

Demo: Proactive Car Navigation: How Can Destination Prediction Give Us New Navigation Experience?

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ABSTRACT

Conventional car navigation systems that require manual input of a user's destination are not frequently used for familiar routes such as daily commutes and regular shopping. In this paper, we propose and realize proactive car navigation, which integrates daily destination prediction system to car navigation system in order to eliminate input by user by displaying information related to destinations automatically. By questionnaire-based evaluation, we found that proactive car navigation innovates a user's driving experiences, and offers them various advantages, even for regularly frequented destinations.

CCS CONCEPTS

• **Information systems** → **Location based services**; • **Human-centered computing** → **Ubiquitous and mobile computing systems and tools**.

KEYWORDS

Destination prediction, vehicle navigation, proactive application

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1 INTRODUCTION

Car navigation system is a convenient tool that provides information for the destination and route by the driver inputting the destination, and a familiar tool in recent years. As shown in a survey on car navigation system usage in Japan [8] and explained in the existing research [7], the car navigation system is often used when traveling or getting lost, and is usually not used in daily activities. This is because in moving to daily destinations, that is well-known by user like home and office, the cost of inputting the destination is not equal to the convenience provided by navigation. However, even for the same route, the travel time and congested situation vary from day to day, thus these informations lead the driver to more comfortable driving.

In this paper, we propose a **proactive car navigation**, which integrates daily destination prediction system to car navigation system in order to eliminate input by user by displaying information related to destinations automatically, and evaluate it in wild experiment. We describe our system developed to realize a proactive car navigation system by destination prediction, and explain questionnaire basis evaluation for confirming that providing information related to the destination is effective even for daily activities, and leads users to use car navigation system in daily activities. Terada et al. [6, 7] also apply destination prediction to car navigation systems and design a system that provides information without user input, but the evaluation is limited to the performance of the destination prediction method, and the system evaluation has not been done. By evaluating 38 users, we found that proactive car navigation systems motivate daily use in users whose destination prediction accuracy is high, and the feature that updates predicted destinations in

real time using the route information leads to higher accuracy. The contributions of this paper are the following.

- We realize a proactive car navigation system by integrating destination prediction with a car navigation system to resolve the problem of low use frequency for daily activities.
- We evaluate a proactive car navigation system using a questionnaire.

2 RELATED WORKS

Destination Prediction Research

Existing destination prediction research can be divided into two types: research that predicts destinations based on individual daily activity pattern [2–4, 9], and research that predicts destinations based on POI popularity or group flow [1, 5, 10]. In this research, we focus on the daily use of car navigation systems and apply the former destination prediction method to the system.

Car Navigation System with Destination Prediction

Terada et al. [6, 7] applied destination prediction to car navigation systems and designed a system that provides information without user input, but their evaluation is limited to the performance of the destination prediction method, and system evaluation was not done. In this paper, we focus on user evaluation of the car navigation system by questionnaire and use the existing destination prediction method.

3 PROPOSED SYSTEM

System Structure

In this section, we describe an overview of proactive car navigation systems with integrated destination prediction. There are some examples of information related to the destination, such as the location of a destination, trip duration, route, and congestion information of the route.

Our goal is to find out if there is information in these that is useful for a user’s daily activities, and to confirm if providing this information leads to the daily use of car navigation systems. It should be noted when only the top destination is displayed, the hit rate of the destination might be low (e.g., Imai et al. report while top-1 destination prediction accuracy is about 70%, top-3 destination prediction accuracy is over 90%). Therefore, our system will display the top 3 destinations. As the user is familiar with the route to the daily destination, our system does not display routes to the destination candidates. That is, our system provides user with “address of destination”, “duration time”, and “congestion information of route” automatically.

Fig 1 shows the application example.

Our system is divided into training and prediction parts. During training, the destination prediction model is trained



Figure 1: Application example. “Address”, “duration time”, and “congestion information of the route” of top-3 predicted destinations are displayed. Here, color of duration shows congestion information.

by using the route trajectory log of users. This part is run regularly, e.g., once per week, to keep the learning model up-to-date. Prediction is performed based on the trained parameters by providing the user ID, GPS, and timestamp sent from the device to the trained model, and the prediction result is sent to the device: i.e., the prediction is performed in real time. The proactive car navigation system updates predicted destinations along with the movement of the car.

Early Destination Prediction

The early destination prediction performance is one of key factor for the proposed navigation system. We apply early destination prediction model [3] to our system. Features of this prediction method are to predict a destination with high accuracy in early stages of movement, and to update the prediction by using route congestion information. Moreover, since this prediction method uses daily staying pattern for predicting destination in early stages of movement, and daily route patterns for updating prediction, high prediction accuracy for daily activities is expected.

4 EXPERIMENT

Overview

To find out whether providing information related to the destination by car navigation systems is useful for daily activities, and whether a proactive car navigation system will lead to the daily use of the car navigation system, we conducted a questionnaire survey targeting 38 people. We describe the demographic information of the target user. About 69% of target users were male and 31% were female. As for the distribution of age, 55% of target users were in thirties, 37% in forties, and 8% in fifties. Also, as for the driving frequency, 38% of users once a day, 50% several times a week, and 12% several times a month.

