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Development of a passenger flow forecasting model

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Abstract: Providing timely transportation services to passengers in cities is a very complex issue. Because the change in the volume of passenger traffic depends on many factors. In order to provide transportation services to existing passengers, it is necessary to know their volume in advance, after which it is possible to plan the type and number of vehicles in accordance with the existing volume. For this, it is necessary to develop and predict a forecasting model for determining what the volume of passengers will be in the future. This article is devoted to the development of a model for predicting the volume of passengers that can be transported by regular buses in Tashkent and, based on it, to predict the volume of passengers expected in the coming years. Studies conducted on the forecasting of passenger traffic in passenger transport were studied, a model for predicting the volume of passengers that can be transported by regular buses in Tashkent was developed, and on its basis the expected volume of passengers in the next 10 years was determined.

Keywords: Passenger flow, passenger volume, transport service, passenger transport, bus route, forecast

Yo'lovchilar oqimini bashorat qilish modelini ishlab chiqish

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Annotatsiya: Shaharlarda yo'lovchilarga o'z vaqtida transport xizmati ko'rsatish juda murakkab masala hisoblanadi. Chunki, yo'lovchilar oqimi hajmining o'zgarishi juda ko'p omillarga bog'liq bo'ladi. Mavjud yo'lovchilarga tashish bo'yicha transport xizmati ko'rsatish uchun ular miqdorini oldindan bilish talab etiladi, shundan so'ng transport vositalari turi va sonini mavjud miqdorga muvofiqlashtirishni rejalashtirish mumkin. Buning uchun esa, yo'lovchilar hajmini kelajakda qanday bo'lishini aniqlash bo'yicha bashorat modelini ishlab chiqish va bashorat qilish zarur bo'ladi. Mazkur maqola Toshkent shahridagi yo'nalishli avtobuslarda tashilishi mumkin bo'lgan yo'lovchilar hajmini bashorat qilish modelini ishlab chiqish va uning asosida keyingi yillarda kutiladigan yo'lovchilar hajmini bashorat qilishga bag'ishlanadi. Yo'lovchi transportida yo'lovchilar oqimini bashorat qilish bo'yicha olib borilgan tadqiqotlar o'rganlib, Toshkent shahridagi yo'nalishli avtobuslar tashilishi mumkin bo'lgan yo'lovchilar hajmini bashorat qilish modeli ishlab chiqilgan va uning asosida keyingi 10 yillikda kutiladigan yo'lovchilar hajmi aniqlangan.

Kalit so'zlar: Yo'lovchilar oqimi, yo'lovchilar hajmi, transport xizmati, yo'lovchi transporti, yo'nalishli avtobus, bashorat

1. Kirish

Yo'lovchilar oqimi juda ko'p omillar ta'sirida shakllanadigan kattalik bo'lganligi sababli, yo'lovchi transporti ishini tashkil etish juda murakkab hisoblanadi. Shu sababli, dunyo miqyosida, ayniqsa yirik shaharlarda yo'lovchi transporti ishini tashkil etish, kelajakda kutiladigan yo'lovchilar oqimini hisobga olgan holda harakat tarkibi turi va sonini rejalashtirish, ularga xavfsiz va ishonchli transport xizmati ko'rsatish masalalari muhim ahamiyat kasb etmoqda. AQSh, Singapur, Germaniya, Yaponiya, Janubiy Koreya kabi rivojlangan xorij mamlakatlarida yo'lovchi transportlari ishini tashkil etishning yangi ilmiy-texnikaviy yechimlarini ishlab chiqishga alohida e'tibor qaratilmoqda.

Mamlakatimizda ham yo'lovchi transportlari jozibadorligini oshirish, xizmatlar sifatini oshirishga alohida

e'tibor qaratilmoqda va mazkur masalalar yechimiga yo'naltirilgan ilmiy tadqiqot ishlari olib borilmoqda.

Tashiladigan yo'lovchilarning katta qismi shaharlarga to'g'ri keladi. Shaharlarda aholi zichligining yuqoriligi, ta'lim muassasalarining ko'pligi, kunlik kirib-chiquvchi aholi hajmining kattaligi va boshqa omillar yo'lovchilar oqimini keskin o'zgartirib yuborishi mumkin. Natijada, yo'lovchilar oqimiga transport vositalari sonining mos kelmasligi, ularni bo'sh yurishiga yoki (yo'lovchi bilan ortiqcha yuklangan) transport vositasi xizmatidan foydalana olmasdan yo'lovchilarni bekatda qolib ketishiga sabab bo'ladi. Toshkent shahri yirik shaharlar toifasiga kiradi. Yo'lovchilar oqimi hajmi yuqoriligi, o'zgaruvchanligi yo'lovchi transporti ishini tashkil etishda kelajakda mazkur ko'rsatkich qancha bo'lishini bilish zarur hisoblanadi. Buning uchun tashilishi mumkin bo'lgan yo'lovchilar hajmini kelajakda bashorat qilish bo'yicha tadqiqotlar olib

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borish zarur hisoblanadi. Mazkur muammolar yuzasidan ko'plab tadqiqotlar olib borilgan [1-12].

