On-line character recognition system based on artificial neural networks

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The main aim of this work, was to develop system, based on artificial neural networks, which can recognize handwritten symbols. It also can be used for gestures recognition. Due to the significant development communicators, smartphones, etc., this problem is extremely urgent. Recognition rates for the system vary depending on the consistency of the writing. On average, the untrained system achieved 70% recognition. After training, average recognition rates of 90% were achieved

Introduction

Computer technology has rapidly improved over the last few years, with more powerful machines becoming ever smaller and cheaper. The latest growth area is in portable personal computers and comunicators, providing powerful facilities to the mobile business person. Alongside this development has been the vast improvement to the human computer interface, allowing non computer -literate users access to computing facilities. These two aspects are now being combined into a portable computer that can be operated with a stylus of just finger, without the need for a keyboard. Handwriting is the obvious method for entering data and cursive script recognition research aims to comprehend unconstrained, natural handwriting. The system which was developed, recognizes handwriting symbols on-line, in real time. After preprocessing, to remove any hardware-related errors, and normalizing, the script is segmented and features of each segment measured. A template matching algorithm, based on neural networks is used to identify the characters. The system allows ambiguous matching, since cursive script is an ambiguous communications medium when taken out of context, and a probability for each match is calculated. These probabilities can be combined across the word to produce a ranked list of possible interpretations of the script word.

The goals:

- Convenience and natural text input for users;
- Increases functional area of screen(system can be adapted for gesture recognition);
- Intuitive control using gestures

Terminology

Artificial neural networks (ANN) - mathematical models and their software and hardware implementation, based on the principle of functioning of biological neural networks.

On-line Recognition On-line handwriting recognition means that the data is captured as the user writes, usually on some form of digitizing tablet or surface. This has also been referred to as dynamic or real-time recognition. The digitizer encodes the script into a time-ordered list of coordinates

Off-line, or static, recognition uses data supplied after the writing process is complete, usually in the form of an image or bit-map from a scanner or similar device. Static recognition is not within the scope of this thesis.

The recognition process

In general, recognition of handwriting symbols can be divided into several distinct stages. Some of them are executed sequentially and another ones - parallel. Overall, all stages can be grouped into three major stages of procession:

- Preprocessing;
- Recognition;

- Post processing

Preprocessing

Data, directly collected from users are often incomplete noisy and inconsistent, which are needed to be pre-processed before applying to the system in order to receive the correct classification.

Data capture

For an on-line recognition system it is necessary to collect the data as it is being written so that the order of the strokes of the pen can be recorded as well as the position of the pen. Typically information usually represented as time ordered list of coordinates. In my system, also stored information about the number of times the pen touches the surface. However, some digitizes also supply data about the angle at which the pen is being held, timing information that may be used to calculate dynamic information on the pen-tip travel, or vertical position of the pen above the digitizing surface.

Smoothing and noise elimination

The input data provided by the tablet may contain a considerable amount of noise that complicates the work in next stages. This noise is caused by the digitizer as well as by a shaking hand. So the interpolation algorithm were used for smoothing and noise elimination.

Coding

Freeman [1] proposed a method for representing a geometric configuration, such as a character within script, by a simple numerical code. A small number of directions are specified and labelled. A stroke is then encoded by dividing it into equal length parts, and coding each part by its nearest directional label. A complex curve can in this way be represented by a short list of digits.

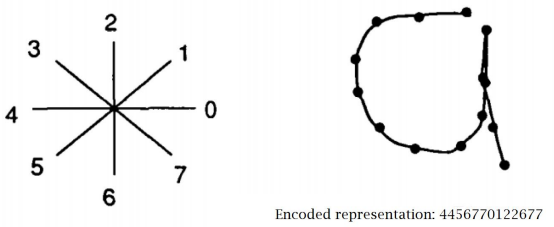

Figure 1. Freeman representing of geometric configurations.

Miller [2] segmented a stroke into six parts and encodes these with an 8 direction code so that each stroke is represented by six digits. A simple sum of the differences between the coded sample and template is used as the distance measure.

Wright [3] used an 8 direction code, but compresses any sequential vectors in the same direction into one code, and stores a length for each vector. Each template is stored as a five vector code, by compressing any short vectors into a neighboring vector. A sample segment is similarly compressed, and for those templates that match the coding precisely.

After receiving the data, the system vectorized input character: character is vectored by scaling into a given number of points, with the extra point removing.

