



HARORATNI BASHORAT QILISHNING VAQT SERIYALARI TAHLILI METODI

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Annotatsiya: Ushbu maqolada haroratni bashorat qilishning matematik usullari haqida so'z yuritiladi. Unda eng sodda va samarali yondashuvlardan biri — vaqt qatorlari (seriyalari) tahlili usuli tanlanadi. Mazkur usul asosida o'tkazilgan tajriba natijalari tahlil qilinib, prognoz ma'lumotlari keltiriladi. Tadqiqot davomida harorat o'zgarishlarini vaqt bo'yicha kuzatish orqali kelajakdagi qiymatlarni aniqlash imkoniyati o'rganiladi. Ushbu metod yordamida haroratni istalgan paytda yanada aniqroq prognoz qilish yo'llari yoritiladi va amaliy natijalar bilan mustahkamlanadi.

Kalit so'zlar: harorat, raqamli ob-havo bashorati, statistik usullar, vaqt seriyalari tahlili.

Ushbu maqolda ob-havoni prognoz qilishning vaqt seriyalari metodi bilan tanishamiz. [1] maqolada vaqt seriyalar tahlili bo'yicha tajriba natijalari keltirilgan. Biz ham shu metod bo'yicha tajriba o'tkazamiz. Ammo, [1] ishdan farqli o'laroq, biz prognoz funksiyasini boshqacha ko'rinishda izlaymiz.

Vaqt seriyalari tahlili: Bu metodda oldingi vaqt seriyalaridagi haroratlar haqidagi to'plangan axborat haqidagi to'plangan axborat yordamida biror-bir funksiya sinfidan bu axboratlarini eng yaxshi modellashtiradigan funksiya topiladi va bu funksiya orqali keyingi vaqt uchun prognoz beriladi.

Ushbu maqolada yuqoridagi 3-metodni qanday ishlashini bayon qilamiz.



Uning algoritmi quyadagicha:

1. Avval iloji boricha biror bir vaqt oralig'ida o'sha vaqtdagi aniq haroratlar ma'lumotlar to'plandi
2. Keyin esa bu funksiya yordamida modellashtiramiz;
3. Model funksiya yordamida bizga kerakli vaqt uchun haroratni aniqlaymiz.

Masalan ,o'tkazilgan tajribada quyidagicha natijalar olingan:

	Soat	Vaqt seriyasi hisobida t_i	Harorat (Selsiy)
1	00:00	$t_0 = 0$	14
2	01:00	$t_1 = 1$	14
3	02:00	$t_2 = 2$	13
4	03:00	$t_3 = 3$	13
5	04:00	$t_4 = 4$	12
6	05:00	$t_5 = 5$	12
7	06:00	$t_6 = 6$	11
8	07:00	$t_7 = 7$	11
9	08:00	$t_8 = 8$	14
10	09:00	$t_9 = 9$	16

1-jadval .Soat 00:00 dan 09:00gacha bo'lgan oralig'ida har soatdagi harorat ma'lumotlari.

Yuqoridagi jarayonni modellashtirishda har 24 soatda nisbatan bir-biriga yaqin haroratlar takrorlanishini inobatga olib , eng kichik musbat davri 24 ga teng bo'lgan davriy funksiyalarga murojat qilamiz,masalan:

$$T(t) = a \cdot \sin \frac{\pi t}{12} + b \cdot \cos \frac{\pi t}{12} + c + k \cdot \frac{\ln(t+1)}{t+1}.$$

Yuqoridagi $T(t)$ funksiyani “eng kichik kvadrat usuli” orqali topamiz,

Buning uchun quyidagi funksiyani qaraymiz:

$$S(a, b, c, k) = \sum_{i=0}^9 \left(a \cdot \sin \frac{\pi t_i}{12} + b \cdot \cos \frac{\pi t_i}{12} + c + k \cdot \frac{\ln(t_i + 1)}{t_i + 1} - T_i \right)^2$$



