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Generalized net model of the process of evaluation of the environmental impact of refinery activity using intuitionistic fuzzy estimations

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Abstract: A generalized net model of the process of evaluation of the environmental impact of refinery activity is described. The model uses intuitionistic fuzzy estimations, that give more detailed values than the crisp estimations. Presented model considers different aspects of evaluation of environmental impact of refinery activity on soil, water and air pollution. Developed model can be used to collect and interpret the data in different units and in a definite period of refinery activity.
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1 Introduction

In [6], the authors constructed a Generalized Net (GN; see [1, 2, 4]) of the process of evaluation of the environmental impact of refinery activity. Here, we will extend and modify this model, adding Intuitionistic Fuzzy Estimations (IFEs; for the concepts related with the intuitionistic fuzziness see [3, 5]) of the evaluations of the environmental impact of the separate refinery activities (see [7, 8, 9, 10, 11]).

Below, we assume that there are criteria C_{soil}, C_{water} and C_{air} for the soil, water and air impact of the separate refinery activities. Let each one of them uses a scale with maximal values m_s, m_w and m_a, respectively. Let these criteria have scores ρ_s, ρ_w and ρ_a, respectively, where $\rho_s, \rho_w, \rho_a \geq 1$ are natural numbers. Let us assume that the measurement tools that evaluate the environmental impact of the separate refinery activities, have tolerances $2t_s, 2t_w$ and $2t_a$, respectively. Let the estimations of the measurement tools for the separate criteria for concrete place P in the plant, be $C_{soil}(P), C_{water}(P)$ and $C_{air}(P)$.

Below, we will construct IFEs of the environmental impacts of the separate refinery activities, using the so described parameters.

All notations, related to the GNs are used by [2, 4].

2 The generalized net model

The GN-model (see Fig. 1), contains $n + 4$ transitions and $6n + 15$ places, where n is the number of the separate units in the plant.

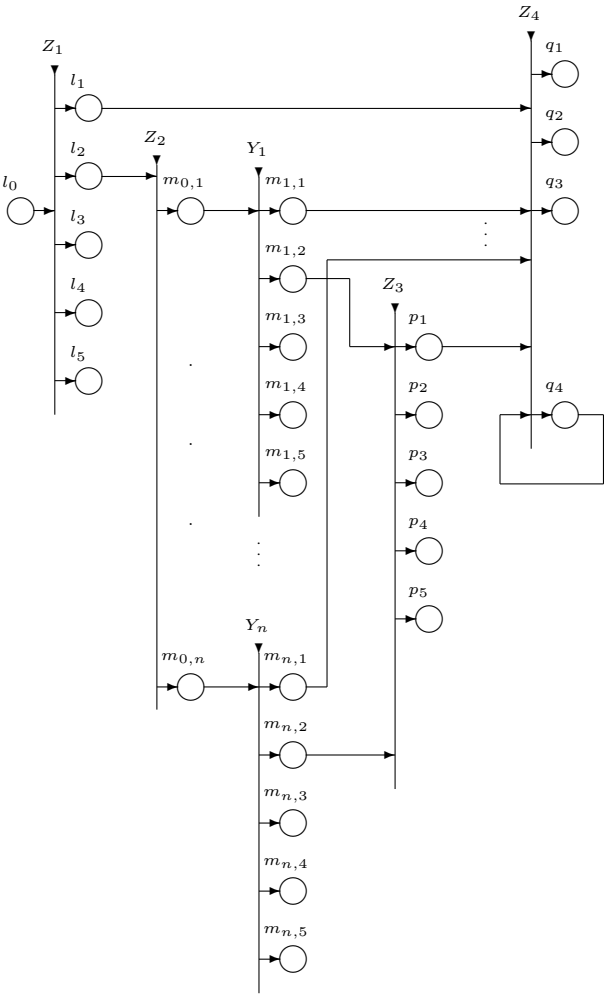

Figure 1: The GN-model

Initially, token δ stays in place q_4 with an initial and current characteristic

"current evaluations for the environmental impacts of the separate and total refinery activities".

