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Volume II: Applications

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Generalized net model of the integrated system for early forest-fire detection

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Abstract

In this paper we present a generalized net model of multi-sensorial integrated systems for early detection of forest fires. Many information and data sources have been used, including infrared images, visual images, sensors data, and geographic data bases. One of the main purpose is using of the intelligent methods for decision when must alarm starts. Here we use MultiLayer Perceptron for a color recognition and if there is a possibility of forest fire the other procedures for detection will be started.

Keywords: Modelling, Generalized nets, Early forest-fire detection Neural network.

1 Introduction

Forest-fire detection is a real-time problem. In fact, early fire detection should be carried out in few seconds or minutes at large [12]. The location of the fire with enough resolution is also very important.

Very often the combination of minimal delay and resolution makes some detection techniques such as satellite-based techniques not usable yet. Sometimes, these satellite technologies seem to be very useful to activate early detection

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systems, to tune their parameters according to the current conditions, and to validate alarms.

The intelligent systems are useful for detections of the conditions in natural environments. The detection problem is more complex than in other industrial fields, that's why sometimes the direct application of some detection technologies fails. Here we will use neural network to detect real fire using the intuitionistic fuzzy data, taken from the infrared images, visual images, radar images and others. Infrared images are the basic information source of some of the existing detection systems. The few existing applications have a False Alarm Reduction system to avoid the relatively high false alarm rate and that increases significantly their reliability. This is the basic problem that we want to remove. Visual image processing is also the basis of some of the existing detection techniques. These techniques can be applied to detect smoke plumes in appropriate lighting conditions and good contrast to segment the plume. Furthermore, it should be noted that all the infrared detection systems provide visual images to the operator.

In this paper is constructed a GN model of the integrated system for early forest-fire detection that use MLP. The mentioned above Intuitionistic Fuzzy Multilayer Perceptron (IFMLP) is a part of this system.

2 GN Model

The below constructed GN-model is reduced one. It does not have temporal components, the priorities of the transitions, places and tokens are equal, the place and arc capacities are equal to infinity. It is shown on Fig. 1.

Initially, the tokens α, β, γ, δ, ε, ξ and τ stay in places S_{1A}, S_{2A}, S_{3A}, S_{IP}, S_{MS}, S_{GIS} and S_{IS}. They will be in their own places during the whole time during which the GN functions. All tokens that enter transitions Z_1, Z_2, Z_3, Z_4, Z_5, Z_6 and Z_7 will unite with the corresponding original token (α, β, γ, δ, ε, ξ and τ respectively). While α, β, γ, δ, ε, ξ and τ tokens may split into two or more tokens, the original token will remain in its own place the whole time. The original tokens have the following initial and current characteristics:

- token α in place S_{1A}: x_{cu}^{α} = "Current image devices",
- token β in place S_{2A}: x_{cu}^{β} = "Current local meteorological devices",
- token γ in place S_{3A}: x_{cu}^{γ} = "GPS system",
- token δ in place S_{IP}: x_{cu}^{δ} = "Algorithms and systems for image processing",
- token ε in place S_{MS}: x_{cu}^{ε} = "Local meteorological station",

- token ξ in place S_{GIS}: x_{cu}^{ξ} = "Geo Information system",
- token τ in place S_{IS}: x_{cu}^{τ} = "Decision making system".