Bu a, b, c, k larga bog'liq $S(a, b, c, k)$ funksiyani minimumga erishtiruvchi a, b, c, k larni topamiz. Bu to'rt o'zgaruvchili funksiyaning hosila yordamida ekstremlarni topish masalasi orqali hal qilinadi. Bu usulni ishlab ko'rsatadigan bo'lsak:

$$S = \sum_{i=0}^9 \left(a \cdot \sin \frac{\pi t_i}{12} + b \cdot \cos \frac{\pi t_i}{12} + c + k \cdot \frac{\ln(t_i+1)}{t_i+1} - T_i \right)^2 = (b + c - 14)^2 +$$

$$(a \cdot \sin \frac{\pi}{12} + b \cdot \cos \frac{\pi}{12} + c + k \cdot \frac{\ln 2}{2} - 14)^2 + (a \cdot \sin \frac{2\pi}{12} + b \cdot \cos \frac{2\pi}{12} + c + k \cdot$$

$$\frac{\ln 3}{3} - 13)^2 + (a \cdot \sin \frac{3\pi}{12} + b \cdot \cos \frac{3\pi}{12} + c + k \cdot \frac{\ln 4}{4} - 13)^2 + (a \cdot \sin \frac{4\pi}{12} + b \cdot$$

$$\cos \frac{4\pi}{12} + c + k \cdot \frac{\ln 5}{5} - 12)^2 + (a \cdot \sin \frac{5\pi}{12} + b \cdot \cos \frac{5\pi}{12} + c + k \cdot \frac{\ln 6}{6} - 12)^2$$

$$+ (a \cdot \sin \frac{6\pi}{12} + b \cdot \cos \frac{6\pi}{12} + c + k \cdot \frac{\ln 7}{7} - 11)^2 + (a \cdot \sin \frac{7\pi}{12} + b \cdot \cos \frac{7\pi}{12} + c + k \cdot$$

$$\frac{\ln 8}{8} - 11)^2 + (a \cdot \sin \frac{8\pi}{12} + b \cdot \cos \frac{8\pi}{12} + c + k \cdot \frac{\ln 9}{9} - 14)^2 + (a \cdot \sin \frac{9\pi}{12} + b \cdot$$

$$\cos \frac{9\pi}{12} + c + k \cdot \frac{\ln 10}{10} - 16)^2.$$

Hosil bo'lgan misolimizni S_a, S_b, S_c va S_k larga nisbatan nolga tenglab hosilasini topamiz. Yani:

$$S'_a = 0$$

$$S'_b = 0$$

$$S'_c = 0$$

$$S'_k = 0$$

Funksiyalarni hisoblab a, b, c, k koefisientlarni hisoblaymiz.

Avvalam bor misolni tushinish uchun bosqichma bosqich ishlab ketamiz.

birinchi qiladigan ishimiz S'_a ga nisbatan hosila olib nolga tenglaymiz.

$$S'_a = \sum_{i=0}^9 \left(a \cdot \sin \frac{\pi t_i}{12} + b \cdot \cos \frac{\pi t_i}{12} + c + k \cdot \frac{\ln(t_i+1)}{t_i+1} - T_i \right)^2 = \sum_{i=0}^9 2 \left(a \sin \frac{\pi}{12} +$$

$$b \cos \frac{\pi}{12} + c + k \frac{\ln 2}{2} - 14 \right) \cdot \sin \frac{\pi}{12} + 2 \left(a \sin \frac{2\pi}{12} + b \cos \frac{2\pi}{12} + c + k \frac{\ln 3}{3} - 13 \right) \cdot$$

$$\sin \frac{2\pi}{12} + 2 \left(a \sin \frac{3\pi}{12} + b \cos \frac{3\pi}{12} + c + k \frac{\ln 4}{4} - 13 \right) \sin \frac{3\pi}{12} + 2 \left(a \sin \frac{4\pi}{12} + b \cos \frac{4\pi}{12} +$$

