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Design and Implementation of Intelligent Agent System for Pattern Classification

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Abstract

Recently, due to the widely use of personal computers and internet, many computer users requested intelligent system that can cope with various types of requirements and user-friendly interfaces. Based on this background, researches on the intelligent agent are now activating in various fields.

In this paper, we modeled, designed and implemented an intelligent agent system for pattern classification by adopting intelligent agent concepts. We also investigated the pattern classification method by utilizing some pattern classification algorithms for the common data. As a result, we identified that 300 3-dimensional data are applied to three pattern classification algorithms and returned correct results. Our system showed a distinguished user-friendly interface feature by adopting various agents including graphic agent.

Key Words : Intelligent Agent, Pattern Classification, Management Agent, Clustering, Intelligent Agent System

1. Introduction

Recently, some systems or programs are introduced that is intelligent and user-friendly interface and it can act as an agent[13]. In spite of that attempt, there are lots of gap between user and system. To overcome this kind of problem, the study on the more user-friendly interfaces has been progressed since 1990.

A more intelligent and user-friendly interface system is under development as an agent concept that can act instead of human beings. Agent is often defined as an information processing program that can be applied to numerous fields such as autonomous agent[12], electronic commerce[3], knowledge discovery[5], bank asset management system[9], intelligent user interface[13], pattern classification[1, 2, 10, 11], and computer vision[8].

Intelligent agent is generally considered as an intelligent system that can obtain synergy effects by combining practical user interface and theory of intelligent system based on Artificial Intelligence, Neural Networks, and fuzzy theory.

But intelligent agent so far is in the level of merely providing a user interface, and fusion of theory and practical issue on intelligent agent technology is still in the starting point.

Moreover, the problems of efficient connection between agents, job distribution between agents, and conflicts and errors between agents are not solved yet. This kind of problems can appear in any kind of applications that is based on the intelligent agent.

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The study on the pattern recognition that can substitute visual recognition by computer vision is widely progressed. The techniques to recognize 3-dimensional data such as letter, digit, simple mark, picture, figure are already investigated and ready to be applied to the real world. Nowadays, lots of researchers are investigating voice recognition and 3-dimensional image recognition.

Among the pattern recognition system, voice recognition utilizing time information adopts Hidden Markov model, but most of the pattern recognition can be achieved by pattern classification techniques. Major classification methods are k-means algorithm, Fuzzy c-means algorithm[3], and SONN algorithm[7, 8]. This kind of technique provides clustering information and its membership values for pattern classification, but it does not provide user-friendly interface for the user. There fore, the visualization including 3-dimensional graphic is very important.

The goal of our study is to design and implement intelligent an agent system for pattern classification.

2. Pattern Classification and Intelligent Agent System

Pattern classification is a function to map the given pattern to a class or category.The problem of classification is basically partitioning the feature space into regions, one region for each category. Ideally, one would like to arrange this partitioning so that none of the decisions is ever wrong. If it is not possible, one would like to minimize the probability of errors, or to reduce the average cost of errors.

One of the controversial topic of the pattern classi-

fication nowadays is a validity proof. The major reason is that we need to apply ambiguous membership instead of clear decision.

The salient feature of this study is that can express data by graphic in addition to membership value and clustering center.

2.1 Intelligent agent and pattern classification

The research level of intelligent agent system is considered as an early stage. We propose an Intelligent Agent System for Pattern Classification by fusioning pattern classification theory and user interface. We analyzed and compared the same data simultaneously, and therefore the user can notice the difference easily and quickly. This system uses several kinds of pattern classification algorithms and helps the user understand clearly and easily by using graphic user interface.

2.2 Pattern classification method

Pattern classification methods in this paper include discriminant function classifier, Neural Network(NN) classifier utilizing LGB algorithm, and 1-NN classifier utilizing k-means algorithm. Each method classifies the given input data in different ways and returns the classification class which the data belongs to and returns the clustering center value.

① k-means algorithm

The procedure of k-means algorithm is to repeat the following steps until to get the clustering. Here k is the repeating number variable, Sj(k) is the set of pattern classification such that the center of jth cluster is zj(k), Nj is the number of patterns that belongs to sample pattern set Sj(k), and k is the number of clusters.

[1] Select k number of initial cluster centers randomly z1(1), z2(1), ..., zk(1).

[2] For i=1, 2, ..., k, i≠j, execute d(x-zj(k)) < d(x-zi(k)) → x ∈Sj(k).

[3] For j=1, 2,..., k, compute the new cluster center zj=(k+1) such that

$$Z_j(k+1) = \frac{1}{N_j} \sum_{x \in S_j(k)}$$

[4] For every j=1 ,2,..., k, if zj(k+1)= zj(k) is satisfied then stop the execution, if not, go to step 2.

