Educational Character Recognition System Implementing an Interactive Visualization of Multi-dimensional Distribution

Takehiro Yamamoto, Nobuyuki Esaki, and Tetsuo Takeshita

Department of Information and Computer Engineering,
Toyota College of Technology, 2-1 Eiseicho, Toyota, Aichi 4718525, Japan
esaki@toyota-ct.ac.jp
http://www.ice.toyota-ct.ac.jp/experience/digit_recognition/

Abstract. In this paper, we propose visualizing multi-dimensional distribution used in pattern recognition system and construct a visualization system for multi-dimensional space which stimulates intuitive and visual understanding of pattern distribution for the purpose of education. We treat the method of visualizing the multi-dimensional vector data of each character on the handwritten digit recognition system. By applying principal component analysis, the original vectors are converted into principal components and three components. Ellipsoids of equal probability for each category are derived and visualized in the three-dimensional space shown in the visualization system. As a result, the boundary surfaces of each distribution of categories can be seen easily in the reduced three-dimensional space in spite of the fact that visualized vectors distributions do not represent all of vectors data. In conclusion, learners of pattern recognition can be stimulated their interest in and comprehension of multi-dimensional distribution through using this system.

Keywords: educational character recognition, principal component analysis, visualization of feature space.

1 Introduction

Pattern recognition systems including character or speech recognition systems are used in many places and occasions. They generally process multi-dimensional random vectors[1]. This makes it difficult for us to understand how the vectors are distributed in space because humans can imagine three-dimensional space at most. Furthermore, it is also difficult to compare mass and multi-dimensional vector data to recognize the objects. In this paper, we propose visualizing multi-dimensional distribution used in pattern recognition system and construct a visualization system for multi-dimensional space which stimulates intuitive and visual understanding of pattern distribution for the purpose of education.

In the previous paper, K. Yamamoto et al. proposed a visualization method for multi-dimensional data carrying out repetitive application of fuzzy clustering

C. Stephanidis (Ed.): Posters, Part II, HCII 2013, CCIS 374, pp. 118–122, 2013.

and fuzzy mlitiple discriminalt analysis[2]. And we, D. Mochizuki et al. created the character-recognition sysytem for education as shown in Fig. 1. The questionnaire result of a user shows the difficulty of visualization of feature quantity comparison on the weighted direction index histogram method[3]. N. Esaki et al. produced the visualization system using principal component analysis as an experiment based on the questionnaire result[4]. The system of this study further improves these prototypes.

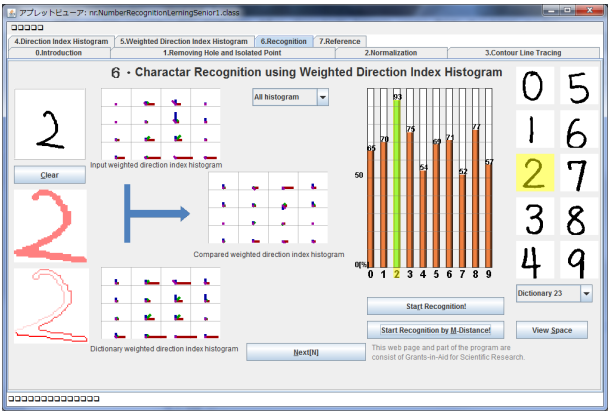

Fig. 1. Educational character recognition system showing a result of the weighted direction index histogram method. It is difficult to understand the process, although recognition is successful.

2 Methods

As a subject of study, we treat the method of visualizing the multi-dimensional vector data of each character on the handwritten digit recognition system. This system recognizes digits by using weighted direction index histogram (WDIH) that is a 64-dimensional random vector. WDIH vectors are processed dimensional reduction of random variables by using principal component analysis (PCA). In this section, we describe the feature space derived from WDIH method and give details of PCA to perform dimension compression of vector space easily.

