Observations of Traffic Flow in Tomei Express Way

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1 Introduction

Physical understanding of the traffic flow in expressways has been improved mainly with the help of computer simulations. Most of models seem to reproduce the fundamental features of the traffic flow in one-lane expressways. To improve models, especially for treating two-lane systems, it is necessary to compare the simulation results and the observed data. Unfortunately, however, very limited observation data have been available to validate the simulation results.

In Tomei expressway (connecting Tokyo and Nagoya), there are some induction-loop detectors installed by the Japan Public Highway Corporation. They observe the flow (the number of cars) q passing by a detector for 5 minutes and the average velocity v. The data are collected monthly.

Some parts of observed data have been summarized by one of the current authors[1]. It includes the fundamental diagrams, the headway-velocity relations and so on. To analyze the data systematically and extensively, the authors are constructing the on-line database system to provide traffic flow data. In this talk, we present some new knowledge from observation data in Tomei expressway.

2 Observed Features

2.1 Fundamental diagram

Here we analyze the observation data in August, 1996, detected in lanes bound for Tokyo at the 170.64 Km point (near the Nihonzaka tunnel) as an example. At the point, the expressway has two lanes for each direction (bound for Tokyo and for Nagoya).

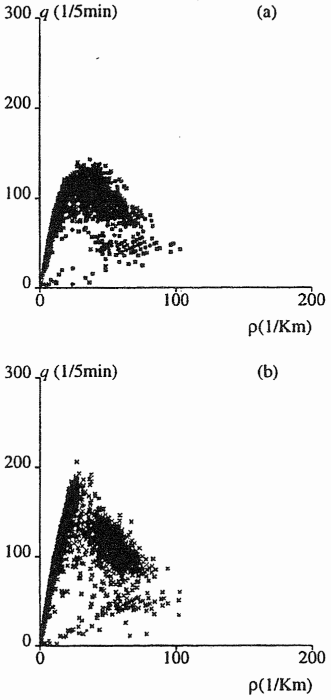

Figure 1: Fundamental diagram: The density ρ and flow q relations are shown for the slow lane (a) and the fast lane (b). The data observed during one month are shown.

First we show the fundamental diagram (Fig. 1),

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the density-flow relation. The density ρ is calculated with the flow and the average velocity as $\rho = q/v$. We can see a clear phase transition from a freely moving phase (the left side of the peak) to a jam phase (the right side of the peak). The sparse distribution of data near the peak corresponds to the instability of the super-saturated flow.

2.2 Headway-velocity relation

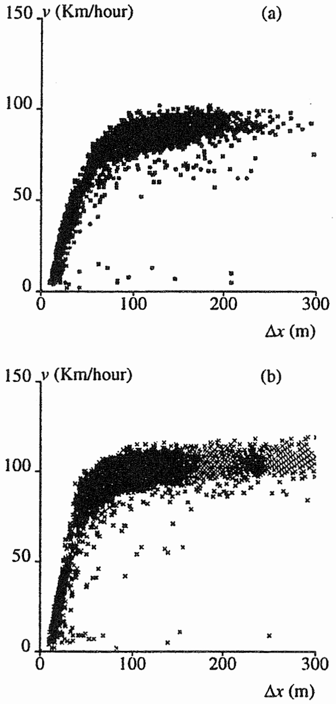

Figure 2: The headway-velocity relations of cars in the slow (a) and fast (b) lanes.

The headway-velocity relations of cars in the slow and fast lanes are shown in Fig. 2. The headway Δx is defined as $\Delta x = 1/\rho$. The maximum speed in the slow lane remains below 100 Km/hour. On the contrary, cars in the fast lane run faster than 100 Km/hour.

Besides the difference of the maximum speed in the slow and fast lanes, the headway-velocity relation in the fast lane shows steeper behavior than in the slow lane. Namely the speed almost approaches the maximum value at $\Delta x \sim 50$ m in the fast lane and at $\Delta x \sim 100$ m in the slow lane. This suggests us to employ different optimal velocity function [2] for cars in different lanes.