$$c + k \frac{\ln 5}{5} - 12 \right) \sin \frac{4\pi}{12} + 2 \left(a \sin \frac{5\pi}{12} + b \cos \frac{5\pi}{12} + c + k \frac{\ln 6}{6} - 12 \right) \sin \frac{5\pi}{12} +$$



$$2(a \sin \frac{6\pi}{12} + b \cos \frac{6\pi}{12} + c + k \frac{\ln 7}{7} - 11) \sin \frac{7\pi}{12} + 2(a \sin \frac{7\pi}{12} + b \cos \frac{7\pi}{12} + c + k \frac{\ln 8}{8} - 11) \sin \frac{7\pi}{12} + 2(a \sin \frac{8\pi}{12} + b \cos \frac{8\pi}{12} + c + k \frac{\ln 9}{9} - 14) \sin \frac{8\pi}{12} + 2(a \sin \frac{9\pi}{12} + b \cos \frac{9\pi}{12} + c + k \frac{\ln 10}{10} - 16) \sin \frac{9\pi}{12} = 0$$

$$2(0.25881a(0.25881a + 0.96592b + c + 0.34657k - 14) + 0.5(0.5a + 0.86602 + c + 0.3662k - 13) + 0.7071(0.7071a + 0.7071b + c + 0.34657k - 13) + 0.86602(0.86602a + 0.5b + c + 0.32188k - 12) + 0.96592(0.96592a - 0.25881b + c + 0.29862k - 12) + 0.25881(0.25881a - 0.96592b + c + 0.25993k - 11) + 0.86602(0.86602a - 0.5b + c + 0.24413k - 14) + 0.7071(0.7071a - 0.7071b + c + 0.23025k - 16)) = 0$$

$$0.6698a + 0.24999b - 0.25881c + 3.62334k - 6.25a + 0.43301b + 0.5c + 0.1831k - 6.5 + 0.5a + 0.5b + 0.7071c + 0.25859k - 12.29289 + 0.75a + 0.43301b + 0.86602c + 0.27876k - 10.3923 + 0.933a + 0.24999b + 0.96592c + 0.28844k - 11.5910 + a + c + 0.27798k - 11 + 0.933a - 0.24999b + 0.96693c + 0.25107k - 10.62512 + 0.47999a - 0.43301b + 0.86602c + 0.21424k - 12.1248a + 0.49999a + 0.7071c + 0.1628k - 11.3136 = 0$$

$$6.28578a + 0.68301b + 6.83107c + 1.72418k - 71.96253 = 0$$

Keying hisoblashimiz b koefisientga nisbatan hosila olib $S_b' = 0$ ga tenglab ishlaymiz.

$$S_b' = \sum_{i=0}^9 (a \cdot \sin \frac{\pi t_i}{12} + b \cdot \cos \frac{\pi t_i}{12} + c + k \cdot \frac{\ln(t_i+1)}{t_i+1} - T_i)^2 = \sum_{i=0}^9 2(b + c - 14) + 2(a \sin \frac{\pi}{12} + b \cos \frac{\pi}{12} + c + k \frac{\ln 2}{2} - 14) \cdot \cos \frac{\pi}{12} + 2(a \sin \frac{2\pi}{12} + b \cos \frac{2\pi}{12} + c + k \frac{\ln 3}{3} - 13) \cdot \cos \frac{2\pi}{12} + 2(a \sin \frac{3\pi}{12} + b \cos \frac{3\pi}{12} + c + k \frac{\ln 4}{4} - 13) \cos \frac{3\pi}{12}$$