2.1 Weighted Direction Index Histogram Method

In the educational character recognition system in Fig. 1, we can use the WDIH[5] as a useful recognition method. In process of recognition, the weighted direction index histogram is processed, where the 64-dimensional feature quantity can be obtained from a handwritten character. And the 64 dimensions consist of vertical four cell, width four cell, and four directions as shown in Fig. 2.

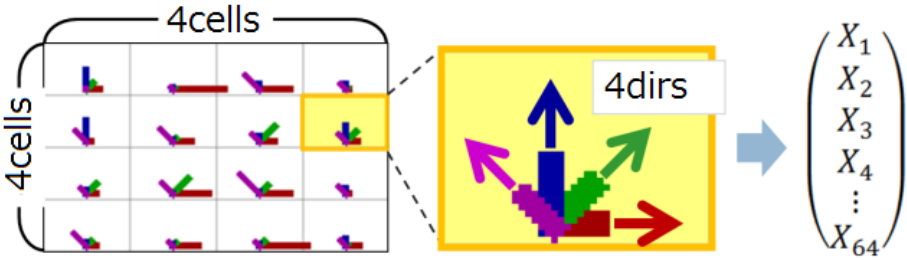

Fig. 2. Concept of WDIH

It is easy for a computer to compare with a user input each of the multi-dimension feature quantity obtained from dictionary data. On the other hand, it is difficult for a student to follow this process when learning pattern recognition. Furthermore, when there is many dictionary data, it is necessary to investigate the similarity of input feature quantity to a lot of multi-dimension feature quantity in detail. Therefore, it is thought that it leads to improvement in a student's degree of comprehension by visualizing so that the similarity of dictionary data and a user input can be sighted intelligibly intuitively.

2.2 Visualization for Multi-dimensional Data

Principal component analysis (PCA)[6] is originally a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables, which are called principal components. To use PCA, we can collect multivariate distributed over many dimensional space to the eigenvalue of a large small number of dispersion. Therefore we reduce the dimension of feature space into three or less, where humans can imagine space.

Feature vectors are distributed over three-dimensional space. About the vector in the same category, distribution of a principal component score follows a normal distribution. Therefore we try to visualize the vector group in the same category with each equal probability ellipsoid.

3 Products

We implement interactive visualization as mentioned above. On our educational system, first, recognition processing is carried out to a user's input character by the WDIH method. Then in the feature space where recognition processing was performed, a feature vector is obtained from each dictionary data to a user's input character. Finally, each vector which carried out dimension compression is drawn to three dimensions by PCA.

On the system of the previous version[4], We have drawn the vector group in the scatter diagram simply, where data must be plotted according to the number of dictionaries as shown in the left part of Fig 3. On the other hand, in the system after improvement, in the right part of Fig 3, feature space is classified according to the equal probability ellipsoid, and it could be more familiar with a beginner.

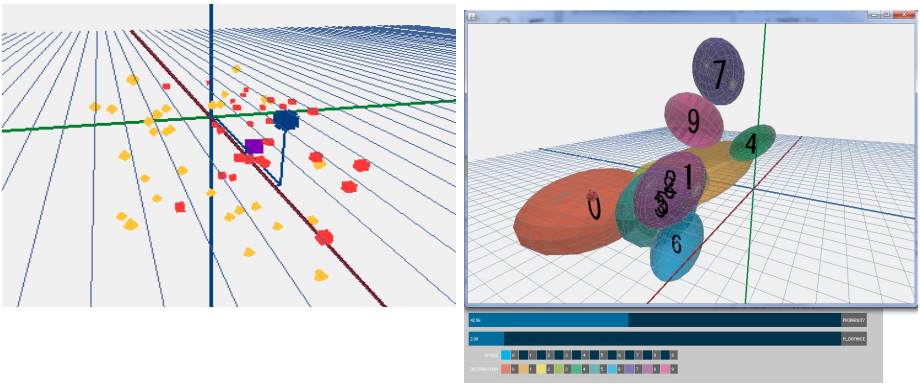

Fig. 3. The results of visualization for multi-dimensional data with the point diagram (left part) and with the probability ellipsoids (right part)

However, the size of the equal probability ellipsoids shown here is dependent on the Mahalanobis' generalised distance in fact. Figure 4 shows the equal probability ellipsoids which are not painted in the suitable size. At the present stage, this distance cannot be determined automatically but it has become the specification which a user defines free with a slide bar.

