Modern Approaches in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics
Volume II: Applications

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Modeling the process of the color recognition with MLP using symbol visualization

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Abstract

Multilayer perceptron (MLP) can be used to recognize many processes. In the following paper a neural network that recognizes colors inside a picture was described by Generalized net. The result is recreated by symbols, which have different order, on a white background. In the current case testing with the neural network that recognizes the red, green and blue colors.

Keywords: Generalized Nets, Multilayer Neural Networks, Image Processing

1 Introduction

Neural Networks are used in many projects. They can be very helpful in the recognition process and they are distinguished by a wide variety of kinds. This is an advantage that gives them a great potential. The learning method is the general difference between the varieties of neural networks types. They are two types of networks: supervised and unsupervised. In the present paper a supervised learning [6] Multilayer Neural Network is used.

According to [4], the artificial neural systems, or neural networks, are physical cellular systems, capable of perceiving, storing and using the perceived.

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In [3] neural networks are presented as a part of the theory of automata, relating to the theoretical field of mathematical analysis, oftentimes based on the models of the biological neural systems and being a system that may generate, encode, store and utilize information using a complex of neurons, nerve terminals and chemical synapses.

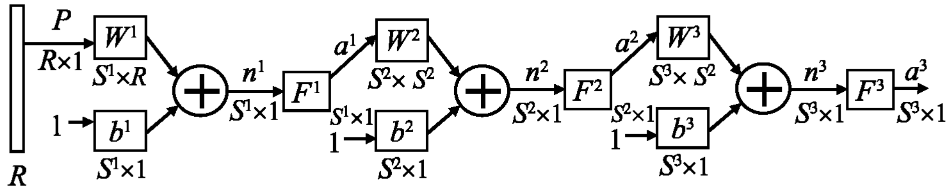

Fig.1 Flow chart of the MLP

Neural networks that use feedback connections (recurrent neural networks) exist [5]. In the multilayered networks, the exits of one layer become entries for the next one. The equations that describe this operation are:

$$a^{m+1} = f^{m+1}(w^{m+1}.a^m + b^{m+1}) \qquad (1)$$

for $m = 0,1, ..., M-1$. On Fig 1.1 and equation (1):

- m is the current number of layers in the network;
- M is the number of layers in the network;
- P is a network's entry vector, where

$$P = \begin{vmatrix} P_1 \\ P_2 \\ \vdots \\ P_R \end{vmatrix}; \qquad (2)$$

- R is a number of inputs of the neural network;
- a^m is the exit of the m-th layer of the neural network, where

$$a^m = \begin{vmatrix} a_1 \\ a_2 \\ \vdots \\ a_s \end{vmatrix}; \qquad (3)$$

- s^m is a number of neurons of a m-th layer of the neural network;
- w^m is a matrix of the coefficients of all inputs, where

$$w^m = \begin{vmatrix} W_{11} & W_{12} & \cdots & W_{1R} \\ W_{21} & W_{22} & \cdots & W_{2R} \\ \vdots & \vdots & \ddots & \vdots \\ W_{S1} & W_{S2} & \cdots & W_{SR} \end{vmatrix}; \qquad (4)$$

- b^m is neuron's input bias, where

$$b^m = \begin{vmatrix} b_1 \\ b_2 \\ \vdots \\ b_s \end{vmatrix}; \quad (5)$$

- F^m is the transfer function of the m-th layer exit.
  When we use neural network with supervised learning we need matrix with target vectors
- t is a network's target vector, where

$$t = \begin{vmatrix} t_1 \\ t_2 \\ \vdots \\ t_R \end{vmatrix}; \quad (6)$$

Transfer function can be different type.

The aim of this paper is to describe algorithm with GN where neural network recognize the three basic colors – red, green and blue. After that it takes the data and recreates a new picture with symbols. The symbols are same but they have a different order for every color. When we have picture like this we can easily recognize the color that we need without RGB palette.

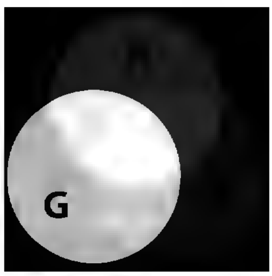

Fig.2 RGB color model

The values change between 0 and 255. Table1 shows some combinations of basic colors:

Table1. Combinations of basic colors

Color / RGB	Red	Green	Blue
Red	255	0	0
Green	0	255	0
Blue	0	0	255
White	255	255	255
Black	0	0	0

Neural network has following parameters:

- Input vector contains three elements that have a value in the range between 0 and 255;
- In this case the target vector contains three elements that have value 0 or 1, because we want to make a neural network that recognize color – red, green or blue. When input vector is close to red color, the target vector has value – [1 0 0].
- Number of hidden neurons – 20;
- Number of output neurons – 3;
- Epochs – 1000;
- Training – Levenberg-Marquardt;
- Performance – Mean Squared Error.

