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Обзор върху публикациите по индексирани матрици

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Красимир Атанасов дава идея за понятието за Индексирана Матрица (ИМ) през 1984 година в [9]. След това това дава формална дефиниция в [10]. През 2014 в книгата [25] той описва в детайли ИМ, разглеждайки случаите на ИМ, чиито елементи са реални числа, елементи но множеството $\{0, 1\}$; съждения; предикати; интуиционистки размити двойки и други, както и дефиниции за операции, релации и оператори върху съответния вид ИМ. Нека $\mathcal{I}$ е фиксирано множество от индекси и $\mathcal{R}$ е множество от реални числа.

Тази книга е написана на базата на [17–20, 22–24, 45, 46, 75].

Нека множествата K, L удовлетворяват условието K, L $\subset \mathcal{I}$.

Индексирана матрица с индексни множества K и L, където K, L $\subset \mathcal{I}$ ще наричаме обекта:

$$A = [K, L, \{a_{k_i,l_j}\}] = \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_1 & a_{k_1,l_1} & a_{k_1,l_2} & \dots & a_{k_1,l_n} \\ k_2 & a_{k_2,l_1} & a_{k_2,l_2} & \dots & a_{k_2,l_n} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ k_m & a_{k_m,l_1} & a_{k_m,l_2} & \dots & a_{k_m,l_n} \end{array}$$

където K = $\{k_1, k_2, ..., k_m\}$, L = $\{l_1, l_2, ..., l_n\}$, и за $1 \leq$ i $\leq$ m, $1 \leq$ j $\leq$ n: $a_{k_i,l_j} \in \mathcal{R}$, където $\mathcal{R}$ е множество на реалните числа.

Нека са дадени две индексирани матрици $A = [K, L, \{a_{k_i,l_j}\}]$ and $B = [P, Q, \{b_{p_r,q_s}\}]$, чиито елементи принадлежат на множеството на реалните числа.

В [25] за двете ИМ $A = [K, L, \{a_{k_i,l_j}\}]$ и $B = [P, Q, \{b_{p_r,q_s}\}]$ са дефинирани разширения на стандартните матрични операции „събиране" и „умножение на две матрици" „умножение на матрица и реално число". Тези операции са означени с: $\oplus_{(\circ)}$, $\otimes_{(\circ)}$, $\odot_{(\circ,*)}$, където $\circ, * : \mathcal{R} \times \mathcal{R} \to \mathcal{R}$ са подоперациите, които ще се изпълняват над елементите на A и B. Тези операции имат следния вид.

Събиране

$$A \oplus_{(\circ)} B = [K \cup P, L \cup Q, \{c_{t_u,v_w}\}],$$

където

$$c_{t_u,v_w} = \begin{cases} a_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \text{ и } v_w = l_j \in L; \\ & \\ b_{p_r,q_s}, & \text{ако } t_u = p_r \in P \text{ и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \text{ и } v_w = q_s \in Q; \\ & \\ a_{k_i,l_j} \circ b_{p_r,q_s}, & \text{ако } t_u = k_i = p_r \in K \cap P \\ & \text{и } v_w = l_j = q_s \in L \cap Q \\ & \\ e_\circ, & \text{в противен случай,} \end{cases},$$

където $e_\circ$ е единичният елемент на $\mathcal{R}$ относно операция $\circ$. Например, тук и по-надолу ако $\mathcal{R}$ е множеството на реалните числа и $\circ \in \{+, -\}$, тогава $e_\circ$ е “0”, а когато $\circ \in \{\times, :\}$, тогава $e_\circ$ е “1”.

Почленно умножение

$$A \otimes_{(\circ)} B = [K \cap P, L \cap Q, \{c_{t_u,v_w}\}],$$

където за $t_u = k_i = p_r \in K \cap P$ и $v_w = l_j = q_s \in L \cap Q$

$$c_{t_u,v_w} = a_{k_i,l_j} \circ b_{p_r,q_s},$$

Умножение

$$A \odot_{(\circ,*)} B = [K \cap (P - L), Q \cap (L - P), \{c_{t_u,v_w}\}],$$

където

$$c_{t_u,v_w} = \begin{cases} a_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - P - Q \\ & \\ b_{p_r,q_s}, & \text{ако } t_u = p_r \in P - L - K \text{ и } v_w = q_s \in Q \\ & \\ \underset{l_j = p_r \in L \cap P}{\circ} (a_{k_i,l_j} * b_{p_r,q_s}), & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in Q \\ & \\ e_\circ, & \text{в противен случай,} \end{cases}.$$

В [25] са описани и други операции над ИМ, например:

Изваждане

$$A \ominus B = [K - P, L - Q, \{c_{t_u,v_w}\}],$$

където “–” е операция изваждане на множества и

$$c_{t_u,v_w} = a_{k_i,l_j}, \text{ за } t_u = k_i \in K - P \text{ и } v_w = l_j \in L - Q.$$

Нека имаме индексираната матрица A, чиито елементи са реални числа, а $k_0 \notin K$ и $l_0 \notin L$ да бъдат два индекса. К. Атанасов, Евдокия Сотирова и Веселина Бурева в [46] въвеждат осем агрегиращи операции, които приложени върху A имат следния вид.

Агрегиране за максимална стойност по редове $\rho_{\max}(A, k_0)$

$$\rho_{\max}(A, k_0) = \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_0 & \max\limits_{1 \leq i \leq m} a_{k_i, l_1} & \max\limits_{1 \leq i \leq m} a_{k_i, l_2} & \dots & \max\limits_{1 \leq i \leq m} a_{k_i, l_n} \end{array}$$

Агрегиране за минимална стойност по редове $\rho_{\min}(A, k_0)$
$\rho_{\min}(A, k_0)$

$$\rho_{\min}(A, k_0) = \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_0 & \min\limits_{1 \leq i \leq m} a_{k_i, l_1} & \min\limits_{1 \leq i \leq m} a_{k_i, l_2} & \dots & \min\limits_{1 \leq i \leq m} a_{k_i, l_n} \end{array}$$

