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Organizing passenger flows at the station complex

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Abstract. This article considers the issue of optimizing passenger traffic at the station complex in modern conditions. The experience and scientific research of foreign scientists from China, Japan and Russia have been studied. Four different ways of organising passengers are discussed, with the most promising and working method revealed to be a comprehensive change in the train schedule and dynamic routing of passengers with absolute blocking. A forecast model in its turn depends on verifiable information, can more or less produce anticipated approaching volume of people, but it appears to be compelling when there are celebrations or understudy occasions. Whereas building a modern stage with a reason of facilitating an exchanging section does relieve the circumstance at the station and security measures considerably. Lastly, the most issue of serving traveler amid the COVID-19 pandemic were taking off strategy from stations and arrangement of travelers to sit separated at a certain distance for shirking of cleansing. In this master's proposal, the procedures to handle and gauge traveler stream have been regarded, but activities need to be made amid breakdown of trains have not been surveyed.

Keywords: passenger flow, prediction model, integrated timetable rescheduling, passenger routing, COVID-19.

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Introduction

There are several types of railroad stations: some are placed under the ground (subway) and other are located above the ground. In this paper, above the ground level type is considered, namely, a station complex [1].

Due to their consistently increasing speed, high level of safety, and exceptional comfort, trains are becoming the preferred mode of transportation for an increasing number of people. The railway station, which serves as both a hub and a carrier for passengers, has a significant impact on rail passenger transportation since a steady stream of passengers is what keeps the station operating normally and without load redundancy [1]. This implies that a fair and accurate forecast of the number of passengers entering and departing the station may serve as a solid foundation for both the deployment of employees and the distribution of resources, as well as the work of security. The passenger flow volume is a highly nonlinear function of time that not only varies over time but is also influenced by a variety of outside sources. The passengers visiting the train station have more visible features than those entering other similar application scenarios (shopping centers, highways, scenic areas), such as obvious periodicity that is measured in days. For instance, the weather might affect how many people are traveling through the train station. Nevertheless, notwithstanding the regional variations brought on by the weather, the general trend is almost unchanged. Second, there are times when the number of people entering the station at each interval and the number of trains at the following interval are closely related. This variation in the number of people is particularly noticeable during the winter and summer vacations as well as other statutory holidays. Despite the fact that railroad transportation was developed to achieve a large transport capacity for overcoming activity clog and transport capacity imperatives in some countries with a large population (such as China and Japan), it is still difficult to manage railroad operation while adjusting the large transport capacity and spatiotemporally uneven distribution of traveler demand [2].

Having reviewed the importance of the challenge, in the next section of this article, there will be reviewed different means of estimating passenger flow starting from prediction models, commercial software, timetable rescheduling, and ending with COVID-19 period case as well as innovative management.

Literature review

2.1 Neural network-based prediction model for passenger flow in a large passenger station: An exploratory study

The Chinese researchers have conducted a study involving passenger flow of Beijing station in a period from 2017 to 2018. The primary method used to create the passenger flow prediction model is neural network-based prediction, where the inputs are the primary variables that affect how the passenger flow changes and the outputs are the outcomes of the prediction [2]. It is more accurate to create the weighted forecast by combining with the historical data since the station schedule is planned in a day cycle and the passenger flow is of distinct periodicity without considering the interference of external variables. The estimations from the prediction model can be seen in the following table:

Table 1

The annual passenger flow of Beijing from June 1 to May 31 (2017-2018) [3]

Data	Daily passenger/ Ten thousand people	Data	Daily passenger/ Ten thousand people
2017/6/1	132.5	2017/10/1	134.2
2017/6/2	113.5	2017/10/2	106.5
2017/6/3	136.5	2017/10/3	117.5
2017/6/4	96.7	2017/10/4	86.8
2017/6/5	124.7	2017/10/5	117.6
2017/6/6	94.2	2017/10/6	93.9
2017/6/7	88.3	2017/10/7	94.8
2017/6/8	85.2	2017/10/8	128.7
2017/6/9	95.3	2017/10/9	116.2
2017/6/10	105.8	2017/10/10	124.4
2017/6/11	111.7	2017/10/11	128.4
2017/6/12	125.7	2017/10/12	97.2
2017/6/13	93.7	2017/10/13	138.2
2017/6/14	105.5	2017/10/14	137.1
2017/6/15	94.6	2017/10/15	121.6
2017/6/31	85.2	2018/2/14	72.9