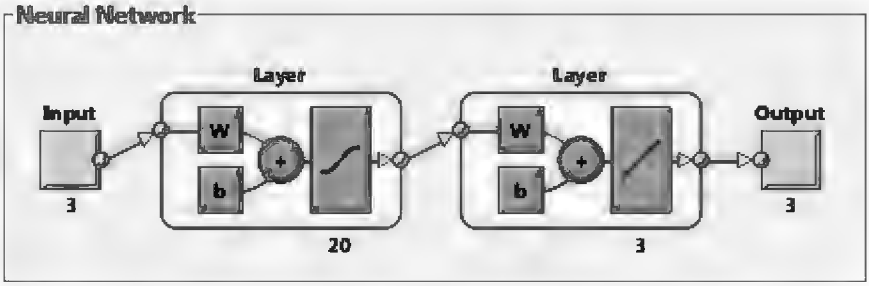

Fig.3 Neural Network structure

The process of color recognition using multilayer neural network is described below.

The first step in the recognition process is the preparation of data.

The picture is converted in test vectors that contain information about the color for every pixel.

When the parameters of the neural network are ready, next step is the training of the neural network. The training is completed. The test vectors are taken and used by the neural network. The new data is corrected by correction parameter. After that the picture is converted in standard picture format. The basic picture and the converted picture are presented on the Fig.4 and Fig.5.

Fig.4 Color picture

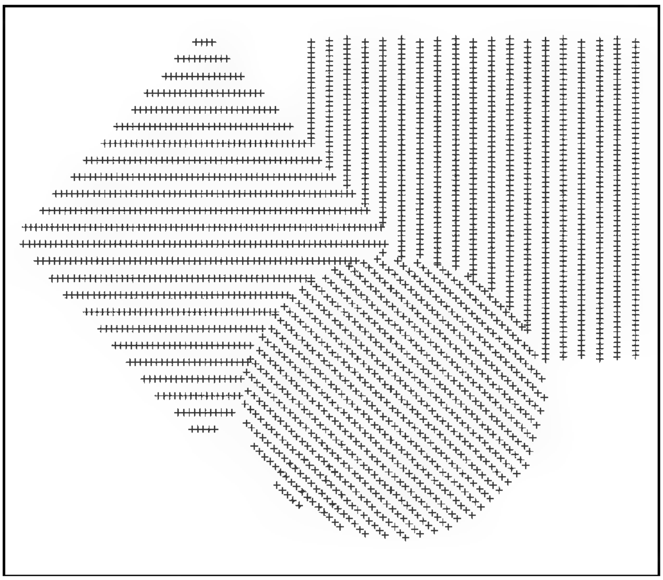

Fig.5 Picture with symbols

2 GN-Model

Initially the following tokens enter the GN[1].

In place L_1 – α token with initial characteristic $x_0^{\alpha} = "colors"$. In place L_5 – β token with initial characteristic

$$x_0^{\beta} = "Neural\ Network\ structure, maximum\ iterations,\ type\ of\ performance, minimum\ value\ of\ performance"$$

In place L_8 – γ token with initial characteristic $x_0^{\gamma} =$ "criterion for correction".

In place L_9 – δ token with initial characteristic $x_0^{\delta} = "picture"$.

The GN is presented on Fig.6 by set of transitions:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5\}$$