② Pattern classification utilizing NN rules

NN rule is as follows. For any pattern x∈V, total template pattern T1∪T2∪…∪Tk, We set t0 as a pattern that minimizes the value of distance function d(x, t). If t0∈Tj, then we set δ(x) as δ(x)=wj. That means we classify x as the nearest pattern class

Other pattern classification algorithms are Fuzzy c-means algorithm and SONN algorithm and so on.

2.3 Design of Intelligent Agent System

Fig.1 shows the overall intelligent agent system. Pattern Classification Agent is a part of intelligent agent system, and also there are several application agents.

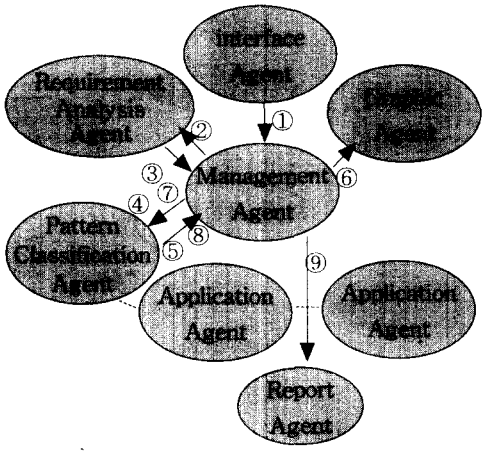

Fig. 1. Intelligent Agent System

The numbers in Fig. 1 a example of the scenario designed in this system.

① Interface Agent : It helps the user interface with the intelligent agent system.

② Requirement Analysis Agent : It analyzes the requirement specifications of the user.

③ Management Agent : It infers the requirement specifications of the user and chooses the appropriate agent and calls it.

④ Pattern Classification Agent : It analyzes the given data. There would be several Pattern Classification Agents to perform pattern classification.

⑤ Management Agent : It receives the information of the data from the Pattern Classification Agent and calls Graphic Agent.

⑥ Graphic Agent : It notices the specific type of the given data and shows the result in a visual fashion.

⑦ Management Agent : It calls Pattern Classification Agent.

⑧ Pattern Classification Agent : It classifies the pattern and calls Management Agent.

⑨ Management Agent : It sends the result to Report Agent to show the result.

⑩ Report Agent : It shows the result.

3. Design of Intelligent Agent System for Pattern Classification

The conceptual model of Intelligent Agent System for Pattern Classification consists of Main Agent and Management Agent that control the overall agents. As shown in Fig.2, Management Agent interacts with 4 Pattern Classification Agents and a Graphic Agent. Every agent has its own role and the total system is controlled and managed by Management Agent.

(1) Modeling of the Intelligent Agent System for Pattern Classification

Modeling of the Intelligent Agent System for Pattern

Classification is illustrated in Fig.2.

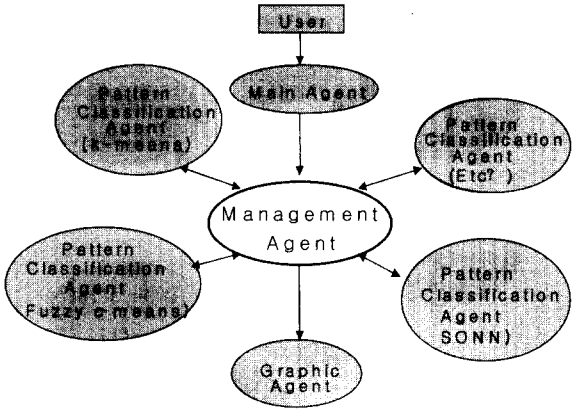

Fig. 2. Intelligent Agent System for Pattern Classification

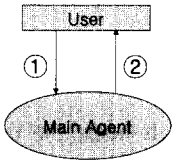

Fig. 3.

(2) Clustering technique

Pattern Classification Agent uses several kinds of algorithms. As shown in Fig. 2, Pattern Classification Agent uses k-means Algorithm, fuzzy-c-means Algorithm, SONN Algorithm, and other algorithms. For example, k-means Pattern Classification Agent uses k-mean clustering algorithm.

(3) The role and function of Intelligent Agent system for Pattern Classification.

There are several kinds of agents to implement the Intelligent Agent System. Here we define and implement Main Agent, Management Agent, Pattern Classification Agent, and Graphic Agent as in Fig.2. The role and function of major agents are as follows.

○ Main Agent

It enables the user to use the system easily and efficiently. It is a kind of user interface agent and it receives the requirement specification of user and makes the user easy to use the system. It is an interface between the user and the Management Agent.

① User interacts with Main Agent
② Main Agent responds with the user very friendly and finds the job what the user wants.

