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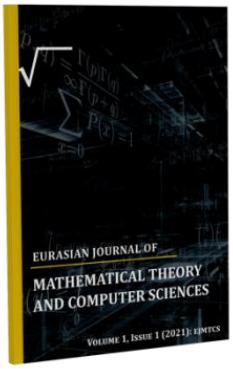

CLASSIFICATION AND TRAINING SAMPLE IN THE PHASE OF INFORMATIVE SIGNS ALGORITHM FOR DETERMINING THE IMPORTANCE OF CLASSES

Beglerbekov Rasul Jubatkhanovich
t.f.b.f.d. or Ph.D.,Head of the Department of Information Technology, Mathematics, Physics and Chemistry of the Faculty of Zooengineering of the Karakalpakstan Institute of Agriculture and Agrotechnologies
Khudaybergenova Gulaim Sultanbay qızı
trainee-teacher of the Faculty of Zooengineering, Department of Information Technology, Mathematics, Physics and Chemistry, Karakalpakstan Institute of Agriculture and Agrotechnologies
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ABSTRACT
The article proposes a method and algorithm for constructing an informative phase, which is one of the most important issues of symbol recognition. All the concepts related to the problems of symbol recognition have been attempted to be expressed in a logical perfection, mathematical clarity and simplicity. The main issue of classification of symbols??, the formation of the phase of informative signs, the determination of the levels of importance of the objects and symbols of the study sample were thoroughly analyzed. The Fisher functional elements used to determine the values of the proximity function in the informative signs phase Upper and lower bounds of the similarity function between objects are identified and supporting data is provided.

INFORMATIV BELGILAR FAZOSIDA SINFLASHTIRISH VA O‘QUV TANLANMA SINFLARINI MUHIMLIK DARAJALARINI ANIQLASH ALGORITMI

Beglerbekov Rasul Jubatxanovich
t.f.b.f.d. PhD, Zooinjeneriya fakulteti, Axborot texnologiyalari, matematika, fizika va kimyo kafedrasi mudiri Qoraqalpog’iston qishloq xo’jaligi va agrotexnologiyalar instituti
Xudaybergenova Gulayim Sultanbay qızı
Zooinjeneriya fakulteti, Axborot texnologiyalari, matematika, fizika va kimyo kafedrasi stajyor-o’qituvchisi, Qoraqalpog’iston qishloq xo’jaligi va agrotexnologiyalar instituti
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ABSTRACT
Maqolada timsollarni aniqlashning muhim masalalaridan biri informativ fazoni qurish usuli va algoritmi taklif etilgan. Timsollarni aniqlashning muammolari bilan bog‘liq bo‘lgan barcha tushunchalar mantiqiy mukammal, matematik aniq va sodda ko‘rinishda ifodalashga harakat qilingan. Timsollarni asosiy masalasi – sinflashtirish, informativ belgilar fazosini shakllantirish, o‘quv tanlanma ob’yekt va belgilarining muhimlik darajalarini aniqlash kabi masalalar chuqur tahlil

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etilgan. Informativ belgilar fazosida yaqinlik funksiya qiymatlarini aniqlashda Fisher funksionali elementlaridan foydalanilgan. Ob'yektlar aro o'xshashlik funksiyasining yuqori va quyi chegaralari aniqlangan hamda ularni tasdiqlovchi ma'lumotlar keltirilgan.

Kirish

[1] Timsollarni aniqlash, dastlabki belgilar majmualarini shakllantirish, informativ belgilarni tanlash, hal qiluvchi qoidalarni qurish kabi masalalar baholarni hisoblash algoritmlari asosida nazariy amaliy yechimlarda aks ettirilgan.

[2] Maqolada, informativ belgilar fazosida Fisher tipidagi informativlik mezonidagi informativlik me'yorlaridan foydalangan holda baholarni hisoblab chiqarish asosida tanib olish algoritmining bosqichlarini ishlab chiqish vazifalari shakllantirilgan. Faqat bitta sinfga mansub ob'yektlarga ega bo'lgan informativ xususiyatlar to'plamini tanlashni optimallashtirish masalasi tuzilgan, informativ belgilar fazosida yaqinlik funksiyasi qurildi. Yaqinlik funksiyasining qiymatlarini aniqlashda Fisher funksionalining elementlari va xossalaridan foydalaniladi, yaqinlik funksiyasining yuqori va quyi chegaralari ham aniqlanadi, ularni qo'llab-quvvatlovchi lemmalar, xossalar va taxminlar shakllantiriladi.

Asosiy qism

1. Informativ belgilar fazosi va Fisher mezoni

Faraz qilaylik, o'quv tanlanmalar majmuasi quyidagi ko'rinishda ifodalangan $x_{p1}, x_{p2}, \dots, x_{pm_p} \in X_p, p = \overline{1,r}$ bo'lsin. Bu yerda x_{pi}- N - o'lchovli belgilar fazosi vektori, har bir obekt $x_{pi} = \left(x_{pi}^1, x_{pi}^2, \dots x_{pi}^N\right), i = \overline{1,m_p}$, N - o'lchovli belgilar fazosida qaralgan, X_p esa obektlar r - sinfini bildirib, $p = \overline{1,r}$ qiymatlarni qabul qiladi, X_p sinf m_p ta $x_{p1}, \dots, x_{p_{m_p}}$ obektlardan tashkil topgan.

Informativ belgilar qism fazosini bir qiymatli xarakterlovchi X_p sinfga mos $\lambda_p = (\lambda_p^1, \lambda_p^2, \dots, \lambda_p^N), \lambda_p \in \{0;1\}, i = \overline{1,N}$ vektor kiritiladi.

