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Dedicated to Professor Beloslav Riečan on his 75th anniversary

Generalized net model of the students' knowledge assessments using self organizing map with intuitionistic fuzzy estimations

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Abstract

The paper presents a generalized net model of the Self Organizing Map (SOM) that evaluates the students' answers based on defined set criterions. To be involved in practice there are used evaluation in intuitionistic fuzzy form about the students' knowledge. This is proper to be used as a basic element for e-learning systems' building.

Keywords: generalized net, intuitionistic fuzzy sets, self organizing map, e-learning.

1 Introduction

Within the context of e-learning, the information exchange between the education and training system and the student is performed electronically. The student obtains information on a given topic at his/her local machine. After this the student's acquisition of knowledge can be rated by asking appropriate questions and problems, in order to pass on to the next topic of training.

It is based on [14]. Generalized Nets (GNs, see [2, 3]) are used to describe the process of student assessment [7, 8, 9, 10, 13]). The evaluations to cope with the varying student background on different themes are represented in intuitionistic fuzzy form; (for the concept of Intuitionistic Fuzzy Set (IFS, see [1]).

The paper [9] describes the process of evaluation by lecturers of the tasks presented by students. In [10] a generalized net is used to construct a model which describes of the process of evaluation by lecturers. In [11] is constructed a generalized net that corresponds to a model which describes the standard-

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ization of the process of evaluation by lecturers. In [12] the process of evaluation of student's course is described. The evaluation of student's course is a function of the student's evaluations from examination of the course.

The aim of the present paper is to use the techniques of Self Organizing Map (SOM) and generalized net to model the process of e-learning and to assess the students' knowledge on relevant topics in intuitionistic fuzzy form. The students fill in the closed tests with *m* questions (with tree possible answers for the each question: a; b or c). The evaluation is formed on the basis of these answers.

These assessments, which estimate the degree of the assimilation (μ) and the non-assimilation (ν) of the information obtained, are represented by ordered pairs $<\mu, \nu>$ of real numbers from the set $[0,1]\times[0,1]$.

The degree of uncertainty $\pi=1-\mu-\nu$ represents those cases where the student is currently unable to answer the question asked and needs additional information. Everywhere the ordered pairs have been defined in the sense of intuitionistic fuzzy sets.

2 Neural network

According to [5], Self-organizing map (SOM) is an effective software tool for the visualization of high-dimensional data. It converts complex, nonlinear statistical relationships between high-dimensional data items into simple geometric relationships on a low-dimensional display. As it thereby compresses information while preserving the most important topological and metric relationships of the primary data items on the display, it may also be thought to produce some kind of abstractions. These two aspects, visualization and abstraction, can be utilized in a number of ways in complex tasks such as process analysis, machine perception, control, and communication.

SOM usually consists of a two-dimensional regular grid of nodes. A model of some observation is associated with each node.

Clustering is the process of organizing objects into groups whose members are similar in some way [4]. A cluster is therefore a collection of objects which are "similar" and are "dissimilar" to the objects belonging to other clusters. A SOM is a type of artificial intelligence that is trained using unsupervised learning to produce a low-dimensional representation of the input space of the training samples, called a map. The SOM is based on an issue of competitive learning. The net consists of a set A with n neurons, represented with weight vectors w_i. Furthermore, neurons are mutually interconnected and these bindings form some topological grid.

If we present a pattern x into this network, then exactly one neuron could be the winner and its weights are adapted proportionally to the pattern (the neuron is then closer). Neighbourhood $N(c)$ could be formally defined as a set of neurons that are topologically near to the winner. The winner of the competition is determined as the neuron with the minimum distance to the pattern. Then, adaptation of the weights proceeds. Weight vectors for the next iteration of the winner and neurons in the neighborhood are adapted in a way that current weights are modified (either added or subtracted) with a variance of current weight and input pattern. The weight vector of pattern is called template vector of that pattern. The SOM tries to adapt weights of neurons to cover the most dense regions and therefore SOM naturally finds data clusters [15, 16, 17] (Figure 1).

