

**BOG'LIQSIZ TAJRIBALAR KETMA-KETLIGI. BERNULLI
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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

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

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

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

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,

$$\begin{aligned} \sum_{\omega \in \Omega} p(\omega) &= \sum_{\omega_1; \omega_2; \dots; \omega_n=0}^N p(\omega_1, \omega_2, \dots, \omega_n) = \\ &= \sum_{\omega_1; \omega_2; \dots; \omega_n=0}^N p_{\omega_1} p_{\omega_2} \dots p_{\omega_n} = \prod_{i=1}^n \sum_{\omega_i=0}^{N-1} p_{\omega_i} = 1. \end{aligned}$$

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

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

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

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

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

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 $(\Omega_1, \mathcal{A}_1, P_1), (\Omega_2, \mathcal{A}_2, P_2), \dots, (\Omega_n, \mathcal{A}_n, P_n)$ 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, ular bog'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:

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

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:

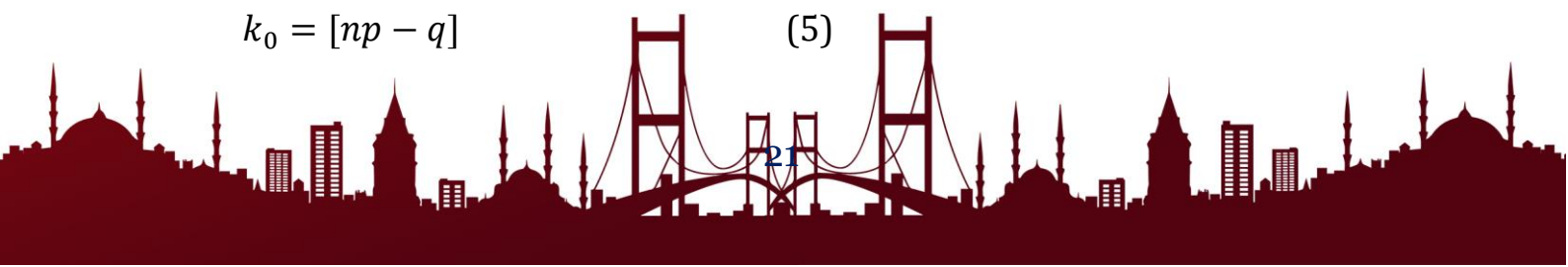
$$1) P_n(k \geq k_1) = P_n(k_1) + P_n(k_1 + 1) + \dots + P_n(n);$$

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

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

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

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



formula bo'yicha 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 bo'lsa, u holda eng ehtimolli son ikkita bo'ladi, ya'ni $k_0 + 1$ son ham o'sha $P_n(k_0)$ ehtimol bilan eng ehtimolli son bo'ladi. Agar $[np - q]$ butun son bo'lmasa, u holda eng ehtimolli son bitta bo'ladi va u (5) formula yordamida hisoblanadi.

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

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

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

2-misol. Talabaga fan bo'yicha mavzuning 80 % ini o'zlashtirgan. Yakuniy nazorat variantlariga to'rttadan savol kiritilgan. Agar talaba barcha savollarga to'g'ri javob bersa unga 5 baho qo'yiladi. Xuddi shunday agar talaba 3 ta savolga to'g'ri javob bersa unga 4 baho, agar 2 ta savolga to'g'ri javob bersa unga 3 baho, agar faqat bitta savolga to'g'ri javob bersa yoki birorta ham savolga javob bera olmasa talabaga 2 baho qo'yiladi. Talabani yakuniy nazoratdan a'lo yaxshi, qoniqarli, qoniqarsiz baholar olish ehtimollarini toping hamda ularni taqqoslang.

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

$$p_1 = P(X = 2) = C_4^1 p^1 q^3 + C_4^0 p^0 q^4 = 4 \cdot 0,8^1 \cdot 0,2^3 + 1 \cdot 0,8^0 \cdot 0,2^4 = 0,0272;$$

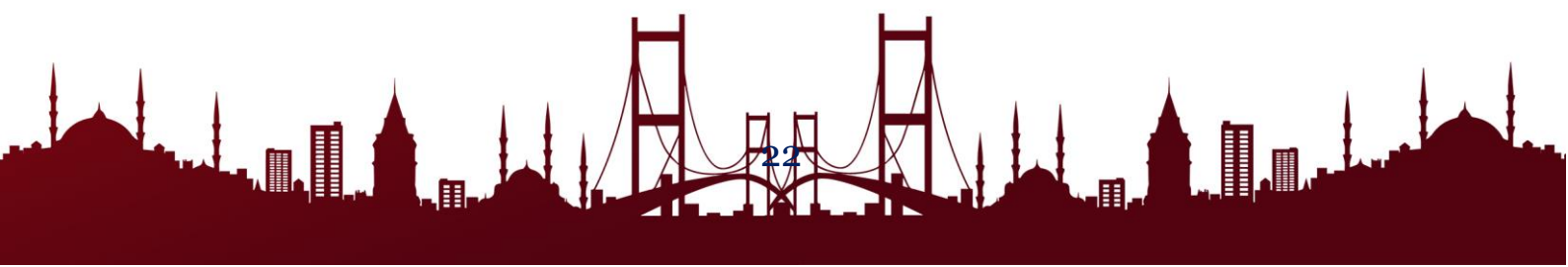
$$p_2 = P(X = 3) = C_4^2 p^2 q^2 = 6 \cdot 0,8^2 \cdot 0,2^2 = 0,1536;$$

$$p_3 = P(X = 4) = C_4^3 p^3 q^1 = 4 \cdot 0,8^3 \cdot 0,2^1 = 0,4096;$$

$$p_4 = P(X = 5) = C_4^4 p^4 q^0 = 1 \cdot 0,8^4 \cdot 0,2^0 = 0,4096;$$

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

3-misol. Ishchi ishlov berayotgan detallar orasida o'rtacha 4% i nostandart bo'ladi. Sinash uchun olingan 30 ta detaldan ikkitasi nostandart bo'lish 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 bo'yicha

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

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

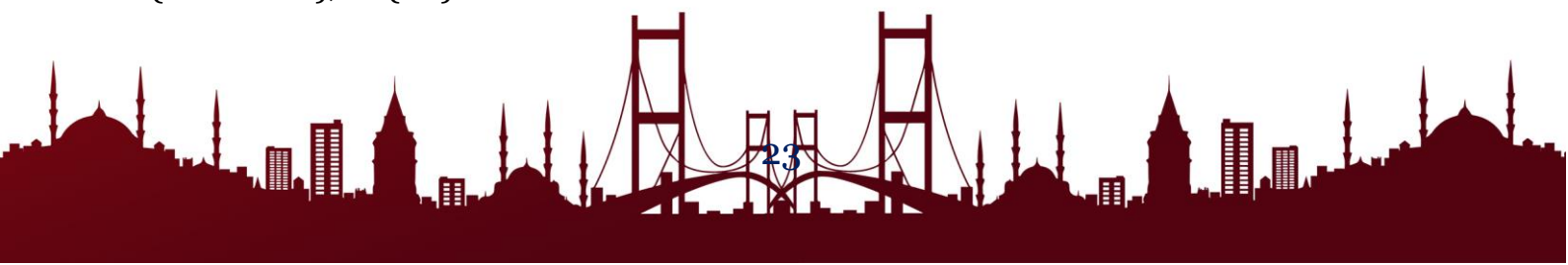
$$k_0 = [30 \cdot 0,04] = [1,2] = 1,$$

uning ehtimoli esa

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

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