$$\begin{aligned}
 &+2(a \sin \frac{4\pi}{12} + b \cos \frac{4\pi}{12} + c + k \frac{\ln 5}{5} - 12) \cos \frac{4\pi}{12} + 2(a \sin \frac{5\pi}{12} + b \cos \frac{5\pi}{12} + c + \\
 &k \frac{\ln 6}{6} - 12) \cos \frac{5\pi}{12} + 2(a \sin \frac{6\pi}{12} + b \cos \frac{6\pi}{12} + c + k \frac{\ln 7}{7} - 11) \cos \frac{6\pi}{12} + 2(a \sin \frac{7\pi}{12} + \\
 &b \cos \frac{7\pi}{12} + c + k \frac{\ln 8}{8} - 11) \cos \frac{7\pi}{12} + 2(a \sin \frac{8\pi}{12} + b \cos \frac{8\pi}{12} + c + k \frac{\ln 9}{9} - 14) \cos \frac{8\pi}{12} + \\
 &2(a \sin \frac{9\pi}{12} + b \cos \frac{9\pi}{12} + c + k \frac{\ln 10}{10} - 16) \cos \frac{9\pi}{10} = 0 \\
 &2(b + c - 14 + 0,96592(0,25881a + 0,96592b + c + 0,34657k - 14) + \\
 &0,86602(0,5a + 0,86602b + c + 0,3662k - 13) + 0,7071(0,7071a + \\
 &0,7071b + c + 0,34657k - 13) + 0,5(0,86602a + 0,5b + c + 0,32188k - \\
 &12) + 0,25881(0,96592a + 0,25881b + c + 0,29862k - 12) - \\
 &0,25881(0,96592a - 0,25881(0,96592a - 0,25881b + c + 0,25993k \\
 &11) - 0,5(0,86602a - 0,5b + c + 0,24413k - 14) - 0,7071(0,7071a - \\
 &0,7071b + c + 0,23025k - 16) = 0 \\
 &0,24999a + 0,933b + 0,96592c + 0,33475k - 13,52288 + 0,43301a + \\
 &0,75b + 0,86602c + 0,31713k - 11,25826 + 0,5a + 0,5b + 0,7071c + \\
 &0,24506k - 9,1923 - 0,43301a + 0,25b + 0,5c + 0,16094k - 6 + 0,24999a + \\
 &0,06698b + 0,25881c + 0,07728k - 3,10572 - 0,24999a + 0,06698b - \\
 &0,25881c - 0,06727k + 2,84691 - 0,43301a + 0,25b - 0,5c - 0,12206k + \\
 &7 - 0,49999a + 0,49999b - 0,7071c - 0,1628k + 11,3136 = 0 \\
 &0,68301a + 4,31695b - 0,83194c + 1,47855k - 35,91865 = 0.
 \end{aligned}$$

Endi esa c koefisientga nisbatan hosila olib $S_c = 0$ ga tenglab ko'p had ko'rinishiga keltiramiz.

$$\begin{aligned}
 S_c' = \sum_{i=0}^9 (a \cdot \sin \frac{\pi t_i}{12} + b \cdot \cos \frac{\pi t_i}{12} + c + k \cdot \frac{\ln(t_i+1)}{t_i+1} - T_i)^2 = \sum_{i=0}^9 2(b + c - 14) + \\
 2(a \sin \frac{\pi}{12} + b \cos \frac{\pi}{12} + c + k \frac{\ln 2}{2} - 14) + 2(a \sin \frac{2\pi}{12} + b \cos \frac{2\pi}{12} + c + k \frac{\ln 3}{3} - \\
 13) + 2(a \sin \frac{3\pi}{12} + b \cos \frac{3\pi}{12} + c + k \frac{\ln 4}{4} - 13) + 2(a \sin \frac{4\pi}{12} + b \cos \frac{4\pi}{12} + c + \\
 k \frac{\ln 5}{5} - 12) + 2(a \sin \frac{5\pi}{12} + b \cos \frac{5\pi}{12} + c + k \frac{\ln 6}{6} - 12) + 2(a \sin \frac{6\pi}{12} + b \cos \frac{6\pi}{12} +
 \end{aligned}$$