Berilgan p-sinf obektlariga mos sifat mezoni $I(\lambda_p)$ orqali belgilanadi va tanlanishi lozim bo'lgan ℓ_p ta $\left(\ell_p \ll N\right)$, λ_p informativ belgilar fazosi esa quyidagicha quriladi:

$$\Lambda^{\ell_p} = \left\{\lambda_p : \sum_{k=1}^{N} \lambda_p^k = \ell_p, \lambda^{\ell_p} \in \{0;1\}, p = \overline{1,r}\right\} \qquad (1)$$

Qaralayotgan sinf obektlari uchun muhim bo'lgan informativ belgi yoki belgilar majmuasi (1) to'plam elementi λ_p bul vektoriga ko'ra ularning, ya'ni belgi va belgilarning informativlik darajasi $I(\lambda_p)$ sifat mezonining qabul qilgan qiymatiga asoslangan holda aniqlanadi.

Faraz qilaylik $I(\lambda_p)$ sifat mezoni Fisher funsionali ko'rinishida ifodalangan bo'lsin:

$$I(\lambda_p) = \frac{(a,\lambda_p)}{(b_p,\lambda_p)} \qquad (2)$$

Bu erda (2.2) Fisher funsionali, $a = (a^1, a^2, \dots, a^N)$, $a = (b_p^1, b_p^2, \dots, b_p^N)$ vektorlar N - o'lchovli belgilar fazosida qaralib, ularning komponentlari quyidagicha hisoblanadi:

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$$a^j = \sum_{p,q=1}^{r} \left(\bar{x}_q^j - \bar{x}_p^j\right)^2, j = \overline{1,N}, b_p^j = \frac{1}{m_p}\sum_{i=1}^{m_p}\left(x_{pi}^j - \bar{x}_p^j\right)^2, j = \overline{1,N} \qquad (3)$$

X_p sinfning o‘rtacha obekti $\bar{x}_p$ quyidagicha hisoblanadi:

$x_p = \frac{1}{m_p}\sum_{i=1}^{m_p} x_{pi}, p = \overline{1,r}$, $(*,*)$ – vektorlarning skalyar ko‘paytmasini bildiradi. [2; 62-69 b, 1, 6; 77-82 b.]

Informativ belgilar majmuasini quyidagi optimizatsiya masalasini yechish orqali amalga oshiriladi:

$$\begin{cases} I(\lambda_p) = \dfrac{(a,\lambda_p)}{(b_p,\lambda_p)} \to \max\limits_{\lambda_p \in \Lambda^{\ell_p}} \\ \Lambda^{\ell_p} = \left\{\lambda_p : \sum\limits_{k=1}^{N} \lambda_p^k = \ell_p, \lambda^{\ell_p} \in \{0,1\}, p = \overline{1,r}\right\} \end{cases} \qquad (4)$$

Faraz qilaylik o‘quv tanlanma quyidagi 4 ta sinf ko‘rinishda berilgan bo‘lsin:

$$X_1 = \begin{pmatrix} 3\,2\,2\,2\,4\,1\,1\,2\,2\,5\,2\,2 \\ 3\,2\,2\,2\,2\,1\,1\,2\,2\,8\,2\,2 \\ 3\,2\,2\,2\,3\,1\,1\,2\,2\,8\,2\,2 \\ 5\,2\,3\,2\,7\,1\,1\,2\,2\,5\,2\,2 \\ 5\,2\,3\,2\,7\,1\,1\,2\,2\,5\,2\,1 \\ 5\,2\,3\,2\,7\,1\,1\,2\,2\,5\,2\,2 \end{pmatrix}; X_2 = \begin{pmatrix} 1\,2\,2\,2\,4\,1\,1\,2\,2\,3\,2\,3 \\ 6\,2\,2\,2\,2\,1\,1\,2\,2\,7\,2\,3 \\ 3\,2\,2\,2\,3\,1\,1\,3\,2\,8\,2\,1 \\ 3\,2\,2\,2\,7\,1\,1\,2\,1\,10\,2\,4 \\ 5\,2\,2\,2\,7\,1\,1\,2\,1\,11\,2\,4 \\ 5\,2\,2\,2\,7\,1\,2\,2\,2\,5\,2\,2 \\ 4\,2\,3\,2\,7\,1\,1\,2\,2\,5\,2\,1 \end{pmatrix};$$

$$X_3 = \begin{pmatrix} 3\,3\,2\,2\,3\,1\,1\,2\,2\,3\,2\,1 \\ 3\,2\,3\,2\,4\,2\,1\,2\,2\,4\,2\,2 \\ 3\,2\,3\,2\,4\,1\,1\,3\,1\,7\,2\,1 \\ 2\,4\,3\,2\,1\,1\,1\,2\,2\,3\,2\,1 \\ 3\,3\,3\,2\,6\,1\,1\,2\,1\,9\,2\,2 \\ 1\,2\,3\,2\,5\,1\,1\,2\,1\,7\,2\,3 \end{pmatrix}; X_4 = \begin{pmatrix} 3\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,4 \\ 2\,2\,1\,1\,2\,1\,2\,2\,2\,2\,1\,3 \\ 2\,4\,2\,3\,5\,3\,2\,2\,3\,6\,3\,3 \\ 3\,2\,3\,2\,5\,1\,1\,2\,2\,8\,2\,1 \\ 2\,3\,1\,2\,8\,1\,1\,2\,1\,7\,2\,4 \end{pmatrix}.$$

