
Influencing Driver Behavior through Future Expressway Traffic Predictions

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UbiComp '14 Adjunct, September 13-17, 2014, Seattle, WA, USA
ACM 978-1-4503-3047-3/14/09.
<http://dx.doi.org/10.1145/2638728.2638778>

Abstract

Unlike trains or buses, automobiles are essentially uncontrollable for road management companies. However, we can influence driver behavior to a certain degree by displaying appropriate traffic information. When taking a break at the rest area of an expressway, many drivers are unaware of the future traffic conditions along the highway toward their destination. We propose a method for changing the driver's departure time by predicting the future traffic conditions and informing the driver on how long the driver will expect to wait in a traffic jam based on the time at which the driver chooses to depart from the rest area. We created a prototype system for implementing the proposed method using the driver's smartphone and big data regarding the traffic conditions on an expressway in real-time. In this paper, we report the survey results of an elementary questionnaire regarding the proposed method.

Author Keywords

Behavior induction, Future prediction, Traffic jam, Drivers' behavior

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction

Automobiles are not directly controllable because each vehicle driver has a different intention and drives independently, and road administrators can only control traffic signals or electric bulletin boards. Therefore, traffic can become concentrated at a particular region or time, which can increase traffic congestion and accidents.

Congestion prediction by expressway management depends on the time and location and is not focused on individual vehicles. However, Takeuchi et al. studied a method for effectively changing or influencing personal behaviors by displaying the future conditions[1]. We believe we can decentralize traffic demand by presenting future driving behaviors to individual drivers.

In particular, we focus on drivers currently in a service area (SA), also known as a rest area, on an expressway. We aim to change the driver's departure time from the SA by presenting a future prediction of the traffic congestion the driver will encounter and when the driver will arrive at their destination on the basis of their time of departure. We believe we can decentralize the traffic demand as well as decrease the driver's mental fatigue by prolonging their rest time at an SA, thereby increasing the profits of the expressway management companies by increasing consumer consumption at the SAs. For this study, we built a system that presents the future traffic conditions for each driver, and changes or influences the driver's future behavior. In addition, we conducted a questionnaire survey.

Influencing the Departure Using Future Traffic Conditions

Presentation of Future Traffic

Currently, congestion information presented on an information board at an SA is for the current time only. Therefore, drivers cannot know how much congestion they will encounter and when they will arrive at their destination based on their departure time from the SA. However, given two choices, i.e., (1) start immediately, encounter traffic congestion 60 min later, and arrive after 80 min from the present time or (2) rest for 30 min at the SA, not encounter traffic congestion, and arrive after 90 min from the current time, which option would a driver choose? For this question, we investigated whether the drivers at an SA would change their departure time if we can predict and present them with future driving behaviors.

We propose a two-dimensional UI for the prediction presentation using two time axes for presenting all future driving behaviors corresponding to various departure times (Figure 1). The vertical axis in Figure 1 represents the departure time; for example, the top of the axis indicates an immediate start time. Areas classified by color in the UI represent the driver's condition: light blue is the amount of time the driver remains at the SA, green is normal traffic conditions, red is driving during traffic congestion (average speed of 40 km/h or less), and gray is the destination IC. For example, the black line near the center of the graph represents a prediction that the driver will encounter little traffic congestion and drive smoothly if the driver takes a 20 min rest at the Ashigara SA and departs at 17:18, arriving at Yokohama-Machida IC at 18:27.

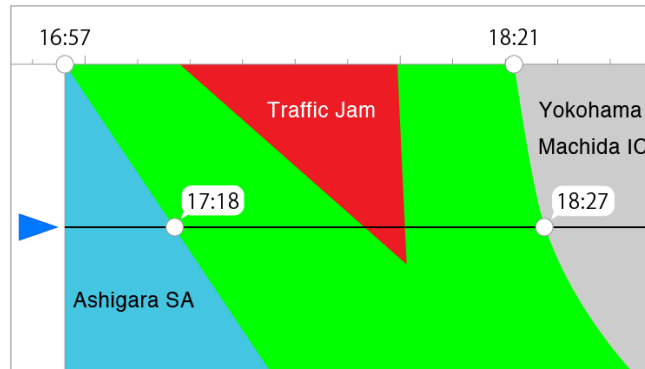


Figure 1: UI for presenting future driving behaviors.

Experiment

We conducted a paper-based questionnaire to determine how drivers would react after seeing images of various traffic patterns like Figure 1, and collected their answers regarding their intended departure time from the SA based on the patterns shown. We prepared 13 images consisting of either no traffic congestion or traffic congestion using the location, duration, and length parameters in Table 1. The duration is indicated by the vertical axis in Figure 1, and the length is indicated by the horizontal axis. In this experiment, for simplicity, we assumed that there was only one area of traffic congestion. We asked the participants to assume that they came to the SA for a short break, not for shopping or eating, and that the proposed images they viewed before they wanted to depart showed the actual current traffic situation. In addition, we told them that the distance from the SA to their destination was 120 km and would take about 90 min under normal conditions. Next, we showed each participant 13 randomly ordered UIs and asked them to draw a horizontal line to the point indicating their selected departure time. Forty of the participants answered the questionnaire.