Агрегиране за сума по редове $\rho_{sum}(A, k_0)$

$$\rho_{sum}(A, k_0) = \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_0 & \sum\limits_{\substack{i=1 \\ 1 \leq i \leq m}}^{n} a_{k_i, l_1} & \sum\limits_{\substack{i=1 \\ 1 \leq i \leq m}}^{n} a_{k_i, l_2} & \dots & \sum\limits_{\substack{i=1 \\ 1 \leq i \leq m}}^{n} a_{k_i, l_n} \end{array}$$

Агрегиране за средноаритметична стойност по редове $\rho_{ave}(A, k_0)$

$$\rho_{ave}(A, k_0) = \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_0 & \frac{1}{m} \sum\limits_{\substack{i=1 \\ 1 \leq i \leq m}}^{n} a_{k_i, l_1} & \frac{1}{m} \sum\limits_{\substack{i=1 \\ 1 \leq i \leq m}}^{n} a_{k_i, l_2} & \dots & \frac{1}{m} \sum\limits_{\substack{i=1 \\ 1 \leq i \leq m}}^{n} a_{k_i, l_n} \end{array}$$

Агрегиране за максимална стойност по колони $\sigma_{\max}(A, l_0)$

$$\sigma_{\max}(A, l_0) = \begin{array}{c|c} & l_0 \\ \hline k_1 & \max\limits_{1 \leq j \leq n} a_{k_1, l_j} \\ \vdots & \vdots \\ k_m & \max\limits_{1 \leq j \leq n} a_{k_m, l_j} \end{array}$$

Агрегиране за минимална стойност по колони $\sigma_{\min}(A, l_0)$

$$\sigma_{\min}(A, l_0) = \begin{array}{c|c} & l_0 \\ \hline k_1 & \min\limits_{1 \leq j \leq n} a_{k_1, l_j} \\ \vdots & \vdots \\ k_m & \min\limits_{1 \leq j \leq n} a_{k_m, l_j} \end{array}$$

Агрегиране за сума по колони $\sigma_{sum}(A, l_0)$

$$\sigma_{sum}(A,l_0)=\begin{array}{c|c} & l_0 \\ \hline k_1 & \sum\limits_{\substack{j=1\\1\le j\le n}}^{n} a_{k_1,l_j} \\ \vdots & \vdots \\ k_m & \sum\limits_{\substack{j=1\\1\le j\le n}}^{n} a_{k_m,l_j} \end{array}$$

Агрегиране за средноаритметична стойност по колони $\sigma_{ave}(A,l_0)$

$$\sigma_{ave}(A,l_0)=\begin{array}{c|c} & l_0 \\ \hline k_1 & \frac{1}{n}\sum\limits_{\substack{j=1\\1\le j\le n}}^{n} a_{k_1,l_j} \\ \vdots & \vdots \\ k_m & \frac{1}{n}\sum\limits_{\substack{j=1\\1\le j\le n}}^{n} a_{k_m,l_j} \end{array}$$

В [25] са дадени и дефиниции за релации между две индексирани матрици $A=[K,L,a_{k_i,l_j}]$ и $B=[P,Q,b_{p_r,q_s}]$. С "$\subset$" и "$\subseteq$" се означават релациите „строго включване“ и „слабо включване“.

Строгата релация „включване относно размерност“ е

$$A\subset_d B, (((K\subset P)\&(L\subset Q))\vee$$

$$((K\subseteq P)\&(L\subset Q))\vee((K\subset P)\&(L\subseteq Q)))\&(\forall k\in K)(\forall l\in L)(a_{k_i,l_j}=b_{p_r,q_s}).$$

Нестрогата релация „включване относно размерност“ е

$$A\subseteq_d B, (K\subseteq_d P)\&(L\subseteq_d Q)\&(\forall k\in K)(\forall l\in L)(a_{k_i,l_j}=b_{p_r,q_s}).$$

В [33] е дадена дефиниция на ИМ, чиито елементи са предикати.

Нека *x* е променлива, получаваща (краен брой) стойности E = $\{a_1,a_2,\dots,a_n\}$ и *p(x)*} е предикат с променлива *x*. Нека *V* е оценъчна функция, дефинирана чрез

$$V(p(x))=\langle\mu(p(x)),\nu(p(x))\rangle,$$

където $\mu(p(x))$ и $\nu(p(x))$ са степеније на вярност и невярност на p.

Интуиционистки размитите интерпретации на (интуиционистки размитите) кванторите „за всяко“ ($\forall$) и „съществува“ ($\exists$) са въведени от К. Атанасов и Георги Гаргов в статиите [12, 39] чрез:

$$V(\exists x p(x))=\langle\max_{y\in E}\mu(p(y)),\min_{y\in E}\nu(p(y))\rangle,$$

$$V(\forall x p(x))=\langle\min_{y\in E}\mu(p(y)),\max_{y\in E}\nu(p(y))\rangle.$$

Нека елементите $\{a_{k_i,l_j}\}$ и $\{b_{p_r,q_s}\}$ на индексирани матрици $A = [K, L, \{a_{k_i,l_j}\}]$ и $B = [P, Q, \{b_{p_r,q_s}\}]$ са предикати. Тогава операции $\circ, * \in \{\vee, \wedge\}$.

За двете индексирани матрици A и B са дефинирани следните операции:

Събиране

$$A \oplus_{(\circ)} B = [K \cup P, L \cup Q, \{c_{t_u,v_w}\}],$$

където

$$c_{t_u,v_w} = \begin{cases} a_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \text{ и } v_w = l_j \in L; \\ & \\ b_{p_r,q_s}, & \text{ако } t_u = p_r \in P \text{ и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \text{ и } v_w = q_s \in Q; \\ & \\ a_{k_i,l_j} \circ b_{p_r,q_s}, & \text{ако } t_u = k_i = p_r \in K \cap P \\ & \text{и } v_w = l_j = q_s \in L \cap Q \\ & \\ false, & \text{в противен случай,} \end{cases} .$$