2. Tadqiqot metodologiyasi

Yo'lovchilar oqimini bashorat qilishning turli usullari mavjud.

Analistik vaqt ketma-ketligi – vaqt qatorlarini tekislashning eng keng tarqalgan turi, ya'ni eng kichik kvadratlar usuli hisoblanadi.

$$\sum_{i=1}^n (y_i - \hat{y}_i)^2 \rightarrow \min (i = 1, 2, \dots, n) \quad (1)$$

bu yerda: y_i – vaqtli qatorlar darajalarining yo'lovchilar hajmining o'zgarishini haqiqiy qiymatlari; $\hat{y}_i$ – berilgan ifoda bo'yicha yo'lovchilar hajmining o'zgarishini hisoblangan qiymatlari.

Ko'p hollarda (2) va (3) ifodalardan foydalaniladi [13-17]:

– birinchi darajali,

$$y_t = a_0 + a_1 t \quad (2)$$

– ikkinchi darajali,

$$y_t = a_0 + a_1 t + a_2 t^2 \quad (3)$$

Bizni masalada (3) ifodadan foydalanish maqsadga muvofiq sanaladi.

Noma'lum parametrlarni aniqlash uchun normal tenglamalar tizimi a_1, a_2 va a_3 quyidagicha yoziladi:

$$\begin{cases} Na_0 + a_1 \sum t + a_2 \sum t^2 = \sum y; \\ a_0 \sum t + a_1 \sum t^2 + a_2 \sum t^3 = \sum yt; \\ a_0 \sum t^2 + a_1 \sum t^3 + a_2 \sum t^4 = \sum yt^2 \end{cases} \quad (4)$$

Agar t ning toq darajalar yig'indisi nolga teng bo'lsa, tizimni ancha soddalashtirish mumkin:

$$\begin{cases} Na_0 + a_2 \sum t^2 = \sum y; \\ a_1 \sum t^2 = \sum yt; \\ a_0 \sum t^2 + a_2 \sum t^4 = \sum yt^2 \end{cases} \quad (5)$$

Vaqtli qatorlarni tekislashdan foydalanib, tashiladigan yo'lovchilar hajmining o'zgarishini kelajakdagi hajmlarini bashorat qilish lozim, ularning dastlabki vaqt qatori ikkinchi darajali parabola bilan tavsiflanadi.

Tashilishi mumkin bo'lgan yo'lovchilar hajmini kelajakka bashorat qilishda mukammal natija olish uchun ko'p yillik statistik ma'lumot asosida ishlash maqsadga muvofiq hisoblanadi. Shu sababli, masalani ishlashda Toshkent shahrida yo'nalishli avtobuslarda so'nggi 10 yilda tashilgan yo'lovchilar soni bo'yicha ma'lumotlardan foydalanildi. Masalani yechish uchun dastlabki va hisoblangan qiymatlari 1-jadvalda keltirilgan.

1-jadval

Vaqtli qatorlar usulida aniqlangan yo'nalishli avtobuslarning yo'lovchilar tashish hajmi

Hisobot davri, yillar	Tashish hajmi, ming yo'lovchi, y_t	t	t ²	t ⁴	y_t	yt^2	$\hat{y}_t$
2015	220165,5	-9	81	6561	-	17833405,5	245612,4
2016	197785,7	-7	49	2401	-	9691499,3	210026,7
2017	205784	-5	25	625	-1028920	5144600	183756,8
2018	211260,9	-3	9	81	-633782,7	1901348,1	166802,7
2019	220577,9	-1	1	1	-220577,9	220577,9	159164,4
2020	104727,6	1	1	1	104727,6	104727,6	160842,0
2021	138209,1	3	9	81	414627,3	1243881,9	171835,3
2022	144967,2	5	25	625	724836	3624180	192144,4
2023	240403	7	49	2401	1682821	11779747	221769,3
2024	288783	9	81	6561	2599047	23391423	260710,0
Jami:	1972663,90	0	330	19338	276788,9	74935390,3	1972664,0

