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Analysis of individual risk perception during highway lane-change scenes

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ABSTRACT

In this study, we develop a method of estimating the level of risk perceived by individuals for lane changes. Driver behavior signals, vehicle status and surrounding vehicle information are collected using multi-modal sensors, and features which could influence perceived risk are selected. Subjective feedback is then collected from study participants while they view video of right and left lane changes during expressway driving. A random forest method is applied to assess the importance of each feature for each individual in relation to risk perception, revealing individual differences in the importance of the various features. We find that the levels of risk perceived by individuals can be effectively predicted using the random forest method when features selected according to their importance for each individual.

I. INTRODUCTION

More and more Advanced Driver Assistance Systems (ADASs) are entering the market in order to improve driving safety and convenience. However, few studies have examined individual differences in risk perception while driving. Drivers likely differ in their important risk factors when deciding if a situation is risky or not, and these factors influence how drivers operate their vehicles and how comfortable they feel when supported by ADASs [1][2].

In this paper, we investigate the factors that influence individual risk perception in lane change situations. We apply a random forest method to assess the importance of each feature for each individual in relation to risk perception and to predict overall perceived risk levels for each individual.

II. COLLECTING DRIVING DATA AND PERCEIVED RISK LEVELS

An instrumented vehicle was used to collect driving data from eleven drivers, including driver behavior, vehicle states, and environmental information. They drove on expressways and made 988 lane changes in total. Video of front camera facing the road ahead is used to collect subjective risk scores of lane change scenes. Ten participants (different from the eleven drivers) watched the video of lane change scenes without knowing who was driving, and reported their perceived level ofrisk on a scale of 1 to 5 for each lane scene.

III. FEATURES OF PERCEIVED RISK

In order to investigate the relationship between individual risk perception and driving situations, three categories of features representing driving situations were selected, i.e., driver behavior, vehicle states, and environmental information (Table II). These features were calculated from driving data collected in Section II. Environmental information includes the relative positions of surrounding vehicles and the driver's own vehicle, and road curvature. We divided the area surrounding the driver's vehicle into nine zones as shown in Fig. 1, and calculated TTC (Time-To-Collision) and THW (Time-Headway) for each zone.

TABLE I. FEATURES REPRESENTING DRIVING SITUATOIN

Feature categories	Features
Driver behavior	Braking force
	Acceleration force
	Steering angles
Vehicle states	Velocity
	Acceleration X
	Acceleration Y
	Acceleration Z
Environmental information (Surrounding vehicle and road information)	TTC_*n*X (*n*=1,…, 9)
	TTC_*n*Y (*n*=1,…, 9)
	THW_*n*X (*n*=1,…, 9)
	THW_*n*Y (*n*=1,…, 9)
	Road curvature

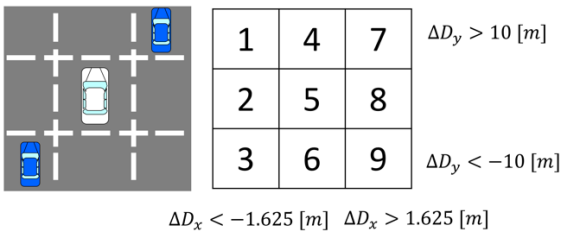

Figure 1. TTC and THW for surrounding vehicles are calculated for the nine surrounding zones.

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IV. ASSESSING FEATURE IMPORTANCE USING RANDOM FORESTS

After acquiring data for features related to individual risk perception, we used a random forest method [3] to assess the importance of each feature for each participant. We measured feature importance as the averaged impurity decrease computed from all of the decision trees in the forest.

Experimental results of our feature importance assessment for four of our participants are shown in Fig. 2 (left lane change scenes) and Fig. 3 (right lane change scenes). Our observations are as follows:

- Overall, velocity was the most important component of perceived risk. Strong braking force and high longitudinal acceleration were both perceived as risky by most of the participants.
- Overall, surrounding vehicles in zone 8 had great effect on perceived risk during lane changes.
- Road curvature increased the level of perceived risk for Participants 2 and 4, but not for Participants 1 and 3, which implies that driving on curves increases perceived risk only for some drivers.