Почленно умножение

$$A \otimes_{(\circ)} B = [K \cap P, L \cap Q, \{c_{t_u,v_w}\}],$$

където за $t_u = k_i = p_r \in K \cap P$ и $v_w = l_j = q_s \in L \cap Q$

$$c_{t_u,v_w} = a_{k_i,l_j} \circ b_{p_r,q_s},$$

Умножение

$$A \odot_{(\circ,*)} B = [K \cap (P - L), Q \cap (L - P), \{c_{t_u,v_w}\}],$$

където

$$c_{t_u,v_w} = \begin{cases} a_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - P - Q \\ & \\ b_{p_r,q_s}, & \text{ако } t_u = p_r \in P - L - K \text{ и } v_w = q_s \in Q \\ & \\ \underset{l_j=p_r \in L \cap P}{\circ}(a_{k_i,l_j*b_{p_r,q_s}}), & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in Q \\ & \\ false, & \text{в противен случай,} \end{cases} .$$

Нека елементите $\{a_{k_i,l_j}\}$ и $\{b_{p_r,q_s}\}$ на индексирани матрици $A = [K, L, \{a_{k_i,l_j}\}]$ и $B = [P, Q, \{b_{p_r,q_s}\}]$ принадлежат на множеството $\{0, 1\}$. Тогава $\circ, * \in \{\min, \max\}$. За двете индексирани матрици A и B може да се дефинират следните операции: $\oplus_{(\circ)}, \otimes_{(\circ)}, \ominus_{(\circ)}$, където $\circ, * \in \{\min, \max\}$.

Събиране

$$A \oplus_{(\circ)} B = [K \cup P, L \cup Q, \{c_{t_u,v_w}\}],$$

където

$$c_{t_u,v_w} = \begin{cases} a_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \text{ и } v_w = l_j \in L; \\ \\ b_{p_r,q_s}, & \text{ако } t_u = p_r \in P \text{ и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \text{ и } v_w = q_s \in Q; \\ \\ a_{k_i,l_j} \circ b_{p_r,q_s}, & \text{ако } t_u = k_i = p_r \in K \cap P \\ & \text{и } v_w = l_j = q_s \in L \cap Q \\ \\ 0, & \text{в противен случай,} \end{cases} .$$

Почленно умножение

$$A \otimes_{(\circ)} B = [K \cap P, L \cap Q, \{c_{t_u,v_w}\}],$$

където за $t_u = k_i = p_r \in K \cap P$ и $v_w = l_j = q_s \in L \cap Q$

$$c_{t_u,v_w} = a_{k_i,l_j} \circ b_{p_r,q_s},$$

Умножение

$$A \odot_{(\circ,*)} B = [K \cap (P - L), Q \cap (L - P), \{c_{t_u,v_w}\}],$$

където

$$c_{t_u,v_w} = \begin{cases} a_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - P - Q \\ \\ b_{p_r,q_s}, & \text{ако } t_u = p_r \in P - L - K \text{ и } v_w = q_s \in Q \\ \\ \underset{l_j = p_r \in L \cap P}{\circ}(a_{k_i,l_j} * b_{p_r,q_s}), & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in Q \\ \\ 0, & \text{в противен случай,} \end{cases} .$$

В [30] е дадена дефиниция за Интуиционистки Размита Двойка (ИРД).

Нека V е оценъчна функция, която на съждение (предикат) p задава вярностната му стойност във вида $V(p) = \langle \mu(p), \nu(p) \rangle$. Тази двойка стойности се нарича ИРД. За всеки две ИРД можем да дефинираме операции $\neg$, &, $\vee$ чрез:

$$V(\neg p) = \langle \mu(p), \nu(p) \rangle,$$

$$V(p \wedge q) = \langle \min(\mu(p), \mu(q)), \max(\nu(p), \nu(q)) \rangle,$$

$$V(p \vee q) = \langle \max(\mu(p), \mu(q)), \min(\nu(p), \nu(q)) \rangle.$$

ИРД $V(p)$ е тавтология, ако $\mu(p) = 1$, $\nu(p) = 0$ и интуиционистки размита тавтология, ако $\mu(p) \geq \nu(p)$.

В [18,25] са дефинирани ИМ, чиито елементи са ИРД и операции върху тях.

Нека
$$e_{\vee} = \langle 0, 1\rangle$$
и
$$e_{\wedge} = \langle 1, 0\rangle.$$

Нека са дадени две ИМ $A = [K, L, \{a_{k_i,l_j}\}]$ и $B = [P, Q, \{b_{p_r,q_s}\}]$, чиито елементи са ИРД, където
$$a_{k_i,l_j} = \langle \alpha_{k_i,l_j}, \beta_{k_i,l_j}\rangle,$$
$$b_{p_r,q_s} = \langle \gamma_{p_r,q_s}, \delta_{p_r,q_s}\rangle.$$

Сега операциите за $\circ, * \in \{\max, \min\}$ са:

Събиране
$$A \oplus_{\vee} B = [K \cup P, L \cup Q, \langle \varphi_{t_u,v_w}, \psi_{t_u,v_w}\rangle]$$
$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w}\rangle = \begin{cases} \langle \alpha_{k_i,l_j}, \beta_{k_i,l_j}\rangle, & \text{ако } t_u = k_i \in K \\ & \text{и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \\ & \text{и } v_w = l_j \in L \\ \langle \gamma_{p_r,q_s}, \delta_{p_r,q_s}\rangle, & \text{ако } t_u = p_r \in P \\ & \text{и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \\ & \text{и } v_w = q_s \in Q \\ \langle \max(\alpha_{k_i,l_j}, \gamma_{k_i,l_j}), & \text{ако } t_u = k_i = p_r \in K \cap P \\ \quad \min(\beta_{p_r,q_s}, \delta_{p_r,q_s})\rangle, & \text{и } v_w = l_j = q_s \in L \cap Q \\ e_{\vee}, & \text{в противен случай} \end{cases},$$
и
$$A \oplus_{\wedge} B = [K \cup P, L \cup Q, \langle \varphi_{t_u,v_w}, \psi_{t_u,v_w}\rangle]$$
$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w}\rangle = \begin{cases} \langle \alpha_{k_i,l_j}, \beta_{k_i,l_j}\rangle, & \text{ако } t_u = k_i \in K \\ & \text{и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \\ & \text{и } v_w = l_j \in L \\ \langle \gamma_{p_r,q_s}, \delta_{p_r,q_s}\rangle, & \text{ако } t_u = p_r \in P \\ & \text{и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \\ & \text{и } v_w = q_s \in Q \\ \langle \min(\alpha_{k_i,l_j}, \gamma_{k_i,l_j}), & \text{ако } t_u = k_i = p_r \in K \cap P \\ \quad \max(\beta_{p_r,q_s}, \delta_{p_r,q_s})\rangle, & \text{и } v_w = l_j = q_s \in L \cap Q \\ e_{\wedge}, & \text{в противен случай} \end{cases},$$

