GENERALIZED NET MODEL OF AN INTUITIONISTIC FUZZY EXPERT SYSTEM WITH FRAME-TYPE DATA BASES AND DIFFERENT FORMS OF HYPOTHESES ESTIMATIONS

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Abstract: *Series of Generalized Net (GN) models were constructed to describe the way of functioning and the results of the work of different types of Expert Systems (ESs) from production or frame-type data bases. The present GN-model represents the functioning and the results of the work of an ES with frame-type data base with intuitionistic fuzzy evaluations of the frames and of the truth-values of the hypotheses.*

Key words: *Database, Expert system, Frame, Generalized net, Modelling, Intuitionistic fuzzy set, Evaluation*

1. Introduction

Ten Generalized Net (GN, see [3]) models were described in series of papers, collected in book [6]. These GN-models describe the way of functioning and the results of the work of different types of Expert Systems (ESs, see, e.g., [1, 5, 11, 12]). Some types of these ESs are introduced for a first time as possible extensions of the ESs, which extensions can be described by the GNs and can obtain real applications.

The first four from the nine GN-models describe ordinary ESs; the fifth and seventh - ESs with priorities of their Database (DB) facts and Knowledge Base (KB) rules, so, the separate facts and/or rules can be changed at the time of the ES functioning. Sixth GN-model describes an ES containing not only facts but also metafacts that can be represented by rules. In the present form they are more useful and more quickly applicable. Eighth GN-model represents Intuitionistic Fuzzy ES (IFES see [2]; for the intuitionistic fuzziness see [7]). On its base the ninth GN-model is constructed so that it represents functioning of an ES working with temporal facts and answering to the temporal questions [4]. The tenth GN-model (see [8]) represents extension to the later ES. In [10] is described GN-model of ESs with Frame-Type Data Bases (FTDB). It is extended in [A] by adding intuitionistic fuzzy estimations of the frames.

The present paper is an expansion of the research from [9]. Now, we will discuss the possibility to evaluate the truth-values of the hypotheses by three estimations types: optimistic, average and pessimistic. Another interpretation of the intuitionistic fuzzy estimations will be given, different from the one in [9].

The frame is an aggregate of attributes and connected values that describes world's entities. The frame-systems are connected combinations of frames.

Every statement, represented by frame, enters in Frame-Type Data Base with rate of the coincidence, represented by intuitionistic fuzzy estimation $<\mu, \nu>$ of real numbers from the set $[0,1]\times[0,1]$ and

$0 \leq \mu + \nu \leq 1$.

This estimation (one for the frame) can be determined by the values of the slots in the frame, if each slot has own intuitionistic fuzzy estimation.

The number $\pi = 1 - \mu - \nu$ corresponds to the degree of the frame uncertainty.

2. A GN-model

The GN-model of ES with FTDB is shown on Fig. 1.

Let Δ be the Frame-Type Data Base (FTDB) of a given ES. Each frame is an ordered set of slots and each slot is an ordered couple: $\langle A, V\rangle$, where A is an attribute and V is its value. In the present paper we will suppose that the value can be single value or method, rule or trigger that calculates this value. Here we will suppose that the intuitionistic fuzzy estimations of the frames will be calculated on the basis of the slot estimations, or, that they are determined in beginning by the users.

For clarity the places are marked by three different symbols: a, b and e such that:

- α-tokens $(\alpha_1, \alpha_2, ...)$ together with their descendants of all generations obtained after splitting will go to the a-places;
- β-tokens $(\beta_1, \beta_2, ...)$ will go to b-places;
- β_0-token permanently stays in place b_3 with initial characteristic

$x_0^{\beta_0}$ = "Δ",

i.e., $x_0^{\beta_0}$ is a set of frames and j-th frame of Δ will have intuitionistic fuzzy estimation $<\mu_j, \nu_j>$;

- γ-token will stays permanently in place e_1.

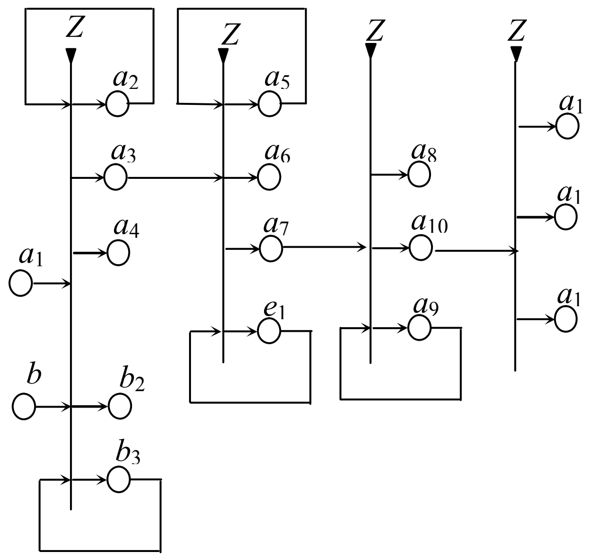

Fig. 1: GN-model of ESs with FTDB with evaluations of the frames

Let current α-token (α_p) enters place a_1 of the GN with an initial characteristic $x_0^{\alpha_p} = "H"$,

where p is the current number of the α-token which enters place a_1 and H is a hypothesis (goal). Let $x_{cu}^{\alpha_i}$ denotes the current characteristic of the α_i-token.