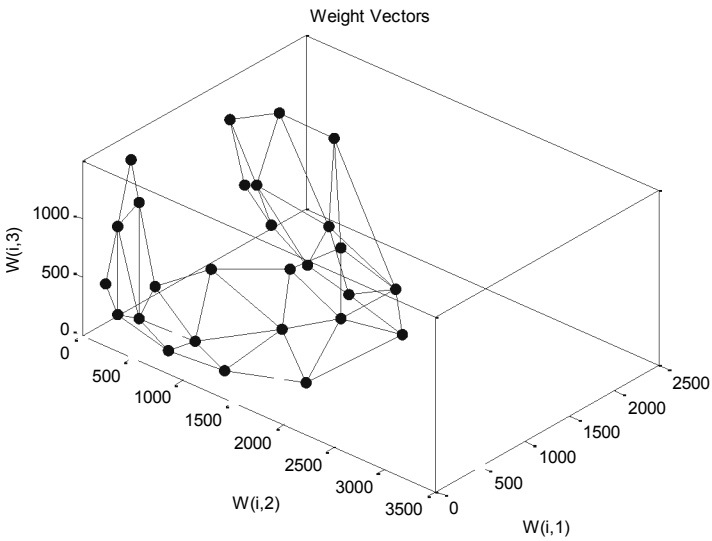

Figure 1: Self-Organizing Map Clustering of the student evaluation

3 The GN-model

Here we design a Generalized Net model that present work of the process of the SOM clustering [4, 5].

All definitions related to the concept SOM are taken from [18, 19].

The GN-model [1, 2] (see Figure 2) contains 5 transitions and 15 places.

Initially, the token β_1 stay in places l_5. They will be in their own places during the whole time during which the GN functions. While they may split into

two or more tokens, the original token will remain in its own place the whole time. The original token have the following initial and current characteristic:

"University information system".

Below we shall omit these characteristics in descriptions of the separate transitions. If δ is one of these tokens that can be split, then the new tokens will be noted by δ′, δ″, and so on.

α_i-token (i = 1, 2,…, n, where n is number of the students) enters the net via place l_1 with initial characteristic "Student i".

Also initially the following tokens enter in the GN

- in place l_6 - one token with initial characteristic "Number of iterations for learning of the SOM";
- in place l_7 - one token with initial characteristic "preliminarily condition for learning".

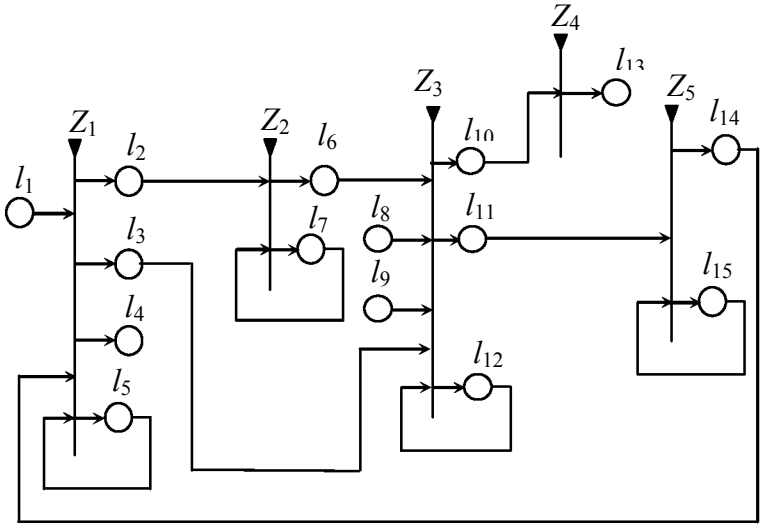

Figure 2: GN model of the students' knowledge assessments using SOM

The GN contains the following set of transitions:

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

and they represent respectively:

- Z_1 – The activities of the University information system;
- Z_2 – Passing examinations;
- Z_3 – Learning and testing of the SOM;
- Z_4 – Data visualization;
- Z_5 – Process of the evaluation of the students.