Почленно умножение

$$A \otimes_{(\wedge)} B = [K \cap P, L \cap Q, \langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle],$$

където

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle = \begin{cases} \langle \min(\alpha_{k_i,l_j}, \gamma_{k_i,l_j}) & \text{ако } t_u = k_i = p_r \in K \cap P \\ \max(\beta_{p_r,q_s}, \delta_{p_r,q_s}) \rangle, & \text{и } v_w = l_j = q_s \in L \cap Q \end{cases},$$

и

$$A \otimes_{(\vee)} B = [K \cap P, L \cap Q, \langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle],$$

където

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle = \begin{cases} \langle \max(\alpha_{k_i,l_j}, \gamma_{k_i,l_j}) & \text{ако } t_u = k_i = p_r \in K \cap P \\ \min(\beta_{p_r,q_s}, \delta_{p_r,q_s}) \rangle, & \text{и } v_w = l_j = q_s \in L \cap Q \end{cases},$$

Умножение, където например при $\circ = \vee$ и $* = \wedge$

$$A \odot_{(\circ,*)} B = [K \cap (P - L), Q \cap (L - P), \langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle],$$

където

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle = \begin{cases} \langle \alpha_{k_i,l_j}, \beta_{k_i,l_j} \rangle, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - P \\ \langle \gamma_{p_r,q_s}, \delta_{p_r,q_s} \rangle, & \text{ако } t_u = p_r \in P - L \text{ и } v_w = q_s \in Q \\ \langle \max\limits_{l_j = p_r \in L \cap P} (\min(\alpha_{k_i,l_j}, \gamma_{k_i,l_j})), & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in Q \\ \min\limits_{l_j = p_r \in L \cap P} \max(\beta_{p_r,q_s}, \delta_{p_r,q_s}) \rangle, & \\ e_{\vee}, & \text{в противен случай,} \end{cases}.$$

В [47] К. Атанасов, Е. Сотирова, В. Бурева и Антъни Шенън дефинират времева интуиционистка размита ИМ във вида:

$$A(\mathcal{T}) \equiv \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_1 & \langle \mu_{k_1,l_1,\tau}, \nu_{k_1,l_1,\tau} \rangle & \langle \mu_{k_1,l_2,\tau}, \nu_{k_1,l_2,\tau} \rangle & \dots & \langle \mu_{k_1,l_n,\tau}, \nu_{k_1,l_n,\tau} \rangle \\ k_2 & \langle \mu_{k_2,l_1,\tau}, \nu_{k_2,l_1,\tau} \rangle & \langle \mu_{k_2,l_2,\tau}, \nu_{k_2,l_2,\tau} \rangle & \dots & \langle \mu_{k_2,l_n,\tau}, \nu_{k_2,l_n,\tau} \rangle \\ \vdots & \vdots & \vdots & \dots & \vdots \\ k_m & \langle \mu_{k_m,l_1,\tau}, \nu_{k_m,l_1,\tau} \rangle & \langle \mu_{k_m,l_2,\tau}, \nu_{k_m,l_2,\tau} \rangle & \dots & \langle \mu_{k_m,l_n,\tau}, \nu_{k_m,l_n,\tau} \rangle \end{array}$$

където за всяко $\tau \in \mathcal{T}$, $1 \leq i \leq m$, $1 \leq j \leq n : \mu_{k_i,l_j,\tau}, \nu_{k_i,l_j,\tau}, \mu_{k_i,l_j,\tau} + \nu_{k_i,l_j,\tau} \in [0,1]$. Тук $\mathcal{T}$ е времена скала, а τ е неин елемент, т.е. момент във времето.

През 2014 в [26] К. Атанасов дава дефиниция за Разширена интуиционистка размита ИМ, а в [24, 28] въвежда понятието за ИМ, чиито елементи са функции.

Нека означим множеството от всички използвани функции с $\mathcal{F}$.

Изследването на ИМ с функционален тип елементи има два случая:
1) всяка функция от множеството $\mathcal{F}$ има един аргумент и той е точно x (т.е. не е възможно една от функциите да има аргумент x и друга функция да има аргумент y) – нека означим множеството от тези функции с $\mathcal{F}_x^1$.
2) Всяка функция от множество $\mathcal{F}$ има един аргумент, но този аргумент може да бъде различен за различните функции или различните функции на множеството $\mathcal{F}$ може да имат различен брой аргументи.

ИМ, чиито елементи са функции ще наричаме обекта

$$[K, L, f_{k_i,l_j}] \equiv \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_1 & f_{k_1,l_1} & f_{k_1,l_2} & \cdots & f_{k_1,l_n} \\ k_2 & f_{k_2,l_1} & f_{k_2,l_2} & \cdots & f_{k_2,l_n} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ k_m & f_{k_m,l_1} & f_{k_m,l_2} & \cdots & f_{k_m,l_n} \end{array},$$

където K = $\{k_1, k_2, ..., k_m\}$, L = $\{l_1, l_2, ..., l_n\}$, и за 1 $\leq$ i $\leq$ m, 1 $\leq$ j $\leq$ n: $f_{k_i,l_j} \in \mathcal{F}_x^1$.