○ Management Agent

It infers the pattern classification method that the user wants to use and decides which agent to order the execution for each agent. It controls the error occurred among agents.

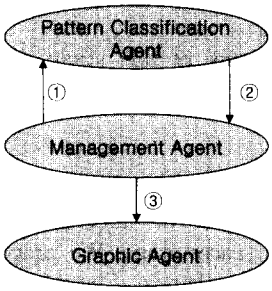

Fig. 4. Management Agent

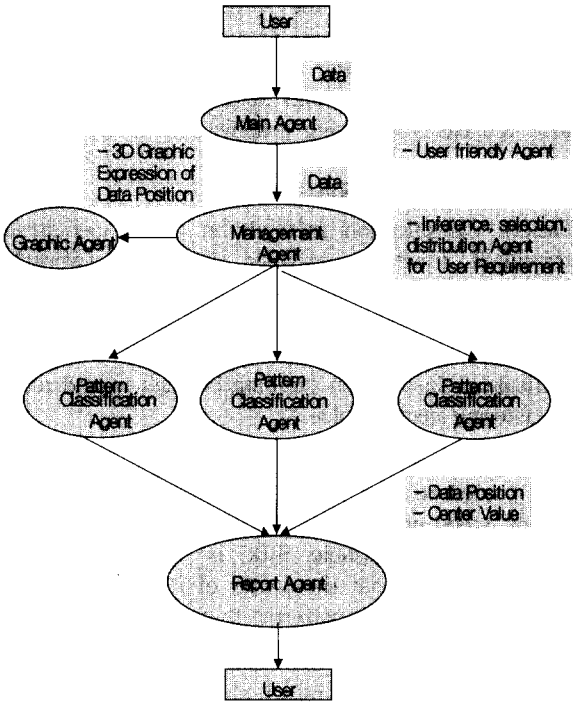

Fig. 5. Block diagram of Intelligent Agent System for Pattern Classification

① Management Agent calls Pattern Classification Agent and orders to perform what the user requested.
② Pattern Classification Agent calls Management Agent after finished the job and informs that the ordered job is finished.
③ Management Agent calls Graphic Agent and shows the results.

○ Pattern Classification Agent

It receives the data from the Main Agent and adopts one of the pattern classification algorithms. And it classifies the data and calculates the cluster center values. It sends the cluster center information to the Management Agent. Management Agent sends both the given data and the cluster center information to the Graphic Agent.

○ Graphic Agent

It shows the data in an appropriate graphic fashion. If

the data is 2-dimensional, it shows 2-dimensional graphic and cluster center values. If the given data is 3-dimensional, it should recognize that the given data is 3-dimensional data, and it should display the 3-dimensional graphic for the user to recognize clearly. If the user tried several pattern classification methods for a given data, it should display several graphic results depending on each method.

(3) Block diagram of Intelligent Pattern Classification Agent System

Block diagram of Intelligent Pattern Classification Agent System is illustrated in Fig.5.

4. Agent scenario

We assume that the incoming data to the Intelligence Agent System for Pattern Classification is arbitrary and unknown. That is, we do not know whether the input value is 3-dimensional or 4-dimensional data. Intelligent Agent System for Pattern Classification recognizes whether pattern classification is possible or not, and decides what kind of Pattern Classification Agent to use depending on the inference result.

Once the dimension and type of the data are decided, Main Agent uses Graphic Agent and shows the data clustering as in Fig. 6.

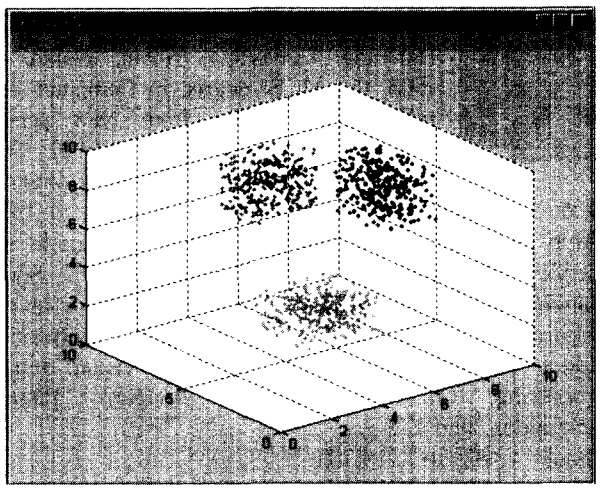

Fig. 6. 3-dimensional data distribution by Graphic Agent

Fig. 6 is an example of 3-dimensional data distribution by Graphic Agent. Input data is sent to the Pattern Classification Agent via Management Agent. Each Pattern Classification Agent performs pattern classification as its own way. It sends the information to the Graphic Agent.