$$\begin{aligned}
 & c + k \frac{\ln 7}{7} - 11) + 2(a \sin \frac{7\pi}{12} + b \cos \frac{7\pi}{12} + c + k \frac{\ln 8}{8} - 11) \sin \frac{7\pi}{12} + 2(a \sin \frac{8\pi}{12} + \\
 & b \cos \frac{8\pi}{12} + c + k \frac{\ln 9}{9} - 14) + 2(a \sin \frac{9\pi}{12} + b \cos \frac{9\pi}{12} + c + k \frac{\ln 10}{10} - 16) = 0 \\
 & 2(b + c - 14 + 0,25881a + 0,96592b + c + 0,34657k - 14 + 0,5b + \\
 & 0,86602b + c + 0,3662k - 13 + 0,7071a + 0,7071b + c + 0,34657k - 13 + \\
 & 0,86602a + 0,5b + c + 0,32188k - 12 + 0,96592a + 0,25881b + c + \\
 & 0,29862k - 12 + a + c + 0,27798k - 11 + 0,96592a - 0,25881b + c + \\
 & 0,25993k - 11 \ 0,86602a - 0,5b + c + 0,24413k - 14 + 0,7071a - \\
 & 0,7071b + c + 0,23025) = 0 \\
 & 6,83689a + 2,83194b + 10c + 2,46188k - 125 = 0.
 \end{aligned}$$

Oxirgi k koefisientiga nisbatan hosila olib $S_k' = 0$ ifodani ko'pxad ko'rinishiga keltiramiz.

$$\begin{aligned}
 S_k' = \sum_{i=0}^9 \left(a \cdot \sin \frac{\pi t_i}{12} + b \cdot \cos \frac{\pi t_i}{12} + c + k \cdot \frac{\ln(t_i+1)}{t_i+1} - T_i \right)^2 &= \sum_{i=0}^9 2(a \sin \frac{\pi}{12} + \\
 b \cos \frac{\pi}{12} + c + k \frac{\ln 2}{2} - 14) \frac{\ln 2}{2} + 2(a \sin \frac{2\pi}{12} + b \cos \frac{2\pi}{12} + c + k \frac{\ln 3}{3} - 13) \frac{\ln 3}{3} \\
 + 2(a \sin \frac{3\pi}{12} + b \cos \frac{3\pi}{12} + c + k \frac{\ln 4}{4} - 13) \frac{\ln 4}{4} + 2(a \sin \frac{4\pi}{12} + b \cos \frac{4\pi}{12} + c + \\
 k \frac{\ln 5}{5} - 12) \frac{\ln 5}{5} + 2(a \sin \frac{5\pi}{12} + b \cos \frac{5\pi}{12} + c + k \frac{\ln 6}{6} - 11) \frac{\ln 6}{6} - 0,32188c + \\
 0,10361k - 3,86256 + 0,28844a + 0,07728b + 0,29862c + 0,08917k - \\
 3,58344 + 0,25107a - 0,06727b + 0,25993c + 0,6756k - 2,85923 + \\
 0,27798a + 0,27798c + 0,07727k - 3,05778 + 0,21142a - 0,12206b + \\
 0,24413c + 0,05959k - 3,41782 + 0,16280a - 0,1628b + 0,23025c + \\
 0,05301k - 3,684 = 0
 \end{aligned}$$

$$\begin{aligned}
 & 1,97143a + 0,75705b + 2,66213c + 0,813537k - 34,19282 = 0 \\
 & 6,28578a + 0,68301b + 6,83107c + 1,72418k = 71,96253 \\
 & 0,68301a + 4,31695b - 0,83194c + 1,47855k = 35,91865. \\
 & 6,83689a + 2,83194b + 10c + 2,46188k = 125. \\
 & 1,97143a + 0,75705b + 2,66213c + 0,813537k = 34,19282
 \end{aligned}$$

