# HAND PRINTED RECOGNITION SYSTEM USING A FUZZY NEURAL NETWORK

**Elviz Ismayilov[1], Nigar Aliyeva[2]**

[1]Azerbaijan State Oil Academy, Baku, Azerbaijan
[2]Institute of Information Technology of ANAS, Baku, Azerbaijan
[1]*elviz.ismayilov@gmail.com*, [2]*aliyevanig@rambler.ru*

The problem of machine recognition of handwritten characters is not completely solved yet, as exist much both theoretical, and practical difficulties connected with huge variety of a possible spelling of separate handwritten characters. Drawbacks of known methods are strong instability of recognition results from a number of the deformations of scanned texts.

Notable successes in the practical application of systems for recognition of visual images are mainly achieved in the creation of devices for pattern recognition of symbols and numbers. Existing machines can read only fixed shapes of signs with the required reliability. Attempts to build machines for visual reading of handwritten letters for arbitrary shapes can not yet be considered successful.

These systems for increase of input reliability and information processing, as a rule, make rigid requirements to the filling of handwritten forms, for example, to use only constrained caps characters. However, in practice it is not always possible to follow this rule since during filling casual infringements of this restriction are probable. Besides that, distortion of recognition area and additional parts in the scanning area are the problems, which are the reasons of poor quality of recognition systems [7].

Offered pattern recognition algorithm combines properties of fuzzy model and multilayer neural networks. The recognized symbol is exposed through the skeletonization procedure (thinning). There are various methods for skeletonization of the symbols [1]. The method of mathematical morphology was applied in described system [2].

Handwritten symbols come in a variety of sizes and for the purpose of developing a recognition scheme it is imperative that all symbols be available in the same size since we need to extract an exact number of features based on their spatial distribution in a two-dimensional grid. To standardize the symbols, extra rows and columns containing only zeros are removed from all four sides of the numeral. The binary array is then fitted into a window of a size of 63×42. This size of the window is fixed, based on the fact that the width of the numeral is almost one-third of the height of the character.

Received thinned image is analyzed, its features are calculated.

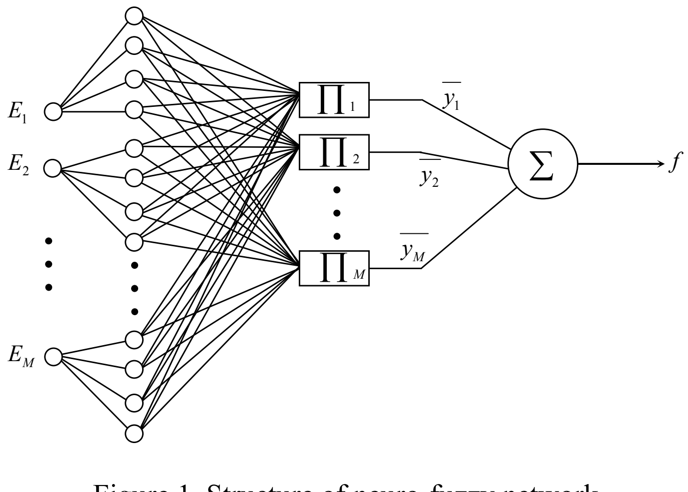


Figure 1. Structure of neuro-fuzzy network

The structure of neural network developed for recognition of hand-written letters is shown on Fig.1 [3]. From the initial image features characterizing structural properties of a recognized character are calculated [6]. Values of features are used as entrance parameters of neural network. The following layer consists from neurons calculating membership degrees of these values to corresponding terms. Scales of knots of connecting entrance neurons and neurons of the first layer are parameters of membership functions. The following layer consists of the block of IF-THEN rules formed for each recognized symbol. Neuron of the third layer calculates value of gravity center defuzzification operation:

$$f = \frac{\sum_{i=1}^{M} z_i \bar{y}_i}{\sum_{i=1}^{M} z_i} \quad . \tag{1}$$

Value is approximated with given accuracy and number of class of recognized image is defined.

In work application of various membership functions for L-R type fuzzy numbers is considered and investigated. Drawback of known L-R type membership functions (triangular, trapezoidal) is first their non-smoothness and their sets of section $A_\alpha$:

$$A_\alpha = \{x, \mu(x) = \alpha\} \tag{2}$$

when α=0 (for triangular membership function) and α=1 (for trapezoidal membership function) consist more than of one point, i.e. are some intervals. Non-smoothness of membership functions leads problem of rough optimization during training of neuro-fuzzy network, and the second drawback leads to uncertainty of direction choice of optimization method if initial value is from set $A_0$.

In this reason in work membership functions of L-R type fuzzy numbers which constructed on spline principle are offered and investigated.