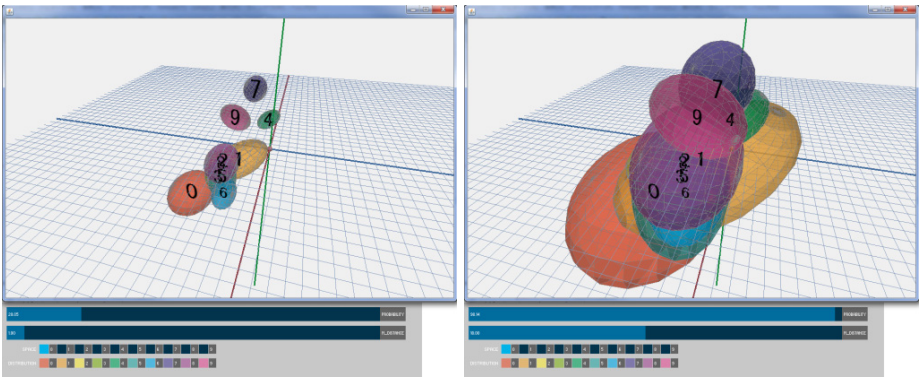

Fig. 4. The difference of the Mahalanobis' generalised distance to the same result

Furthermore, in order to give dialogism more, we improved the system to draw the vector corresponding to the letter which a user inputs on-line. Data is newly inputted interactively, while distribution of the feature space constituted with the data inputted once is drawn. Then the vector corresponding to the interactive inputting data is sequentially drawn in the visualized space.

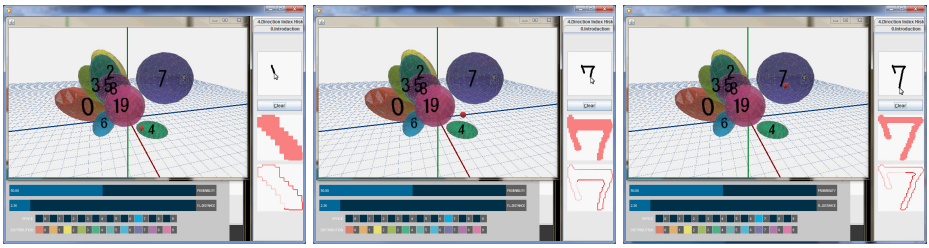

Fig. 5. Interactive vector drawing system

By this improvement, when a user does hand-drawn the same character as the recognized one, the feature vector approaches the classified feature domain until finishing drawing.

Evaluation experiments, such as a questionnaire, are future works.

References

1. Fukunaga, K.: Statistical pattern recognition, 2nd edn. Academic Press, Inc., San Diego (1990)
2. Yamamoto, K., Yoshikawa, T., Furuhashi, T.: A proposal of visualization method for multi-dimensional data using fuzzy clustering based on multiple discriminant analysis. IEICE Trans. J88-D-II(6), 975–984 (2005) (in Japanese)
3. Mochizuki, D., Takeshita, T., Esaki, N.: Development of an educational character recognition system. In: Proceedings of Tokai-Section Joint Conference on Electrical and Related Engineering, ROMBUNNO.N2-5 (2010) (in Japanese)
4. Esaki, N., Hisada, R., Takeshita, T.: Educational mutidimensional pattern recognition system using principal component analysis. In: Abstracts of 5th International Symposium on Advances in Technology Educaiton, p. 119 (2011)
5. Tsuruoka, M.: Handwritten Kanji and Hiragana character recognition using weighted direction index histogram method. IEICE Trans. J70-D(7), 1390–1397 (1987) (in Japanese)
6. Jolliffe, I.T.: Principal Component Analysis, 2nd edn. Springer-Verlag New York, Inc. (2002)