Нека са дадени две ИМ $A = [K, L, \{f_{k_i,l_j}\}]$ и $B = [P, Q, \{g_{p_r,q_s}\}]$, чиито елементи са функции. Операциите над тях имат следния вид:

Събиране

$$A \oplus_{(\circ)} B = [K \cup P, L \cup Q, \{h_{t_u,v_w}\}],$$

където

$$h_{t_u,v_w} = \begin{cases} f_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \text{ и } v_w = l_j \in L; \\ \\ g_{p_r,q_s}, & \text{ако } t_u = p_r \in P \text{ и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \text{ и } v_w = q_s \in Q; \\ \\ f_{k_i,l_j} \circ g_{p_r,q_s}, & \text{ако } t_u = k_i = p_r \in K \cap P \\ & \text{и } v_w = l_j = q_s \in L \cap Q \\ \\ \perp, & \text{в противен случай,} \end{cases},$$

където $\perp$ означава липса на операция на определено място и $\circ \in \{+, \times, \max, \min, \dots\}$.

Почленно умножение

$$A \otimes_{(\circ)} B = [K \cap P, L \cap Q, \{h_{t_u,v_w}\}],$$

където за $t_u = k_i = p_r \in K \cap P$ и $v_w = l_j = q_s \in L \cap Q$

$$h_{t_u,v_w} = f_{k_i,l_j} \circ g_{p_r,q_s},$$

Умножение

$$A \odot_{(\circ,*)} B = [K \cap (P - L), Q \cap (L - P), \{h_{t_u,v_w}\}],$$

където

$$h_{t_u,v_w} = \begin{cases} g_{k_i,l_j}, & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in L - P - Q \\ g_{p_r,q_s}, & \text{ако } t_u = p_r \in P - L - K \text{ и } v_w = q_s \in Q \\ \underset{l_j = p_r \in L \cap P}{\circ} (a_{k_i,l_j} * b_{p_r,q_s}), & \text{ако } t_u = k_i \in K \text{ и } v_w = l_j \in Q \\ \bot, & \text{в противен случай,} \end{cases},$$

където $\circ \in \{(+, \times), (\max, \min), (\min, \max), \dots\}$.

В [42] К. Атанасов и Таня Пенчева дават дефиниция за Декартово произведение върху ИМ, чиито елементи са ИРД.
Нека са дадени две индексирани матрици $A = [K, L, a_{k_i,l_j}]$ и $B = [P, Q, b_{p_r,q_s}]$, където a_{k_i,l_j} and b_{p_r,q_s} са ИРД или реални числа.

Първият вид Декартово произведение е следният:

$$A \times_C B = [K \times P, L \times Q, c_{\langle k_i,p_r \rangle, \langle l_j,q_s \rangle}],$$

където

$$c_{\langle \langle k_i,p_r \rangle, \langle l_j,q_s \rangle \rangle} = \langle a_{k_i,l_j}, b_{p_r,q_s} \rangle$$

и операцията × между K и P, и между L и Q е стандартното Декартово произведение на множества.
Нека за три елементи $a, b, c \in \mathcal{X}$ са верни следните равенства
$\langle \langle a, b \rangle, c \rangle = \langle a, b, c \rangle = \langle a, \langle b, c \rangle \rangle$. В [42] е доказано, че операцията $\times_C$ е асоциативна, но не комутативна.

Когато ИМ A и B имат за елементи ИРД, тогава елементите на ИМ $A \times_C B$ ще имат вида

$$c_{\langle \langle k_i,p_r \rangle, \langle l_j,q_s \rangle \rangle} = \langle a_{k_i,l_j}, b_{p_r,q_s} \rangle = \langle \langle \mu_{k_i,l_j}, \nu_{k_i,l_sj} \rangle, \langle \varphi_{p_r,q_s}, \psi_{p_r,q_s} \rangle \rangle,$$

т.е., двойка от ИРД.

Нека $(\circ, *) \in \{(\max, \min), (\min, \max), (+, .), (., +), (@, @)\}$ и нека за две интуиционистки размити двойки $\langle a, b \rangle, \langle c, d \rangle$:

$$\langle a, b \rangle (\circ, *) \langle c, d \rangle = \langle a \circ c, b * d \rangle.$$

Вторият вид Декартово произведение е следното

$$A \times_{(\circ,*)} B = [K \times P, L \times Q, c_{\langle \langle k_i,p_r \rangle, \langle l_j,q_s \rangle \rangle}],$$

където

$$c_{\langle \langle k_i,p_r \rangle, \langle l_j,q_s \rangle \rangle} = (\circ, *) \langle a_{k_i,l_j}, b_{p_r,q_s} \rangle$$

и за променливите t, u, v, w, в някои случаи (напр. конюнкция или дизюнкция)

$$(\circ, *)\langle\langle t, u\rangle, \langle v, w\rangle\rangle = \langle\circ(t, v), *(u, w)\rangle$$

и в други (напр. импликация)

$$(\circ, *)\langle\langle t, u\rangle, \langle v, w\rangle\rangle = \langle\circ(u, v), *(t, w)\rangle$$

по отношение на вида на операцията, която двойката $(\circ, *)$ представлява. Тогава, когато

$$a_{k_i,l_j} = \langle\mu_{k_i,l_j}, \nu_{k_i,l_sj}\rangle,$$

$$b_{p_r,q_s} = \langle\varphi_{p_r,q_s}, \psi_{p_r,q_s}\rangle,$$

както по-горе, в някои случаи (т.е. конюнкция или дизюнкция) имаме

$$c_{\langle\langle k_i,p_r\rangle,\langle l_j,q_s\rangle\rangle} = \langle\circ(\mu_{k_i,l_j}, \varphi_{p_r,q_s}), *(\nu_{k_i,l_sj}, \psi_{p_r,q_s})\rangle$$

а в други (напр. импликация)

$$c_{\langle\langle k_i,p_r\rangle,\langle l_j,q_s\rangle\rangle} = \langle\circ(\nu_{k_i,l_j}, \psi_{p_r,q_s}), *(\mu_{k_i,l_sj}, \varphi_{p_r,q_s})\rangle.$$

Декартови произведения са дефинирани и над разширени ИМ в [36].

В [32] са описани ИМ с елементи ИМ.

