Quantitatively identifying characteristics of the flow of passengers in crowded spaces such as station concourses and platforms is of great importance when considering station design. The Frontier Service Development Laboratory had developed a passenger flow tracking system using laser technology to track the flow of passengers over a broad area of stations. Sensing was done with that system in station concourses using floor-type horizontal laser sensors, but it could not be done on platforms due to a lack of sufficient space to set up sensors. We thus developed a method to install laser sensors above the platform and conduct sensing and analysis to observe the change of the flow of passengers. We used that to conduct sensing before and after installation of automatic platform gates at Ebisu Station. Analyzing sensing results allowed us to identify locations of congestion in the morning peak time, the level of that congestion, time series variation in density of passengers and time required to alleviate congestion.

Keywords: Flow of passengers, Laser sensor, Automatic platform gate, Change in congestion level on platform

1 Introduction

JR East is implementing measures to allow passengers to use stations comfortably and at ease, such as improving layout of station concourses to make station facilities barrier-free and developing of in-station shopping malls. And, to allow safe use of platforms, we are proceeding with an automatic platform gate installation plan, having installed automatic platform gates at Ebisu and Meguro Stations on the Yamanote line ahead of other stations.

In implementing improvement plans and assessing and verifying measures taken, it is essential to quantitatively identify and visualize the flow of passengers.

The Frontier Service Development Laboratory had developed a tracking system using laser sensors to make high-accuracy tracking of passenger flow over a broad area. We used the system to assess and verify measures taken by sensing locations such as crowded concourses and over- or under-railway passages. But sensing had not been conducted on platforms. The reasons were that, when sensing with two or more floor-type horizontal laser sensors (two-dimensional), ① flow of passengers could be impeded when sensing, ② space to install sensor is limited and ③ passengers might block sensor view of other passengers in very crowded locations.

In light of those circumstances, we undertook development of a new tracking method with an aim of analyzing passenger flow before and after installation of the aforementioned automatic platform gates.

2 Overview of Development of Tracking System Using Laser Sensors

2.1 Features of Laser Sensors

Station concourses and platforms become extremely congested mainly at peak times. Traditionally, in such situations, we manually sensed cross-sectional traffic or analyzed passenger density (congestion level) using still images. The cross-sectional quantities of passengers could be identified with those methods, but it was difficult to identify the flow and behavior characteristics of passengers and the change in congestion level for the station as a whole.

We thus commenced research with an aim of gaining quantitative understanding of positions and numbers of passengers, congestion level and tracks of passengers and of analyzing passenger flow with high accuracy. The tracks of passengers, which are drawn by tracking individual passengers with time series data, allow us to identify the directions and speeds of passengers. We decided to use laser sensors as the elemental technology for the research.

Reasons of adopting laser sensors were as follows.

① Ability to conduct sensing in a broad area
Since laser beams have low diffusion and extremely low attenuation due to being a single wavelength and frequency, they can accurately detect the positions of objects over a broad area.

② Ability for passenger samples to be used as data
Data obtained using laser beams is easy to analyze and smaller in volume than image data.

The following covers the background of the development of a system to identify passenger flow in a broad area of the station platform using laser sensors.

2.2 Background of Development of Tracking System Using Laser Sensors

As explained above, use of floor-type horizontal laser sensors (two-dimensional) had a disadvantage in that the space where they can be installed on the platform is limited. To enable sensing on crowded platforms, we developed a system with laser sensors (three-dimensional) installed above the platform that obtains three-dimensional data to complement two-dimensional data (Fig. 1).
4.1 Overview of Tracking on the Platform of Ebisu Station

Using the developed tracking system, we sensed passenger flow at Ebisu Station on the Yamanote line for two weekdays each before and after installation of automatic platform gates.

As shown in Fig. 4 and 5, six three-dimensional laser sensors were installed above the platform and made to swing to scan passengers. The sensing area was divided into six sections for the morning peak time, and we conducted sensing at 55-degree angles and 1.0 second frequencies using six sensors. We further installed six two-dimensional floor-type laser sensors on the platform and installed a camera to verify the situation from above the platform.
numbers of people passing through the gates were almost the same on both days, so the numbers of the passengers in those periods did not differ much.

(2) Comparison of Change of Passenger Flow Before and After Installation of Automatic Platform Gates

Based on the results shown in (1), we compared Yamanote Line inner track trains arriving at Ebisu Station at 8:37:20 on March 3 and at 8:37:28 on July 14 through time series variation of the congestion level near train doors of the Yamanote Line inner track from the arrival time (0.00 in the graph) at the platform section. The comparison demonstrated that congestion reached its peak and was alleviated in about the same time from the arrival of the trains (Fig. 10). In the future, we plan to carry out analysis over a longer span of time to assess the change in passenger flow before and after installation of automatic platform gates.

4.3 Future Verification and Development

Since the swing frequency of the three-dimensional sensors was 1.0 second, it was difficult to sample the tracks of individually sampled passengers by tracking data of those passengers analyzed this time. Thus, we are planning to combine data at different swing frequencies and in different sensing ranges with two-dimensional sensing data to explore the possibility of sampling the passenger tracks.

5 Conclusion

To allow passenger to use stations smoothly, it is important in station designing to consider the flow of passengers and to verify the situation before and after implementing improvement measures before reflecting results in future measures. We found the developed tracking system effective as a measure to identify and visualize the flow of passengers in station concourses and on platforms. In the future, we will make efforts to identify the flow of passengers in a broader area and to effectively combine different tracking methods making use of their differing advantages. Through those, we aim to identify the congestion level and the characteristics of movement and stay of passengers in a station as a whole.
#1 Yamanote Line outer track
Inner track platform near train doors (#2) became congested with passengers from the train, and then passengers moved to ESCs.

#2 Yamanote Line inner track
#3 In front of ESC on Meguro side
#4 In front of ESC on Shibuya side

Congestion on platform near train doors (#2) was alleviated and long queues were formed in front of ESCs.

Passenger Time (hour: minute: second)

Number of persons per section

8:37:20 Inner track train arrives
#1 (Yamanote Line outer track)
#2 (Yamanote Line inner track)
#3 (In front of ESC on Meguro side)
#4 (In front of ESC on Shibuya side)

8:38:48 Outer track train arrives
#1 Yamanote Line outer track
#2 Yamanote Line inner track
(Compared in Fig. 10)

8:39:56 Inner track train arrives
#3 In front of ESC on Meguro side
#4 In front of ESC on Shibuya side

8:39:58 Outer track train arrives
#1 Yamanote Line outer track
#2 Yamanote Line inner track
(Compared in Fig. 10)

Fig. 6 8:37:38 Congestion Peak Time of Yamanote Line Inner Track Platform

Fig. 7 8:37:56 Time Congestion of Yamanote Line Inner Track Platform Alleviated

Fig. 8 Change in Congestion Level Before Installation of Automatic Platform Gates
(Yamanote Line Platform of Ebisu Station, at 8:37 - 8:40 on March 3, 2010)

Fig. 9 Change in Congestion Level After Installation of Automatic Platform Gates
(Yamanote Line Platform of Ebisu Station, at 8:37 - 8:40 on July 14, 2010)

Fig. 10 Comparison of Changes in Congestion Level in #2 Yamanote Line Inner Track Platform Section Before and After Installation of Automatic Platform Gates (Yamanote Line Platform of Ebisu Station)