Masala №1. Fisher funsionali, $a = (a^1, a^2, \dots, a^N)$, $b = (b^1, b_p^2, \dots, b_p^N)$ vektorlar N – o‘lchovli belgilar fazosida qaralib, ularning komponentalari quyidagicha hisoblanadi:

$$a^j = \sum_{p,q=1}^{r} \left(\bar{x}_q^j - \bar{x}_p^j\right)^2, \; j = \overline{1,N}, b^j = \sum_{p=1}^{r}\left[\frac{1}{m_p}\sum_{i=1}^{m_p}\left(x_{pi}^j - \bar{x}_p^j\right)^2\right], j = \overline{1,N}$$

Natijada:

$\varepsilon = (2{,}08; 0{,}8; 2{,}9; 0{,}2; 0{,}3; 0{,}5; 1{,}17; 0{,}8; 0{,}5; 0{,}46; 0{,}21; 1{,}44);$

$\bar{x}_1 = (4; 2; 2{,}5; 2; 5; 1; 1; 2; 2; 6; 2; 1{,}8333);$

$\bar{x}_2 = (3{,}8571; 2; 2{,}1428; 2; 5{,}2857; 1; 1{,}1428; 2{,}1428; 1{,}7143; 7; 2; 2{,}5714);$

$\bar{x}_3 = (2{,}5; 2{,}6667; 2{,}8333; 2; 3{,}8333; 1{,}1667; 1; 2{,}1667; 1{,}5; 5{,}5; 2; 1{,}6667);$

$\bar{x}_4 = (2{,}4; 2{,}4; 1{,}6; 1{,}8; 4{,}2; 1{,}4; 1{,}4; 1{,}8; 1{,}8; 4{,}8; 1{,}8; 3);$

$a = (8{,}80; 1{,}28; 3{,}34; 0{,}12; 5{,}50; 0{,}43; 0{,}43; 0{,}34; 0{,}51; 10{,}27; 0{,}12; 4{,}71),$

$b = (4{,}23; 1{,}59; 1{,}51; 0{,}56; 17{,}17; 0{,}78; 0{,}36; 0{,}42; 1{,}01; 22{,}15; 0{,}56; 3{,}28)$

qiymatlarga ega bo‘linadi.

Masala №2. Informativ belgilar majmuasini tanlash masalasi. Bunda $\ell = \overline{1,N}$ gacha bo‘lgan qiymatlar uchun (4) optimizatsiya masalasi yechilsin. Ushbu masalani to‘la tanlov usuli bilan yechish taklif etiladi.

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Faraz qilaylik $\ell = 1$ bo‘lsin. Bu holat uchun optimal natija $\lambda = (0,0,1,0 \ \dots,0)$ qiymatda erishadi. Bunda Fisher funsionalining qiymati $I(\lambda) = 2{,}21$ ga teng bo‘ladi. Endi $\ell = 2$ bo‘lsin, u holda $\lambda = (1,0,1,0 \ \dots,0)$ qiymatga erishadi. Bunda Fisher funsionalining qiymati $I(\lambda) = 2{,}11$ ga teng bo‘ladi va hokazo. Natijalarni quyidagi jadvalda aks ettiramiz.

1-jadval

ℓ	Informativ belgilar majmuasi	$I(\lambda)$ *funksional qiymati*
1	x^3	2,21
2	x^1, x^3	2,11
3	x^1, x^3, x^{12}	1,87
4	x^1, x^3, x^7, x^{12}	1,84
5	$x^1, x^3, x^7, x^8, x^{12}$	1,80
6	$x^1, x^2, x^3, x^7, x^8, x^{12}$	1,66
7	$x^1, x^2, x^3, x^6, x^7, x^8, x^{12}$	1,59
8	$x^1, x^2, x^3, x^6, x^7, x^8, x^9, x^{12}$	1,50
9	$x^1, x^2, x^3, x^6, x^7, x^8, x^9, x^{10}, x^{12}$	0,85
10	$x^1, x^2, x^3, x^5, x^6, x^7, x^8, x^9, x^{10}, x^{12}$	0,68
11	$x^1, x^2, x^3, x^4, x^5, x^6, x^7, x^8, x^9, x^{10}, x^{12}$	0,67
12	$x^1, x^2, x^3, x^4, x^5, x^6, x^7, x^8, x^9, x^{10}, x^{11}, x^{12}$	0,67

Ushbu to‘rtala sinflarning bir biridan farqlarini ko‘rsatuvchi belgilar majmuasi aniqlangan.

2. Informativ belgilar fazosida ε bo‘saqaviy qiymat va yaqinlik funksiyasi asosida ob’yektlarning muhimlik darajasini aniqlash

Fisher funsionali $I(\lambda_p)$ elementlari N – o‘lchovli belgilar fazosida $a = (a^1, a^2, \dots, a^N)$, $b_p = (b_p^1, b_p^2, \dots, b_p^N)$ vektorlar ko‘rinishida berilgan, komponentalari (3) formula asosida hisoblangan hamda informativ belgilar majmuasi (1) orqali ifodalangan bo‘lsin.

Berilgan $a = (a^1, a^2, \dots, a^N)$ informativ belgilar fazosida deyiladi, agarda $\lambda_p a = (\lambda_p^1 a^1, \lambda_p^2 a^2, \dots, \lambda_p^N a^N)$, $\lambda_p \in \Lambda^{\ell_p}$ amal o‘rinli bo‘lsa.