В [20,25] е дадена дефиниция за разширена интуиционистка размита ИМ. Там са дадени дефиниции за операции върху две разширени индексирани матрици, чиито елементи са интуиционистки размити двойки, също така са дадени дефиниции за агрегации и оператори. За две $A = [K^*, L^*, \langle\mu_{k_i,l_j}, \nu_{k_i,l_j}\rangle]B = [P^*, Q^*, \langle\rho_{p_r,q_s}, \sigma_{p_r,q_s}\rangle]$, чиито елементи са интуиционистки размити двойки, може да дефинираме матрични операции $\oplus_{(\max,\min)}$, $\oplus_{(\min,\max)}$, $\otimes_{(\max,\min)}$, $\otimes_{(\min,\max)}$, $\odot_{(\circ,*)}$ аналогично на индексираните матрици, чиито елементи са интуиционистки размити двойки:

Събиране-$(\max, \min)$

$$A \oplus_{(\max,\min)} B = [T^*, V^*, \{\langle\varphi_{t_u,v_w}, \psi_{t_u,v_w}\rangle\}],$$

където

$$T^* = K^* \cup P^* = \{\langle t_u, \alpha_u^t, \beta_u^t\rangle | t_u \in K \cup P\},$$

$$V^* = L^* \cup Q^* = \{\langle v_w, \alpha_w^v, \beta_w^v\rangle | v_w \in L \cup Q\},$$

$$\alpha_u^t = \begin{cases} \alpha_i^k, & \text{ако } t_u \in K - P \\ \alpha_r^p, & \text{ако } t_u \in P - K \\ \max(\alpha_i^k, \alpha_r^p), & \text{ако } t_u \in K \cap P \end{cases},$$

$$\beta_w^v = \begin{cases} \beta_j^l, & \text{ако } v_w \in L - Q \\ \beta_s^q, & \text{ако } v_w \in Q - L \\ \min(\beta_j^l, \beta_s^q), & \text{ако } v_w \in L \cap Q \end{cases},$$

и

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle \ = \begin{cases} \langle \mu_{k_i,l_j}, \nu_{k_i,l_j} \rangle, & \text{ако } t_u = k_i \in K \\ & \text{и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \\ & \text{и } v_w = l_j \in L \\ \langle \rho_{p_r,q_s}, \sigma_{p_r,q_s} \rangle, & \text{ако } t_u = p_r \in P \\ & \text{и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \\ & \text{и } v_w = q_s \in Q \\ \langle \max(\mu_{k_i,l_j}, \rho_{k_i,l_j}), & \text{ако } t_u = k_i = p_r \in K \cap P \\ \ \min(\nu_{p_r,q_s}, \sigma_{p_r,q_s}) \rangle, & \text{и } v_w = l_j = q_s \in L \cap Q \\ \langle 1, 0 \rangle, & \text{в противен случай} \end{cases},$$

Събиране-$(\min, \max)$

$$A \oplus_{(\min,\max)} B = [T^*, V^*, \{\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle\}],$$

където

$$T^* = K^* \cup P^* = \{\langle t_u, \alpha_u^t, \beta_u^t \rangle | t_u \in K \cup P\},$$

$$V^* = L^* \cup Q^* = \{\langle v_w, \alpha_w^v, \beta_w^v \rangle | v_w \in L \cup Q\},$$

$$\alpha_u^t = \begin{cases} \alpha_i^k, & \text{ако } t_u \in K - P \\ \alpha_r^p, & \text{ако } t_u \in P - K \\ \max(\alpha_i^k, \alpha_r^p), & \text{ако } t_u \in K \cap P \end{cases},$$

$$\beta_w^v = \begin{cases} \beta_j^l, & \text{ако } v_w \in L - Q \\ \beta_s^q, & \text{ако } v_w \in Q - L \\ \min(\beta_j^l, \beta_s^q), & \text{ако } v_w \in L \cap Q \end{cases},$$

и

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle \ = \begin{cases} \langle \mu_{k_i,l_j}, \nu_{k_i,l_j} \rangle, & \text{ако } t_u = k_i \in K \\ & \text{и } v_w = l_j \in L - Q \\ & \text{или } t_u = k_i \in K - P \\ & \text{и } v_w = l_j \in L \\ \langle \rho_{p_r,q_s}, \sigma_{p_r,q_s} \rangle, & \text{ако } t_u = p_r \in P \\ & \text{и } v_w = q_s \in Q - L \\ & \text{или } t_u = p_r \in P - K \\ & \text{и } v_w = q_s \in Q \\ \langle \min(\mu_{k_i,l_j}, \rho_{k_i,l_j}), & \text{ако } t_u = k_i = p_r \in K \cap P \\ \ \max(\nu_{p_r,q_s}, \sigma_{p_r,q_s}) \rangle, & \text{и } v_w = l_j = q_s \in L \cap Q \\ \langle 1, 0 \rangle, & \text{в противен случай} \end{cases},$$

Почленно умножение-$(\max, \min)$

$$A \otimes_{(\max,\min)} B = [T^*, V^*, \{\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle\}],$$

където

$$\begin{gathered}
T^* = K^* \cap P^* = \{\langle t_u, \alpha_u^t, \beta_u^t \rangle | t_u \in K \cap P\}, \\
V^* = L^* \cap Q^* = \{\langle v_w, \alpha_w^v, \beta_w^v \rangle | v_w \in L \cap Q\}, \\
\alpha_u^t = \min(\alpha_i^k, \alpha_r^p) \text{ за } t_u = k_i = p_r \in K \cap P, \\
\beta_w^v = \min(\beta_j^l, \beta_s^q) \text{ за } v_w = l_j = q_s \in L \cap Q \\
\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle = \langle \max(\mu_{k_i,l_j}, \rho_{k_i,l_j}), \min(\nu_{p_r,q_s}, \sigma_{p_r,q_s}) \rangle
\end{gathered}$$

Почленно умножение-$(\min, \max)$

$$A \otimes_{(\max,\min)} B = [T^*, V^*, \{\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle\}],$$