Table 1 shows that there is some regularity to the Beijing's passenger movement. Among them, there is a significant variation in the passenger flow in February 2018. The Spring Festival, China's most significant traditional holiday, is the primary cause of this phenomena. Beijing was a top city dominated by immigrants in January [3]. A significant surge in passenger traffic was brought on by the high number of immigrants who left Beijing during this time of year to travel back to their hometowns. Additionally, each year's July sees a surge in the rise of passenger traffic. This time frame corresponds to China's school year's summer break, in which students are observed to travel a lot. Though the neural network-based prediction model applies formula for passenger flow estimation and errors in calculations are inevitable, this method has proven to clearly show a significant difference of fare stream during festivals and student holidays. It cannot be denied though predicting the flow through historical data is prone to be an old means itself and to have a lot of errors, being used for many years should be definitely replaced with novel techniques of forecasting [4].

2.2 Estimation of passenger flow for planning and management of railway stations

Another study held by Japanese investigators delivers the information about the organizing process of passenger flow at Takatsuki station. Given the station's popularity, a smooth organization process of passengers' movement within the station is discussed. In this paper, to assess the suggested layout, a supplementary platform Osaka bound is adjoined to Kyoto bound (see Figure 1) [5].

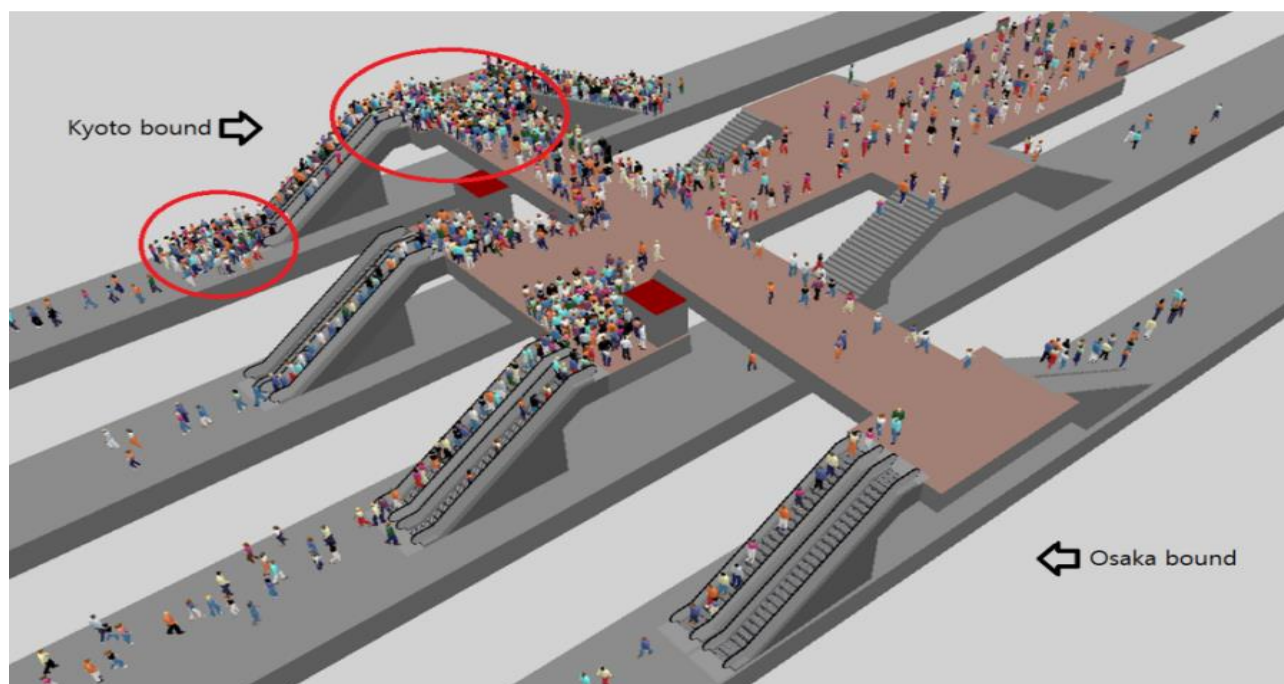


Figure 1 - Artistic imagination of the proposed platform [5]

