MVA '96 IAPR Workshop on Machine Vision Applications, November. 12-14, 1996, Tokyo, Japan

Dynamic Feature in Complicated Pattern Recognition

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Abstract

An off-line handwritten Chinese character recognition system is described based on a particular model of Chinese character prototype. The concept of dynamic feature verification is introduced to tolerate variations in handwritten character and filter noise in character image. Our experiments show the methods is effective.

1 INTRODUCTION

Chinese character is one of the most complicated ones in the world. It goes without saying that handwritten Chinese character recognition is a hard nut to crack. Handwritten Chinese character recognition has been the subject of extensive research in the area of pattern recognition for many years[1-6].Chinese character mainly consists of four types of strokes, e.g. horizontal stroke, vertical stroke, lift-falling stroke and right-falling stroke, according to statistics. In fact, each stroke is very difficult to write exactly in the way of block character. The problem become even more complicated in free writing. Variations in handwritten Chinese character, such as deformed writing, stroke connection and stroke mismatching, is nothing new. Noise and disturbance are too numerous to mention individually. There are many problems to solve in theory and application. We put our attention to two key problems : how to concisely represent Chinese character in the abstract and how to effectively obtain true features. In this paper Chinese character prototype and dynamic feature verification are introduced. Chinese character prototype yields notable results in embodying the characteristics of the structure of Chinese character. Dynamic feature verification is very useful to select reliable features for recognizing decision. The method we propose has been developed in the framework of a handwritten Chinese recognition system with the purpose of dynamic feature verification useful to obtain reliable features, rather than false ones.

2 CHINESE CHARACTER PROTOTYPE

It is well known that Chinese characters are very unique. The reasons are :

1) The number of Chinese character is enormous, over 3000 characters in common use.

2) There are many strokes in a Chinese character, over 12 strokes per character on an average.

3) Many similar characters are in common use, for example, 土(ground) and 士(soldier), 曰(say) and 日(sun).

These characteristics of Chinese characters bring a number of troublesome things to our researchers in the field of handwritten Chinese character recognition. The existing approaches to handwritten Chinese character recognition draw from the conventional theory of pattern recognition and some traditional ideas. We briefly list the shortcomings of the approaches as follows:

1. Chinese character coding has a great influence upon handwritten Chinese character recognition. In order to input a Chinese character into computer by keyboard or look up a Chinese character in Chinese dictionaries, we have to disassemble the Chinese character. This idea came from ancient Chinese researchers about 1700 years ago. There are exist over 250 radicals by which characters are arranged in Chinese dictionaries. Modern people follow the idea to successfully input Chinese characters into computer. Many researchers also imitated this method, for example, 扌 and 亻 as radicals, in

handwritten Chinese character recognition. A lot of research works have shown that it is difficulty to extract such kinds of radicals.

2. The methods to recognize handwritten Chinese characters confine to the conventional theory of pattern recognition. From the papers which have been published, the methods most of the papers used draw from the theory[7]. The theory divides recognition phase into two isolated stages: feature extraction and classification. In fact, there are mutual relations and dependent information between the two stages.

3. There is much effort to the research on algorithms and little effort to the structure of Chinese characters. The recent situation has indicated that the improvements of single algorithm or single feature extraction do not make significant progress in handwritten Chinese character recognition. Multi-feature extraction and multi-system combination are more extensive, diversified and conplementary sources of information concerning handwritten Chinese character recognition[8]. It can be deduced that system performance can be improved significantly by deeply understanding the structure of Chinese character.

After a thorough investigation and study in the view of geometry and topology, we design Chinese character prototypes in the abstract to represent Chinese characters as templets. What we pay close attention to is a change within a stroke and a connection between strokes. Stroke length is less important. This representation reflects our main ideas. The prototypes consist of elements and constrained relations. There are four categories in element and four types in constrained relation. The total number of elements is fifty-eight. All elements are shown in fig. 1.