The transitions of the GN are the following (see Fig. 1).

$Z_1 = \langle\{a_1, a_2, b_1, b_3\}, \{a_2, a_3, a_4, b_2, b_3\}, r_1, \wedge(\vee(a_1, a_2),\vee(b_1, b_3))\rangle$,

where

$$r_1 = \begin{array}{c|ccccc} & a_2 & a_3 & a_4 & b_2 & b_3 \\ \hline a_1 & r_{a_1,a_2} & r_{a_1,a_3} & r_{a_1,a_4} & false & false \\ a_2 & r_{a_2,a_2} & r_{a_2,a_3} & false & false & false \\ b_1 & false & false & false & false & true \\ b_3 & false & false & false & r_{b_3,b_2} & r_{b_3,b_3} \end{array}$$

and

$r_{a_1,a_2} = r_{a_2,a_2} =$ "There are more than one frame with a slot having the searching attribute that is not used by the moment for the current token",

$r_{a_1,a_3} = r_{a_2,a_3} =$ "There is a frame with a slot having the searching attribute",

$r_{a_1,a_4} =$ "There is no frame with a slot having the searching attribute",

$r_{b3,b2} =$ "There are no α-tokens for processing",

$r_{b3,b3} = \neg r_{b3,b2}$.

The α-tokens can split to two tokens – the same token α and another α-token. The token in place a_3 obtains the characteristic

x_1^{α} = "number of the suitable frame (let it be j-th frame of Δ), its intuitionistic fuzzy evaluations $<\mu_j,\nu_j>$"

and the characteristic

"$\neg ! x_0^{\alpha}$, <0, 1>",

that symbolizes that the hypothesis is not valid, in place a_4. The other α-token (if such exists) does not obtain any characteristic in place a_2.

When there is β-token in place b_1 on the next time-step β_0-token obtains the characteristic

$$x_{cu}^{\beta_0} = \begin{cases} \left(x_{cu-1}^{\beta_0} - \left\{\left[x_0^{\beta_j}\right]\right\}\right) \cup \left\{x_0^{\beta_j}\right\}, & \text{if in the DB there is a frame with key } x_0^{\beta_j} \\ x_{cu-1}^{\beta_0} \cup \left\{x_0^{\beta_j}\right\}, & \text{otherwise} \end{cases}$$

where $[x_0^{\beta_j}]$ denotes the frame of Δ which has the same key as the frame $x_0^{\beta_j}$ and

$$x_0^{\beta_j} = \text{“frame, } <\mu_j, \nu_j> \text{”.}$$

$$Z_2 = \langle \{a_3, a_5, e_1\}, \{a_5, a_6, a_7, e_1\}, r_2, \vee(a_3, a_5, e_1)\rangle,$$

where

$$r_2 = \begin{array}{c|cccc} & a_5 & a_6 & a_7 & e_1 \\ \hline a_3 & false & false & false & true \\ a_5 & false & false & false & true \\ e_1 & r_{e_1,a_5} & r_{e_1,a_6} & r_{e_1,a_7} & true \end{array},$$

and

r_{e_1,a_5} = “The slot value (method, rule or trigger) of the current frame must be calculated by a procedure”,

r_{e_1,a_6} = “The frame values are not satisfactory”,

r_{e_1,a_7} = “The frame values are satisfactory”.

The characteristic of the γ-token from place e_1 contains two threshold values for the μ_j (M_{min} and M_{max}) and two threshold values for the ν_j (N_{min} and N_{max}).

If $\mu_j > M_{max}$ & $\nu_j < N_{min}$,

then the α-token enter in place a_7 without a new characteristic.

If $\mu_j < M_{min}$ & $\nu_j > N_{max}$,

then the α-token enter in place a_6 and if there is only one α-token in the net, then it obtains the characteristic “$\neg ! \, x_0^{\alpha}$,$<\mu_j, \nu_j>$”.

If there are more than one α-token in the net, then the present one leaves the net without any characteristic.

In the rest case the current α-token enters place a_5 and obtains the characteristic “new frame value, obtained by the determined method, rule or trigger”.

$Z_3 = \langle \{a_7, a_9\}, \{a_8, a_9\}, r_3, \vee(a_7, a_9)\rangle$,

where

$$r_3 = \begin{array}{c|ccc} & a_8 & a_9 & a_{10} \\ \hline a_7 & r_{a_7,a_8} & r_{a_7,a_9} & false \\ a_9 & false & r_{a_9,a_9} & r_{a_9,a_{10}} \end{array}$$

and

r_{a_7,a_8} = “There are no other α-tokens in the GN outside place a_7”,

$r_{a_9,a_{10}}$ = “There are no other α-tokens in the GN outside place a_9”,

$r_{a_7,a_9} = \neg r_{a_7,a_8}$,

$r_{a_9,a_9} = \neg \; r_{a_9,a_{10}}$.