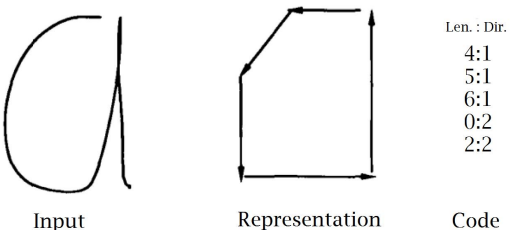

Figure 2. Wright representing of geometric configurations

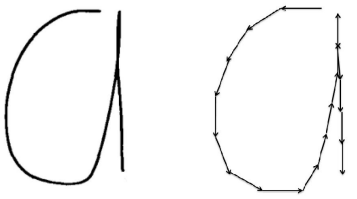

Figure 3. My representing of geometric configurations(v̈ectorizeds̈ymbol)

So, it helped to overcome the inaccuracies of writing and digitizing of characters. When vectorization is completed , the system calculates cosine of the angle between each of a sequence of vectors and the axis Ox

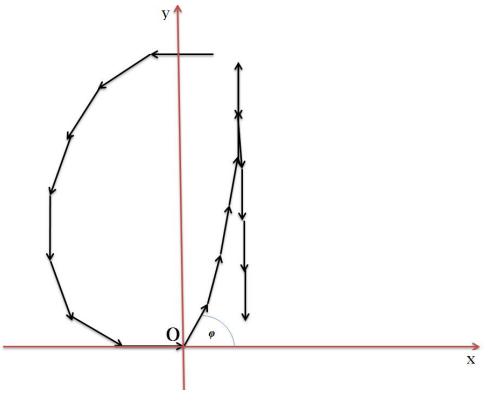

Figure 4. Calculating cosines of the angles between each of vectors and the axis Ox.

Ox as a result we obtain the sequence of numbers [-1, 1] which is the normalized data for artificial neural network.

Recognition

The recognition process perform artificial neural network, or rather multilayer perceptron. For this problem, one hidden layer is enough. The input of the network gets a list of points obtained on a preprocessing stage. As result we obtain the vector of probabilities for every character.

Where x_1 ... x_n - cosines of the angles between each of vectors and the axis Ox, r_1 ... r_m - probabilities for every character.

Post processing

At this stage, the system uses the probability for each character and built-in dictionary. Based on these data, the system tries to guess the word that introduces the user. Also the caps are very similar to regular, the neural network cannot determine what letter the user enters, but the post processing can.

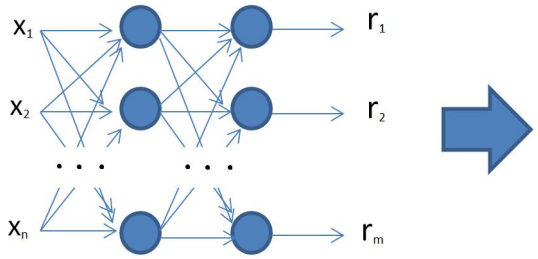

Figure 5. Multilayer perceptron, used for recognition

Conclusions

Today, there are many approaches (algorithms) to solve the problem character recognition, but most of them either narrowly focused on a particular area of recognition (they show high recognition results, but not universal) or recognition quality is very low, and the algorithm is slow. Therefore, to solve the problems of character recognition are often used systems based on artificial neural networks. These research based on the methods of character recognition using neural networks. As result, there was developed smart module of artificial neural network, which operates on the principle of multilayer perceptron, and is able to recognize handwritten characters of the alphabet. The system is configured by each user separately retraining the network can take some time. The recognition quality is quite high, while lower recognition quality can supplement learning sample characters that the system is not able to properly recognize and retrain ANN.

Comparison of different methods of geometric representation of recognition quality:

Method	Accuracy
Freeman	78% - 83%
Wright	82% - 87%
Designed	89% - 95%

The system has great potential. It can be re configured to recognize gestures. It can be useful when used on tablet computers when a developer tries not to use screen buttons and controls.

References

[1] Freeman, H., "On the Encoding of Arbitiary Geometiic Configurations," IRE Transactions on Electronic Computing, vol. 10, pp. 260-268, June 196

[2] Miller, G. M., "Real-Time Classification of Handwritten Script Words," Information Processing 71, pp. 218-223, North-Holland Publishing Company,1972.

[3] Wright, P., "Algorithms for the Recognition of Handwriting in Real-Time," PhD Thesis (CNAA), Trent Polytechnic, 1989.

[4] David Malcolm Ford "On-Line Recognition of Connected Handwriting ", PhD Thesis, pp 31-121, May 1991.

[5] Heaton J. "Introduction to Neural Networks for Java", Heaton Research, Inc. St. Louis, 2008

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