According to the findings, the existing platform's congestion will lessen. However, due to flow conflicts between passengers transferring and those boarding and alighting, connecting routes to the new platform may get crowded [5]. In other words, the concourse area would experience more congestion than the current platform does. That is considerably preferable than the existing scenario in terms of safety. In any case, it could now be viable to look at altering the train schedule to lessen harmonics among transferring passenger flows in order to further ease the congestion on the sidewalks. The methods authors of this paper suggest is going to be described in more details in the next literature.

2.3 Integrated railway timetable rescheduling and dynamic passenger routing during a complete blockage

Further research conducted by Chinese investigators reveals that for railway dispatchers and passengers, real-time train rescheduling is crucial during a total track closure. In this study, they added the passenger route option to the train rescheduling problem [6]. A space-time network-based integer linear programming (ILP) model creates the integrated train rescheduling and passenger routing. This algorithm was able to determine the precise paths for each train as well as the viable, complete train disposition timetable. Additionally, routes for passengers were adjusted taking into account a disruption's restricted train capacity. With the assumption that the passenger Origin-Destination (OD) requests are known both before and after the interruption, the model was proven to be appropriate for train systems without seat reservations [6]. Estimations from ILP model yields the following data:

The sensitivity analysis of parameter ω .

Test	Value of ω	Objective value	Train operation cost	Passenger travel cost	Canceled train
1	1	7976	416	7560	0
2	10	11,360	236	9000	1
3	20	12,760	88	11,000	2
4	30	13,640	88	11,000	2
5	40	14,520	88	11,000	2
6	50	15,000	0	15,000	3

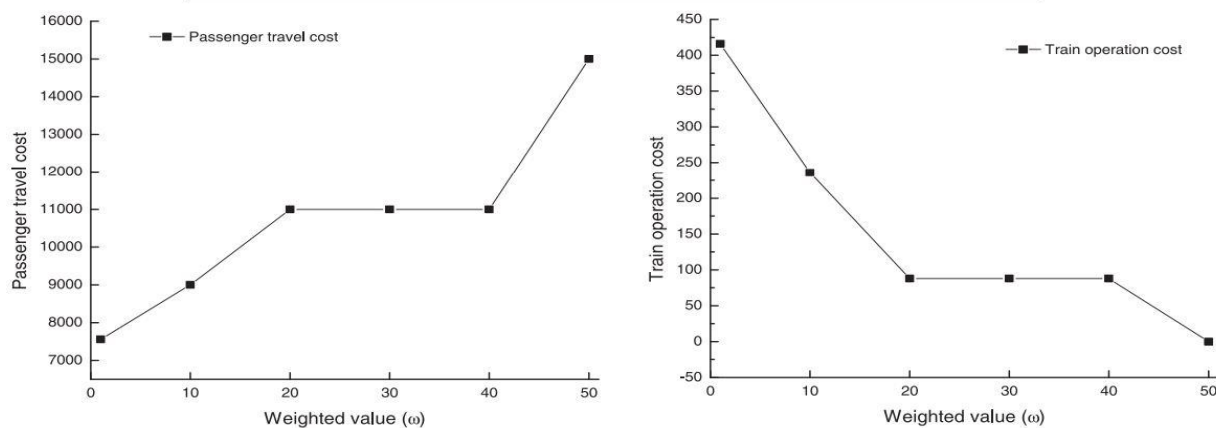


Figure 2 - The influence of train rescheduling and passenger routing on both the train operation cost and passenger travel cost [7]

Application of integrated train rescheduling along with passenger routing proves itself to be efficiently operating [7]. In comparison with the former two techniques, this method excels them by challenging case solution. Namely, using ILP model for cases when passenger flow is highly dense and how train rescheduling can aid to resolve the issue subsequently.