2.3 Lane usage characteristic

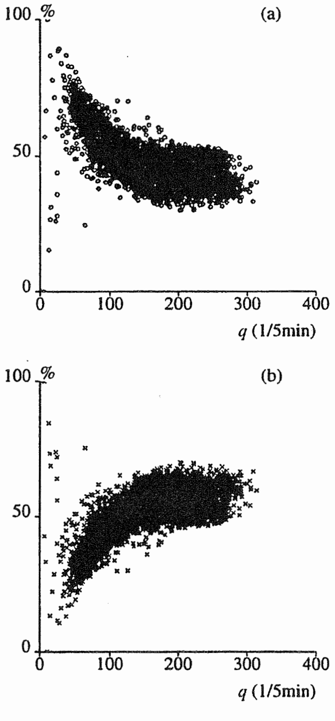

Figure 3: The lane usage characteristic: The ratios of the flow in the slow (a) and fast (b) lanes to the total flow are plotted.

The lane usage characteristic, the ratios r_i of the flow in the slow and fast lanes to the total flow are shown in Fig. 3.

$$r_i = \frac{q_i}{q_{\text{slow}} + q_{\text{fast}}}, \quad i \in (\text{slow}, \text{fast}). \qquad (1)$$

In the low flow region, most of cars run in the slow lane. With increase of the total flow, the flow in the fast lane exceeds that in the slow lane at $q_{\text{total}} \sim 100$ (1/5min). As the flow approaches the saturation, the ratios seems to return to 50%.

2.4 Temporal behavior

Here we investigate the temporal behavior of the traffic flow. First we show the temporal sequence of the flow (Fig. 4), which shows the data for almost three days (4320 minutes). We can see the quasi-periodic daily (1440 minutes) behavior.

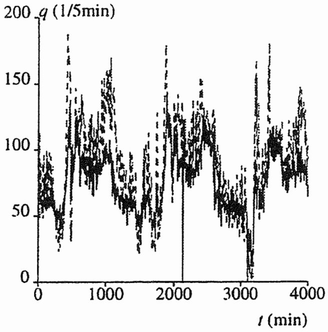

Figure 4: The temporal behavior of the flow. The flow in the slow (fast) lane is denoted with the solid (broken) line.

We can see also the strong correlation between lanes in Fig. 4. To investigate the lane-correlation closely, the relations between the flow in the slow and fast lane are shown in Fig. 5.

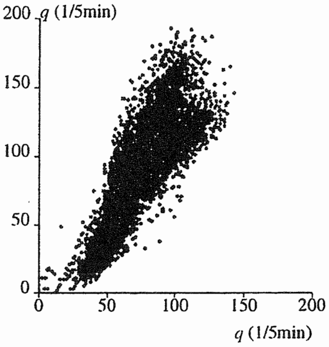

Figure 5: The correlation of the flow. The flow in the fast lane (the vertical axis) is plotted as a function of the flow in the slow lane (the horizontal axis).

Finally we show the temporal spectrum of the flow.

$$I_q(k) = \left| \frac{1}{T} \sum_{t=0}^{T-1} q(t) e^{-2\pi i k t/T} \right|^2 . \qquad (2)$$

Figure 6 shows the $1/f$ behavior in the long wave length region.

Acknowledgments

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References

[1] K. Nishinari and M. Hayashi ed., *Traffic Statistics in Tomei Express Way* (The Mathematical Society of Traffic Flow, 1999).

[2] M. Bando, K. Hasebe, A. Nakayama, A. Shibata and Y. Sugiyama, Phys. Rev. **E51**, 1035 (1995).

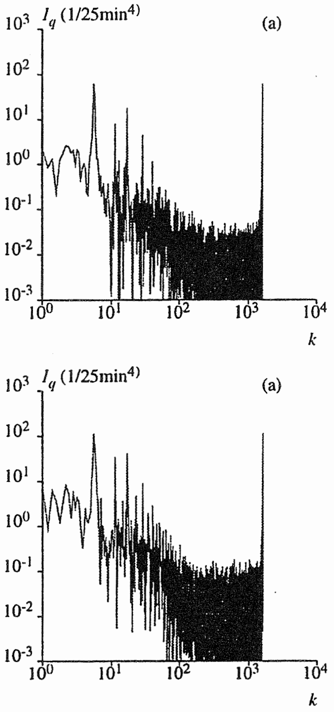

Figure 6: The temporal power spectrum of the flow in the slow (a) and fast (b) lanes.