Xosil bo'lgan to'rt nomalumli tenglamani yechimlari



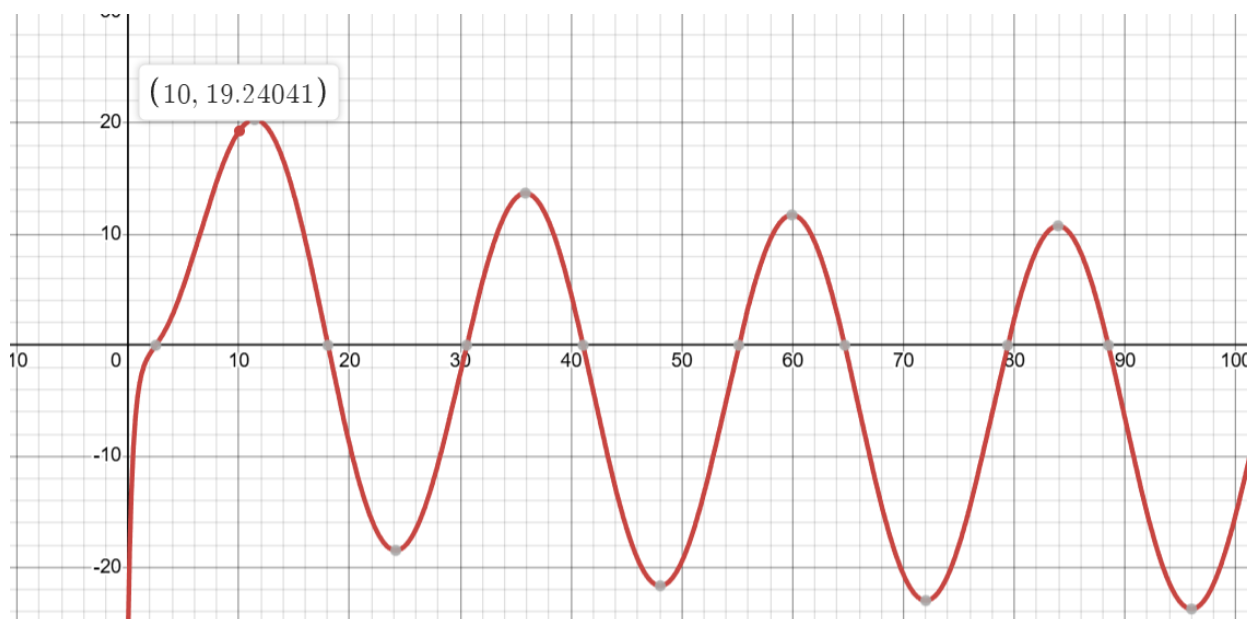
$$a = 0,082288 \quad b = -17,0796 \quad c = -9,71597 \quad k = 64,7912.$$

$$T(t) = a \cdot \sin \frac{\pi t}{12} + b \cdot \cos \frac{\pi t}{12} + c + k \cdot \frac{\ln(t+1)}{t+1}.$$

$$\begin{aligned} T &= 0,082288 \cdot \sin \frac{10\pi}{12} - 17,0796 \cdot \cos \frac{10\pi}{12} - 9,71597 + 64,7912 \cdot \frac{\ln 11}{11} \\ &= 0,082288 \cdot 0,5 + 17,0796 \cdot 0,86602 - 9,71597 + 64,7912 \\ &\quad \cdot 0,21799 = 0,041144 + 14,12386 - 9,71597 + 14,79136 \\ &= 19,24. \end{aligned}$$

Demak, ko‘rish mumkinki, soat 10:00 dagi vaqtdagi tempratura $T(10) \approx 19,24^\circ$ bo‘lar ekan.

Bu $T(t)$ funktsiya grafigini quyida ko‘rishimiz mumkin:



XULOSA VA TAKLIFLAR

Ushbu maqolada haroratni bashorat qilishning matematik usullaridan biri ko‘rsatib o‘tilgan bo‘lib, bu metod oxirgi tajribadan keying yaqin vaqt momentlarida aniqroq natija ko‘rsatishini yuqirdagi grafikdan ham ko‘rish mumkin. Keyingi tajribalarda yanada aniqroq natija olish uchun va keying vaqtlarni ham aniq prognoz qilish uchun eng mos prognoz funksiyasini topish va dastlabki o‘lshashlar sonini oshirish va o‘lchash oraliqlarini qisqartirish kerak.



Foydalanilgan adabiyotlar

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