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On another method for assessing effectiveness indicators of emergency response

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Abstract: This article examines the application of statistical hypothesis testing to the comparison of average fire and rescue unit performance indicators. To test the hypothesis presented in this article and determine the critical point with a specified accuracy, a Student's t-distribution table of critical points was used. The article analyzes how individual fire and rescue unit performance indicators changed over a certain period of time when changes were made to the organization of fire and rescue units, such as equipping units with new types of fire and rescue equipment, implementing preventive measures, in particular, monthly fire safety events, making changes to the organizational structure of units, etc. A method for determining whether performance indicators have changed positively or negatively is developed. This article examines the application of hypothesis testing to the comparison of average fire and rescue unit performance indicators.

Keywords: statistics, statistical hypothesis, critical point, table of critical points, critical region, t-statistics criterion, (criterion), service channels, absolute system throughput, relative system throughput, probability of system failure, Student's distribution, table of critical points, degree of freedom of the parameter

Favqulodda vaziyatlarni bartaraf etishning samaradorlik ko'rsatkichlarini baholashning yana bir usuli to'g'risida

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Annotatsiya: Ushbu maqolada yong'in - qutqaruv qismlari faoliyatini o'rtacha samaradorlik ko'rsatkichlarini taqqoslashga statistik gipotezalarni tekshirish nazariyasini tadbiriq keltirilgan. Mazkur maqolada keltirilgan gipotezani tekshirish, kritik nuqtani ma'lum bir aniqlik darajasida topish uchun Student taqsimotining kritik nuqtalar jadvalidan foydalanilgan. Maqolada, yong'in -qutqaruv qismlari ishini tashkil etishda biron o'zgarish kiritilgan xolda, masalan, qismlar yangi turdagi yong'in -qutqaruv texnikalari bilan ta'minlangan, ular tomonidan profilaktik tadbirlar, xususan, yong'in xafsizligi oyiligi tadbirlari o'tkazilgan, qismlarning tashkiliy - shtat birliklariga o'zgartirishlar kiritilgan va h.k. xolda ma'lum bir muddatdan so'ng yong'in - qutqaruv qismlari faoliyatining muayyan samaradorlik ko'rsatkichlari qanday o'zgarganligi taxlil qilingan. Samaradorlik ko'rsatkichlarning ijobiy yoki salbiy tomonga o'zgarganligini bilish usuli keltirilgan. Mazkur maqolada yong'in - qutqaruv qismlari ishining o'rtacha samaradorlik ko'rsatkichlarini solishtirishga gipotezani tekshirish usulini tadbiriq qilish keltirilgan.

Kalit so'zlar: statistika, statistik gipoteza, kritik nuqta, kritik nuqtalar jadvali, kritik soha, t statistika mezoni, xizmat ko'rsatish kanallari, tizimning absolyut o'tkazuvchanlik qobiliyati, tizimning nisbiy o'tkazuvchanlik qobiliyati, tizimning xizmat ko'rsatishni rad etish ehtimoli, Student taqsimoti, kritik nuqtalar jadvali, parametrlarning erklilik darajasi

1. Kirish

Statistika gipotezalarni tekshirish va uning xulosalarini amalyotga tadbiriq etish masalalari qator adabiyotlarda keltirilgan.[1-4]

Bir xil tipdagi masalalarni yechishda (xizmatlarni bajarishda) ko'p marotaba foydalaniladigan tizimlarni,

ommaviy xizmat ko'rsatish tizimi (OXKT) deb ataladi. Bunday tizimlarga YoQQ lar yaqqol misol bo'ladi. [2,3]

Xizmat qilish tartibi bo'yicha OXKT uchta sinfga ajratiladi:

Rad qilish joriy qilingan OXKT. Bunday tizimning barcha kanallari chaqiriqlarga xizmat ko'rsatish bilan band

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bo'lgan vaqtda tizimga yangi chaqiriq kelib tushsa, unga xizmat ko'rsatishni rad etadi.

Rad qilmaydigan OXKT. Bunday tizimning barcha kanallari chaqiriqlarga xizmat ko'rsatish bilan band bo'lgan vaqtda tizimga yangi chaqiriqlar kelib tushsa, ularga xizmat ko'rsatishni rad etmaydi. Kelib tushgan yangi chaqiriqlar kanallar bo'shshini kutadilar. Xizmat ko'rsatish uchun navbat joriy qilinadi.