The forms of the transitions are the following.

$$Z_1 = \langle \{l_1, l_5, l_{14}\}, \{ l_2, l_3, l_4, l_5\}, \begin{array}{c|cccc} & l_2 & l_3 & l_4 & l_5 \\ \hline l_1 & False & False & False & True \\ l_5 & W_{5,2} & W_{5,3} & W_{5,4} & True \\ l_{14} & False & False & False & True \end{array}, \vee(l_1, l_5, l_{14})\rangle$$

where:

- $W_{5,2}$ = "The test for the current student is loaded";
- $W_{5,3} = W_{5,2}$;
- $W_{5,4}$ = "The assessment for the i-th student is ready".

The α-tokens that enter places l_2, l_3 and l_4 obtain characteristic respectively:

"student i, test",

"student i, test with true answers",

"student i, assessment".

$$Z_2 = \langle \{l_2, l_7\}, \{l_6, l_7\}, \begin{array}{c|cc} & l_6 & l_7 \\ \hline l_2 & False & True \\ l_7 & W_{7,6} & W_{7,7} \end{array}, \vee(l_2, l_7)\rangle$$

where:

- $W_{7,6}$ = "The i-th student finishes the test";
- $W_{7,7} = \neg W_{7,6}$.

The α-tokens that enter places l_6 and l_7 obtain characteristic respectively:

"student i, test, final answers",

"student i, test, current answers".

$$Z_3 = \langle \{l_3, l_6, l_8, l_9, l_{12}\}, \{l_{10}, l_{11}, l_{12}\}, \begin{array}{c|ccc} & l_{10} & l_{11} & l_{12} \\ \hline l_3 & False & False & True \\ l_6 & False & False & True \\ l_8 & False & False & True \\ l_9 & False & False & True \\ l_{12} & W_{12,10} & W_{12,11} & W_{12,12} \end{array}, \vee(l_3, l_6, l_8, l_9, l_{12})\rangle$$

where:

- $W_{12,10}$ = "The self organizing map is learned and tested";

- $W_{12,11} = W_{12,10}$;
- $W_{12,12} = \neg W_{12,10}$.

The α-tokens that enter places l_{10} and l_{11} obtain characteristic:

"student i, test vector , number of a cluster".

$$Z_4 = \langle \{l_{10}\}, \{l_{13}\}, \begin{array}{c|c} & l_{13} \\ \hline l_{10} & True \end{array}, \vee(l_{10}) \rangle$$

Token that enters in position l_{13} obtain characteristic "data visualization of the results of the SOM".

$$Z_5 = <\{l_{11}, l_{15}\}, \{l_{14}, l_{15}\}, \begin{array}{c|cc} & l_{14} & l_{15} \\ \hline l_{11} & False & True \\ l_{15} & W_{15,14} & W_{15,15} \end{array}, \vee(l_{11}, l_{15})>$$

where:

- $W_{15,15}$ = "There are students who are not yet evaluated";
- $W_{15,14} = \neg W_{15,15}$.

The α-tokens that enter places l_{14} and l_{15} obtain characteristic respectively:

"Final calculated assessment for the test",

"Current calculated assessment for the test".

4 Conclusions

The proposed GN model present the process of Clustering with SOM. Here we use SOM as a one effective software tool for the visualization of high-dimensional data and as a tool for clustering. We use the answers from the tests as a sequence for the learning the SOM.

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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 Tenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2011) organized in Warsaw on September 30, 2011 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, and the University of Westminster, Harrow, UK:

Http://www.ibspan.waw.pl/ifs2011

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 Tenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2011) 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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