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## Estimation of Passenger Flow for Planning and Management of Railway Stations

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### Abstract

Large scale renovation of rail stations to cater for growing passenger demand has been taking place in various sites in Japan. These projects pose a challenge to researchers to identify suitable technical methods to develop infrastructure layouts that efficiently cater for movement of walking passengers.

This paper presents an application in relation to the JR Takatsuki station where there was a narrow island platform catering for large volume of boarding, alighting and transferring passengers. In 2015, the operator has begun expanding the station to alleviate the platform congestion.

The objective of the project is to develop a method of forecasting pedestrian flow patterns within a railway station for a proposed new layout of platforms and interconnecting links. The methodology will be demonstrated using Takatsuki station as a case study. The core of the methodology utilizes pedestrian origin-destination pattern to estimate measures of walking effort of pedestrians. In addition to the analytical modelling technique an application of a simulation model is also described. The simulation method is helpful as it is able to provide a visual appreciation of the future operation of the railway concourses.

Results indicate that the congestion on the current platform will be alleviated. However, connecting passages to the new platform can become congested because of flow conflicts among transferring passengers and those boarding and alighting.

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## 1. Introduction

### 1.1. Backgrounds

Large scale renovation of rail stations to cater for growing passenger demand has been taking place in various sites in Japan. On one hand this involves introduction of commercial activities that can take advantage of passenger accumulation and on the other hand it deals with providing more space to manage passenger flows and collection areas. Typically, such projects go hand in hand with urban renewal programs that revitalize the land-use surrounding major railway stations. Such a renovation program is currently in progress in and around JR (Japan Railway) Osaka station. These projects pose a challenge to researchers to identify suitable technical methods to develop infrastructure layouts that efficiently cater for movement of walking passengers.

Space optimization for the benefit of users can be considered in the context of different elements of the terminal space such as platforms, ticket vending and validation areas, rest facilities and various connecting concourses. A previous study (Ahn and Tsukaguchi, 2015) has provided some useful guides about pedestrian flow behavior at an underground shopping area near a transportation terminal.

For understanding pedestrian flow, they measured generation/attraction traffic and section traffic of each link. And they estimated pedestrian OD traffic using these data. Another previous study (Kowada et al., 2014) estimated pedestrian OD traffic of JR Osaka station using similar estimate method. They measured boarding/alighting passenger counts at rail car and entry/exit passenger counts at up/down facilities and they estimated OD demand. As a result, they found that impedance parameters among stairs and escalators were different. In other words, walking resistance against distance was different as up/down facilities.

The OD estimated method as we mentioned above was developed by Cascetta (1984), Bell (1991) and Yang et al. (1991). This method is an OD estimated method using link traffic data on a road network, which means that the method is used for vehicular traffic and Kowada et al. (2014) used for pedestrian traffic.

Many studies about passenger's movement on platforms, corridors and concourses at stations are progressed. Generally, most are studies to analyze passenger's movement using camera image. A particular interest in passenger movement through railway stations have been documented recently by Lee et al. (2007), Lu et al. (2014), Al Widyan et al. (2015) and Virgona et al. (2015).

Density estimation in crowded space at Munich Airport has been studied using Wi-Fi and Bluetooth by Schauer et al. (2014). Crowd behavior in movements through corridors has been reported recently by Shiwakoti et al. (2015). Galiza et al. (2009) used a micro traffic simulation to investigate pedestrians' behavior in a railway station.

However, it was a few studies to estimate OD demand in a railway station. Hanseler et al. (2012, 2015) analyzed pedestrian flows in multi-platform railway station and they estimated OD demand from count data, trajectories or flows.

The current paper focuses on the interaction between platforms and location of entry/exit facilities in terms of stairs, escalators and lifts. The application presented later investigates a station where the platforms were routinely overcrowded where congestion on platforms had raised safety fears and caused train delays.

A recent innovation to handle platform congestion is the introduction of screens or wire doors that open and close in sync with the train doors. They are less suitable when different train configurations serve the platform. Also, the space occupied by such doors can further restrict passenger circulation in narrow platforms built long time ago. Also some operators are hesitant to consider retrofitting platforms doors as they are concerned about operational disruptions and safety issues during the period of installation and testing.

This paper presents an application in relation to the JR Takatsuki station where there was a narrow island platform catering for large volume of boarding, alighting and transferring passengers. The large amount of transfer passengers use different types of trains (express, limited express and local trains) serving this platform. In 2015, the operator has begun expanding the station to alleviate the platform congestion. A new platform is being added mainly for the limited express trains. This gives rise to the interesting research question about what is the best arrangement of links between platforms to minimize walking distances of transfer passengers. The links between platforms is via a 2<sup>nd</sup> floor concourse.

### 1.2. Objectives

The final objective of the project is to develop a method of forecasting pedestrian flow patterns within a railway

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