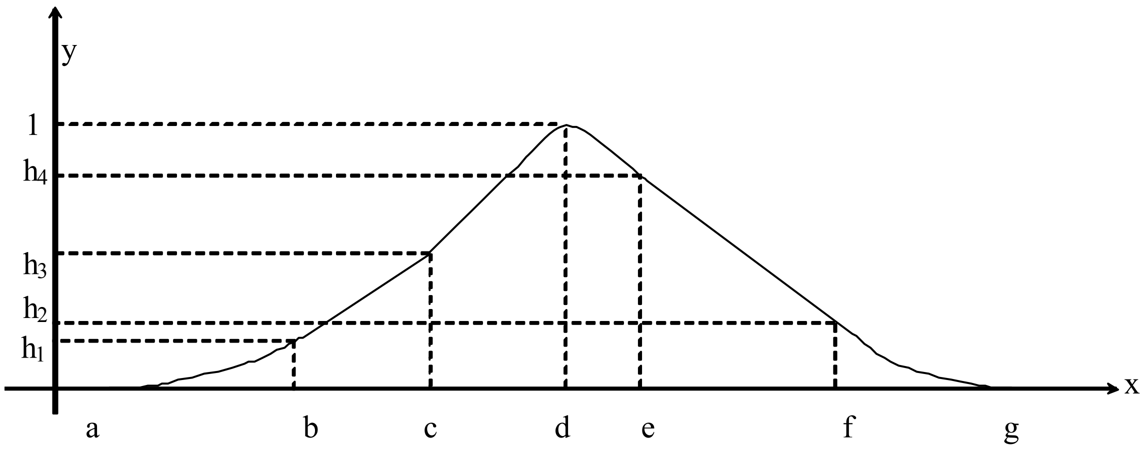


Figure 2. Spline membership functions for L-R type fuzzy numbers

For training neural network is used error back propagation method and the training samples (supervision) *(X, D).* Each pair includes a vector of known entrance signals of a network *X* (image features) and a corresponding vector of the desirable target data *D* (values of network). Training presents minimization of error function of neural network depending on parameters neurons-$w_j$ and set of training examples – $d_q$. As estimation function is usually used:

$$E(w)=\frac{1}{2}\sum_{q}\left(y_q-d_q\right)^2 \tag{3}$$

where $y_q$ is real condition of neural network for $q^{th}$ training example; $d_q$ –is desired output for $q^{th}$ training example; $w$– vector of improving parameters of neural network. The given function numerically is minimized by a nonlinear conjugate gradient method.

The following steps are used for training:

Step 1. Initial values of parameters ($w_i^0$, $i=1, 2, ..., M$) are given;

Step 2. Initial direction $S^0=-\nabla E\left(w^0\right)$ is counted;

Step 3. Weights of the network are updated using following formulas:

$$w^{(k+1)}=w^{(k)}+\eta_k S^k ,$$

$$S^{(k)}=-\nabla E\left(w_j^{(0)}\right)+\lambda_k S_j^{(k-1)} ,$$

$$\lambda_k=\frac{\left\|\nabla E\left(w^{(k)}\right)\right\|}{\left\|\nabla E\left(w^{(k-1)}\right)\right\|} ,$$

$\eta$ is the rate of the method, which determined using golden ratio method.

Step 4. If $\left\|S^k\right\|<\varepsilon$ or $\left\|w^{(k)}-w^{(k-1)}\right\|<\varepsilon$ then optimal values of weights $w^*=w^k$ are defining and the process is stopping.

Step 5. Else $k=k+1$ and go to step 2.

The greatest interest and difficulty in this algorithm is a method for calculation of a gradient $\nabla E(w)$ of the function (3) in base of error back propagation method which was modified in respect of fuzziness of mathematical models of neurons.

After training (defining $\omega^*$ values) network is ready for recognition of pre-processed (equalizing, cleaning, thinning, etc.) separate characters.

After recognition of separate symbols with in advance set degree of the reliability, separate words in which there were not distinguished any symbols, is exposed to the further analysis and recognition with dictionary (lexicon) [4].

The developed software is included in recognition system for hand-printed texts of the Azerbaijan language as one of the approaches in the system [5].

Results of the developed software as separately from recognition system for hand-printed texts, and as a part of system are received. The comparative analysis of work of the system was resulted.

## References

1. Nacken P. Image analysis methods based on hierarchies of graphs and multi-scale mathematical morphology: PhD thesis, Univ. of Amsterdam. 1994. 176 p.
2. Lam L., Suen C.Y. An Evaluation of Parallel Thinning Algorithms for Character Recognition. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 17, no. 9, 1995, pp. 914-919.
3. L. Rutkowski Flexible neuro-fuzzy systems: structures, learning, and performance evaluation, Kluwer Academic Publishers, 2004, 277 p.

4. Aida-zade K. R., Hasanov J. Z. Word base line detection in handwritten text recognition systems, International Journal of Computer Systems Science and Engineering, Vol.4, no.1, pp. 49-54. http://www.waset.org/journals/ijcsse/v4/v4-1-7.pdf
5. Aida-zade K.R., Mustafayev E.E. On a hierarchical handwritten forms recognition system on the basis of the neural networks // Conference material of TAINN 2003 (International XII Turkish Symposium on Artifical Intelligence and Neural Networks), Canakkale, Turkey, 2003.
6. E.A. Ismayilov, N.T. Aliyeva. Analysis Of Application Of Fuzzy Neural Networks To Structured Method Of Recognition Of Printed And Handwritten Symbols. // Of the International Scientifically and Practical Conference "Information Innovation Technologies: Integration of Business, Education and Science", dedicated to the 75-th Anniversary of the KazNTU named after K.Satpaev, Almaty, Kazakhstan, November, 2008, pp. 27-28.
7. www.statistical-pattern-recognition.net