

A Simulation Method for Adjustment of Public Transportation Routes using Geotagged Smart Card Data

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Abstract. In most studies on adjusting public transportation routes, passengers' behavior is identified through surveys, and travel demand is forecast by traffic zone. In recent years, passenger's travel information such as stops, routes, and boarding times have been stored through automated fare collection(AFC) systems, and studies are being conducted to utilize them. So, we proposed a simulation method of public transportation routes adjustment using smart card data. And then we used an actual bus adjustment case to verify the proposed simulation method.

Keywords. Geotagged smart card, Public transportation, Route adjustment

1. Introduction

An adjustment of public transportation routes is carried out in consideration of various interests, including users, operators and administrators (Yun 2018). Related studies on route adjustment have been analyzing passengers' behavior based on survey and forecasted travel demand by units of traffic zone such as administrative areas (Tsekeris & Tsekeris 2011, Briem et al. 2017). Since the use of smart cards has become more common, it has become easier to obtain travel information for individual passengers (Djavadian & Chow 2017, Liu et al. 2019). Therefore, recent studies have been trying to adjust public transportation route at a more microscopic level. In this study, we proposed a method of simulating public transportation routes adjustment. It can analyze changes before and after the route adjustment with quantitative indicators using personal travel information recorded on the smart card.

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The simulations are conducted in the order of GUI-based network editing, transit assignment and effect analysis. To verify the proposed simulation method, we used the actual bus adjustment case in Seoul city

2. Methodology

2.1. Smart card data

Smart card data are generated when passengers tag their cards to terminals while riding and alighting the vehicle. *Table 1* shows an example of smart card data. Since smart card data store passenger's travel information such as stops, routes and boarding time, it is possible to know which route passengers were at a certain time and which stop they were waiting at. In addition, if we analyze passenger's travel on a daily basis, we can predict the travel patterns and trajectories of passengers

Table 1. An example of travel information in smart card data

Passenger ID	Passenger Type	Ride Station	Ride Time	Alight Station	Alight Time	Routename
1	Adult	A3	08:07	B2	09:03	Line 3
1	Adult	B2	9:06	C5	09:15	160
2	Student	A4	15:33	C2	16:09	8863

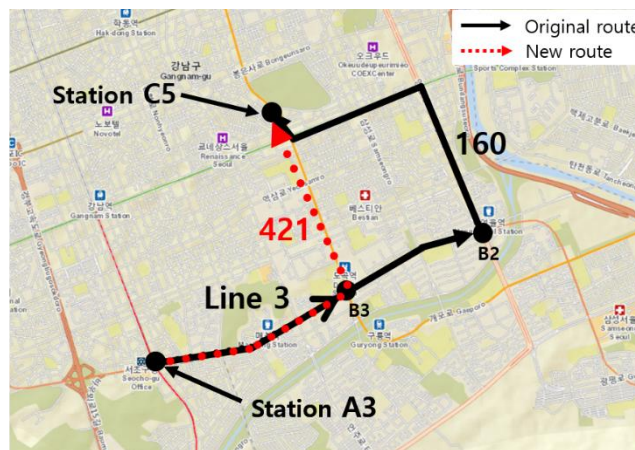
2.2. Simulation method for public transportation routes adjustment

The purpose of the public transportation route adjustment simulation is to predict how passenger's travel time and operation cost change according to route adjustment plan. We assumed that the travel demand recorded in the smart card data is current demand and calculated how this demand will change after adjustment. For this purpose, we carry out three steps. The first step is to change the transit network such as stops, routes, timetables according to the route adjustment plan. At this stage, the route adjustment planner creates a new public transit network through the GUI, changing the order of stops on the route, the headway of bus, and so on. The second step is traffic assignment to new created network. In short, it is to estimate which stops and routes will use by the passengers on the smart card after the new networks are created. The detailed description will be further explained in Section 2.3. The final step is to calculate the change in demand by route, the reduction in travel time and the change in operating costs before and after

the adjustment of the routes. We developed a simulator that can do all of this, and then used it to simulate.

