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# On the implementation of elements of the intuitionistic fuzzy logic for decision making by medical generalized net midels

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A guiding principle of medical practice is the assessment of a wide variety of undifferentiated diseases. Each disease or a combination of diseases presents with one or more chief complaints. The physician must rapidly direct clinical skills and laboratory resourses to resolve each complaint into a weighted diagnosis and clinical impression. Thus the diagnosis is central to the practice of medicine. Physicians make their decisions in a climate of uncertainty. They estimate the likelihood of disease and decide whether test or therapies are justified. The information used to modify the diagnostic hypothesis consists of the medical history, the pertinent physical examination, the results of laboratory tests and other diagnostic procedures. Not infrequently there is a lack of precise information (e.g., history of birth trauma, kernicterus), or the information is ambiguous (results in the upper or lower limits of the normal), or uncertain (family history), or doubtful (history of rheumatic fever) as it is discussed in [1]. The algorithm represented as a Gneneralized Net (GN; see [2]) displays the logical and temporal sequence in clinical decision making.

Primary focused on medical presenting complaints, signs and symptoms, it is designated also to aid one's memory and help organize the evaluation and treatment of patient signs and symptoms. Consequently thus, on the basis of information gathered at the subsequent moment of the patients is determined. By pursuing each presenting complaint in an organized manner, the physician gains accuracy, confidence, and speed in establishing an organized plan for therapeutic intervention and disposition.

In a series of papers and books (see, e.g., [3-5]) GN-models of the processes of diagnostic are described. The patients are represented by GN tokens and all information related to the patients - by the tokens' characteristics.

Below we shall illustrate the possibility for implementation of the elements of the Intuitionistic Fuzzy Logic (IFL; see [6]) in the decision making in medicine, constructing a GN that contains elements of the IFL.

To each proposition (in the classical sense) we can assign its truth value: truth – denoted by 1, or falsity – 0. In the case of fuzzy logic this truth value is a real number in the interval $[0, 1]$ and may be called "truth degree" of a particular proposition. Here we add one more value – "falsity degree" (see[6]), which will also be in the interval $[0, 1]$. Thus two real numbers, $\mu(p)$ and $\nu(p)$, are assigned to the proposition $p$ with the following constraint to hold:

$$\mu(p) + \nu(p) \leq 1.$$

In [1] every condition transition predicate of the GN thus constructed was estimated in the above (intuitionistic fuzzy) sense. Here we shall illustrate another possibility for application of the apparatus of the intuitionistic fuzzy logic – we shall give intuitionistic fuzzy estimation of the final token's characteristics.

The present GN deals with the decision making in a neurologic condition connected with the presence of neonatal seizures in children. This paper is based on [7], where the possible elements of uncertainty have not been discussed. The paper is an element of the book "Generalized Nets in Child Neurology" prepared by the "Prof. M. Drinov" Academic Publishing House.

All GN-notations are used as in [2].

The tokens enter the GN with an initial characteristic "patient with neonatal seizures".

$$Z_1 =< \{l_1\}, \{l_2\}, \begin{array}{c|c} & l_2 \\ \hline l_1 & TRUE \end{array}, \vee(l_1) > .$$

The tokens obtain the characteristic "history (description of seizure activity, predisposing factors and time of onset) and examination (observation for seizure activity) are necessary" in place $l_2$.

$$Z_2 =< \{l_2\}, \{l_3\}, \begin{array}{c|c} & l_3 \\ \hline l_2 & TRUE \end{array}, \vee(l_2) > .$$

The tokens obtain the characteristic "laboratory studies (glucose, Ca, Mg, Na, $NH_4$, BUN, ABG, CSF) and assessment for the response to treatment, for possible etiology and EEG are necessary" in place $l_3$.

$$Z_3 =< \{l_3\}, \{l_4, l_5, l_6, l_7, l_8, l_9\},$$

$$\begin{array}{c|cccccc} & l_4 & l_5 & l_6 & l_7 & l_8 & l_9 \\ \hline l_3 & W_{3,4} & W_{3,5} & W_{3,6} & W_{3,7} & W_{3,8} & W_{3,9} \end{array}, \vee(l_3) >,$$

$W_{3,4}$ = "the seizure resolves",

$W_{3,5}$ = "there is poor seizure control",

$W_{3,6}$ = "the etiology is favorable",
$W_{3,7}$ = "the etiology is unfavorable",
$W_{3,8}$ = "there are normal unfocal spikes",
$W_{3,9}$ = "there are abnormal backgrounds, burst suppression or multilocal spikes".

Token (let us call it $\alpha$) from place $l_3$ splits into three tokens $\alpha_1$, $\alpha_2$ and $\alpha_3$, that enter places $l_4$ or $l_5$, $l_6$ or $l_7$, $l_8$ or $l_9$, respectively.

The tokens do not obtain any characteristic in places $l_4$, ... $l_9$.

$$Z_4 = < \{l_4, l_5, l_6, l_7, l_8, l_9\}, \{l_{10}\}, \begin{array}{c|c} & l_{10} \\ \hline l_4 & TRUE \\ l_5 & TRUE \\ l_6 & TRUE \\ l_7 & TRUE \\ l_8 & TRUE \\ l_9 & TRUE \end{array}, \wedge(\vee(l_4, l_5), \vee(l_6, l_7), \vee(l_8, l_9)) > .$$

We must note that the last transition type is the unique complex one for the present GN-model. It shows that transition $Z_4$ can be activated only if each one couple of places $l_4$ and $l_5$, $l_6$ and $l_7$, and $l_8$ and $l_9$ contains a token.

The three tokens $\alpha_1$, $\alpha_2$ and $\alpha_3$ united in one token $\alpha$ that obtains the characteristic "the intuitionistic fuzzy truth-value estimation for a good prognosis is as follows:

$$\begin{cases} < 1, 0 >, & \text{if the three tokens enter place } l_{10} \text{ via places } l_4, l_6 \text{ and } l_8 \\ < \frac{1}{2}, \frac{1}{4} >, & \text{if the three tokens enter place } l_{10} \text{ via places } l_5, l_6 \text{ and } l_8 \\ < \frac{1}{4}, \frac{1}{2} >, & \text{if the three tokens enter place } l_{10} \text{ via places } l_4, l_6 \text{ and } l_9 \\ & \text{or from places } l_4, l_7 \text{ and } l_8 \\ < \frac{1}{8}, \frac{3}{4} >, & \text{if the three tokens enter place } l_{10} \text{ via places } l_4, l_7 \text{ and } l_9 \\ & \text{or via places } l_5, l_7 \text{ aqnd } l_8 \\ & \text{or via places } l_5, l_6 \text{ and } l_9 \\ < 0, 1 >, & \text{if the three tokens enter place } l_{10} \text{ via places } l_5, l_7 \text{ and } l_9 \end{cases}$$

The GN-model can be extended with information, e.g., about predisposing, doubtful and other factors, estimated by intuitionistic fuzzy tools.

Therefore, the so given truth-values can be different with respect:
- to the opinion of a larger group of specialists,
- to the result of a long-time observation of the patients, or
- to the values of the parameters of the investigations for the current patient.

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