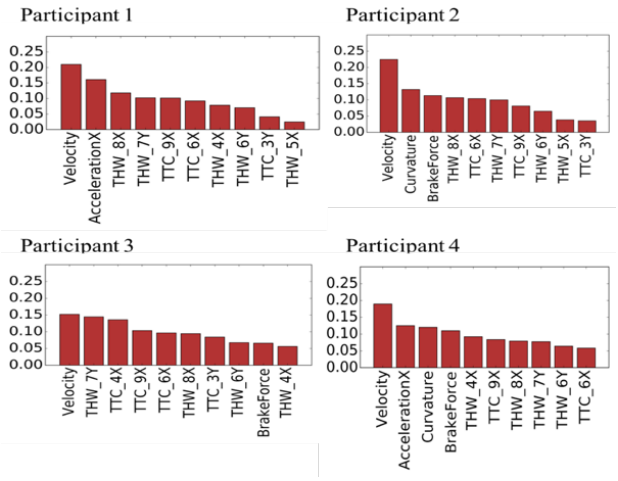

Figure 2. Individualized risk feature importance rankings for four participants (left lane change scenes).

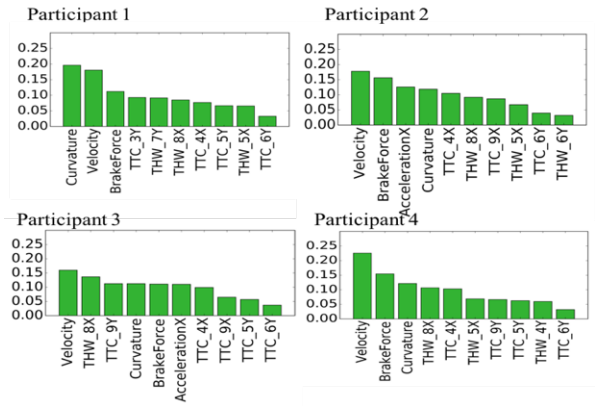

Figure 3. Individualized risk feature importance rankings for four participants (right lane change scenes).

V. RISK PERCEPTION PREDICTION

After assessing the importance of the selected features on the perceived risk levels of each of our participants, a set of unique, important features for each participant was selected and a random forest was applied to predict the overall level of risk perceived by each participant.

An example of the risk perception prediction result for Participant 4 is shown in Fig. 4. The y-axis represents Participant 4's reported overall risk perception level, while the x-axis represents the level of perceived risk predicted using the random forest. In Fig. 4, the darker the color of a square, the more frequently a participant perceived that particular level of risk when viewing the driving situations in the video. Therefore, Participant 4 has a tendency to perceive little risk when viewing the driving scenes. The results show that the random forest method could successfully predict the level of risk perceived by each participant.

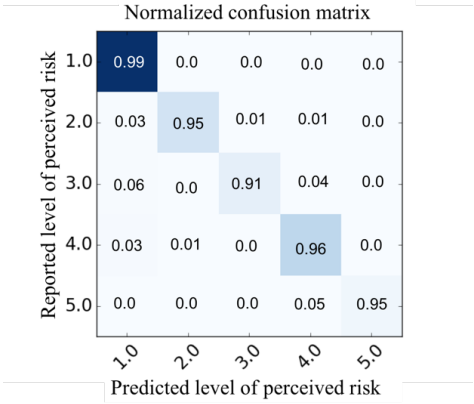

Figure 4. Confusion matrix of random forest classification for Participant 4, comparing reported and predicted levels of perceived risk.

VI. CONCLUSION AND FUTURE WORK

In this study, we investigate the features that influence individual risk perception in lane change situations. A random forest method was then applied to assess and rank the importance of each of these risk features individually for each participant. We then predicted overall perceived risk levels for each participant. Experimental results showed that our method performed well for estimating driving-related risk as perceived by different individuals.

In further investigations, structural feature analysis methods, such as group lasso, will be applied to analyze structural differences in perceived risk among individuals

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