The separate transitions of the GN-model have the following forms.

$$Z_1 = \langle \{l_0\}, \{l_1, l_2, l_3, l_4, l_5\}, \begin{array}{c|ccccc} & l_1 & l_2 & l_3 & l_4 & l_5 \\ \hline l_0 & true & true & true & true & true \end{array} \rangle.$$

Token ν from place l_0 splits to five tokens θ_0, π, σ_0, β_0 and α_0, that enter places l_1, l_2, l_3, l_4, l_5, respectively, with characteristics:

"total evaluation of area pollution in the region of the refinery port

$$\langle \frac{C_{soil}(\text{refinery port}) - t_s}{m_s + t_s}, \frac{m_s - C_{soil}(\text{refinery port}) - t_s}{m_s + t_s} \rangle,$$
$$\langle \frac{C_{water}(\text{refinery port}) - t_w}{m_w + t_w}, \frac{m_w - C_{water}(\text{refinery port}) - t_w}{m_w + t_w} \rangle,$$
$$\langle \frac{C_{air}(\text{refinery port}) - t_a}{m_a + t_a}, \frac{m_a - C_{air}(\text{refinery port}) - t_a}{m_a + t_a} \rangle";$$

"crude oil quality supplied to refinery units";

"evaluation of soil pollution in the region of the refinery port,

$$\langle \frac{C_{soil}(\text{refinery port}) - t_s}{m_s + t_s}, \frac{m_s - C_{soil}(\text{refinery port}) - t_s}{m_s + t_s} \rangle";$$

"evaluation of water pollution in the region of the refinery port

$$\langle \frac{C_{water}(\text{refinery port}) - t_w}{m_w + t_w}, \frac{m_w - C_{water}(\text{refinery port}) - t_w}{m_w + t_w} \rangle";$$

"evaluation of air pollution in the region of the refinery port,

$$\langle \frac{C_{air}(\text{refinery port}) - t_a}{m_a + t_a}, \frac{m_a - C_{air}(\text{refinery port}) - t_a}{m_a + t_a} \rangle".$$

$$Z_2 = \langle \{l_2\}, \{m_{0,1}, ..., m_{0,n}\}, \begin{array}{c|ccc} & m_{0,1} & ... & l_{0,n} \\ \hline l_2 & true & ... & true \end{array} \rangle.$$

Token π from place l_2 splits to n tokens π_1, ... π_n that enter places $m_{0,1}, ..., m_{0,n}$, respectively, with characteristics:

"distribution of crude oil amoung process first unit",

. . .

"distribution of crude oil amoung process n-th unit".

Fof each i $(1 \leq i \leq n)$ transition Y_i has the form.

$$Y_i = \langle \{m_{0,i}\}, \{m_{i,1}, m_{i,2}, m_{i,3}, m_{i,4}, m_{i,5}\}, \begin{array}{c|ccccc} & m_{i,1} & m_{i,2} & m_{i,3} & m_{i,4} & m_{i,5} \\ \hline m_{0,i} & true & true & true & true & true \end{array} \rangle.$$

Token π_i from place $m_{0,i}$ splits to five tokens $\theta_{i,0}$, $\pi_{i,0}$, $\sigma_{i,0}$, $\beta_{i,0}$ and $\alpha_{i,0}$ that enter places $m_{i,1}, m_{i,2}, m_{i,3}, m_{i,4}, m_{i,5}$, respectively, with characteristics:

"total evaluation of area pollution in the region of the i-th unit

$$\langle \frac{C_{soil}(i\text{-th unit}) - t_s}{m_s + t_s}, \frac{m_s - C_{soil}(i\text{-th unit}) - t_s}{m_s + t_s} \rangle,$$
$$\langle \frac{C_{water}(i\text{-th unit}) - t_w}{m_w + t_w}, \frac{m_w - C_{water}(i\text{-th unit}) - t_w}{m_w + t_w} \rangle,$$
$$\langle \frac{C_{air}(i\text{-th unit}) - t_a}{m_a + t_a}, \frac{m_a - C_{air}(i\text{-th unit}) - t_a}{m_a + t_a} \rangle";$$