Informativ belgilar fazosida bo‘sag‘aviy vektor $\lambda_p \varepsilon = (\lambda_p^1 \varepsilon^1, \lambda_p^2 \varepsilon^2, \dots, \lambda_p^N \varepsilon^N)$, $\lambda_p \in \Lambda^{\ell_p}$ ko‘rinishda bo‘lib, komponentalarining qiymatlari quyidagicha aniqlansin:

$$\varepsilon_i^j = \begin{cases} \frac{a_i^j}{b^j}, agar\ \lambda_p^j = 1\ bo‘lsa, \\ 0, agar\ \lambda_p^j = 0\ bo‘lsa. \end{cases} \qquad (6)$$

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Shuningdek, bo‘sag‘aviy qiymat vektori komponentalaridan foydalangan holda X_p sinfning ikkita obektlari $x_{pi}\, va\, \bar{x}_p$ orasidagi yaqinlik funksiyasi $\rho_{pi}^{j}(x_{pi}, \bar{x}_p)$ ni ℓ_p ta $(\ell_p \ll N), \lambda_p$ informativ belgilar fazosida quyidagicha kiritib olinadi:

$$\rho_{pi}^{j}(x_{pi}, \bar{x}_p, \lambda_p) = \begin{cases} 1 \text{ agar } |\lambda_p^j(x_{pi}^j - \bar{x}_p^j)| < \varepsilon^j, j = \overline{1,N}. \\ 0 \text{ aks holda } |\lambda_p^j(x_{pi}^j - \bar{x}_p^j)| \geq \varepsilon^j, j = \overline{1,N}. \end{cases} \quad (7)$$

Birinchi shart ikkita obektlar orasidagi o‘xshashlik darajasini bildirsa, ikkinchi shart esa ularning bir-biridan farqi kattaligini bildiradi, ya’ni bu komponentalar bir-biriga o‘xshash emasligini bildiradi. [1; 35-43 b, 4; 40-45 b, 5; 119 b, 7; 43-77 b, 8; 319-322 b].

Informativ belgilar fazosida i –obektlarning X_p sinfni shakllanishiga qo‘shgan hissasini baholash. Quyida $x_{pi} \in X_p, i - o$bektning $p -$ sinfni shakllantirishga informativ belgilar fazosida qo‘shgan hissasini baholash formulasi keltirilgan

$\Gamma_i(x_{pi}, \bar{x}_{pk}, \lambda_p) = \sum_{i=1}^{m_p} \sum_{j=1}^{N} \rho_{pi}^{j}(x_{pi}, \bar{x}_p, \lambda_p), i = \overline{1, m_p};\ k = \overline{1, m_p};\ i \neq k$ (8) Ishlab chiqilgan bo‘sag‘aviy qiymat algoritmi va yaqinlik funksiyalarini amalda qo‘llash masalasi ko‘rib chiqiladi.

Masala №3. Informativ belgilar fazosi (1) da, olingan natijalar jadvaliga ko‘ra $x_{pi} \in X_{\text{p}}, i$ – obektning p – sinfni shakllantirishga qo‘shgan hissasini hisoblang.

Faraz qilaylik $\ell = 1$ bo‘lsin, u holda $\lambda = (0{,}0{,}1{,}0\ \ldots{,}0)$ va $I(\lambda) = 2{,}21$ ga teng bo‘ladi. Xuddi shuningdek $\lambda\varepsilon = (0{,}0, \varepsilon^3, 0\ \ldots{,}0)$ teng bo‘ladi. Endi ε^3 bo‘sag‘aviy qiymat uchun masala №3 ni echamiz.

Dastlab, X_1 sinf obektlarini baholaymiz. Bunda o‘rtacha obekt quyidagicha aniqlangan edi $\lambda\bar{x}_1 = (0; 0; 2{,}5; 0; 0; 0; 0; 0; 0; 0; 0; 0)$.

Formula (7) asosida $\rho(x_{pi,}\bar{x}_p, \lambda)\ ning\ qiymatlari\ p = 1, i = \overline{1{,}6}$ lar uchun hisoblanadi. Bunda $\rho(x_{11,}\bar{x}_1, \lambda) = 1$ ga, chunki $|2 - 2{,}5| < 2{,}21$ va hokazo.

$$\rho(x_{12,}\bar{x}_1, \lambda) = 1, \ldots, \rho(x_{16,}\bar{x}_1, \lambda) = 1.$$

Xuddi shuningdek, X_2, X_3, X_4 sinf obektlari quyidagicha baholanadi:

$$\lambda\bar{x}_2 = (0; 0; 2{,}14; 0; 0; 0; 0; 0; 0; 0; 0; 0): \rho(x_{21,}\bar{x}_2, \lambda) = 1,$$

$$\rho(x_{22,}\bar{x}_2, \lambda) = 1, \ldots, \rho(x_{27,}\bar{x}_2, \lambda) = 1;$$

$$\lambda\bar{x}_3 = (0; 0; 2{,}83; 0; 0; 0; 0; 0; 0; 0; 0; 0): \rho(x_{31,}\bar{x}_3, \lambda) = 1,$$

$$\rho(x_{32,}\bar{x}_3, \lambda) = 1, \ldots, \rho(x_{36,}\bar{x}_3, \lambda) = 1;$$

$$\lambda\bar{x}_4 = (0; 0; 1{,}6; 0; 0; 0; 0; 0; 0; 0; 0; 0): \rho(x_{41,}\bar{x}_4, \lambda) = 1,$$

$$\rho(x_{42,}\bar{x}_4, \lambda) = 1, \ldots, \rho(x_{45,}\bar{x}_4, \lambda) = 1.$$