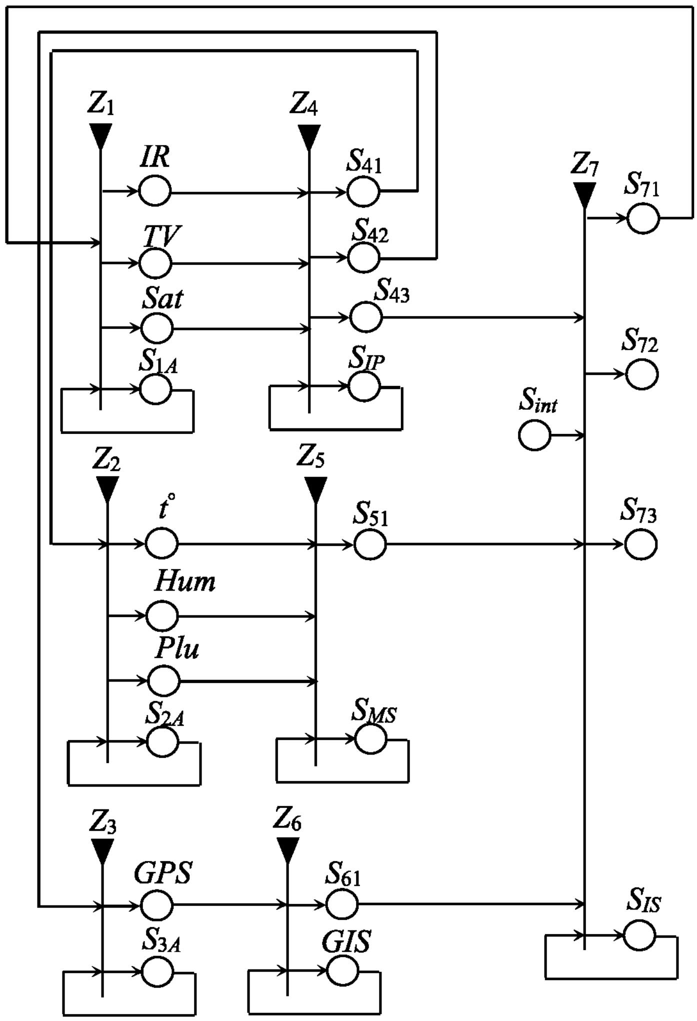

Fig. 1. Generalized net model of the integrated systems for early forest-fire detection

The generalized net is presented by a set of transitions:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7\},$$

where transitions describe the following processes:

- Z_1 – Work of the image devices;
- Z_2 – Work of the local meteorological devices;
- Z_3 – Work of the GPS system;
- Z_4 – Image processing;
- Z_5 – Meteorological processing;
- Z_6 – Work of the Geo Information system;
- Z_7 – Work of the decision making system.

Transitions of GN-model have the following form.

$$Z_1 = \langle \{S_{1A}, S_{71}\}, \{IR, TV, Sat, S_{1A}\}, R_1, \vee(S_{1A}, S_{71})\rangle,$$

$$R_1 = \begin{array}{c|cccc} & IR & TV & Sat & S_{1A} \\ \hline S_{1A} & W_{1A,IR} & W_{1A,TV} & W_{1A,Sat} & True \\ S_{71} & False & False & False & True \end{array},$$

where:

- $W_{1A,IR}$ = "There is an information from an infrared camera",
- $W_{1A,TV}$ = "There is an information from a TV camera",
- $W_{1A,Sat}$ = "There is an information from a satellite".

The τ_1-token that enters place S_{1A} (from place S_{71}) do not obtain new characteristic. It unites with the α-token in place S_{1A} with the above mentioned characteristic.

The α_1-, α_2- and α_3-tokens that enter places *IR*, *TV* and *Sat* obtain characteristic respectively: $x_{cu}^{\alpha 1}$ = "Information from infrared camera" in place *IR*, $x_{cu}^{\alpha 2}$ = "Information from TV camera" in place *TV*, $x_{cu}^{\alpha 3}$ = "Information from satellite" in place *Sat*.

$$Z_2 = \langle \{S_{2A}, S_{41}\}, \{ t^{\circ}, Hum, Plu, S_{2A}\}, R_2, \vee(S_{2A}, S_{41})\rangle,$$

$$R_2 = \begin{array}{c|cccc} & t^{\circ} & Hum & Plu & S_{2A} \\ \hline S_{2A} & W_{2A,t} & W_{2A,Hum} & W_{2A,Plu} & True \\ S_{41} & False & False & False & True \end{array},$$

where

- $W_{2A,t}$ = "There is an information from a thermometer",
- $W_{2A,Hum}$ = "There is an information from a humidity sensor",
- $W_{2A,Plu}$ = "There is an information from a pluviometer".

The α_4-token that enters place S_{2A} (from place S_{41}) do not obtain new characteristic. It unites with the β-token in place S_{2A} with the above mentioned characteristic.