където

$$\begin{gathered}
T^* = K^* \cap P^* = \{\langle t_u, \alpha_u^t, \beta_u^t \rangle | t_u \in K \cap P\}, \\
V^* = L^* \cap Q^* = \{\langle v_w, \alpha_w^v, \beta_w^v \rangle | v_w \in L \cap Q\}, \\
\alpha_u^t = \min(\alpha_i^k, \alpha_r^p) \text{ за } t_u = k_i = p_r \in K \cap P, \\
\beta_w^v = \min(\beta_j^l, \beta_s^q) \text{ за } v_w = l_j = q_s \in L \cap Q \\
\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle \ = \langle \min(\mu_{k_i,l_j}, \rho_{k_i,l_j}), \max(\nu_{p_r,q_s}, \sigma_{p_r,q_s}) \rangle
\end{gathered}$$

Умножение-$(\max, \min)$

$$A \odot_{(\max,\min)} B = [T^*, V^*, \{\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle\}],$$

където

$$\begin{gathered}
T^* = [K \cap (P - L)]^* = \{\langle t_u, \alpha_u^t, \beta_u^t \rangle | t_u \in K \cap (P - L)\}, \\
V^* = (Q \cap (L - P))^* = \{\langle v_w, \alpha_w^v, \beta_w^v \rangle | v_w \in Q \cap (L - P)\}, \\
\alpha_u^t = \begin{cases} \alpha_i^k, & \text{ако } t_u \in K \\ \alpha_r^p, & \text{ако } t_u \in P - L \end{cases}, \\
\beta_w^v = \begin{cases} \beta_j^l, & \text{ако } v_w \in L - P \\ \beta_s^q, & \text{ако } v_w \in Q \end{cases},
\end{gathered}$$

и

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle = \begin{cases}
\langle \mu_{k_i,l_j}, \nu_{k_i,l_j} \rangle, & \text{ако } t_u = k_i \in K \\
 & \text{ и } v_w = l_j \in L - P - Q \\
\langle \varphi_{p_r,q_s}, \psi_{p_r,q_s} \rangle, & \text{ако } t_u = p_r \in P - L - K \\
 & \text{ и } v_w = q_s \in Q \\
\langle \max\limits_{l_j = p_r \in L \cap P} \min(\mu_{k_i,l_j}, \varphi_{k_i,l_j}), & \text{ако } t_u = k_i \in K \\
 & \text{ и } v_w = l_j \in Q \\
\min\limits_{l_j = p_r \in L \cap P} \max(\nu_{p_r,q_s}, \psi_{p_r,q_s}) \rangle, & \\
\langle 0, 1 \rangle, & \text{в противен случай,}
\end{cases}.$$

Умножение-$(\min, \max)$

$$A \odot_{(\max,\min)} B = [T^*, V^*, \{\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle\}],$$

където

$$T^* = (K \cap (P - L))^* = \{\langle t_u, \alpha^t_u, \beta^t_u \rangle | t_u \in K \cap (P - L)\},$$

$$V^* = (Q \cap (L - P))^* = \{\langle v_w, \alpha^v_w, \beta^v_w \rangle | v_w \in Q \cap (L - P)\},$$

$$\alpha^t_u = \begin{cases} \alpha^k_i, & \text{ако } t_u \in K \\ \alpha^p_r, & \text{ако } t_u \in P - L \end{cases},$$

$$\beta^v_w = \begin{cases} \beta^l_j, & \text{ако } v_w \in L - P \\ \beta^q_s, & \text{ако } v_w \in Q \end{cases}$$

и

$$\langle \varphi_{t_u,v_w}, \psi_{t_u,v_w} \rangle = \begin{cases} \langle \mu_{k_i,l_j}, \nu_{k_i,l_j} \rangle, & \text{ако } t_u = k_i \in K \\ & \text{ и } v_w = l_j \in L - P - Q \\ \\ \langle \varphi_{p_r,q_s}, \psi_{p_r,q_s} \rangle, & \text{ако } t_u = p_r \in P - L - K \\ & \text{ и } v_w = q_s \in Q \\ \\ \langle \max\limits_{l_j = p_r \in L \cap P} (\min(\mu_{k_i,l_j}, \varphi_{k_i,l_j})), & \text{ако } t_u = k_i \in K \\ & \text{ и } v_w = l_j \in Q \\ \min\limits_{l_j = p_r \in L \cap P} \max(\nu_{p_r,q_s}, \psi_{p_r,q_s}) \rangle, & \\ \\ \langle 0, 1 \rangle, & \text{в противен случай,} \end{cases}.$$

В [35] К. Атанасов дава дефиниция за разширена интуиционистка размита ИМ с интервални стойрости, а в [29] - на времева разширена интуиционистка размита ИМ:

$$A^*(\mathcal{T}) \equiv$$

$$\begin{array}{c|cccc} & l_1, \langle \alpha^l_1, \beta^l_1, \tau \rangle & l_2, \langle \alpha^l_2, \beta^l_2, \tau \rangle & \dots & l_n, \langle \alpha^l_n, \beta^l_n, \tau \rangle \\ \hline k_1, \langle \alpha^k_1, \beta^k_1, \tau \rangle & \langle \mu_{k_1,l_1}, \nu_{k_1,l_1}, \tau \rangle & \langle \mu_{k_1,l_2}, \nu_{k_1,l_2}, \tau \rangle & \dots & \langle \mu_{k_1,l_n}, \nu_{k_1,l_n}, \tau \rangle \\ k_2, \langle \alpha^k_2, \beta^k_2, \tau \rangle & \langle \mu_{k_2,l_1}, \nu_{k_2,l_1}, \tau \rangle & \langle \mu_{k_2,l_2}, \nu_{k_2,l_2}, \tau \rangle & \dots & \langle \mu_{k_2,l_n}, \nu_{k_2,l_n}, \tau \rangle | \tau \in \mathcal{T}_, \\ \vdots & \vdots & \vdots & \dots & \vdots \\ k_m, \langle \alpha^k_m, \beta^k_m, \tau \rangle & \langle \mu_{k_m,l_1}, \nu_{k_m,l_1}, \tau \rangle & \langle \mu_{k_m,l_2}, \nu_{k_m,l_2}, \tau \rangle & \dots & \langle \mu_{k_m,l_n}, \nu_{k_m,l_n}, \tau \rangle \end{array}$$