Agar bizga yuqorida bayon etilgan 4 ta sinf ob’yektlari tadqiq etilayotgan bo‘lsa, u holda sinflarning muhimlik darajalari quyidagi algoritmga asosan hisoblanadi:

1 – qadam. Algoritmga ko‘ra har bir sinfning o‘rtacha obekti $\bar{x}_p = \frac{1}{m_p}\sum_{i=1}^{m_p} x_{pi}, p = \overline{1,r}$ ko‘ra topiladi. O‘rtacha obektning parametrlari quyidagi formula asosida hisoblanadi, $\bar{x}_p^j = \frac{1}{m_p}\sum_{i=1}^{m_p} \mathrm{x}_{pi}^j, p = \overline{1{,}4}$, bu formulaga asosan o‘rtacha obektlar quyidagicha bo‘ladi:

$$\bar{x}_1^1 = \frac{1}{6}\sum_{j=1}^{6} \mathrm{x}_{1j}^1 = \frac{1}{6}(3 + 3 + 3 + 5 + 5 + 5) = 4\,; \bar{x}_1^1 = 4;$$

$$\bar{x}_1^2 = \frac{1}{6}\sum_{j=1}^{6} \mathrm{x}_{1j}^2 = \frac{1}{6}(2 + 2 + 2 + 2 + 2 + 2) = 2\,; \bar{x}_1^2 = 2;$$

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$\bar{x}_1^3 = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^3 = \frac{1}{6}(2+2+2+3+3+3) = 2{,}5\,; \bar{x}_1^3 = 2{,}5;$

$\bar{x}_1^4 = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^4 = \frac{1}{6}(2+2+2+2+2+2) = 2\,; \bar{x}_1^4 = 2;$

$\bar{x}_1^5 = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^5 = \frac{1}{6}(4+2+3+7+7+7) = 5\,; \bar{x}_1^5 = 5;$

$\bar{x}_1^6 = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^6 = \frac{1}{6}(1+1+1+1+1+1) = 1\,; \bar{x}_1^6 = 1;$

$\bar{x}_1^7 = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^7 = \frac{1}{6}(1+1+1+1+1+1) = 1\,; \bar{x}_1^7 = 1;$

$\bar{x}_1^8 = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^8 = \frac{1}{6}(2+2+2+2+2+2) = 2\,; \bar{x}_1^8 = 2;$

$\bar{x}_1^{10} = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^{10} = \frac{1}{6}(5+8+8+5+5+5) = 6\,; \bar{x}_1^{10} = 6;$

$\bar{x}_1^{11} = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^{11} = \frac{1}{6}(2+2+2+2+2+2) = 2\,; \bar{x}_1^{11} = 2;$

$\bar{x}_1^{12} = \frac{1}{6}\sum_{j=1}^{6} x_{1j}^{12} = \frac{1}{6}(2+2+2+2+1+2) = 2\,; \bar{x}_1^{12} = 2;$

$\bar{x}_1 = (4; 2; 2{,}5; 2; 5; 1; 1; 2; 2; 6; 2; 1{,}8333).$

Shuningdek, ikkinchi, uchinchi va to‘rtinchi sinflar o‘rta obektlari hisoblanadi va uning qiymatlari quyidagicha bo‘ladi:

$\bar{x}_2 = (3{,}8571; 2; 2{,}1428; 2; 5{,}2857; 1; 1{,}1428; 2{,}1428; 1{,}7143; 7; 2; 2{,}5714);$

$\bar{x}_3 = (2{,}5; 2{,}6667; 2{,}8333; 2; 3{,}8333; 1{,}1667; 1; 2{,}1667; 1{,}5; 5{,}5; 2; 1{,}6667);$

$\bar{x}_4 = (2{,}4; 2{,}4; 1{,}6; 1{,}8; 4{,}2; 1{,}4; 1{,}4; 1{,}8; 1{,}8; 4{,}8; 1{,}8; 3);$

2-qadam. Bu yerda Fisher funsionali, $a = (a^1, a^2, \dots, a^N)$, $b = (b_p^1, b_p^2, \dots, b_p^N)$ vektorlari komponentalarining qiymatlarini (2.2.1) formulaga asosan hisoblaymiz:

$a^1 = (x_1^1 - \bar{x}_1^1)^2 = (3-4)^2 = 1;\ a^2 = (x_1^2 - \bar{x}_1^2)^2 = (2-2)^2 = 0;$

$a^3 = (x_1^3 - \bar{x}_1^3)^2 = (2-2{,}5)^2 = 0{,}25;\ a^4 = (x_1^4 - \bar{x}_1^4)^2 = (2-2)^2 = 0;$

$a^5 = (x_1^5 - \bar{x}_1^5)^2 = (4-5)^2 = 1;\ a^6 = (x_1^6 - \bar{x}_1^6)^2 = (1-1)^2 = 0;$

$a^7 = (x_1^7 - \bar{x}_1^7)^2 = (1-1)^2 = 0;\ a^8 = (x_1^8 - \bar{x}_1^8)^2 = (2-2)^2 = 0;$

$a^9 = (x_1^9 - \bar{x}_1^9)^2 = (2-2)^2 = 0;\ a^{10} = (x_1^{10} - \bar{x}_1^{10})^2 = (5-6)^2 = 1;$

$a^{11} = (x_1^{11} - \bar{x}_1^{11})^2 = (2-2)^2 = 0;\ a^{12} = (2-1{,}8333)^2 = 0{,}0278.$

