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Proposal and Application of Parking Area Performance Measurement Methodology

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Abstract
The function of parking areas at expressway rest stops is to provide drivers with opportunities to park their vehicles for their own purposes, so the number of parking spots has been discussed. However, as the number of parking spots increases, the parking area becomes maze-like and the use of the parking spots becomes inefficient. This leads to skepticism that an increase in parking area capacity will contribute to enhancing parking area performance. Meanwhile, one vehicle is able to park in a parking spot when another vehicle exits the area that is fully occupied, so the condition of drop-by traffic at a rest stop can be discussed using the queuing theory by viewing a rest stop as a warehouse. Thus, this study aims to determine the applicability of the queuing theory when discussing drop-by traffic situations, while assuming a first-in first-out (FIFO) condition. For the applicability of the queuing theory of describing parking area performance, this study employed the ETC probe time-stamp data. The observed values from the ETC probe time-stamp data and FIFO assumed time lags are described, and the applicability of the observed ETC time-stamp data to representing the exact conditions was determined by comparing the number of vehicles parked on the hour every hour and those counted by the observed ETC probe time-stamp data. Finally, the applicability of the FIFO assumption was discussed using the correlation between the observed ETC probe time-stamp data and the FIFO assumed time lags calculated by the data. The results indicate that a FIFO assumption could alternate the observed ETC probe time-stamp data. The number of vehicles staying on the hour every hour can be represented by the calculation results from FIFO assuming time lags. These findings show that it could be possible to determine the congregative situations of an expressway rest stop analyzed by the ingress and egress time-stamp records. Also, this result assumes any contribution to assessing the functional performance by measuring only the number of vehicles entering and exiting a parking area.

Keywords: Parking area, First-in first-out (FIFO), Queuing theory, Time-stamp data, Performance

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1 Introduction

The function of parking areas at expressway rest stops is to provide drivers with opportunities to park their vehicles for their own purposes, so highway administrators or operators have focused on how many vehicles can park in a parking area, which means that the capabilities of parking areas have generally been discussed based on capacity or the number of parking spots. For example, the design specification for the rest stop of Japanese expressways prescribes only the capacity of a parking area, width of an access aisle, and the dimensions and angle of a parking spot. As the specification, the capacity, which is the number of parking spots, is supposed to be calculated based on the traffic volume on the main line. Thus, many parking spots are required for rest stops in sections with heavy traffic. Therefore, as the number of parking spots increases, the parking area becomes maze-like and the use of the parking spots becomes inefficient. For example, Ebina Service Area (SA) on the Tomei Expressway, which was opened in 1968, expanded its parking area capacity in 1991, because there was no suitable location to develop an alternative new rest stop on the route. As a result, there are many invisible parking spots that have been developed farther from the entrance, and those are not effectively used even during busy hours, while closer zones are always full, which frequently leads to long queues near the entrance. This leads to skepticism that an increase in parking area capacity will contribute to enhancing parking area performance.

For this inefficiency problem, some research has been conducted and measures taken to enhance traffic conditions inside a huge parking area. For example, Muramatsu et al. (2011) indicated that information delivery to drivers contributes to increasing parking spot use, specifically in invisible parking zones on the farther side of the entrance, and Muramatsu and Tada (2012) reported that more detailed information provided in a closer zone contributes to reducing travel time to park in a parking spot. Some research is available that is related to available parking spot choice behavior or to prediction models for parking area occupancy and parking demand control. Other researches focused on the drop-by demand allocation for several rest stops on the route. However, the aspects of those research projects focused more on vehicle travel behavior than the functional performance of parking areas.

Essentially, each driver has a different purpose and a different expected time of stay, so the duration of stay by drop-by vehicles fluctuates. Meanwhile, it can be seen that one vehicle is able to enter a rest stop and park in a parking spot if another vehicle exits the area, which means that the condition of drop-by traffic at a rest stop can be discussed using the deterministic queuing theory by viewing a rest stop as a warehouse, without identifying each vehicle license plate. Thus, this study aims to determine the applicability of the queuing theory when discussing drop-by traffic circumstances, while assuming a first-in first-out (FIFO) condition.

2 Queuing Theory Application to Time Series Analyses

The function of parking areas at expressway rest stops is to provide drivers with opportunities to park their vehicles for their own purposes, so expressway operators are required to provide vehicle drivers with enough parking spots as well as smooth and safe moving conditions. This means that the parking area performs the same functions as both a traffic facility that provides vehicles with efficient and safe travel, and a warehouse that accumulates vehicles whose drivers want to stay (how long and how many). Both of these phenomena are often analyzed using the queuing theory.

2.1 Queuing Theory Applied to Traffic Flow Analysis

The deterministic queuing theory is applied to the traffic flow analysis, because traffic demand changes depending on the time, and it is convenient to describe changes in congestion from moment to