Rad qilmaydigan- lekin navbatning uzunligi yoki kutish vaqti chegaralangan aralash tipdagi OXKT. Bunday tizimning barcha kanallari chaqiriqlarga xizmat ko'rsatish bilan band bo'lgan vaqtda tizimga yangi chaqiriqlar kelib tushsa, ularga xizmat ko'rsatishni rad etmaydi. Shu bilan birgalikda, navbat uzunligi yoki kutish vaqtiga cheklov qo'yiladi. Ushbu ko'rsatkichlar o'rnatilgan cheklovdan ortiganda tizim yangi chaqiriqqa xizmat ko'rsatishni rad etadi.

2. Tadqiqot metodologiyasi

Alohida olingan YoQQ faoliyatini tadqiq qilishda, ularni rad qilish joriy qilingan OXKT sifatida qarash lozim. Bunday qarash notabiiy ko'rinsada (chunki, YoQQ lar yong'in o'chirishni rad etmaydi!) yuqorida keltirilgan 1-3 sinflar ta'rifiga ko'ra aynan shundaydir. Chunki, qismning barcha jangavor bo'linmalari yong'in o'chirish bilan band bo'lgan vaqtda qismga yangi chaqiriq kelib tushsa, dispetcherlik xizmati unga kutib turishni, yoki navbatda turishni taklif qilmaydi. Yong'in o'chirish bilan band bo'lgan jangavor bo'linmalar o'chirayotgan yong'inni qoldirib, yangi yong'inni bartaraf etish uchun yo'lga chiqmaydilar. (Bunday vaziyatda, avvaldan belgilangan reja asosida chaqiriqqa xizmat ko'rsatish boshqa qismga yuklatiladi.) Aynan shu xolat qaralyotgan ushbu qism xizmat ko'rsatishni rad etishini (ilojsiz xolda, albatta) anglatadi.

Shu sababli, yong'in - qutqaruv qismining yong'inlarni bartaraf etishga chiqishi bilan bog'liq masalalarni yechishga OXKN ning «Rad qilish joriy qilingan OXKT» bo'limiga oid nazariyani qo'llash maqsadga muvofiqdir.

Odatda, rad qilish joriy qilingan OXKT ning samaradorligi ko'rsatkichlari sifatida quyidagilar qaraladi:

1) A — absolyut o'tkazuvchanlik qobiliyati - birlik vaqt ichida xizmat ko'rsatiladigan o'rtacha chaqiruvlar soni;

2) Q — nisbiy o'tkazuvchanlik qobiliyati - tizim tomonidan birlik vaqt ichida xizmat ko'rsatiladigan o'rtacha chaqiruvlar sonini oqim intensivligiga nisbati, ya'ni A/λ . Bu esa o'z navbatida OXKT ga kelib tushgan chaqiruvga xizmat ko'rsatilishi ehtimoliga teng;

3) R_{rad} — xizmat ko'rsatishni rad etish ehtimoli, ya'ni OXKT ga kelib tushgan chaqiruvning xizmat ko'rsatilmagan OXKT ni tark etishi ehtimoli.

Bunday samaradorlik ko'rsatkichlarini baholash ular asosida tegishli tavsiyalar ishlab chiqish muhim amaliy ahamiyatga ega.

3. Tadqiqot natijalari

Faraz qilaylik, YoQQ lar ishini tashkil etishda biron o'zgarish kiritilgan bo'lsin. Masalan, qismlar yangi turdagi yong'in -qutqaruv texnikalari bilan ta'minlangan, ular tomonidan profilaktik tadbirlar, xususan, yong'in xafsizligi oyligi tadbirlari o'tkazilgan, qismlarning tashkiliy- shtat birliklariga o'zgartirishlar kiritilgan va h.k. shular

jumlasidandir. Tabiiyki bu o'zgarishlar (ma'lum bir muddatdan so'ng) YoQQ lar faoliyatining muayyan samaradorlik ko'rsatkichiga qanday ta'sir etganligini (ijobiy yoki salbiy) bilish muhimdir. Mazkur maqolada YoQQ lar ishining o'rtacha samaradorlik ko'rsatkichlarini solishtirishga gipotezani tekshirish usulini tadbiiq qilish keltirilgan.