Shunday qilib a vektori komponentalari orqali quyidagicha ifodalanadi:

$$a = \begin{pmatrix} 1\ 0\ 0{,}25\ 0\ 1\ 0\ 0\ 0\ 0\ 1\ 0\ 0{,}0278 \\ 1\ 0\ 0{,}25\ 0\ 9\ 0\ 0\ 0\ 0\ 4\ 0\ 0{,}0278 \\ 1\ 0\ 0{,}25\ 0\ 4\ 0\ 0\ 0\ 0\ 4\ 0\ 0{,}0278 \\ 1\ 0\ 0{,}25\ 0\ 4\ 0\ 0\ 0\ 0\ 1\ 0\ 0{,}0278 \\ 1\ 0\ 0{,}25\ 0\ 4\ 0\ 0\ 0\ 0\ 1\ 0\ 0{,}0278 \\ 1\ 0\ 0{,}25\ 0\ 4\ 0\ 0\ 0\ 0\ 1\ 0\ 0{,}0278 \end{pmatrix}$$

Bu kelib chiqqan jadvaldan ustunlari 0 bo‘lgan parametlarni o‘chirib tashlasak, a vektori quyidagi komponentalarga ega bo‘ladi:

$$a = \begin{pmatrix} 1\ 0{,}25\ 1\ 1\ 0{,}0278 \\ 1\ 0{,}25\ 9\ 4\ 0{,}0278 \\ 1\ 0{,}25\ 4\ 4\ 0{,}0278 \\ 1\ 0{,}25\ 4\ 1\ 0{,}0278 \\ 1\ 0{,}25\ 4\ 1\ 0{,}0278 \\ 1\ 0{,}25\ 4\ 1\ 0{,}0278 \end{pmatrix}$$

b vektori komponentalari ham hisoblanib komponentalari quyidagi qiymatlarni qabul qiladi:

$b = (1; 0{,}25; 4{,}3333; 2; 0{,}1389).$

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3-qadam. Aniqlangan ikkita vektor komponentalari asosida bo‘sag‘aviy vektor komponentalari (2.12) formula asosida quyidagicha aniqlanadi:

$\varepsilon_i = (\varepsilon_i^1, \varepsilon_i^2, \dots, \varepsilon_i^N) : i = \overline{1,6}.$ $\varepsilon_1 = (1; 1; 0{,}23; 0{,}5; 0{,}2);$

$\varepsilon_2 = (1; 1; 2{,}08; 2; 0{,}2);$

$\varepsilon_3 = (1; 1; 0{,}92; 2; 0{,}2);$ $\varepsilon_4 = (1; 1; 0{,}92; 0{,}5; 0{,}2);$ $\varepsilon_5 = (1; 1; 0{,}92; 0{,}5; 5);$

$\varepsilon_6 = (1; 1; 0{,}92; 0{,}5; 0{,}2);$

4-qadam. Aniqlangan birinchi sinf o‘rta obekti va bo‘sag‘aviy vektor asosida (2.13) formuladan foydalanib o‘rta obekt va boshqa obektlar orasidagi yaqinlik vektori aniqlanadi:

*Eslatma:*1-sinfning bir xil elementlarga ega bo‘lgan ustunlarining yaqinlik vektori aniqlanmaydi, ularga nisbatan bo‘sag‘aviy vektorlari komponentlari mavjud emas. Bu ustunlar 2,4,6,7,8,9,1

$x_{11} = (3; 2; 4; 5; 2), \bar{x}_1 = (4; 2{,}5; 5; 6; 1{,}8333);$ $\varepsilon_1 = (1; 1; 0{,}23; 0{,}5; 0{,}2),$ $\rho(x_{11}; \bar{x}_1) = (0; 1; 0; 0; 1), \sum \rho(x_{11}; \bar{x}_1) = 2.$

$x_{12} = (3; 2; 2; 8; 2), \bar{x}_1 = (4; 2{,}5; 5; 6; 1{,}8333);$ $\varepsilon_2 = (1; 1; 2{,}08; 2; 0{,}2),$ $\rho(x_{12}; \bar{x}_1) = (0; 1; 0; 0; 1), \sum \rho(x_{12}; \bar{x}_1) = 2.$

$x_{13} = (3; 2; 3; 8; 2), \bar{x}_1 = (4; 2{,}5; 5; 6; 1{,}8333);$

$\varepsilon_3 = (1; 1; 0{,}92; 2; 0{,}2), \rho(x_{13}; \bar{x}_1) = (0; 1; 0; 0; 1), \sum \rho(x_{13}; \bar{x}_1) = 2.$

$x_{14} = (5; 3; 7; 5; 2), \bar{x}_1 = (4; 2{,}5; 5; 6; 1{,}8333);$

$\varepsilon_4 = (1; 1; 0{,}92; 0{,}5; 0{,}2), \rho(x_{14}; \bar{x}_1) = (0; 1; 0; 0; 1), \sum \rho(x_{14}; \bar{x}_1) = 2.$

$x_{15} = (5; 3; 7; 5; 1), \bar{x}_1 = (4; 2{,}5; 5; 6; 1{,}8333);$

$\varepsilon_5 = (1; 1; 0{,}92; 0{,}5; 5), \rho(x_{15}; \bar{x}_1) = (0; 1; 0; 0; 1), \sum \rho(x_{15}; \bar{x}_1) = 2.$

$x_{16} = (5; 3; 7; 5; 2), \bar{x}_1 = (4; 2{,}5; 5; 6; 1{,}8333);$

$\varepsilon_6 = (1; 1; 0{,}92; 0{,}5; 0{,}2), \rho(x_{16}; \bar{x}_1) = (0; 1; 0; 0; 1), \sum \rho(x_{16}; \bar{x}_1) = 2.$