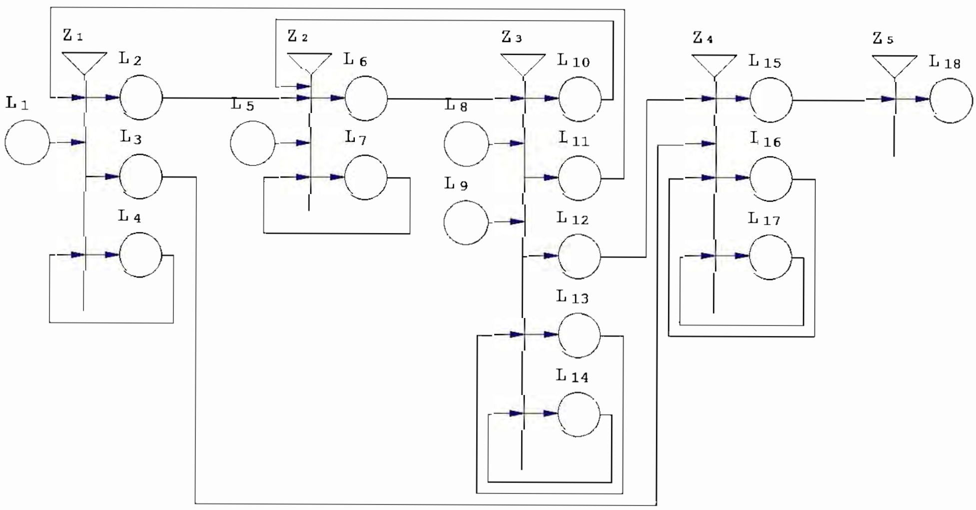

Fig.6 GN – Model

These transitions describe the following processes:

- Z_1 = "Creating input and target vectors and computing number of colors"
- Z_2 = "Creating and training Neural Network"
- Z_3 = "Testing neural network"
- Z_4 = "Normalization of results and applying symbols"
- Z_5 = "Visualization"

$$Z_1 = \langle \{L_1, L_4, L_{11}\}, \{L_2, L_3, L_4\}, R_1, \vee(L_1, L_4, L_{11})\rangle,$$

where

$$R_1 = \begin{array}{c|ccc} & L_2 & L_3 & L_4 \\ \hline L_1 & False & False & True \\ L_4 & W_{4,2} & W_{4,3} & True \\ L_{11} & False & False & True \end{array}$$

where $W_{4,2} = W_{4,3}$ = "(p & t)≠ 0"

The token-α enters place L_4 from place L_1 and it obtains new characteristic

$$x_{cu}^{\alpha'} = \text{"pr}_1\text{x}_{\text{cu}}^{\alpha}\text{, P, t, number of colors"}$$

It splits to three tokens. The first token - α' stays in place L_4 for the all live time of the generalized net. The second token enters place L_2 from place L_4 with characteristic $x_{cu}^{\alpha''} = "pr_2 x_{\text{cu}}^{\alpha'}, x_{\text{cu}}^{\alpha'}"$. The third token enters place L_3 from L_4 with characteristic $x_{cu}^{\alpha'''} = "pr_4 x_{\text{cu}}^{\alpha'}"$. The token - ζ'' enters place L_4 from place L_{11}.

$$Z_2 = \langle \{L_2, L_5, L_7, L_{10}\}, \{L_6, L_7\}, R_2, \vee(\wedge(L_2, L_5), L_7, L_{10})\rangle,$$

$$R_2 = \begin{array}{c|cc} & L_6 & L_7 \\ \hline L_2 & False & True \\ L_5 & False & True \\ L_7 & W_{7,6} & True \\ L_{10} & False & True \end{array}$$

where $W_{7,6}$ = "neural network is trained"

The tokens α″ and β enter place L_7 from places L_2 and L_5. They unite in token - ε and obtain new characteristic $x_{cu}^{\varepsilon} = "x_{cu}^{\alpha''}, x_0^{\beta}, trained\ neural\ network"$.
It splits to two tokens ε and ε'. The first token - ε stays in place L_7 for the all live time of the generalized net. Second token ε' enters place L_6 with characteristic $x_{cu}^{\varepsilon'} = "pr_3 x_{cu}^{\varepsilon}"$. The token - ζ'' enters place L_4 from place L_{10}.

$$Z_3 = \langle \{L_6, L_8, L_9, L_{13}, L_{14}\}, \{L_{10}, L_{11}, L_{12}, L_{13}, L_{14}\}, R_3,$$
$$\vee(\wedge(L_6, L_9), \wedge(L_8, L_{14}), L_{13}\rangle,$$

where

$R_3 =$

	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}
L_6	*False*	*False*	*False*	*False*	*True*
L_8	*False*	*False*	*False*	*True*	*False*
L_9	*False*	*False*	*False*	*False*	*True*
L_{13}	$W_{13,10}$	$W_{13,11}$	$W_{13,12}$	*True*	*False*
L_{14}	*False*	*False*	*False*	$W_{14,13}$	*True*

where

- $W_{13,10} = W_{13,11} =$ "incorrect results"
- $W_{13,12} = \neg W_{13,10}$ where $\neg W_{13,10}$ in the negation of the predicate $W_{13,10}$.
- $W_{14,13} =$ "picture is tested in the neural network"