2.3. Transit assignment based on smart card data

Smartcard data includes travel information that has been moved through current public transportation network. However, since we do not know how passengers will move in the newly created network, we need to estimate the route to use based on smart card data. First, only the passenger's departure stop, arrival stop and departure time are extracted from the smart card data, and all other information is deleted. Then, we input into the path finding algorithm the O-D(Origin-Destination) and departure time of passengers extracted from the smart card data to estimate passengers' path. The algorithm searches for the minimum travel time path from the origin to the destination according to the departure time based on the timetable, and we use it to calculate the minimum travel time path for all passengers. Figure 1 shows a simple example of estimating a passenger's path in new transit network. Figure 1 (a) shows the travel information recorded on the smart card and travel trajectory is represented by a solid line on the map. If bus No. 421 was newly



(a)

Passenger ID	Departure Station	Transfer Station	Arrival Station	Departure Time	1 st Routename	2 nd Routename
1	A3	B2	C5	08:07	Line 3	160



(b)

Passenger ID	Departure Station	Transfer Station	Arrival Station	Departure Time	1 st Routename	2 nd Routename
1	A3	B3	C5	08:07	Line 3	421

Figure 1. An example of transit assignment after routes adjustment

established, we input the passenger's departure stop(A3), arrival stop(C5) and departure time(08:07) into the algorithm. Then, as shown in Figure 1 (b), it is estimated that different transfer stop(B3) is used and the route using bus 421 instead of bus 160 is used. passengers choose No. 160 bus, which is bypassed because there is no alternative route, but after route adjustment, they will probably choose a path that took No. 421 directly to the arrival stop.

3. Simulation results

To verify the methodology of this study, simulation was conducted based on the case of the established new bus line. The target of the case is the new bus line No.1167, which was established August 2018. About 1 million people who stored on smartcard data on October 12, 2017 were simulated, and the simulation results were compared to the average daily usage of the No.1167 bus in May 2019. Figure 2 shows a comparison of the number of passengers by stops in simulation and No.1167 bus. The solid line is the actual number of passengers, the dotted line is the number of passengers in the simulation results, and the horizontal axis means the order of stops along the bus line. As a result, we confirmed that the actual demands and the simulation results were very similar. Also, comparing the daily average number of passengers on the new bus line with simulation results, the simulation was forecast at 1,724 and the actual number of passengers was 1,696. As a result, the number of passengers per stops on the new route came out similar to the actual demand, and other routes also were derived very similar to the actual demand.

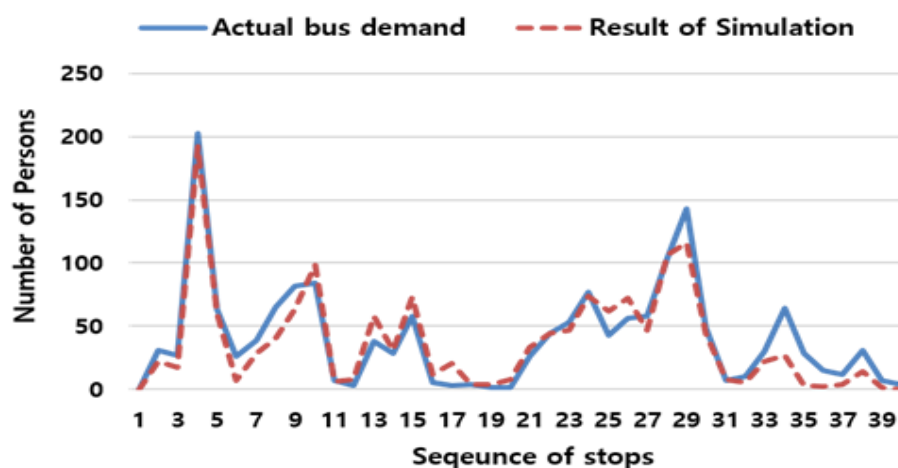


Figure 2. Comparison of the number of passengers by stops in simulation and No.1167 bus

4. Conclusion

In this study, we proposed a simulation methodology that analyzed the effects before and after routes adjustment using the smart card data which recorded the travel information of public transportation passengers. The simulation results applied to actual route adjustment case were very similar to the number of passengers in actual bus line by stops. In later studies, we plan to verify the simulations in more diverse scenarios.

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