5-qadam. Bo‘sag‘aviy vektor komponentalari (2.12) formula asosida X_2 sinf obektlari uchun aniqlanadi:

$\varepsilon_i = (\varepsilon_i^1, \varepsilon_i^2, \dots, \varepsilon_i^N) : i = \overline{1,7};$

$\varepsilon_1 = (3{,}4; 0{,}17; 0{,}39; 0{,}17; 0{,}17; 0{,}4; 2{,}24; 0{,}13);$

$\varepsilon_2 = (1{,}9; 0{,}17; 2{,}57; 0{,}17; 0{,}17; 0{,}4; 0; 0{,}13);$

$\varepsilon_3 = (0{,}3; 0{,}17; 1{,}24; 0{,}17; 6; 0{,}4; 0{,}14; 1{,}78);$

$\varepsilon_4 = (0{,}3; 0{,}17; 0{,}7; 0{,}17; 0{,}17; 2{,}5; 1{,}26; 1{,}47);$

$\varepsilon_5 = (0{,}54; 0{,}17; 0{,}7; 0{,}17; 0{,}17; 2{,}5; 2{,}24; 1{,}47);$

$\varepsilon_6 = (0{,}54; 0{,}17; 0{,}7; 6; 0{,}17; 0{,}4; 0{,}56; 0{,}23);$

$\varepsilon_7 = (0{,}008; 6; 0{,}7; 0{,}17; 0{,}17; 0{,}4; 0{,}56; 1{,}78);$

X_3 sinf obektlari uchun:

$\varepsilon_i = (\varepsilon_i^1, \varepsilon_i^2, \dots, \varepsilon_i^N) : i = \overline{1,6};$

$\varepsilon_1 = (0{,}43; 0{,}2; 5; 0{,}28; 0{,}2; 0{,}2; 1; 1{,}19; 0{,}8);$

$\varepsilon_2 = (0{,}43; 0{,}8; 0{,}2; 0{,}01; 5; 0{,}2; 1; 0{,}43; 0{,}2);$

$\varepsilon_3 = (0{,}43; 0{,}8; 0{,}2; 0{,}01; 5; 0{,}2; 1; 0{,}43; 0{,}2);$

$\varepsilon_4 = (0{,}43; 3{,}2; 0{,}2; 3{,}25; 0{,}2; 0{,}2; 1; 1{,}19; 0{,}8);$

$\varepsilon_5 = (0{,}43; 0{,}2; 0{,}2; 1{,}9; 0{,}2; 0{,}2; 1; 2{,}34; 0{,}2);$

$\varepsilon_6 = (3{,}86; 0{,}8; 0{,}2; 0{,}55; 0{,}2; 0{,}2; 1; 10{,}43; 3{,}2);$

X_4 sinf obektlari uchun:

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$\varepsilon_i = (\varepsilon_i^1, \varepsilon_i^2, \dots, \varepsilon_i^N) : i = \overline{1,5};$

$\varepsilon_1 = (1{,}5; 1{,}9; 0{,}56; 1{,}14; 1{,}66; 0{,}25; 0{,}67; 4; 1{,}14; 1{,}86; 1{,}14; 0{,}83);$

$\varepsilon_2 = (0{,}67; 0{,}15; 0{,}56; 1{,}14; 0{,}78; 0{,}25; 1{,}5; 0{,}25; 0{,}07; 1{,}01; 1{,}14; 0);$

$\varepsilon_3 = (0{,}67; 2{,}46; 0{,}25; 2{,}57; 0{,}1; 4; 1{,}5; 0{,}25; 2{,}57; 0{,}18; 2{,}57; 0);$

$\varepsilon_4 = (1{,}5; 0{,}15; 3{,}06; 0{,}07; 0{,}1; 0{,}25; 0{,}67; 0{,}25; 0{,}07; 1{,}32; 0{,}07; 3{,}3);$

$\varepsilon_5 = (0{,}67; 0{,}35; 0{,}56; 0{,}07; 2{,}34; 0{,}25; 0{,}67; 0{,}25; 1{,}14; 0{,}62; 0{,}07; 0{,}83);$

6-qadam. Shuningdek, X_2 sinfning obektlari uchun 4-qadamda bajarilgan hisoblashlar amalga oshiriladi va quyidagi natijaga ega bo‘lamiz:

$\rho(x_{21}, \bar{x}_2) = (1; 1; 0; 1; 1; 1; 0; 0), \sum \rho(x_{21}; \bar{x}_2) = 5;$

$\rho(x_{22}, \bar{x}_2) = (0; 1; 0; 1; 1; 1; 0; 0), \sum \rho(x_{22}; \bar{x}_2) = 4;$

$\rho(x_{23}, \bar{x}_2) = (0; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{23}; \bar{x}_2) = 5;$

$\rho(x_{24}, \bar{x}_2) = (0; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{24}; \bar{x}_2) = 5;$

$\rho(x_{25}, \bar{x}_2) = (0; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{25}; \bar{x}_2) = 5;$

$\rho(x_{26}, \bar{x}_2) = (0; 1; 0; 1; 1; 1; 0; 0), \sum \rho(x_{26}; \bar{x}_2) = 4;$

$\rho(x_{27}, \bar{x}_2) = (0; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{27}; \bar{x}_2) = 5;$

X_3 sinf obektlari uchun:

$\rho(x_{31}, \bar{x}_3) = (0; 0; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{31}; \bar{x}_3) = 5;$

$\rho(x_{32}, \bar{x}_3) = (0; 1; 1; 0; 1; 1; 1; 0; 0), \sum \rho(x_{32}; \bar{x}_3) = 5;$