Matematik ifoda parametrlarining hisoblangan qiymatlarini aniqlashda, 1-jadval ma'lumotlarini tenglamalar tizimiga kiritish orqali quyidagi parametrlarni hisoblash tenglamalar tizimiga erishiladi.

$$\begin{cases} 10a_0 + 330a_2 = 1972663,9 \\ 330a_1 = 276788,9 \\ 330a_0 + 19338a_2 = 74935390,3 \end{cases}$$

Tenglama parametrlari hisoblanib, a_0, a_1 va a_2 larning qiymatlari aniqlanadi:

$$a_2 = \frac{-9837481,6}{8448} = -1164,47$$

$$a_1 = \frac{276788,9}{330} = 838,75$$

$$a_0 = 158838,73$$

Bundan, quyidagi model hosil bo'ladi,

$$\hat{y}_t = 5263,72 + 1338,2t + 360,13t^2$$

Parametrlari eng kichik kvadratlar usuli bilan aniqlanganda quyidagi mezonlarni aniqlash maqsadga muvofiq:

- o'rtacha mutloq og'ish:

$$|A| = (y_t - \hat{y}_t) \quad (6)$$

- o'rtacha kvadratik og'ish:

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (y_t - \hat{y}_t)^2}{N}} \quad (7)$$

- o'zgaruvchanlik (variatsiya) koeffitsiyenti:

$$v = \frac{\sigma}{\bar{y}} \cdot 100\% \quad (8)$$

- nazariy jarayon $\hat{y}_t$ ni boshlang'ich ma'lumotlarga yaqinligini baholash

- R korrelyatsiya koeffitsiyenti:

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_t - \hat{y}_t)^2}{\sum_{i=1}^n (y_t - \bar{y})^2} \quad (9)$$

bunda $y_t, \hat{y}_t, \bar{y}_t$ - vaqt qatorining boshlang'ich, nazariy va arifmetik o'rtacha darajalari; n - trend funksiyasida aniqlanadigan parametrlar soni.

2-jadval

Yo'lovchilar hajmi o'zgarishini ifodalovchi model parametrlari

Hisobot davri, yil	$\hat{y}_t = 5263,72 + 1338,2t + 360,13t^2$	$(y_t - \hat{y}_t)^2$
2015	-25446,9	647545559,4
2016	-12241,0	149842680,8
2017	22027,2	485196108,1
2018	44458,2	1976527946,1
2019	61413,5	3771612025,1
2020	-56114,4	3148821005,4
2021	-33626,2	1130718939,0
2022	-47177,2	2225685605,1
2023	18633,7	347215502,4
2024	28073,0	788093974,7
Jami:	-0,1	14671259346,1

Yuqorida keltirilgan ifodalar yordamida quyidagi mezonlar hisoblanadi: $|A|, \sigma, v$ va R^2 .

3-jadval

Ishlab chiqilgan model mezonlarini hisoblash jadvali

Ishlab chiqilgan modellar	Mezonlar			
	$ A $	σ	v	R^2
$\hat{y}_t = 5263,72 + 1338,2t + 360,13t^2$	-0,1	38303	19,4	0,89



3. Natijalar

Yuqoridagi model asosida keyingi 10 yilda Toshkent shahridagi yo'nalishli avtobuslarda tashilishi mumkin bo'lgan yo'lovchilar hajmi bashorat qilindi va natijalar 4-jadvalda keltirilgan.

4-jadval

Yo'lovchilar tashish hajmini bashoratlash jadvali

Yillar	Bashorat	Bashorat xatosi	Ishonchlilik intervali	
			Yuqori	Quyi
2025	283674	2,7476	283677	283671
2026	308966	2,9926	308969	308964
2027	336588	3,2602	336591	336585
2028	366539	3,5503	366542	366535
2029	398818	3,8629	398822	398815
2030	433427	4,1981	433431	433423

4. Xulosa

Toshkent shahridagi yo'nalishli avtobuslarda tashilishi mumkin bo'lgan yo'lovchilar hajmini bashorat qilish modeli ishlab chiqildi va uning asosida keyingi 10 yilda kutilayotgan yo'lovchilar hajmi bashorat qilindi. Toshkent shahridagi yo'nalishli avtobuslarda yo'lovchilar hajmi keyingi 10 yilda o'sish suratida oshishi aniqlandi. Bu Toshkent shahrida keyingi yillarda avtobuslarga bo'lgan ehtiyojni aniqlash imkonini beradi. Keying tadqiqotlar yo'nalishli avtobuslarga bo'lgan ehtiyojni aniqlashga yo'naltiriladi.

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