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Spatial Analysis of Subway Ridership: Rainfall and Ridership

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Abstract

In-vehicle congestion of the urban railway system is the most important indicator to reflect the operation state of the urban railway. To provide the good service quality of urban railway, the crowdedness of the urban railway should be managed appropriately. The weather is one of the critical factors for the crowdedness. That is because even though the crowdedness of the urban railway is the same, passengers feel more uncomfortable in rainy weather condition. Indeed if specific sections and stations suddenly are concentrated excessive demand, it will lead far more serious problem. Therefore, this study analysis the relationship between the number of urban railway passenger and rainfall intensity in Seoul metropolitan subway system and then conducts the spatial analysis to deduct passenger demand patterns. This study is expected to be useful base study in order to manage the congestion at the urban railway station effectively by considering the different rainfall intensity.

Keywords: subway ridership, spatial analysis, ridership analysis

1. Introduction

The crowdedness of the urban railway is the most important indicator to reflect the operation state of the urban railway. To provide the good service quality of urban railway, the crowdedness of the urban railway should be managed appropriately. To evaluate the crowdedness in the urban railway, quantitative factors and qualitative factors are needed. The weather is one of the critical factors to influence the crowdedness. This is because even though the crowdedness of the urban railway is the same, passengers feel more uncomfortable in rainy weather condition. Indeed if specific sections and stations suddenly are concentrated excessive demand, it will lead far more serious problem.

However, few literatures had been studied to analyze the relationship between the weather and traffic demand. This is because collecting the traffic demand and weather data was difficult. However, these data have been opened to the public; it is possible as get detailed information such as Passenger data.

Park and Lee analyzed the passenger's transfer pattern during rainfall in Busan [1]. This study showed that the ratio of the passenger's mode choice is different with the different amount of rain. This research also showed that the ratio of mode choice is more influenced by the rainfall on weekend.

Lee et al. conducted the relationship between the number of public transportation passenger and the weather, especially for rain with the smart card data [2]. This study revealed that both the number of bus and urban railway passengers were reduced in the rain. With these results, they pointed out that the public transportation passengers at Seodaemun-gu, Dongdaemun-gu, and Jung-gu were easily influenced by the rain intensity.

Yi et al., analyzed the rain intensity and the bus travel time to verify the quality of bus services. The study showed that the quality of the bus services was greatly influenced by rain start in the morning peak hours [3].

However, these researches focused on the specific regions so that it could not show a detail analysis.

Therefore, this study constructs the database set about the urban railway passenger with the

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rainfall intensity in Seoul and conducts the spatial analysis to deduct passenger demand patterns. This paper collects rainfall data which are collected from July to September and urban railway passenger data. With these data, this study analyzed the relationship between the number of urban railway passenger and rainfall intensity.

2. Method

Seoul is one of the biggest cities in the world and eight subway lines are connected so people can reach every single place in Seoul. So many people use subway for commuting and other travel purposes. According to the Kang et al., up to 36 % of people responded that they choose subway as a travel mode [4].

This paper analyses the rainfall intensity to show its impact on demand of the Seoul urban railway with the urban railway passenger data. This study use railway passenger data which are collected from July to September 2012 and 2013. Daily rainfall data which are used are collected from the Automatic Weather Stations (AWS). To analyse the relationship between the rainfall intensity and the subway passenger ridership, this study selects in that same period rainfall data and then conducts a spatial analysis.

Urban railway passenger dataset from Seoul metro (Line 1-4) and Seoul Metropolitan Rapid Transit Corporation (Line 5-8) are obtained and total number of board passengers in July to September 2012, and 2013 are extracted. The total number of stations on line 1 to 4 in the 2012-2013 is 119 stations. However, total number of stations on line 5 to 8 is different. In 2012, there are 148 stations on line 5 to 8. However, 9 stations which are Gulpocheon station, Kkachiul station, Bucheon Cityhall Station, Bucheon Stadium station, Samsan Gymnasium station, Sangdong station, Sinjung-dong station, and Chun-ui station data from October 2013 added.

