. Finally, the example is introduced by using the proposed method and demonstrates the scientific of the proposed method.

The rest of the paper is organized as follows: Section 2 introduces the corresponding concepts of ant colony algorithm. Section 3 constructs the framework of a general intelligent medical decision support system and proposes the procedure of the improved ant colony algorithm. Section 4 demonstrated the illustrative example. Section 5 concludes this paper.

2. Ant colony algorithm

In this section, some concepts of ant colony algorithm are reviewed.

As mentioned above, since Dorigo (1991) proposed the ant colony algorithm, it has been widely applied in many fields. The purpose of the ant colony algorithm is to search for an optimal path according to the behavior of ants seeking a path between their colony and a source of food. It is widely accepted that in the natural world, ants initially wander randomly and upon finding food return to their colony while laying down pheromone trails. Hereinto, pheromone trails are very important factor to guide other ants. If other ants find such a path, they are likely to follow the trail, returning and reinforcing the pheromone trails if they eventually find corresponding food. However, it is worth to note that the pheromone trails will gradually evaporate as time passed. Then, the more time it takes for an ant to go down the path and return again, the more the pheromone trails will evaporate. Thus, if the path is shorter, the ant will choose more frequently. The pheromone density will further become higher and higher. On the contrary, the longer path may get marched less and have the lower pheromone density. If there were no evaporation at all, the paths selected by the first ant may tend to be excessively attractive to the following ones. But this case may constrain the exploration of the solution space. Therefore, when an ant searches a short path from the colony to a food source, other ants are more likely to follow this path. Based on these behaviors, the ant colony algorithm is developed and applied to deal with some problems.

Firstly, the fitness function of an ant *i* at the iteration *t* is defined as

$$f_i(t) = \frac{1}{|A|}\sum_{j\in A}\frac{1}{1+d_{ij}} \tag{1}$$

Here, A represents the *i*'s neighborhood in its living context, $|A|$ is the number of ants in A and d_{ij} is the distance between *i* and *j*.

In the ant colony algorithm, an ant is a simple computational agent that iteratively constructs a solution for the problem at hand (Akarsu and Karahoca, 2011). The intermediate solutions are called solution states. At any iteration, an ant moves from state s_i to adjacent state s_j, corresponding to a more complete intermediate solution. Therefore, each ant k computes set A_k of feasible expansions to its current state in each iteration, and moves to one of these in probability. For the ant *k* at iteration *t*, the probability of moving from state s_i to adjacent state s_j depends on the combination of two values (such as the attractiveness $\tau_{ij}(t)$ of the move) as computed by some heuristic algorithms indicating the priori desirability of that move and the pheromone trail η_{ij} of the move which indicates how proficient it has been in the past to make that particular move (Huang et al., 2013). In general, and *k* moves from state s_i to adjacent state s_j which is demonstrated as

$$p_{ij}(t) = \begin{cases} \dfrac{\left[\tau_{ij}(t)\right]^{\alpha}\left[\eta_{ij}\right]^{\beta}}{\sum_{s_j \in A_k}\left[\tau_{ij}(t)\right]^{\alpha}\left[\eta_{ij}\right]^{\beta}} & if\ s_j \in A_k \\ 0 & otherwise \end{cases}, \tag{2}$$

where α and β are positive parameters used to express the importance of $\tau_{ij}(t)$ and η_{ij}, respectively, in the above probability computation equation.

At each iteration t, pheromone trails are updated usually when all ants have completed their solution, which may increase or decrease the pheromone trails corresponding to moves that were part of "good" or "bad" solutions, respectively. The pheromone trail on the path from the state s_i to adjacent state s_j is updated as follows:

$$\tau_{ij}(t+1) = \rho \cdot \tau_{ij}(t) + \Delta\tau_{ij}(t), \tag{3}$$

where $\tau_{ij}(t)$ and $\tau_{ij}(t+1)$ are the pheromone trail on the path from the state s_i to adjacent state s_j before and after updating, respectively. In addition, ρ is the pheromone evaporation coefficient expressed by a constant within interval (0, 1). Moreover, $\triangle\tau_{ij}(t)$ is the pheromone trail updated by all the ants which is showed as

$$\Delta\tau_{ij}(t) = \sum_{k}^{m} \Delta\tau_{ij}^{k}(t), \tag{4}$$

where m is the number of ants and $\triangle\tau_{ij}^{k}(t)$ is the following pheromone trail updated by ant k.

$$\Delta\tau_{ij}^{k}(t) = \begin{cases} \dfrac{1}{L_k} & if\ ant\ k\ moves\ from\ s_i\ to\ s_j\ at\ step\ t \\ 0 & otherwise \end{cases}, \tag{5}$$

where $\frac{1}{Lk}$ is the reciprocal of the path length experienced by ant k. Thus, the path is shorter, the pheromone trail is higher.

