BOG'LIQSIZ TAJRIBALAR KETMA-KETLIGI. BERNULLI FORMULASI

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Annotatsiya: *Tajriba –bu natijasi uni o'tkazuvchi shaxsning ixtiyoriga bog'liq bo'lmagan sinovdan iborat. Biz qabul qilgan aksiomatikada tajriba qandaydir ehtimollar fazosidan iborat. Bir xil tajriba* n *marta ketma-ket o'tkazilayotgan bo'lsin va tajriba natijalari* N *ta elementar hodisalardan iborat bo'lsin. Umumiylikka zarar keltirmay, ularni* $0,1,\dots,N-1$ *sonlaridan iborat deyishimiz mumkin.*

Kalit so'zlar: *Tajriba, formula, Bernulli formulasi, fazo, metod.*

Elementar hodisalar fazosi bu holda diskret fazo bo'lib, ushbu ko'rinishga ega

$$\Omega = \{\omega: \omega = (\omega_1, \omega_2, \dots, \omega_n); \omega_k = 0,1,\dots,N-1; k = 1,2,\dots,n\}$$

$\omega = (\omega_1, \omega_2, \dots, \omega_n)$ elementar hodisa ω_k ni k-nomerli tajribada ω_k hodisa ro'y beradi deb talqin qilamiz.

Har bir $\omega \in \Omega$ elementar hodisaga

$$p(\omega) = p(\omega_1, \omega_2, \dots, \omega_n) = p_{\omega_1} p_{\omega_2} \dots p_{\omega_n} \qquad (1)$$

ehtimolni mos qo'yamiz, bu yerda manfiy bo'lmagan $p_0, p_1, \dots, p_{N-1}$sonlar quyidagi shartni qanoatlantirsin:

$$\sum_{i=0}^{N-1} p_i = 1 \qquad (2)$$

tenglik bilan berilgan $p(\omega)$ sonlar uchun $(\Omega, \mathcal{M}(\Omega))$o'lchovli fazoda ehtimol o'lchovini aniqlashi uchun $p(\omega) \geq 0$ bo'lganligi sababli $\sum_{\omega\in\Omega} p(\omega) = 1$ ekanligini ko'rsatish kifoya. Haqiqatan ham, (1),(2) tengliklarga ko'ra,

$$\sum_{\omega\in\Omega} p(\omega) = \sum_{\omega_1;\omega_2;\dots\omega_n=0}^{N} p(\omega_1, \omega_2, \dots, \omega_n) =$$

$$= \sum_{\omega_1;\omega_2;\dots\omega_n=0}^{N} p_{\omega_1} p_{\omega_2} \dots p_{\omega_n} = \prod_{i=1}^{n} \sum_{\omega_i=0}^{N-1} p_{\omega_i} = 1.$$

Demak, Ω fazo, uning barcha qism to'plamlaridan tashkil topgan $\mathcal{A}$ Sistema $\sigma - algebra$ va unda

$$P(A) = \sum_{\omega\in A} p(\omega) \qquad (3)$$

formula orqali kiritilgan ehtimol o'lchovi ehtimollik modelini aniqlaydi. tenglikdagi $p_i$sonlar alohida olingan (fiksirlangan) tajribada i-natijaning ro'y berish ehtimolidan iborat. Haqiqatan ham, agar $A_k(i) = \{\omega: \omega_k = i\}$ bo‘lsa, u holda (3) tenglikka ko‘ra

$$P(A_k(i)) = \sum_{\omega \epsilon A_k(i)} p(\omega_1, \omega_2, \dots \omega_k, \dots, \omega_n) =$$

$$= \sum_{\omega_1=0}^{N-1} \dots \sum_{\omega_{k-1}=0}^{N-1} \sum_{\omega_k=0}^{N-1} \sum_{\omega_{k+1}=0}^{N-1} \dots \sum_{\omega_n=0}^{N-1} p_{\omega_1} \dots p_{\omega_{k-1}} p_i p_{\omega_{k+1}} \dots p_{\omega_n} = p_i.$$

Faraz qilaylik, Ω_k k-tajribaning elementar hodisalar fazosi,$\mathcal{A}_k = \mathcal{M}(\Omega_k), P_k$ esa$(\Omega_k, \mathcal{A}_k)$o‘lchovli fazoda $p_0, p_1, \dots, p_{N-1}$ sonlar yordamida kiritilgan ehtimol o‘lchovi bo‘lsin. U holda $(\Omega_k, \mathcal{A}_k, P_k)$ ehtimollar fazosini k-tajribaning matematik modeli va $(\Omega_1, \mathcal{A}_1, P_1)$, $(\Omega_2, \mathcal{A}_2, P_2)$,….,$(\Omega_n, \mathcal{A}_n, P_n)$ ketma-ketlikni esa tajribalar ketma-ketligining modeli deb atash mumkin.

Takrorlanadigan sinovlardan har birining u yoki bu natijasining ehtimolligi boshqa sinovlarda qanday natijalar bo‘lganligiga bog‘liq bo‘lmasa, ularbog‘liqmas tajribalar ketma –ketligini hosil qiladi deyiladi.