където за $1 \leq i \leq m, 1 \leq j \leq n$:

$$\mu_{k_i,l_j,\tau}, \nu_{k_i,l_j,\tau}, \mu_{k_i,l_j,\tau} + \nu_{k_i,l_j,\tau} \in [0, 1],$$

$$\alpha^k_{i,\tau}, \beta^k_{i,\tau}, \alpha^k_{i,\tau} + \beta^k_{i,\tau} \in [0, 1],$$

$$\alpha^l_{j,\tau}, \beta^l_{j,\tau}, \alpha^l_{j,\tau} + \beta^l_{j,\tau} \in [0, 1],$$

където

$$K^* = \{\langle k_i, \alpha^k_{i,\tau}, \beta^k_{i,\tau}\rangle | k_i \in K \& \tau \in \mathcal{T}\} = \{\langle k_i, \alpha^k_{i,\tau}, \beta^k_{i,\tau}\rangle | 1 \leq i \leq m \& \tau \in \mathcal{T}\},$$

$$L^* = \{\langle l_j, \alpha^l_{j,\tau}, \beta^l_{j,\tau}\rangle | l_j \in L \& \tau \in \mathcal{T}\} = \{\langle l_j, \alpha^l_{j,\tau}, \beta^l_{j,\tau}\rangle | 1 \leq j \leq n \& \tau \in \mathcal{T}\}.$$

В [23] К. Атанасов дава дефиниция за тримерна ИМ:

$$[K, L, H, a_{k_i,l_j,h_g}] = \left\{ \begin{array}{c|cccc} & l_1 & l_2 & \dots & l_n \\ \hline k_1 & a_{k_1,l_1,h_g} & a_{k_1,l_2,h_g} & \dots & a_{k_1,l_n,h_g} \\ k_2 & a_{k_2,l_1,h_g} & a_{k_2,l_2,h_g} & \dots & a_{k_2,l_n,h_g} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ k_m & a_{k_m,l_1,h_g} & a_{k_m,l_2,h_g} & \dots & a_{k_m,l_n,h_g} \end{array} | h_g \in H \right\},$$

където

$K = k_1, k_2, ..., k_m, L = l_1, l_2, ..., l_n, H = h_1, h_2, ..., h_f$
и за $1 \leq i \leq m, 1 \leq j \leq n, 1 \leq g \leq \mu : a_{k_i,l_j,h_g} \in \mathcal{X}$.

Тази идея е обобщена до n-мерна ИМ в [31, 67]. В [163] Величка Транева дефинира вътрешни операции върху тримерни разширени индексирани матрици.

В [174] са дефинирани набори от 9 операции, които генерират скала. Тези операции са използвани за агрегиране на елементи на двумерни и тримерни матрици.

В. Транева и Стоян Транев са дефинирали разширения на индексираните матрици под формата на кръгови и елипсовидни интуиционистки размити ИМ в [168, 173], чиито елементи са кръгови и елипсовидни интуиционистки размити двойки.

В [48] са дефинирани оператори на ниво (по аналогия на тези от [30]) над ИМ. Други идеи, свързани с ИМ са описани в [28, 55, 58, 85, 166–169, 171].

През годините, ИМ са намерили приложения в дефинициите на понятията “Обобщени мрежи“ [1, 11, 16],“интуиционистки размита релация“ [14], “интуиционистки размити графи” [13, 15, 82, 115, 117, 142, 144], за представимост на различни видове бази от данни, в т.ч. OLAP-структури и големи бази данни [37, 38, 64, 65, 67, 79–81, 164, 165], на различни видове невронни мрежи [43, 44, 147] и “интеркритериален анализ“ [40, 41, 55, 59, 60]. Например, входните данни за интеркритериалния анализ са от вида

$$A = \begin{array}{c|cccc} & O_1 & O_2 & \dots & O_n \\ \hline C_1 & a_{C_1,O_1} & a_{C_1,O_2} & \dots & a_{C_1,O_n} \\ C_2 & a_{C_2,O_1} & a_{C_2,O_2} & \dots & a_{C_2,O_n} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ C_m & a_{C_m,O_1} & a_{C_m,O_2} & \dots & a_{C_m,O_n} \end{array},$$

където $1 \leq \mathrm{i} \leq \mathrm{m}$, $1 \leq \mathrm{j} \leq \mathrm{n}$, а резултатът от прилагането му има вида

$$A = \begin{array}{c|cccc} & C_1 & C_2 & \dots & C_n \\ \hline C_1 & b_{C_1,C_1} & b_{C_1,C_2} & \dots & b_{C_1,C_n} \\ C_2 & b_{C_2,C_1} & b_{C_2,C_2} & \dots & b_{C_2,C_n} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ C_m & b_{C_m,C_1} & b_{C_m,C_2} & \dots & b_{C_m,C_n} \end{array}$$

където $O_1, ..., O_m$са обекти, $C_1, ..., C_n$ са критерии, a_{O_i,C_k} е оценката на i-обект по j-тия критерий, $\langle b_{C_k,C_l}, c_{C_k,C_L} \rangle$ е ИРД задаваща степените на близост и на различие за критерии C_k и C_l и са в сила равенствата

$$\langle b_{C_k,C_l}, c_{C_k,C_l} \rangle = \langle 1, 0 \rangle,$$

$$\langle b_{C_k,C_l}, c_{C_k,C_l} \rangle = \langle b_{C_l,C_k}, c_{C_l,C_k} \rangle.$$

От 2015 г. насам, интеркритериалният анализ е приложен с успех в следните области:

- * изкуствен интелект (невронни мрежи, процедури за вземане на решения и други), метаевристики, големи бази данни и други - [3–7, 70, 73, 73, 74, 74, 91–100, 118, 119, 127–140, 146, 148, 149]
- * биология, медицина и фармалогия [2, 8, 66, 68, 78, 84, 101, 103, 104, 111, 113, 114, 125, 126, 141, 150–153, 156, 160–162, 170, 172, 175, 176, 179–182]
- * екология [61, 102, 105–110, 120–124, 145, 155, 183]
- * химия [69, 157–159, 159, 173]
- * икономика [49–54, 56, 57, 86–89, 171]
- * сравнение на университети [62, 63, 71, 72, 76, 77, 83, 112, 116, 154]

и други.

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