After reviewing the basic ant colony algorithm, it can help us to develop a new ant colony algorithm in the next section.

3. Improved proposed method and its application in intelligent medical system

In this section, the framework of a general intelligent medical decision support system is constructed based on the information from the interview and investigation. Then, based on the proposed framework, combining the genetic algorithm with the ant colony algorithm as mentioned in section 2, the improved ant colony algorithm is developed to deal with clustering problems in intelligent medical system and further helps select optimal medical service system in next section.

3.1 The intelligent medical system

How to help decision makers make correct decision with timely, useful and valid information is very important for intelligent medical industry. The underlying condition for successful development of such a system is creation of a reliable framework consisting of many attributes. However, it is a big challenge for academic and practical fields.

Intelligent medical system is liability, high-tech, cross-discipline and rewarding. During selecting of intelligent medical system or devices, how to use the system or device to assist doctors and patients to recover from illness and to maintain people's healthy and how to make them cost effective are major selection criteria. So, economical benefit is an attribute that should be considered in the selection process related to intelligent medical decision support system. Obviously, the capability of continuous improvement is a key point to win the competence in the market of medical system. Thus, stability should be included in the intelligent medical decision support system. Because of the characteristics of big data, information security can guarantee the application of the intelligent medical decision support system. In addition, the quality of services is an attribute to weigh the necessity of this intelligent medical decision support system. Moreover, risk is another factor that should be considered owing to the importance of this system. If information leak or system fault, the influence should be considered and corresponding measures should be also prepared in advance. Then, the above attribute framework is constructed to help the decision maker select an appropriate intelligent medical decision support system in different context.

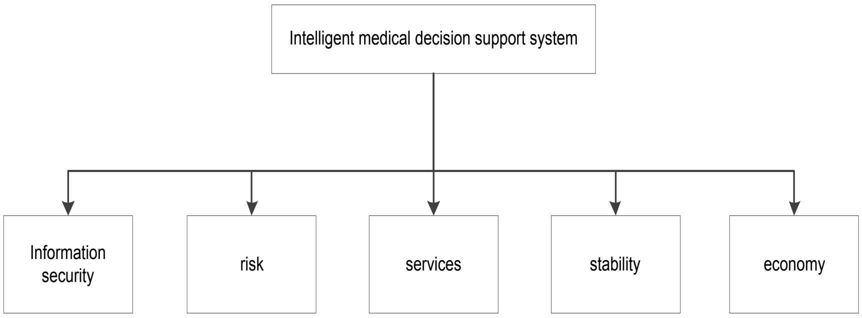

Figure 1: The attributes of cloud computing service evaluation system

In the next section, this attribute framework will be applied in a real case to verify its applicability.

3.2 The proposed method

It is worth to note that before starting the ant colony algorithm, the following parameters need to be initialized: (1) the set of starting states; (2) the set of goal states; (3) the number of ants; (4) the termination condition of iterations for each ant; and (5) the definition of path length.

Genetic algorithms are global, parallel, stochastic search methods, developed from Darwinian evolutionary principles (Goldberg, 2012). During the last decade, genetic algorithm has been widely applied in many areas with varying degrees of success. The computational complexity of the genetic algorithm has proved to be the chief impediment to real-time application of the technique. Commonly the genetic algorithm has been used to optimize both structure and parameter values for some other methods (Michalewica, 2012). In general, the genetic algorithm starts as a general optimization algorithm by defining the optimization algorithm variables, the cost function and the cost. It ends like other optimization algorithm too, by testing for convergence. In nature, the genetic algorithm is a cycle process made up of reproduction operators. In the process of searching for the global optimum solution, GA needs neither the information of gradient nor the calculus computing, it can find out the global optimum solution or near-optimal solution in the solution space with high probability only by operating the reproduction-crossover-mutation operators; thereby, it could reduce the probability of getting into the local minimum efficiently.

In the process of the genetic algorithm, the following tasks should be implemented: Firstly, N chromosomes should be selected from population S in N separate times. The probability of one individual being chosen is $p(x_i)$.In general, the computational formula is defined as

$$P(x_i) = \frac{f(x_i)}{\sum_{j=1}^{n} f(x_i)} . \tag{6}$$

There is a chance that the chromosomes of the two parents are copied unmodified as offspring, or randomly recombined to from offspring. There is also a chance that a gene of a child is changed randomly. However, it is widely accepted that the change of mutation is low.