Har bir sinashda A hodisaning ro‘y berish ehtimoli p $(0 < p < 1)$ o‘zgarmasga teng bo‘lgan n ta erkli sinovda hodisaning (qaysi tartibda bo‘lishidan qat’iy nazar) rosa k marta ro‘y berish ehtimolini $P_n(k)$ orqali belgilaymiz. Masalan, $P_5(3)$ 5 marta sinash o‘tkazilganda, A hodisaning 3 marta ro‘y berish va 2 marta ro‘y bermaslik ehtimolini bildiradi. $P_n(k)$ ehtimol quyidagi formula yordamida hisoblanadi:

$$P_n(k) = C_n^k p^k q^{n-k} \qquad (4)$$

yoki

$$P_n(k) = \frac{n!}{k!(n-k)!} p^k q^{n-k}.$$

Bu yerda $q = 1 - p$. (4) formulaga *Bernulli formulasi* deyiladi.

n marta sinashda A hodisaning: 1) kamida k_1 marta; 2) ko‘pi bilan k_1 gacha ro‘y berish; 3) k_1 bilan k_2 oralig‘ida ro‘y berish ehtimollari mos holda quyidagi formulalar bo‘yicha hisoblanadi:

1) $P_n(k \ge k_1) = P_n(k_1) + P_n(k_1 + 1) + \dots + P_n(n)$;

2) $P_n(k \le k_1) = P_n(0) + P_n(1) + \dots + P_n(k_1)$;

3) $P_n(k_1 \le k \le k_2) = P_n(k_1) + P_n(k_1 + 1) + \dots + P_n(k_2)$.

n ta tajriba seriyasida A hodisa ro‘y berishlarining ehtimoli eng katta bo‘lgan k_0 soni A hodisaning n ta tajribada ro‘y berishining eng ehtimolli soni deyiladi. Bu son

$$k_0 = [np - q] \qquad (5)$$

formula boʻyicha topiladi. Bu yerda $[x]$ simvol orqali x sonining butun qismi belgilangan. Uni topish uchun x sonining kasr qismi tashlab yuboriladi. Agar $[np-q]$ son butun boʻlsa, u holda eng ehtimolli son ikkita boʻladi, ya'ni k_0+1 son ham oʻsha $P_n(k_0)$ ehtimol bilan eng ehtimolli son boʻladi. Agar $[np-q]$ butun son boʻlmasa, u holda eng ehtimolli son bitta boʻladi va u (5) formula yordamida hisoblanadi.

1-misol. Bitta oʻq uzishda nishonga tegish ehtimoli $p=0,8$ ga teng. 10 ta oʻq uzishda nishonga 7 marta tegish ehtimolini toping.

Yechish. Bu yerda $n=10,\ k=7,\ p=0,8,\ q=0,2$ .Bernulli formulasi (1) ga koʻra:

$$P_{10}(7)=\frac{10!}{7!(10-7)!}\cdot(0,8)^2\cdot(0,2)^{10-7}=\frac{10!}{7!3!}\cdot(0,8)^7\cdot(0,2)^3=0,2.$$

2-misol. Talabaga fan boʻyicha mavzuning 80 % ini oʻzlashtirgan. Yakuniy nazorat variantlariga toʻrttadan savol kiritilgan. Agar talaba barcha savollarga toʻgʻri javob bersa unga 5 baho qoʻyiladi. Xuddi shunday agar talaba 3 ta savolga toʻgʻri javob bersa unga 4 baho, agar 2 ta savolga toʻgʻri javob bersa unga 3 baho, agar faqat bitta savolga toʻgʻri javob bersa yoki birorta ham savolga javob bera olmasa talabaga 2 baho qoʻyiladi. Talabaning yakuniy nazoratdan a'lo yaxshi, qoniqarli, qoniqarsiz baholar olish ehtimollarini toping hamda ularni taqqoslang.

Yechish. Talabaning bitta savolga javob berish ehtimoli $p=0,8$ ga teng. Talabaning oraliq nazoratdan olgan bahosidan iborat X tasodifiy miqdor 2,3,4,5 qiymatlarni qabul qiladi, mos ehtimollarni topishda Bernulli formulasidan foydalanamiz.

$$p_1=P(X=2)=C_4^1p^1q^3+C_4^0p^0q^4=4\cdot0,8^1\cdot0,2^3+1\cdot0,8^0\cdot0,2^4=0,0272;$$
$$p_2=P(X=3)=C_4^2p^2q^2=6\cdot0,8^2\cdot0,2^2=0,1536;$$
$$p_3=P(X=4)=C_4^3p^3q^1=4\cdot0,8^3\cdot0,2^1=0,4096;$$
$$p_4=P(X=5)=C_4^4p^4q^0=1\cdot0,8^4\cdot0,2^0=0,4096;$$

Shunday qilib talabaning yakuniy nazoratdan a'lo yoki yaxshi baho olish ehtimollari eng katta ekan.

3-misol. Ishchi ishlov berayotgan detallar orasida oʻrtacha 4% i nostandart boʻladi. Sinash uchun olingan 30 ta detaldan ikkitasi nostandart boʻlish ehtimolini toping. Qaralayotgan 30 ta detaldan iborat tanlanmada nostandart detallarning eng ehtimolli soni nechaga teng va uning ehtimoli qancha?

Yechish. Bu yerda tajriba 30 ta detalning har birini sifatini tekshirishdan iborat. A hodisa – nostandart detal chiqish hodisasi; uning ehtimoli $p=0,04$, u holda $q=0,96$. Bu yerdan Bernulli formulasi boʻyicha

$$P_{30}(2)=C_{30}^2\cdot(0,04)^2\cdot(0,96)^{28}\approx0,202$$

ni topamiz. Berilgan tanlanmadagi nostandart detallarning eng ehtimolli son (6.5) formula boʻyicha topiladi:

$$k_0 = [30 \cdot 0{,}04] = [1{,}2] = 1,$$

uning ehtimoli esa

$$P_{30}(1) = C_{30}^{1} \cdot 0{,}04^{1} \cdot (0{,}96)^{29} \approx 0{,}305.$$

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