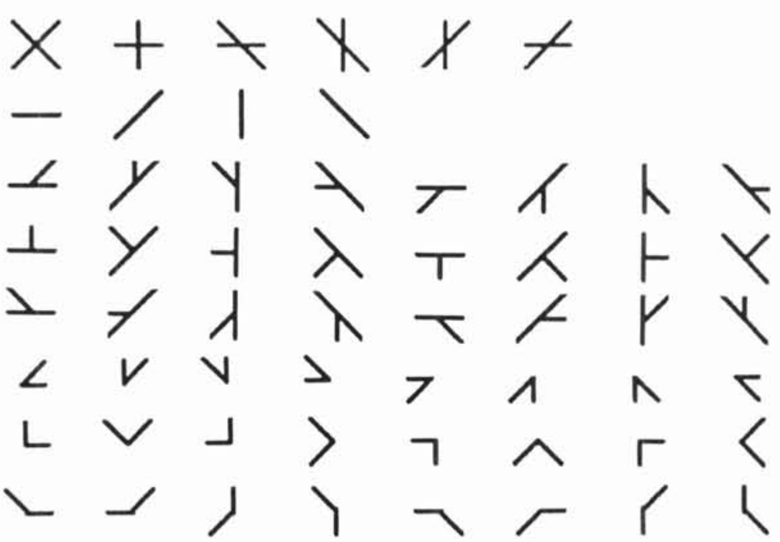

Fig. 1 Overview of elements in character prototype.

The constrained relations are

1. Up-relation.
2. down-relation.
3. lift-relation.
4. right-relation.

By means of the combination of elements and relations, a Chinese character is composed in a abstract way. Each Chinese character has its prototype except the same structure(末 and 未). Concerning the characters which have the same structure, we use context or geometric characteristics to distinguish one from another. Some example are shown in fig. 2.

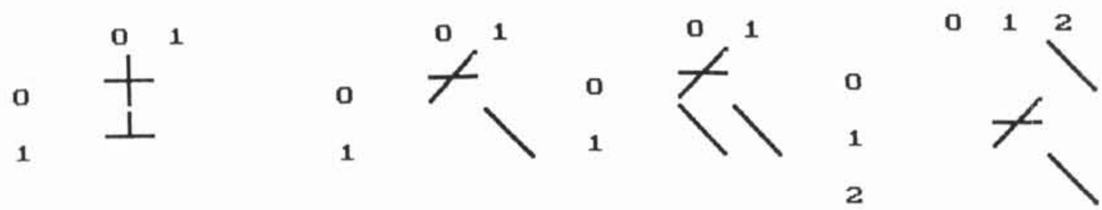

Fig. 2 Chinese characters : 士 土 and 大 太 犬 in prototype representation.

Chinese character prototype (CCP) is insensitive to variation in writing, such as stroke size, and is very sensitive to the construct of characters. We put our attention to in what position a element appears. The relations among elements have much influence on what character is composed.

3 DYNAMIC FEATURE VERIFICATION

In this section, we introduce the concept of dynamic feature verification.

In conventional pattern recognition, a feature set first is defined.

$$F = \{ f_1, f_2, f_3, \ldots , f_n \}$$

$$n = 1, 2, 3, \ldots$$

Then, a feature extraction subroutine (FE) is used to search how many f_i exist in recognizing data, e.g.

$$X \xrightarrow{FE} \begin{cases} m_1 \cdot f_1 \\ m_2 \cdot f_2 \\ \vdots \\ m_n \cdot f_n \end{cases}$$

$$m_1, m_2, \cdots , m_n = 0, 1, 2, \ldots$$

where X is input data.

Above process is generally refereed to as feature extraction. It is well known that there may exist false features as a result of the process. The false features have much negative influence on recognition decision. Another shortcoming in the process is that we cannot get some features from recognizing data X because of noise or disturbance. This phenomenon often happens in handwritten Chinese character recognition, such as connected stroke or broken stroke shown in fig. 3.

Fig. 3 Two handwritten Chinese characters with noise or disturbance.

In order to overcome the weaknesses, we introduce the concept of dynamic feature verification. We use an example to explain what dynamic feature verification is.