Then, based on this genetic algorithm and Section 2, the following method is proposed and applied in this paper.

Improved Algorithm:

Step 1: Start.

Step 2: Initialize the global optimal solution.

Step 3: Initialize the corresponding parameters of the ant colony algorithm and pheromone to generate $n \times m$ ants.

Step 4: Initialize parameters in genetic algorithm and pheromone to randomly generate $n \times m$ codes which can be considered as original population and then compute fitness degree of individual in the population.

Step 5: According to state transition rule, all ants complete primary circulation to renew the global optimal solution.

Step 6: Based on fitness degree of individual, some individuals can be selected from genetic population as parent individuals. Then, they are imposed about interlace operation to generate new individuals which can be combined into the new population.

Step 7: The global optimal solution can be considered as elitist individual and combined into the new population.

Step 8: Some excellent individuals can be also considered as elitist individual and combined into the new population to maintain the size of population.
Step 9: According to mutation probability showed in Eq. (6), the individuals in the new population can be carried out by interlace operation.
Step 10: Calculate fitness degree of the new population to renew the global optimal solution.
Step 11: Renew all information related to paths of ant colony and only add pheromone trail of the path related to the global optimal solution.
Step 12: If the condition of ending the process is satisfied, then the global optimal solution outputs. Otherwise, return to the Step 5.
Step 13: End.

4. Simulation experiment

In general, there are many data in medical field. Thus, intelligent medical system is implemented in the context of big data. In this paper, the data from 10 medical organization including hospitals, medical research laboratory or others medical institutions are selected to be analysed. Firstly, the data should be normalized to remove the impaction of different dimension on the result as follows.

$$x'_{ij} = x_i - x_{ij} , \tag{7}$$

$$x^*_{ij} = \frac{x_{ij} - \min_i \left\{ x_{ij} \right\}}{\max_i \left\{ x_{ij} \right\} - \min_i \left\{ x_{ij} \right\}} , \tag{8}$$

where x^*_{ij} denotes the values after normalization.
Then, the proposed method in Section 3.2 is introduced. Firstly, some parameters are set as: the number of ants is 200, the max number of iteration is denoted by t = 50, P_0 = 0.9, ρ = 0.1, β = 0.5, α = 0.5, crossover probability is 0.8, mutation probability is 0.2. The data in intelligent medical decision support system can be divided in to three types including A_1, A_2, A_3. Using Matlab 2012, the clustering result can be obtained in Figure 2.

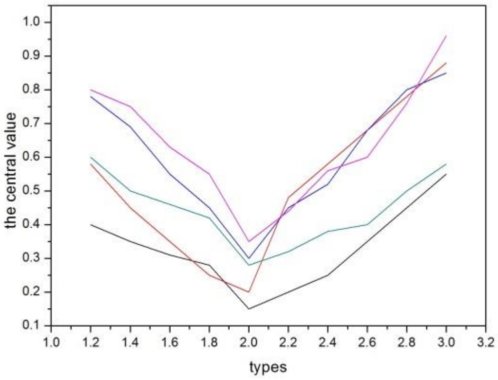

Figure 2: The result of clustering on each attribute

From the Figure 2, the result of clustering can be seen. Based on the result, the different intelligent medical decision support system can be differentiated. Then, medical organizations can select their need intelligent medical decision support system based on the purpose of using the data in the decision support system, which can make the selection more effective.

5. Conclusion

With the development of technology and information science, big data becomes a buzzword on everyone's tongue and changed the style of study and work. Base on the effect of big data and cloud computing, intelligent medical has appeared in our society. Using the advanced internet of things technology in big data context, intelligent medical can build regional information platform of health archive. Then, the purpose of intelligent medical is to achieve interaction among patients, doctors, medical services and medical organizations so as to gradually reach complete information construction. Here, the selection and construction of intelligent medical system is the important task. From the analysis of existing methods related to cluster information, the ant colony algorithm is introduced. The aim of the ant colony algorithm is to search for an optimal path according to the behavior of ants seeking a path between their colony and a source of food. Then, by combining with the genetic algorithm, the improved ant colony algorithm is developed in this paper to cluster and assess corresponding information provided by intelligent medical system in order to improve intelligent medical system. Finally, the example is introduced by using the proposed method and demonstrates the scientific of the proposed method.

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