Mapping Passenger Flow with Ticket Transaction and Gate Data

Yung-Cheng (Rex) Lai and Chung-Wei Huang
Railway Technology Research Center, National Taiwan University
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Using ticket data can capture the dynamics in passenger demand and system utilization.

Reserved Ticket
Non-reserved Ticket
Monthly Pass
Smartcard

Train ID
Transaction Time
Service Type
Entry Time
Exit Time

Source: http://www.railway.gov.tw/tw/
The ticket data can be further used to map passenger flow according to train services

**Commuter**
- All non-reserved seats
- *All-stop*
- Highest service frequency

**Express**
- Reserved/Non-reserved seats
- Skip-stop (more stops)
- At least **30 stopping patterns**

**Intercity Express**
- Reserved/Non-reserved seats
- Skip-stop (few stops)
- At least **30 stopping patterns**

**Premium Intercity Express**
- All reserved seats
- Skip-stop (fewest stops)
- At least **10 stopping patterns**
The implementation of this idea becomes extremely difficult due to the complexity.
The evaluation process of passenger flow for such complex system haven’t been proposed

- A number of previous studies have used automatic fare collection (AFC) data to estimate demand and passenger flow for rail transit systems.

- Most of these studies were developed for rail transit systems with a single fare system or single ticket type.

- Few studies discussed the mapping of different ticket data with various stopping patterns.

This study attempts to develop an evaluation process of passenger flow for rail transit systems with multiple ticket data and various stopping patterns.
We develop a comprehensive process and evaluation framework to map passenger flow.

**Passenger Flow Module:**
On the basis of the transaction and gate data from a particular ticket, the walking and waiting time of the passenger holding this ticket are estimated, and assigns it to the best possible train service according to the timetable.
The passenger journey generally contains the following 6 timestamps:

- Ticket Transaction Time
- Entry Time
- Platform Arrival Time
- Boarding Time
- Alighting Time
- Exit Time
The passenger flow module estimate the passenger journey based on the recorded data.

Based on the difference of recorded data, matching algorithms for each ticket data are developed.
Matching algorithm 1

**Entering System**
- **Entry Time**
- **Walking Time To Platform**

**Platform Arrival Time**
- **Assumed Waiting Time**
- **Boarding Time**
- **On-train Time**

**Assign to Train**
- **Train ID**
- **Passenger OD**

**Exiting System**
- **Alighting Time**
- **Walking Time To Exit Gate**
- **Exit Time**

**Input Data**
Matching algorithm 2

- Passenger OD
- Ticket Transaction Time

**Input Data**
- Access Time To Entry Gate

**Entering System**
- Entry Time
- Walking Time To Platform

**Minimum Waiting Time**
- Platform Arrival Time
- Waiting Time
- Assign to Train

**Boarding Time**
- On-train Time
- Alighting Time

**Leaving System**
- Walking Time To Exit Gate
- Exit Time
Matching algorithm 3

**Input Data**
- Passenger OD
- Entry Time

**Entering System**
- Walking Time To Platform

**Minimum Waiting Time**
- Platform Arrival Time
- Waiting Time
- Assign to Train
- Boarding Time
- On-train Time
- Alighting Time
- Walking Time To Exit Gate

**Leaving System**
- Exit Time
Matching algorithm 4

Ticket Transaction Time ($B_i$)

Entering System
- Entry Time
- Walking Time To Platform

½ Headway
- Platform Arrival Time
- Assumed Waiting Time
- Boarding Time
- On-train Time

Alighting Time
- Assign to Train
- Walking Time To Exit Gate

Minimum Alighting Delay Time

Leaving System
- Walking Time To Exit Gate
- Exit Time
- Passenger OD

Input Data
The estimated passenger flows can be used to evaluate the performance of system.

- **Demand and Utilization Module:**
  Determine passenger OD distribution as well as system utilization in terms of sections, stations and train services in the network.
The demand and utilization module generates passenger demand and system utilization.

The automation of this process is highly beneficial for operators in terms of monitoring and evaluating the demand patterns and service performance over time and space.
The busiest corridor in the conventional rail network was chosen for this study

- **Keelung** to **Hsinchu** corridor
  - Length: 106.4 kilometers
  - Stations: 26 stations (25 section)
  - Average *500,000 passengers* travel in this corridor every day

- Four types of train services are provided

- Data Selection: A Friday evening peak (5PM to 7PM) in 2011

- *80,000 ticket data* were analyzed
Section utilization evaluate the number of passengers in every section

This information is highly beneficial for planners to **design appropriate passenger services, train services and service frequencies**.
Station utilization is an important attribute to understand station performance

- Taipei, Zhongli, and Taoyuan are the top three stations with the largest number of passengers entering and exiting the stations.
The utilization rate of station platform is more meaningful than actual number

Utilization Rate (%)

90% Close to congestion!!

Utilization Rate

+10%
Passenger distribution in terms of time and space can be presented

- All of the stations accommodate more passengers during the morning and evening peaks
- The passenger distribution south of Taipei (from Taipei to Zhongli) is more diverse

Congestion and safety issues can be monitored through passenger distribution to improve service quality
The developed tool can present train utilization in various aspects

- We use the **southbound train** services during the evening peak as an example to demonstrate train utilization
- 32 southbound trains operate on this corridor from 5 PM to 7 PM, including **10 intercity express, 3 express, and 19 commuter trains**
Commuter trains provide the service with the highest frequency.
Service adjustments are proposed based on the evaluation results

- Two additional train services from Qidu to Zhongli
- Extending the service route of one Songshan to Shulin train to Qidu to Zhongli

Utilization Rate (%)

Before
After

stations: Hsinchu, Zhubei, Xinfeng, Hukou, Fugang, Yangmei, Puxin, Zhongli, Neili, Taoyuan, Yingge, Shanja, Shulin, Bangjiao, Wanhua, Taipei, Songshan, Nangang, Xikè, Xizhi, Wudu, Baifu, Qidu, Badu, Sankeng, Keelung
To sum up, an efficient process is proposed to estimate demand and evaluate performance.

- We develop a comprehensive process and evaluation framework to map passenger flow based on ticket transaction and gate data of a complex conventional rail transit system.

- With the proposed passenger flow mapping tool:
  - *Passenger demand* and *service utilization* can be efficiently computed and examined.
  - *Potential service adjustments* can be quickly re-evaluated to estimate the possible outcome.
  - Operators can *adjust their services and management strategies* to account for the variation in demand over time and space.
Thank You!

Railway Technology Research Center at National Taiwan University
Website: http://www2.ce.ntu.edu.tw/~railway/

Telephone Number: +886-2-3366-4362
Email: yclai@ntu.edu.tw