For two patterns ω_1 and ω_2,

to build ω_1, $F_1 = \{ f_1, f_2 \}$

and to build ω_2, $F_2 = \{ f_1, f_3 \}$

$F_1 \cup F_2 = F = \{ f_1, f_2, f_3 \}$.

In conventional mode, a common feature extraction subroutine (FE) is used to deal with X.

$$X \xrightarrow{FE} \begin{cases} m_1 \cdot f_1 \\ m_2 \cdot f_2 \\ m_3 \cdot f_3 \end{cases}$$

$$m_1, m_2, m_3 = 0, 1, 2 \ldots$$

In dynamic feature verification, feature verification subroutines (FV) we build are corresponding to respective patterns, that is to say, each pattern has its own feature verification subroutine.

$$X \xleftarrow{FV1} \begin{cases} m_1 \cdot f_1 \\ m_2 \cdot f_2 \end{cases}$$

$$X \xleftarrow{FV2} \begin{cases} m_2 \cdot f_2 \\ m_3 \cdot f_3 \end{cases}$$

$$m_1,\ m_2,\ m_3 = 0, 1, 2, \ldots$$

That means there exist big difference between conventional mode and dynamic feature verification. FV1 cannot get f_3 and FV2 cannot get f_1. In a sense, f_3 is noise to ω_1 and f_1 is noise to ω_2. Each ω_i only searches what ω_i needs. Whether or not a ω_i is accepted will depend on that FVi confirms all features ω_i needs. It is necessary to point out that dynamic feature verification is to check the number of features ω_i needs. We have proved that dynamic feature verification is a kind of necessary condition for ω_i. For example :

陪/部　　旮/旯

After the process of dynamic feature verification, we use constrained relations to check the space position of elements in order to decide which character is chosen.

4 RESULTS AND CONCLUSION

According to above principles, a system on handwritten Chinese character recognition is accomplished using C language. In the model, dynamic feature verification, rather than conventional feature extraction, is introduced. Our experiments showed the concept of feature verification is effective in filtering noise and disturbance. Experiments have been conducted on the recognition of over 200 handwritten Chinese characters from nine aspects. The recognition rate is 87%. The system block diagram is shown in fig. 4.

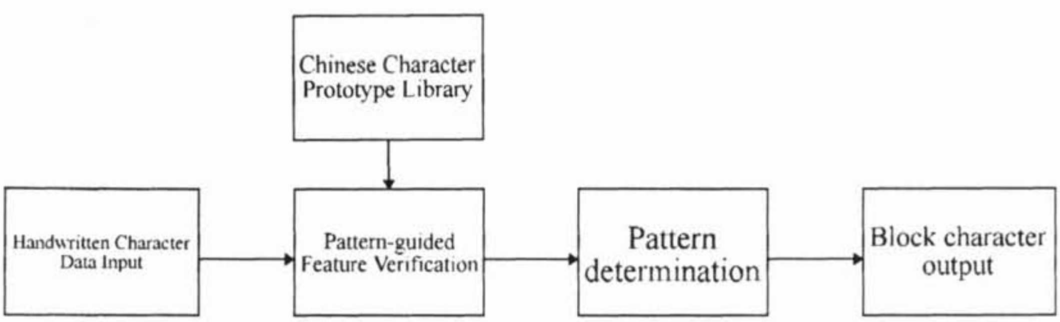

Fig. 4 Block diagram of the handwritten Chinese character recognition system.

The implementation does not specifically define stroke order, direction or size for Chinese character prototypes. The differences in stroke direction are generally treated as experience interval. If a Chinese character prototype is corresponding to two characters, one of the characters is chosen depends on context or geometric characteristics.

In practical experiments, Chinese character prototype and dynamic feature verification have shown several advantages as follows :

1. A character prototype which represents the structure of a character organizes a series of procedures for dynamic feature verification, that means different procedures for different characters.

2. Prototypes have nothing to do with the size and style of characters so as to tolerate considerable variations in handwritten Chinese characters.