2.4 Influence of Passenger Flow at the Station Entrances on Passenger Satisfaction Amid COVID-19

The given report has been made by Russian explorers on Moscow railway stations. The authors utilized the statistics data from the "Railway Media" portal as the baseline information for estimating passenger flow (passenger traffic at Moscow stations for 2019) [8]. Estimates of long-distance railway and suburban train passenger traffic were generated using statistical data. The research had no impact on the perceived quality of long-distance railway stations; in 2019, it accounted for 18% of all passenger traffic at the Moscow stations (statistically significant relationship is not disclosed). Long-distance train passengers often visit Moscow stations far less frequently than suburban train passengers [8]. An emphasis was put on the challenges that visitors to the station complex encountered at the entry in particular. The variation in the number of complaints at stations is mostly caused by the volume of passengers at various stations. The complaint – leaving station process's complexity is the cause. Assessing passenger traffic through stationary inspection equipment resulted in the next numbers:

Table 2

Evaluation of the entry grouping capacity for Moscow station complexes using stationary inspection equipment [8]

Station	Maximum Capacity of Entrance Groups Equipped with Stationary Inspection Equipment (persons/min.)
Yaroslavsky	140
Kursky	280
Kazansky	280
Kievsky	200
Leningradsky	200
Belorussky	220
Savyolovsky	20
Paveletsky	160
Rizhsky	20

This paper is not less important for a reason that it has been explored during COVID-19 outbreak. The operation of station complexes in this kind of situations is of high significance because railway stations are centers of mass accumulation of people [6]. Since the research is based on the pandemic period, it gives thorough understanding of how to handle passenger traffic on station complexes. Overall, the study shows that the majority of passengers waited no more than 5 minutes at each of the mentioned stations in Table 2. It is also reported that there were no problems of serving passengers during this period, considering individuals had to keep a certain distance from each other to prevent disinfection [8]. Even though there were no major casualties in passenger service on station complexes, it is still important to be ready to have a station complex operate in problematic circumstances such as COVID-19 pandemic.

Conclusion

In conclusion, the above ground station complex has been regarded in the given paper. As long as a train station is intended for a surge of a passenger stream, in order for it to function properly, aside from station functions, the process of organizing passenger flow should be taken into account as well. In this article 4 various ways of managing passenger flow have been reviewed. Particularly, neural network-based prediction model relying on historical data of a station, the construction of a new platform to lessen a congestion of sidewalks generated by passengers, train rescheduling and passenger routing in a case of a track closure or high density of boarding passengers, and the arrangement of passenger current amongst COVID-19 ultimately. The first technique, that is prediction model relying on historical data, can more or less generate expected incoming volume of individuals, but it only seems to be effective when there are festivals or student holidays. In our view, a prediction model should be ready to accurately determine passenger flow regardless of time period. Secondly, building a new platform with a purpose of easing transferring passage does mitigate the situation at the station and safety

measures substantially. However, connecting routes to the new platform may get crowded, leading to even more intensive congestions. Thus, authors introducing the second method have recommended the next means themselves. The third and perspective process embraces a concurrent interaction between timetable rescheduling of a rail track and passenger routing. This method surpasses two mentioned ones and the one to be discussed in a way that it puts an emphasis on a case of complete blockage. As a matter of fact, the ILP model offers alteration in conventional timetable of trains because there are circumstances when passenger flow is higher than departing train's capacity. Therefore, the model except from railway timetable rescheduling, takes into consideration holding capacity of boat trains. Lastly, how passenger flow has been affected during COVID-19 was examined. The main issue of serving passenger during the pandemic were leaving procedure from stations and preparation of passenger to sit apart enough for avoidance of disinfection. In spite of the fact that there were no major incidents in traveler maintenance on station complexes, it is still critical to be prepared to have a station complex work in risky circumstances such as COVID-19 widespread. In this master's thesis, the techniques to handle and estimate passenger flow have been regarded, but actions have to be made during malfunction of trains has not been reviewed. This, in our opinion, should be investigated thoroughly because the above-suggested methods are expected to operate in uninterrupted situations. Furthermore, the assumptions and simplifications of the model should be examined using several statistical tests to establish a more realistic simulation model. Ultimately, during the morning peak and rush hours, staff can be added to guide passengers to operate the related equipment in the station hall to speed up ticket purchases, security inspection, and entry.