$\rho(x_{33}, \bar{x}_3) = (0; 1; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{33}; \bar{x}_3) = 6;$

$\rho(x_{34}, \bar{x}_3) = (0; 1; 1; 1; 1; 1; 1; 0; 1), \sum \rho(x_{34}; \bar{x}_3) = 7;$

$\rho(x_{35}, \bar{x}_3) = (0; 0; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{35}; \bar{x}_3) = 5;$

$\rho(x_{36}, \bar{x}_3) = (1; 1; 1; 0; 1; 1; 1; 0; 1), \sum \rho(x_{36}; \bar{x}_3) = 7;$

X_4 sinf obektlari uchun esa:

$\rho(x_{41}, \bar{x}_4) = (1; 1; 0; 1; 0; 0; 1; 1; 1; 0; 1; 1), \sum \rho(x_{41}; \bar{x}_4) = 8;$

$\rho(x_{42}, \bar{x}_4) = (1; 0; 0; 1; 0; 0; 1; 1; 0; 0; 1; 0), \sum \rho(x_{42}; \bar{x}_4) = 5;$

$\rho(x_{43}, \bar{x}_4) = (1; 1; 0; 1; 0; 1; 1; 1; 1; 0; 1; 0), \sum \rho(x_{43}; \bar{x}_4) = 8;$

$\rho(x_{44}, \bar{x}_4) = (1; 0; 1; 0; 0; 0; 1; 1; 0; 0; 0; 1), \sum \rho(x_{44}; \bar{x}_4) = 5;$

$\rho(x_{45}, \bar{x}_4) = (1; 0; 0; 0; 0; 0; 1; 1; 1; 0; 0; 0), \sum \rho(x_{45}; \bar{x}_4) = 4;$

Demak, ikkala sinf uchun ham har bir obektning o‘z sinfi shakllanishiga qo‘shgan hissasi aniqlandi. Barcha obektlarning o‘z sinflariga qo‘shgan hissasi (2.3.3) formula asosida hisoblanadi. Shunday qilib

$$\Gamma(X_1) = \frac{1}{m_p}\sum_{i=1}^{m_p} \Gamma_i\left(x_{pi}, \bar{x}_{pk}, \lambda_r\right) = \frac{1}{6}\sum_{i=1}^{6} \rho(x_{1i}, \bar{x}_1) = 2.$$

$$\Gamma(X_2) = \frac{1}{m_p}\sum_{i=1}^{m_p} \Gamma_i\left(x_{pi}, \bar{x}_{pk}, \lambda_r\right) = \frac{1}{7}\sum_{i=1}^{7} \rho(x_{2i}, \bar{x}_2) = \frac{33}{7} = 4{,}7.$$

$$\Gamma(X_3) = \frac{1}{m_p}\sum_{i=1}^{m_p} \Gamma_i\left(x_{pi}, \bar{x}_{pk}, \lambda_r\right) = \frac{1}{6}\sum_{i=1}^{6} \rho(x_{3i}, \bar{x}_3) = \frac{35}{6} = 5{,}8.$$

$$\Gamma(X_4) = \frac{1}{m_p}\sum_{i=1}^{m_p} \Gamma_i\left(x_{pi}, \bar{x}_{pk}, \lambda_r\right) = \frac{1}{5}\sum_{i=1}^{5} \rho(x_{4i}, \bar{x}_4) = \frac{30}{5} = 6.$$

Hisoblangan qiymatlar barcha obektlarning o‘z sinflarining shakllanishiga qo‘shgan hissasi deb tushunish mumkin. Yoki sinflarning muhimlik darajasi deb ham tushuniladi. [9; DGU 14013,10; 68-73 b.]

Xulosa

Timsollarni tanib olish masalasida informativ belgilar fazosini qurish, ular bilan bohliq tushunchalar va ta'riflar, sinflashtirish, yaqinlik funksiyasi va Fisher mezonlaridan foydalangan holda quyidagi xulosa bandlari shakllantirildi:

Timsollarni tanib olishda o'quv tanlanmaga asoslangan informativ belgilar fazosini shakllantirish usul va algoritmi taklif etildi. Natija to'rtta sinf ob'yektlari kesimida tajriba sinovdan o'tkazildi;

Timsollarni asosiy masalasi – sinflashtirish, informativ belgilar fazosini shakllantirish, o'quv tanlanma ob'yekt va belgilarining muhimlik darajalarini aniqlash kabi masalalar chuqur tahlil etildi;

Fisher tipidagi mezon elementlarini aniqlashning matematik asosi bayon qilingan va uni hisoblash algoritmlari bayon etilgan;

Ma'lumotlarning intellektual tahlilida muhim bo'lgan belgilar majmuasini shakllantirish kabi masalalarning nazariyasi va ularni amalda yechish yo'llari bayon etilgan;

Timsollarni tanib olishning hal qiluvchi qoidalarini hisoblash, informativ belgilar fazosini qurish, yaqinlik funksiya qiymatlarini aniqlash nazariyalari bayon etilib va ularning amaldagi hisoblashlari keltirilgan;

Xuddi shuningdek timsollarni tanib olshda har xil ko'rinishda aniqlangan axborotlarga ishlov berishda foydalaniladigan baholarni hisoblash algoritmlarining amaliyoti keltirilgan hamda o'quv tanlanma ob'yektlar aro o'xshashlik funksiyasining yuqori va quyi chegaralari aniqlangan hamda ularni tasdiqlovchi tegishli lemma, xossa va faraz shakllantirilgan.

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