The β_1-, β_2- and β_3-tokens that enter places t°, *Hum* and *Plu* obtain characteristic respectively: $x_{cu}^{\beta 1}$ = "Information from thermometer" in place t°, $x_{cu}^{\beta 2}$ =

"Information from humidity sensor" in place *Hum*, $x_{cu}^{\beta 3}$ = "Information from pluviometer" in place *Plu*.

$$Z_3 = \langle \{S_{3A}, S_{42}\}, \{ GPS, S_{3A}\}, R_3, \vee(S_{3A}, S_{42})\rangle,$$

$$R_3 = \begin{array}{c|cc} & GPS & S_{3A} \\ \hline S_{3A} & W_{3A,GPS} & True \\ S_{42} & False & True \end{array},$$

where $W_{3A,GPS}$ = "There is an information from a satellite".

The α_5-token that enters place S_{3A} (from place S_{42}) do not obtain new characteristic. It unites with the γ-token in place S_{3A} with the above mentioned characteristic.

The γ_1-token that enters place *GPS* obtain characteristic: $x_{cu}^{\gamma 1}$ = "Information from satellite" in place *GPS*.

$$Z_4 = \langle \{ IR, TV, Sat, S_{IP}\}, \{ S_{41}, S_{42}, S_{43}, S_{IP} \}, R_4, \vee(\wedge(IR, TV, Sat), S_{IP})\rangle,$$

$$R_4 = \begin{array}{c|cccc} & S_{41} & S_{42} & S_{43} & S_{IP} \\ \hline IR & False & False & False & True \\ TV & False & False & False & True \\ Sat & False & False & False & True \\ S_{IP} & W_{IP,41} & W_{IP,42} & W_{IP,43} & True \end{array},$$

where

- $W_{IP,41}$ = "There is a query for information from local meteorological devices",
- $W_{IP,42}$ = "There is a query for information from satellite",
- $W_{IP,43}$ = "There is an information from image devices".

The α_1-, α_2- and α_3-tokens that enter place S_{IP} (from places *IR*, *TV* and *Sat*) do not obtain new characteristic.

The α_4-, α_5- and α_6-tokens that enter places S_{41}, S_{42} and S_{43} obtain characteristic respectively: $x_{cu}^{\alpha 4}$ = "Query for information from local meteorological devices" in place S_{41}, $x_{cu}^{\alpha 5}$ = "Query for information from satellite" in place S_{42}, and $x_{cu}^{\alpha 6}$ = "Information from image devices" in place S_{43}.

$$Z_5 = \langle \{t^\circ, Hum, Plu, S_{MS}\}, \{S_{51}, S_{MS} \}, R_5, \vee(\wedge(t^\circ, Hum, Plu), S_{MS})\rangle,$$

$$R_5 = \begin{array}{c|cc} & S_{51} & S_{MS} \\ \hline t^\circ & False & True \\ Hum & False & True \\ Plu & False & True \\ S_{MS} & W_{MS,51} & True \end{array},$$

where $W_{MS,51}$ = "There is an information from a metrological devices".

The β_1-, β_2- and β_3-tokens that enter place S_{MS} do not obtain new characteristic. The β_4-token that enters place S_{51} obtain characteristic: $x_{cu}^{\beta 4}$ = "Information from local meteorological devices".

$$Z_6 = \langle \{ GPS, GIS \}, \{ S_{61}, GIS \}, R_6, \vee(GPS, GIS) \rangle,$$

$$R_6 = \begin{array}{c|cc} & S_{61} & GIS \\ \hline GPS & False & True \\ GIS & W_{GIS,61} & True \end{array},$$

where $W_{GIS,61}$ = "There is an information from a satellite".

The γ_1-token that enters place GIS (from place GPS) do not obtain new characteristic. The γ_2-token that enters place S_{61} obtain characteristic: $x_{cu}^{\gamma 2}$ = "Information from satellite".

From place S_{int} τ_0-token enters the net with characteristic $x_{cu}^{\tau 0}$ = "New decision making system".

$$Z_7 = \langle \{S_{43}, S_{51}, S_{61}, S_{IS}\}, \{S_{71}, S_{72}, S_{73}, S_{IS}\}, R_7, \vee(\wedge(S_{43}, S_{51}, S_{61}), S_{IS}) \rangle,$$

$$R_7 = \begin{array}{c|cccc} & S_{71} & S_{72} & S_{73} & S_{IS} \\ \hline S_{43} & False & False & False & True \\ S_{51} & False & False & False & True \\ S_{61} & False & False & False & True \\ S_{IS} & W_{IS,71} & W_{IS,72} & W_{IS,73} & True \end{array},$$

where

- $W_{IS,71}$ = "There is a query for setup of the image devices",
- $W_{IS,72}$ = "There is an information for external devices",
- $W_{IS,73}$ = "There is a signal for the alarm".