Faraz qilaylik, muayyan shaxarda k ta N_1, N_2, \dots, N_k YoQQ lar mavjud bo'lib, ularning har biri faoliyatiga umumiy yoki alohida o'zgarishlar kiritilgan bo'lsin. Soddalik uchun YoQQ lar soni $k=10$ bo'lgan xolni aniq raqamlar misolida ko'rib chiqamiz. (bunda hisob-kitoblar soddalashadi, masalaning mohiyatini tushunish osonlashadi). Ushbu YoQQ larning o'zgarishlar kiritilishidan avvalgi va keyingi samaradorlik ko'rsatkichlari to'g'risidagi ma'lumotlar quyidagi jadvalda keltirilgan bo'lsin.

Qismlar	N ₁	N ₂	N ₃	N ₄	N ₅	N ₆	N ₇	N ₈	N ₉	N ₁₀
O'zgarishdan avvalgi	12	14	8	11	13	16	9	10	12	15
O'zgarishdan keyingi	13	9	8	9	12	8	10	12	12	11

Ushbu belgilashlarni kiritamiz: μ_1 va μ_2 mos ravishda o'zgarishdan avvalgi va o'zgarishdan keyingi o'rtacha samaradorlik ko'rsatkichlari bo'lsin. Quyidagi gipotezalarni, masalan, $\alpha=0,05$ aniqlik darajasida tekshiramiz.

$H_0: \mu_1 = \mu_2$ (ijobiy natijaga erishilmagan)

$H_1: \mu_1 > \mu_2$ (ijobiy natijaga erishilgan)

Gipotezalarni tekshirish uchun quyidagi statistikaning qiymatini hisoblaymiz.

$$t_c = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{S_p^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$$

Bu yerda $n_1 = n_2 = 10$ va

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

Hisoblashlar natijasida quyidagilarga ega bo'lamiz:

$$\bar{x}_1 = (12 + 14 + 8 + 11 + 13 + 16 + 9 + 10 + 12 + 15)/10 = 12$$

$$\bar{x}_2 = (12 + 8 + 8 + 9 + 12 + 8 + 10 + 10 + 12 + 11)/10 = 10$$

$$(n_1 - 1)S_1^2 = (12 - 12)^2 + (14 - 12)^2 + (8 - 12)^2 + (11 - 12)^2 + (13 - 12)^2 + (16 - 12)^2 + (9 - 12)^2 + (10 - 12)^2 + (12 - 12)^2 + (15 - 12)^2 = 60$$



$$(n_2 - 1)S_2^2 = (12 - 10)^2 + (8 - 10)^2 + (8 - 10)^2 + (9 - 10)^2 + (12 - 10)^2 + (8 - 10)^2 + (10 - 10)^2 + (10 - 10)^2 + (12 - 10)^2 + (11 - 10)^2 = 26$$

$$\sqrt{S_p^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)} = \sqrt{\frac{60 + 26}{18} * \frac{1}{5}} = 0,98$$

Demak

$$t_c = \frac{(12 - 10)}{0,98} = 2,04$$

Student taqsimotining kritik nuqtalar jadvalidan kritik nuqta t_α ni topamiz. Bunda, Student taqsimotining kritik nuqtalar jadvalidan foydalanishda erklilik darajasi $df = n_1 + n_2 - 2$ tenglik bilan aniqlanishini inobatga olamiz. Bizning misolimizda $df = 18$. Kritik nuqta $t_\alpha = t(18, 0,05)$ ni Student taqsimotining kritik nuqtalar jadvalidan aniqlik darajasi $\alpha=0,05$ da topamiz. Jadvalga muvofiq kritik nuqta $t_\alpha = t(18, 0,05) = 1,734$ bo'lganligi uchun kritik soha $(1,734, \infty)$ interval bo'ladi. Statistikaning kuzatilgan qiymati $t_s = 2,04$ kritik soha $(1,734, \infty)$ tegishli ekan. Demak, mezonga muvofiq H_0 gipotezani rad etamiz, H_1 gipotezani qabul qilamiz [4].

4. Xulosa

Demak, qaralayotgan xolda yong'in -qutqaruv qismlarining o'rganilayotgan o'rtacha ko'rsatkichi kamaygan. Masalan, muayyan vaqt oralig'idagi yong'inlarning o'rta soni kamaygan, qismlarning yong'in-qutqaruv joyiga etib borishining o'rtacha vaqti yoki yong'inni o'chirishga sarflangan o'rtacha vaqt qisqargan, va h.k.. Bu esa kiritilgan o'zgarishlar o'zining ijobiy natijasini berganligini bildiradi. Ushbu natijadan YoQQ lari faoliyatiga tegishli o'zgarishlar kiritish yuzasidan tavsiyalar ishlab chiqishda foydalanish mumkin.

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