"finished product of the i-th unit storage";

"evaluation of soil pollution in the region of the refinery port,

$$\langle \frac{C_{soil}(i\text{-th unit}) - t_s}{m_s + t_s}, \frac{m_s - C_{soil}(\text{refinery port}) - t_s}{m_s + t_s} \rangle";$$

"evaluation of water pollution in the region of the refinery port

$$\langle \frac{C_{water}(i\text{-th unit}) - t_w}{m_w + t_w}, \frac{m_w - C_{water}(i\text{-th unit}) - t_w}{m_w + t_w} \rangle";$$

"evaluation of air pollution in the region of the refinery port,

$$\langle \frac{C_{air}(i\text{-th unit}) - t_a}{m_a + t_a}, \frac{m_a - C_{air}(i\text{-th unit}) - t_a}{m_a + t_a} \rangle".$$

$$Z_3 = \langle \{m_{1,2}, ..., m_{n,2}\}, \{p_1, p_2, p_3, p_4, p_5\}, \begin{array}{c|ccccc} & p_1 & p_2 & p_3 & p_4 & p_5 \\ \hline m_{1,2} & true & true & true & true & true \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ m_{n,2} & true & true & true & true & true \end{array} \rangle.$$

All tokens π_1, ..., π_n are united in one (abstract) token, that splits to five tokens θ, π (the union of the original tokens), σ, β and α that enter places p_1, p_2, p_3, p_4, p_5, respectively, with characteristics:

"total evaluation of all storage tanks pollution,

$$\langle \frac{C_{soil}(\text{tanks}) - t_s}{m_s + t_s}, \frac{m_s - C_{soil}(\text{tanks}) - t_s}{m_s + t_s} \rangle,$$

$$\langle\frac{C_{water}(\text{tanks})-t_w}{m_w+t_w},\frac{m_w-C_{water}(\text{tanks})-t_w}{m_w+t_w}\rangle,$$
$$\langle\frac{C_{air}(\text{tanks})-t_a}{m_a+t_a},\frac{m_a-C_{air}(\text{tanks})-t_a}{m_a+t_a}\rangle\text{"};$$

"total finished products in the tanks";

"evaluation of the pollution of the soil in the region of the storage tanks,
$$\langle\frac{C_{soil}(\text{tanks})-t_s}{m_s+t_s},\frac{m_s-C_{soil}(\text{tanks})-t_s}{m_s+t_s}\rangle\text{"};$$

"evaluation of the pollution of the water in the region of the storage tanks,
$$\langle\frac{C_{water}(\text{tanks})-t_w}{m_w+t_w},\frac{m_w-C_{water}(\text{tanks})-t_w}{m_w+t_w}\rangle\text{"},$$

"evaluation of the pollution of the air in the region of the storage tanks,
$$\langle\frac{C_{air}(\text{tanks})-t_a}{m_a+t_a},\frac{m_a-C_{air}(\text{tanks})-t_a}{m_a+t_a}\rangle\text{"}.$$

$Z_4=\langle\{l_1,m_{1,1},...,m_{n,1},p_1,q_4\},\{q_1,q_2,q_3,q_4\},$

	q_1	q_2	q_3	q_4
l_1	$false$	$false$	$false$	$true$
$m_{1,1}$	$false$	$false$	$false$	$true$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
$m_{n,1}$	$false$	$false$	$false$	$true$
p_1	$false$	$false$	$false$	$true$
q_2	$true$	$true$	$true$	$true$

$\rangle$.