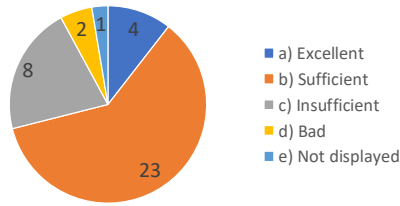


Figure 2: Result of prediction accuracy (Q1)

We asked each of these users to use a car navigation system without proactive car navigation system for 3 weeks to collect training data, and then to use the car navigation with proactive car navigation system for 2 weeks.

Items of the questionnaire are as follows.

- Q1) **Was the prediction accuracy sufficient?**: Whether the predictive performance is sufficient or insufficient may make a difference in the user's evaluation of our system. Therefore, the purpose of this item is to make users evaluate the predicted performance for groups of users for whom predicted performance was sufficient, and those for whom it was not.
- Q2) **Was the new system useful?**: Directly evaluate whether our system was useful.
- Q3) **Which were the useful parts of the new system?**: For a detailed analysis of the evaluation of information related to the destination, we investigate the usefulness of the parts of the system.
- Q4) **Does the new system cause changes in driving behavior or feelings?**: If our system is useful, investigate how it was useful.
- Q5) **Assuming that the prediction accuracy is sufficient, is the daily use of car navigation increased by the new system?**: Depending on prediction accuracy, the user may not be able to correctly experience our system. Therefore, we investigate the usefulness of our system assuming sufficient prediction accuracy.

In addition, we prepared a free answer space, and made a detailed evaluation of the proactive car navigation system.

Questionnaire Results

We show the results of each questionnaire.

- Q1: Fig 2 shows this result. This graph shows that about 70% of users answered that the prediction accuracy is Excellent or Sufficient.
- Q2: Fig 3 shows this result. The proportion of users who answered that it was useful, not useful, and useless were equal. Fig 4 shows the difference between the result of users who answered that the prediction accuracy was sufficient and insufficient. Using these graphs, it can be said that if the accuracy is sufficient,

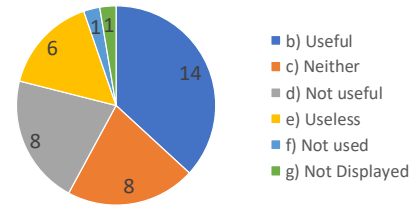
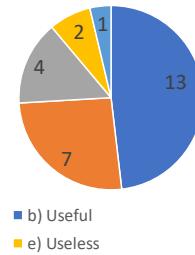


Figure 3: Result of whether the new system is useful or useless (Q2)

Good accuracy users



Bad accuracy users

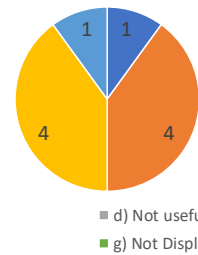


Figure 4: Result of whether the new function is useful or useless for users with sufficient/insufficient prediction accuracy (Q2)

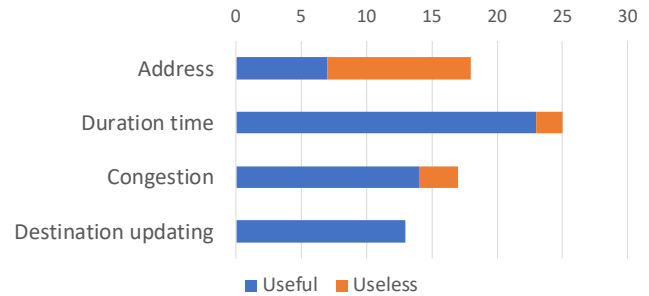


Figure 5: Result of usefulness or uselessness of function (Q3)

the usefulness of proactive car navigation system increases.

- Q3: We evaluate "Address", "Duration time", "Congestion information", and "Updating displayed destinations" as useful or useless. Fig 5 shows this result. "Duration time", "Congestion information", and "Updating displayed destinations" are rated high. On the other hand, "Address" is rated low.
- Q4: There were 3 users who checked "Change driving plan", and 13 users who checked "Change feeling". It is seen that the effect on changed feelings, such as going slowly or in a hurry, is high, and changed destinations and driving plans are low.

- Q5: We use “Seems to increase”, “Seems not to change”, and “Seems to decrease” as items. Overall, the number of users who answered “Seems to increase” is 22, “Seems to not to change” is 16, and “Seems to decrease” is 0. 60% of the users answered “Seems to increase”, and there are no users who answered “Seems to decrease”. These results show that the proactive car navigation system leads to the daily use of car navigation systems.

5 CONCLUSION

We propose to integrate the daily destination prediction system with car navigation systems to eliminate input by user, and provide information related to daily destinations automatically. We develop the proactive car navigation system using destination prediction and evaluate this new system by questionnaire for 38 users. Our evaluation revealed that proactive car navigation could enhance the users' car navigation experience. Evaluation results shows that duration time and congestion information are useful even daily activities, and that the proactive car navigation system leads to daily use for users whose destination prediction accuracy is high. The feature that updates predicted destinations in real time using the route information leads to greater usefulness.

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