3. Results and Discussion

3.1. Urban Railway Demand Analysis

This study set the number of passenger data in level 1 as a standard. Based on this standard, this study compares each level' passenger number and standard and then calculates reduction ratio.

As a result, this study finds out that the number of passengers is decreased during the rainfall. In level 2, total number of passengers is increased by 0.53% than level 1. At level 3, total number of passengers is decreased by 1.84% and level 4, total number of passengers is decreased by 3.17%. Demand was reduced by 2.65% at Level 5. At the level 6, it was reduced by 5.39%. Detailed results are given in Fig. 1.

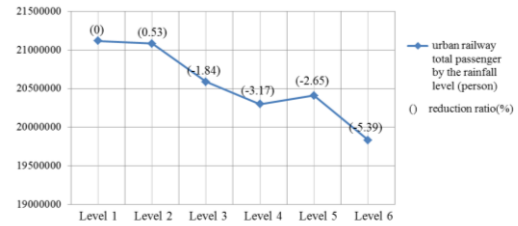

Fig. 1 Relationship between urban railway passengers by rainfall level

This study also conducted the passengers' ridership on each station. The results show that the ridership on Yeouinaru Station and Ttukseom Resort Station is highly influenced by amount of the rain. This is because people visit these stations for leisure activities. On the other hand, the ridership on Samsung station, Gasan Digital Complex Station, and Gangnam Station does not have a significant difference by the rain. These stations are highly involved with work trip.

Contrary to this pattern, Hangnyeoul station subway passenger rate is 47% increase from relationship. Regardless of the rainfall, it can imply that this is because of the Hangnyeoul station event.

3.2. Spatial Analysis on Subway Network by Rainfall Level

A GIS software can be used to store, analyze and allows spatial data layers. First, this study analyzes the high number of the board and alight passenger station in Seoul.

Fig. 2 depicts the high total number of board passenger station analysis data from top 1 to top 10; Gang-nam station: 37,181,419persons, Jam-sil station: 27,974,601 persons, Seoul station: 26,244,942 persons, Sillim station: 26,201,372 persons, etc. Fig. 2 also shows the high total number of alight passenger station: Gang-nam station: 38,498,150 persons, Jam-sil station: 25,588,647 persons, Sillim station: 25,491,673 persons, Hongik university station: 25,019,830 persons.

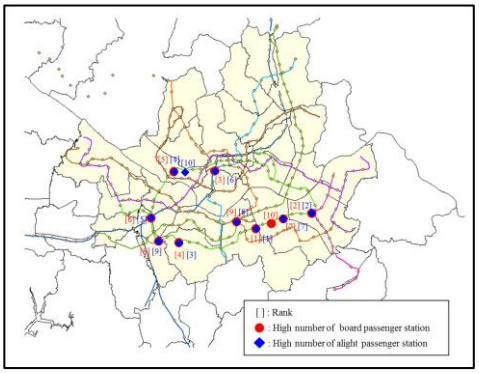

Fig. 2 Board and alight passenger station analysis in Seoul subway system

4. Conclusions

The crowdedness of the urban railway is the most important indicator to reflect the operation state of the urban railway. The weather is one of the critical factors to influence the crowdedness. That is because even though the crowdedness of the urban railway is the same, passengers feel more uncomfortable in rainy weather condition. Indeed if specific sections and stations suddenly are concentrated excessive demand, it will lead far more serious problem.

This study finds out that each station's passenger is decreased by the rainfall level, except for level 2. The number of passengers in level 6 is decreased about 5.39%. The stations which are highly related to leisure activity are sensitive to the rainfall.

Also, we analyzed the sensitivity area of the rainfall level. The station was analyzed by using a high sensitivity for the station leisure activities such as Yeouinaru Station and Ttukseom Resort Station. On the other hand, Samsung station, Gasan Digital Complex Station, Gangnam Station was analyzed and the sensitivity is low.

With the GIS program, this study conducts the spatial analysis to show the relationship between the rainfall intensity and the subway passenger ridership in GIS map.

This study focuses on the entire date of data and passenger data. To conduct more accurate analysis, the study should consider peak-hour and non-peak hour data.

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