The α_6-, β_4- and γ_2-tokens that enter place S_{IS} (from places S_{43}, S_{51} and S_{61}) do not obtain new characteristic.

The τ_1-, τ_2- and τ_3-tokens that enter places S_{71}, S_{72} and S_{73} obtain characteristic respectively: $x_{cu}^{\tau 1}$ = "Query for setup of the image devices" in place S_{41}, $x_{cu}^{\tau 2}$ = "Information for external devices" in place S_{42}, and $x_{cu}^{\tau 3}$ = "Signal for the alarm" in place S_{43}.

3 Recognition of the fire with MLP

A flame is a mixture of reacting gases and solids emitting visible, infrared, and sometimes ultraviolet light, the frequency spectrum of which depends on the chemical composition of the burning material and intermediate reaction products. In many cases, such as the burning of organic matter, for example wood, or the incomplete combustion of gas, incandescent solid particles called soot produce the familiar red-orange glow of 'fire'. This light has a continuous spectrum.

Flame color depends on several factors, the most important typically being black-body radiation and spectral band emission, with both spectral line emission and spectral line absorption playing smaller roles. In the most common type of flame, hydrocarbon flames, the most important factor determining color is oxygen supply and the extent of fuel-oxygen pre-mixing, which determines the rate of combustion and thus the temperature and reaction paths, thereby producing different color hues.

A lot of systems encode pixel color values by devoting eight bits to each of the R, G, and B components (we can take this information from framebuffer in computer). RGB information can be either carried directly by the pixel bits themselves, or provided by a separate color.

Here we use one of the first mathematically defined color spaces – CIE XYZ color space (also known as CIE 1931 color space), created by the International Commission on Illumination in 1931. These data were measured for human observers and a 2-degree field of view. In 1964, supplemental data for a 10-degree field of view were published.

The transformation of the RGB and XYZ is shown below [12]:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.715160 & 0.72169 \\ 0.019334 & 0.119193 & 0.950227 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix}.$$

The XYZ color space is shown on Fig. 2.

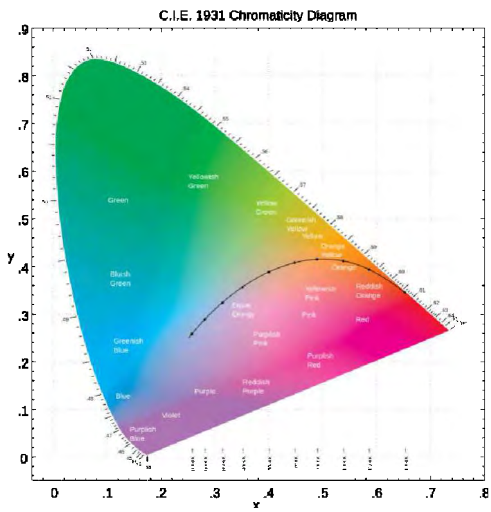

Fig. 2. XYZ color space

One example with picture transformation from RGB to XYZ color space and recognition of the fire with Multi Layer Perceptron is shown below.

We use an original picture from Fig. 3 [12].

Fig. 3. Original picture

On Fig. 4 is shown the transformation from RGB to XYZ color space. In Fig. 5 is the ready for recognition from neural network picture.

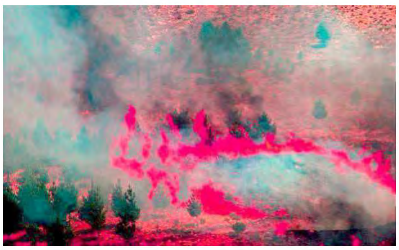

Fig. 4. After XYZ color space transformation

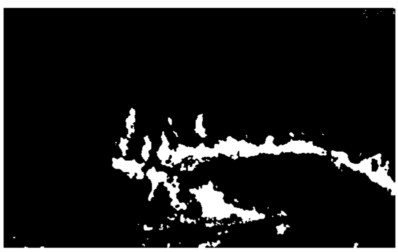

Fig. 5. Ready for neural network recognition

The regions of fire obtained using the segmentation is utilized in training the MLP neural network. The MLP neural network is trained with the XYZ color space values of the pixels that belong to fire regions.