3. Dynamic feature verification is strong in handling random noisy , especially raindrop noise, which is often used to show the advantages of statistical approach. It is obvious that random noise is difficulty to form the parameters prototypes.

4. Dynamic feature verification is selective in the need of a pattern so as to ignore what other patterns need. The characteristic makes classification decision more effective because noparameters which have nothing to with the pattern exist.

Some handwritten Chinese characters are shown in fig. 5 and fig. 6.

Our experimental system is also used in recognizing number and the English alphabet. The results we have got are satisfactory.

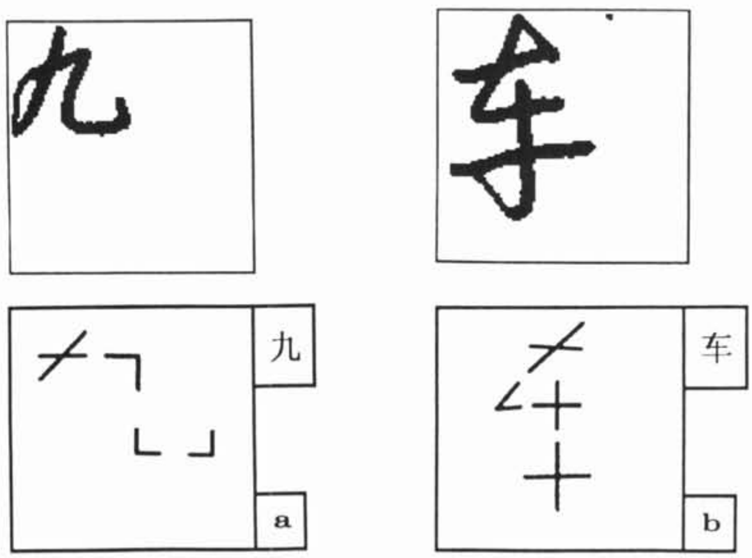

fig. 5 Two handwritten Chinese characters and thire prototypes.

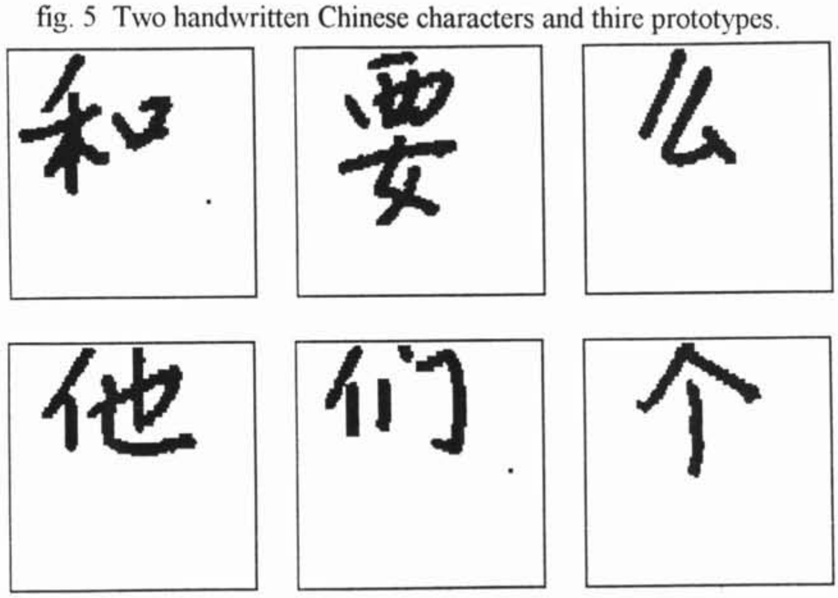

fig. 6 Some handwritten Chinese characters.

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Shan Jiang received the Master in computer structure and system architecture from North China Institute of Computing Technology in June 1987 and Ph.D. in computer application from Tsinghua University in July 1995. He is currently working as a postdoctoral fellow in Institute of Software, Chinese Academy of Sciences. His current research interests are mainly focused on pattern recognition, Chinese character recognition, machine intelligence, and robot vision.

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