The token ε' enters place L_{14} from place L_6. It unites with δ and obtains a new characteristic $x_{cu}^{\zeta} = "pr_1 x_0^{\delta}, pr_1 x_{cu}^{\varepsilon'}, tested\ picture"$.
The token ζ splits to two tokens ζ and ζ'. The first token stays place L_{14} for the all live time of the generalized net. Second token enters place L_{14}. It unites with token γ and obtains new characteristic

$$x_{cu}^{\zeta'} = "x_{cu}^{\zeta}, x_0^{\gamma}, \text{verification of the results }".$$

If predicate $W_{13,10} =$ true, or $W_{13,11} =$ true, token ζ' enter place L_{10} or L_{11} from place L_{13} and it obtains new characteristic

$$x_{cu}^{\zeta''} = "x_{cu}^{\zeta'}, \text{correction of the data}".$$

If predicate $W_{13,12} =$ true, then token ζ' enters place L_{12} from place L_{13} and it does not obtain new characteristic.

$$Z_4 = \langle \{L_3, L_{12}, L_{16}, L_{17}\}, \{L_{15}, L_{16}, L_{17}\}, R_4, \vee(\wedge(L_3, L_{17}), L_{12}, L_{16})\rangle,$$

where

$R_4 =$

	L_{15}	L_{16}	L_{17}
L_3	*False*	*True*	*False*
L_{12}	*False*	*False*	*True*
L_{16}	$W_{16,15}$	*True*	*False*
L_{17}	*False*	$W_{17,16}$	*True*

where

- $W_{16,15} =$ "maximum number of colors is reached"
- $W_{17,16} =$ "data is normalized"

The token ζ' enters place L_{17} from place L_{12} and it obtains new characteristic

$$x_{cu}^{\zeta'''} = "x_{cu}^{\zeta'}, \text{normalizated data }"$$

The tokens ζ''' and α''' enter place L_{16} from places L_3 and L_{17}. They unit in new token η and obtain new characteristics

$$x_{cu}^{\eta} = "x_{cu}^{\zeta'''}, x_{cu}^{\alpha'''}, current\ number\ of\ color, data\ with\ symbols"$$

The token η enters place L_{15} from place L_{16} and does not obtain new characteristic.

$$Z_5 = \langle \{L_{15}\}, \{L_{18}\}, R_5, \vee(L_{15}) \rangle,$$

where

$$R_5 = \begin{array}{c|c} & L_{18} \\ \hline L_{15} & True \end{array}.$$

The token η enters place L_{18} from place L_{15} and it obtains new characteristic $x_{cu}^{\eta'} = "x_{cu}^{\eta}, vizualited\ picture\ with\ symbols".$

3 Conclusion

In the present paper a Multilayer Neural Network, that recognizes color in picture and recreates it in another picture have been described by a Generalized net. The output results of the neural network have been converted in pictures and displayed in figures. The results show that the neural network can recognize special colors that have been given before the training process.

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The papers presented in this Volume 2 constitute a collection of contributions, both of a foundational and applied type, by both well-known experts and young researchers in various fields of broadly perceived intelligent systems.

It may be viewed as a result of fruitful discussions held during the Twelfth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2013) organized in Warsaw on October 11, 2013 by the Systems Research Institute, Polish Academy of Sciences, in Warsaw, Poland, Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences in Sofia, Bulgaria, and WIT - Warsaw School of Information Technology in Warsaw, Poland, and co-organized by: the Matej Bel University, Banska Bystrica, Slovakia, Universidad Publica de Navarra, Pamplona, Spain, Universidade de Tras-Os-Montes e Alto Douro, Vila Real, Portugal, Prof. Asen Zlatarov University, Burgas, Bulgaria, and the University of Westminster, Harrow, UK:

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The consecutive International Workshops on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGNs) have been meant to provide a forum for the presentation of new results and for scientific discussion on new developments in foundations and applications of intuitionistic fuzzy sets and generalized nets pioneered by Professor Krassimir T. Atanassov. Other topics related to broadly perceived representation and processing of uncertain and imprecise information and intelligent systems have also been included. The Twelfth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2013) is a continuation of this undertaking, and provides many new ideas and results in the areas concerned.

We hope that a collection of main contributions presented at the Workshop, completed with many papers by leading experts who have not been able to participate, will provide a source of much needed information on recent trends in the topics considered.

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