The result of pattern classification is sent to the Report Agent. Report Agent shows the result in a very user friendly fashion.

5. Simulation and Results

We used 300 3-dimension data to test the pattern clustering and pattern classification. The input data has 3 clusters and the followings are the sample data.

5.100000 3.500000 1.400000
4.900000 3.000000 1.400000
7.100000 3.000000 5.900000
7.000000 3.200000 4.700000
⋮ ⋮ ⋮

(1) Same input data is given to each Pattern Classification Agent. For the method of pattern classifier utilizing discriminant function and NN rule classifier, we assume that classifiers are already trained. Another k-means algorithm does not need training.

(2) Input data is classified and the centroid of each class is calculated.

(3) Result comparison among three methods. The resulting centroids are illustrated in Table 1, Table 2, and table 3 respectively.

Table. 1 Cluster centroid by discriminant function classifier method

Centroid of Class 1	4.671545	4.732413	4.678920
Centroid of Class 2	7.352539	7.336982	7.313677
Centroid of Class 3	7.258228	7.355703	7.392234

Table. 2 Cluster centroid by NN rule classifier method.

Centroid of Class 1	4.671545	4.732413	4.678920
Centroid of Class 2	7.352539	7.336982	7.313677
Centroid of Class 3	7.258228	7.355703	7.392234

Table. 3 Cluster centroid by k-means classifier method

Centroid of Class 1	0.642100	0.690100	0.969040
Centroid of Class 2	7.119900	7.678933	7.039833
Centroid of Class 3	6.055129	5.663086	6.235771

Each table shows the result of simulation that each has 3 centroids for 3-dimensional data.

We simulated a sample 3-dimensional data, but our system can also recognize other dimensional data, and showed reasonably good results as user-friendly fashion to the user.

6. Conclusion

In this paper, we designed and implemented an Intelligent Agent System for Pattern Classification.

The adoption of intelligent agent concept in the pattern classification showed a promising classification

results and provided user-friendly interfaces. Moreover, the Graphic Agent showed a clear and visible result to the user.

Further researches are suggested to investigate the systematic flow of agent system and various clustering methods.

References

[1] J. C. Bezdek, C. Coray, R. Gunderson, and J. Watson, "Detection and characterization of cluster substructure Part I, Linear structure : Fuzzy c-lines", SIAM J. Applied Math, vol. 40, pp, 339-357, 1981.

[2] J. C. Bezdek, Pattern Recognition with Fuzzy Objective Function Algorithms, Plenum Press, new York, 1981.

[3] S. Bird., "Toward a taxonomy of multi-agent systems," Int. J. of Man-Machine Studies, vol. 39, pp 689-704, 1993.

[4] R. L. Cannon, J. v. Dave, and J. C. Bezdek, Efficient Implementation of the Fuzzy c-means Clustering Algorithm, IEEE Trans. Pattern Analysis and Machine Intelligence, vol. PAMI-8, no. 2, pp. 248-255, 1986.

[5] F. Cheong, Internet Agents : Spiders, Wanderers, Brokers, and Bots, New Riders, 1996.

[6] R. O. Duda and P. E. Hart, Pattern Classification and Scene Analysis, Wiley-Ineterscience, 1973.

[7] Dae Su Kim and T. L. Huntsberger, Self-organizing Neural Networks for Unsupervised Color Image Recognition, 23rd Southeastern Symposium in System Theory, march 1991.

[8] Dae Su Kim and T. L. Huntsberger, Self-organizing Neural Networks for Unsupervised Pattern Recognition, 10th Annual IEEE International Phoenix Conf. on Computers and Communications, March 1991.

[9] Dae-Su Kim and Chang-Suk Kim, Medeling of Bank Asset Management System based on Intelligent Agent, International Journal of Fuzzy Logic and Intelligent Systems, vol. 1, no. 1, June 2001.

[10] P. A. Devijver and J. Kittler, Pattern Recognition as Statistical Approach, Prentice Hall, London, 1982.

[11] J. C. Dunn, "A Fuzzy relative of the ISODATA process and its use in detecting compact well-separated clusters", J. of Cybernetics, vol. 3, no. 3, pp. 32-57, 1973.

[12] R. Goodwin, "Formalizing properties of agents", Technical Report CMU-CS-93-159, School of Computer Science, Carnegie Mellon University, 1993.

[13] A. Kandel, G. Langholz, Hybrid Architectures for Intelligent Systems, CRC Press, 1992.

[14] J. T. Tou and R. C. Gonzalez, Pattern recognition principles, Addison-Wesley, 1977.

[15] D. D. Wolff and M. L. Parsons, Pattern Recognition Approach to Data Interpretation, 1983.

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