All tokens θ_0, $\theta_{1,0}$, ... $\theta_{n,0}$, θ are united with token δ in the latest token in place q_4 with the above mentioned chatacteristic. At each time-step, this token splits to four tokens δ (the original token) and $\delta_1,\delta_2,\delta_3$ that enter places q_1,q_2 and q_3 with characteristics

"current maximal-valued evaluations of the pollution,

$$\langle\max\left(\frac{C_{soil}(\text{refinery port})-t_s}{m_s+t_s},\frac{C_{water}(\text{refinery port})-t_w}{m_w+t_w},\frac{C_{air}(\text{refinery port})-t_a}{m_a+t_a},\right.$$
$$\frac{C_{soil}(\text{1-th unit})-t_s}{m_s+t_s},\frac{C_{water}(\text{1-th unit})-t_w}{m_w+t_w},\frac{C_{air}(\text{1-th unit})-t_a}{m_a+t_a},...,$$
$$\frac{C_{soil}(n\text{-th unit})-t_s}{m_s+t_s},\frac{C_{water}(n\text{-th unit})-t_w}{m_w+t_w},\frac{C_{air}(n\text{-th unit})-t_a}{m_a+t_a},$$
$$\left.\frac{C_{soil}(\text{tanks})-t_s}{m_s+t_s},\frac{C_{water}(\text{tanks})-t_w}{m_w+t_w},\frac{C_{air}(\text{tanks})-t_a}{m_a+t_a}\right),$$

$$\min\left(\frac{m_s-C_{soil}(\text{refinery port})-t_s}{m_s+t_s},\frac{m_w-C_{water}(\text{refinery port})-t_w}{m_w+t_w},\right.$$
$$\frac{m_a-C_{air}(\text{refinery port})-t_a}{m_a+t_a},\frac{m_s-C_{soil}(1\text{-th unit})-t_s}{m_s+t_s},$$
$$\frac{m_w-C_{water}(1\text{-th unit})-t_w}{m_w+t_w},\frac{m_a-C_{air}(1\text{-th unit})-t_a}{m_a+t_a},...,$$
$$\frac{m_s-C_{soil}(n\text{-th unit})-t_s}{m_s+t_s},\frac{m_w-C_{water}(n\text{-th unit})-t_w}{m_w+t_w},\frac{m_a-C_{air}(n\text{-th unit})-t_a}{m_a+t_a},$$
$$\left.\frac{m_s-C_{soil}(\text{tanks})-t_s}{m_s+t_s},\frac{m_w-C_{water}(\text{tanks})-t_w}{m_w+t_w},\frac{m_a-C_{air}(\text{tanks})-t_a}{m_a+t_a}\right)\rangle";$$

"current average-valued evaluations of the pollution,

$$\langle\frac{1}{3(n+2)}\left(\frac{C_{soil}(\text{refinery port})-t_s}{m_s+t_s}+\frac{C_{water}(\text{refinery port})-t_w}{m_w+t_w}+\frac{C_{air}(\text{refinery port})-t_a}{m_a+t_a}\right.$$
$$+\frac{C_{soil}(1\text{-th unit})-t_s}{m_s+t_s}+\frac{C_{water}(1\text{-th unit})-t_w}{m_w+t_w}+\frac{C_{air}(1\text{-th unit})-t_a}{m_a+t_a}+...$$
$$+\frac{C_{soil}(n\text{-th unit})-t_s}{m_s+t_s}+\frac{C_{water}(n\text{-th unit})-t_w}{m_w+t_w}+\frac{C_{air}(n\text{-th unit})-t_a}{m_a+t_a}$$
$$\left.+\frac{C_{soil}(\text{tanks})-t_s}{m_s+t_s}+\frac{C_{water}(\text{tanks})-t_w}{m_w+t_w}+\frac{C_{air}(\text{tanks})-t_a}{m_a+t_a}\right),$$

$$\frac{1}{3(n+2)}\left(\frac{m_s-C_{soil}(\text{refinery port})-t_s}{m_s+t_s}+\frac{m_w-C_{water}(\text{refinery port})-t_w}{m_w+t_w}\right.$$
$$+\frac{m_a-C_{air}(\text{refinery port})-t_a}{m_a+t_a}+\frac{m_s-C_{soil}(1\text{-th unit})-t_s}{m_s+t_s}$$
$$+\frac{m_w-C_{water}(1\text{-th unit})-t_w}{m_w+t_w}+\frac{m_a-C_{air}(1\text{-th unit})-t_a}{m_a+t_a}+...$$
$$+\frac{m_s-C_{soil}(n\text{-th unit})-t_s}{m_s+t_s}+\frac{m_w-C_{water}(n\text{-th unit})-t_w}{m_w+t_w}$$
$$+\frac{m_a-C_{air}(n\text{-th unit})-t_a}{m_a+t_a}+\frac{m_s-C_{soil}(\text{tanks})-t_s}{m_s+t_s}$$
$$\left.+\frac{m_w-C_{water}(\text{tanks})-t_w}{m_w+t_w}+\frac{m_a-C_{air}(\text{tanks})-t_a}{m_a+t_a}\right)\rangle";$$