Author contribution:

Muratbekov B.N. – concept, methodology, resources.

Vakhitova L. – modeling, analysis, visualization, interpretation.

Muratbekova G. – data collection, testing.

Aimanbetov N. – drafting, editing, funding, acquisition.

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Вокзал кешенінде жолаушылар ағынын ұйымдастыру

Андатпа. Мақалада авторлар қазіргі жағдайда вокзал кешеніндегі жолаушылар ағынын оңтайландыру мәселесін қарастырады. Қытай, Жапония және Ресейден келген шетелдік ғалымдардың тәжірибесі мен ғылыми зерттеулері назарға алынады. Мақалада жолаушылар ағынын ұйымдастырудың төрт түрлі әдісін қолдану арқылы оңтайландыру мәселесі талданған. Бақылаулар негізінде ең өзекті және белсенді әдіс пойыздардың қозғалыс кестесін кешенді өзгерту және абсолютті оқшауланған жолаушыларды динамикалық бағыттау болып табылатыны анықталды. Болжалды модель, өз кезегінде, тексерілетін ақпаратқа байланысты, адамдар санының күтілетін мөлшерін азды-көпті қамтамасыз ете алды. Бұл мерекелер немесе шағын іс-шаралар өткізілген кезде сенімді болып көрінді. Тасымалдау торабын жеңілдету мақсатында заманауи алаң құрылысы станция аумағындағы қауіпсіздік шараларын едәуір жеңілдететінін байқатты. COVID-19 пандемиясы кезінде жолаушыларға қызмет көрсетуде туындаған қиындық станциялардан шығу стратегиясы мен тазалықты сақтау және саяхатшылардың белгілі бір қашықтықта оқшаулануын ұйымдастыру болды. Алайда жолаушылар ағынын реттеу мен айналаның тазалығын қадағалау іске асырылғанымен, пойыздар тоқтаған кезде атқарылуы тиіс әрекеттер қарастырылмайды.

Түйін сөздер: жолаушылар ағыны, болжау моделі, интеграцияланған кестені өзгерту, жолаушыларды бағыттау, COVID-19.

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Организация пассажиропотока в вокзальном комплексе

Аннотация. В данной статье авторы рассматривают проблему оптимизации пассажиропотока в вокзальном комплексе в современных условиях. Был изучен опыт и научные исследования зарубежных ученых из Китая, Японии и России. В этой статье рассматривается оптимизация с использованием четырех различных методов организации пассажиропотока. На основании наблюдений было установлено, что наиболее перспективным и работающим методом является комплексное изменение графика движения поездов и динамическое направление пассажиров с абсолютной блокировкой. Прогнозная модель, в свою очередь, может обеспечить более или менее ожидаемое приближение количества людей, в зависимости от проверяемой информации, но она кажется надежной, когда проводятся праздники или небольшие мероприятия. Учитывая, что строительство современной сцены с целью облегчения пересадочного узла значительно упростит среду станции и меры безопасности. Наконец, самой большой проблемой обслуживания путешественников во время пандемии COVID-19 была стратегия выхода со станций и организация, чтобы путешественники сидели отдельно на определенном расстоянии, чтобы избежать уборки. В предложении этого мастера рассматривались процедуры обработки и измерения пассажиропотока, но не рассматривались действия, которые необходимо было предпринять при остановке поездов.

Ключевые слова: пассажиропоток, модель прогнозирования, изменение интегрированного расписания, маршрутизация пассажиров, COVID-19.

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