Location	Near, Far
Duration	Short, Medium, Long
Length	Short, Long

Table 1: Traffic congestion parameters.

Results and Discussion

Figure 2 shows a chart of the 13 types of images that were presented in the questionnaire and a histogram showing the departure times selected by the participants. Semi-transparent yellow bar charts represent the selected departure time partitioned into 10-min intervals. Figure 2 shows that the participants intended to depart immediately when there was no traffic congestion. This indicates that the location of the traffic congestion does not have an effect on the driver's decision because there are only slight differences in the distribution between the patterns, which are different only in the location of the traffic congestion, such as in (b) and (d) and in (g) and (i). A comparison of the patterns, which differ only in the duration of the traffic congestion, such as (b), (f), and (j), indicates that the distribution tends to widen toward the end when the traffic congestion is longer. However, most of the participants intended to depart immediately without waiting for an end to the traffic congestion when it was revealed that the traffic congestion would continue for longer than 120 min, as in (k) or (m). The length of the traffic congestion cannot be simply compared because it has an effect on the traffic congestion duration, which indicates that the participants had a tendency to postpone their departure time when the traffic congestion was longer when comparing patterns in which the duration of the traffic congestion was relatively close, as in (c) and (j). This is considered to be a behavior aimed at avoiding fatigue when caught in traffic congestion. From these discussions, it was considered that a driver's departure time from the SA depends on the duration and length of the traffic congestion.

Figure 3 charts the difference in the departure time and the solution time for traffic congestion. Each error bar in the figure indicates the standard deviation. The solution

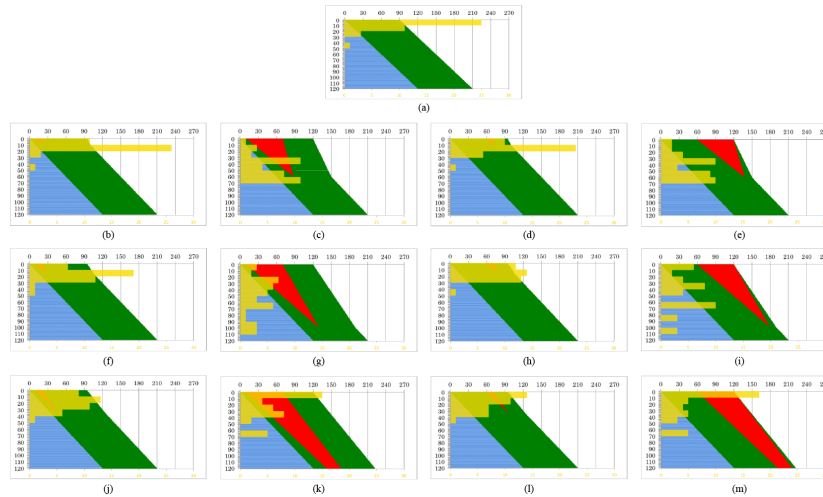


Figure 2: Presented patterns and histogram of the selected departure time ($n = 40$). The two time axes are in units of minutes.

time for the traffic congestion is the duration of traffic congestion because the traffic congestion in the images we prepared was considered to be occurring at the present time.

From Figure 3, drivers who viewed the proposed images departed from the SA after waiting for an end to the traffic congestion when the duration of the traffic congestion was 10 or 15 min. On the other hand, it is indicated that drivers had a tendency to depart immediately, even when they knew they would encounter traffic congestion when the duration of the traffic congestion was longer than 30 min. Therefore, the proposed system has an effect on changing the driver's departure time, particularly up to about 15 min.

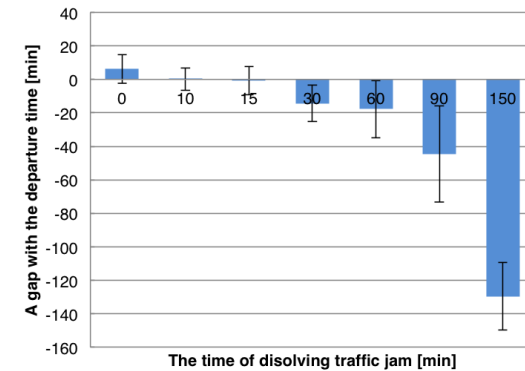


Figure 3: Difference in the departure time and the end time of the traffic congestion.

Conclusions

In this study, we proposed a system for changing a driver's departure time from an SA by presenting the driver with a future prediction of the driving behavior. Through a questionnaire-based experiment, we found that the presentation of the proposed prediction system is effective in inducing about a 15-min change in the departure time.

References

- [1] Takeuchi, T., Suwa, K., Tamura, H., Narumi, T., Tanikawa, T., and Hirose, M. A Task-management System Using Future Prediction Based on Personal Lifelogs and Plans. In *Proceedings of the 2013 ACM Conference on Pervasive and Ubiquitous Computing Adjunct Publication*, UbiComp '13 Adjunct, ACM (2013), 235–238.