"current average-weight-valued evaluations of the pollution,

$$\langle\frac{1}{(n+2)(\rho_s+\rho_w+\rho_a)}\left(\rho_s\left(\frac{C_{soil}(\text{refinery port})-t_s}{m_s+t_s}+\frac{C_{soil}(1\text{-th unit})-t_s}{m_s+t_s}+...\right.\right.$$
$$\left.+\frac{C_{soil}(n\text{-th unit})-t_s}{m_s+t_s}+\frac{C_{soil}(\text{tanks})-t_s}{m_s+t_s}\right)$$
$$+\rho_w\left(\frac{C_{water}(\text{refinery port})-t_w}{m_w+t_w}+\frac{C_{water}(1\text{-th unit})-t_w}{m_w+t_w}+...\right.$$

$$+\frac{C_{water}(n\text{-th unit})-t_w}{m_w+t_w}+\frac{C_{water}(\text{tanks})-t_w}{m_w+t_s}\Bigg)$$

$$+\rho_a\left(\frac{C_{air}(\text{refinery port})-t_a}{m_a+t_a}+\frac{C_{air}(1\text{-th unit})-t_a}{m_a+t_a}+...\right.$$

$$\left.+\frac{C_{air}(n\text{-th unit})-t_a}{m_a+t_a}+\frac{C_{air}(\text{tanks})-t_a}{m_a+t_a}\right)\Bigg),$$

$$\frac{1}{(n+2)(\rho_s+\rho_w+\rho_a)}\left(\rho_s\left(\frac{m_s-C_{soil}(\text{refinery port})-t_s}{m_s+t_s}+\frac{m_s-C_{soil}(1\text{-th unit})-t_s}{m_s+t_s}+...\right.\right.$$

$$\left.+\frac{m_s-C_{soil}(n\text{-th unit})-t_s}{m_s+t_s}+\frac{m_s-C_{soil}(\text{tanks})-t_s}{m_s+t_s}\right)$$

$$+\rho_w\left(\frac{m_w-C_{water}(\text{refinery port})-t_w}{m_w+t_w}+\frac{m_w-C_{water}(1\text{-th unit})-t_w}{m_w+t_w}+...\right.$$

$$\left.+\frac{m_w-C_{water}(n\text{-th unit})-t_w}{m_w+t_w}+\frac{m_w-C_{water}(\text{tanks})-t_w}{m_w+t_w}\right)$$

$$+\rho_a\left(\frac{m_a-C_{air}(\text{refinery port})-t_a}{m_a+t_a}+\frac{m_a-C_{air}(1\text{-th unit})-t_a}{m_a+t_a}+...\right.$$

$$\left.+\frac{m_a-C_{air}(n\text{-th unit})-t_a}{m_a+t_a}+\frac{m_a-C_{air}(\text{tanks})-t_a}{m_a+t_a}\right)\rangle".$$

3 Conclusion

GN model of the process of evaluation of the environmental impact of refinery activity implementing intuitionistic fuzzy estimations is developed. As shown, the oil retraction and production directly affect human life causing air and water pollution as well as soil contamination. Presented here GN model allows information about the processes of soil, water and air pollution to be collected in different units of the plant, as well as in a definite period of refinery activity. Estimations of pollution levels obtained implementing intuitionistic fuzzy logic give unique possibility the information to be further analyzed in details. In this line of thoughts, constructed here GN model might be of a high interest for the process of evaluation of the environmental damages of refinery activity.

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