The current α-token enters place a_9 where eventually there are other α-tokens. All they will merge in this place and the current token will obtain as a characteristic

“<list of used frames, list of their intuitionistic fuzzy estimations>”.

The token does not obtain any characteristic in places a_8 and a_{10}.

$$Z_4 = \langle \{a_{10}\}, \{a_{11}, a_{12}, a_{13}\}, r_4, \vee(a_{10})\rangle,$$

$$r_4 = \begin{array}{c|ccc} & a_{11} & a_{12} & a_{13} \\ \hline a_{10} & r_{10,11} & r_{10,12} & r_{10,13} \end{array}$$

and

$r_{10,11}$ = "an optimistic evaluation is necessary",

$r_{10,12}$ = "an average evaluation is necessary",

$r_{10,13}$ = "a pessimistic evaluation is necessary".

Let the list of the intuitionistic fuzzy estimations from the last α-token characteristic be

$$<\mu_1, \nu_1>, <\mu_2, \nu_2>, \ldots, <\mu_s, \nu_s>,$$

where s is the number of the used frames, collected in the last α-token characteristic. Then the α-token obtains in place a11 the characteristic

$$\text{“}!\ x_0^\alpha, \left\langle \max_{1\le i\le s} \mu_i, \min_{1\le i\le s} \nu_i \right\rangle\text{”},$$

in place a_{12} the characteristic

$$\text{“}!\ x_0^\alpha, \left\langle \frac{1}{s}\sum_{i=1}^{s} \mu_i, \frac{1}{s}\sum_{i=1}^{s} \nu_i \right\rangle\text{”},$$

and in place a_{13} the characteristic

$$\text{“}!\ x_0^\alpha, \left\langle \min_{1\le i\le s} \mu_i, \max_{1\le i\le s} \nu_i \right\rangle\text{”}.$$

3. Conclusion

The described GN is a model of special class of ES, using intuitionistic fuzzy evaluations. In the present paper there are some restrictions on the form of the frames, but in the next authors' research a GN-model of an ES with FTDB without the limitations will be described. Some extensions of the form of the ES with FTDB will be discussed also.

In the future, the presented GN can be worked out in detail, using hierarchical operators which replace a given transition or a place by a complete GN that has the same, but detailed behaviour. The presence of the temporal intuitionistic fuzzy evaluations [4] in the characteristics of the tokens enables various analysis and statistical techniques to be applied to the process of working. The purpose of such analysis would be to generate ideas for improving and optimizing the process.

References

[1] Alty, J., M. Coombs, Expert Systems. NCC, 1984.

[2] Atanassov K., Remark on a temporal intuitionistic fuzzy logic. Second Scientific Session of the "Mathematical Foundation Artificial Intelligence" Seminar, Sofia, March 30, 1990, Preprint IM-MFAIS-1-90, Sofia, 1990, 1-5.

[3] Atanassov, K. Generalized Nets. World Scientific, Singapore, New Jersey, London, 1991.

[4] Atanassov K., Temporal intuitionistic fuzzy sets. Comptes Rendus de l'Academie Bulgare des Sciences, Tome 44, 1991, No. 7, 5-7.

[5] Atanassov K., Remark on intuitionistic fuzzy expert systems, BUSEFAL, Vol. 59, 1994, 71-76.

[6] Atanassov, K. Generalized Nets in Artificial Intelligence. Vol. 1: Generalized nets and Expert Systems. "Prof. M. Drinov" Academic Publishing House, Sofia, 1998.
[7] Atanassov K., Intuitionistic Fuzzy Sets, Springer Physica-Verlag, Berlin, 1999.
[8] Atanassov, K., P. Chountas, B. Kolev, E. Sotirova, Generalized Net Model of an Expert System with Temporal Components, Advanced Studies in Contemporary Mathematics, Vol 12, No 2, April 2006, 255-289.
[9] Atanassov, K., D. Peneva, V. Tasseva, E. Sotirova, D. Orozova. Generalized net model of an expert system with frame-type data bases with intuitionistic fuzzy estimations. First Int. workshop on Intuitionistic Fuzzy Sets, Generalized Nets and Knowledge Engineering, London, 6-7 Sept. 2006, 111-116.
[10] Atanassov, K., E. Sotirova, D. Orozova, Generalized Net Model of Expert Systems with Frame-Type Data Base, Jangjeon Mathematical Society, Vol. 9, No. 1, 2006, 91-101.
[11] Buckley, J., W. Siler, D. Tucker. Fuzzy expert systems. Fuzzy Sets and Systems, Vol. 20, 1986, No 1, 87-96.
[12] Payne E., R. McArthur. Developing Expert Systems. New York, John Wiley & Sons, 1990.