The MLP is tested in Matlab. It has a structure 9:15:1 (nine inputs from aperture 3*3; 15 neuron in hidden layer; one output neuron in the output layer). The structure is shown on Fig. 6

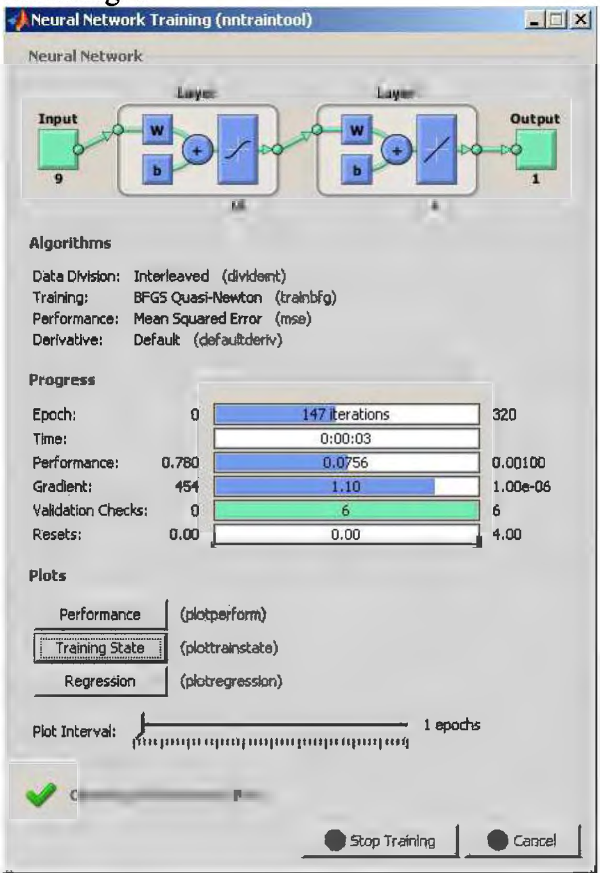

Fig. 6. Structure of the MLP (9:15:1)

The purpose of verification is to protect the neural network from overfitting. In this case we use for training 90% of the input vector, 5 % for verifications and 5 % for testing. The process of the training is shown on Fig. 7.

4 Conclusion

The proposed GN-model introduces multi-sensorial integrated systems for early detection of forest fires. A generalized net model of multi-sensorial integrated systems for early detection of forest fires was presented. Many information and data sources have been used, including infrared images, visual images, sensors data, and geographic data bases. We also presented recognition of the fire with

MLP. One of the main purpose is using of the intelligent methods for decision when alarm have to starts.

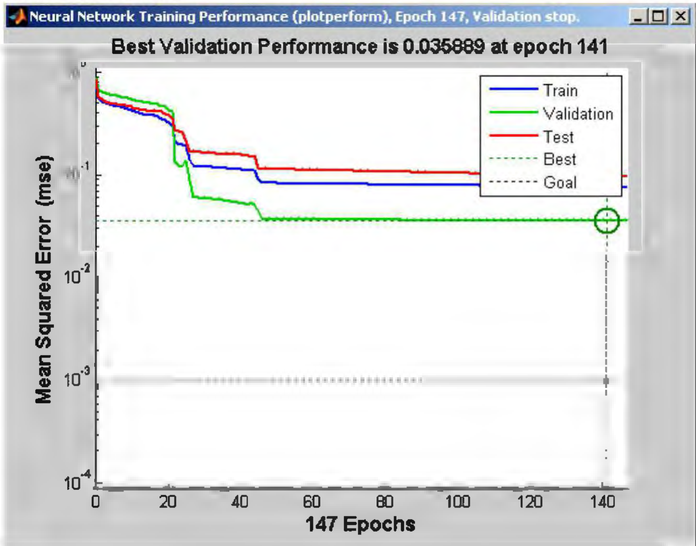

Fig. 7. Training process with Training, Validating and Testing process

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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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