Driver Body Information Analysis with Near-miss Events

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***Abstract*—This study examines safety verification behaviors associated with near-miss events at nonregulated intersections with poor visibility. From an assessment of a driver's eye-gaze movements and facial orientation associated with the sudden appearance of bicyclists encountered while approaching a nonregulated intersection, we attempt to analyze the distinctive motion of the safety verification behaviors before and after near-miss events. Finally, the experimental results suggest that the sudden appearance of a bicyclist in the vehicle path has an increased chance of becoming a near-miss event. Specifically, the trajectory characterized by the eye-gaze movements and facial orientations of the driver before and after near-miss events show close correlation with the interview results of daytime on a sunny day.**

Keywords-driving behavior analysis; facial orientation; eye-gaze movements; near-miss event.

I. INTRODUCTION

In Japan, the proportion of fatal bicycle accidents is low. However, there are about 120,000 bicycle-related nonfatal casualties, which is about 20% of the total vehicle-related casualties [1]. Although, from a recent survey [2], the proportions of casualties appear to be decreasing, a serious situation exists.

In this study, we focus on near-miss events and safety verification behaviors at nonregulated intersections. Specifically, by devoting attention to the facial orientation and eye-gaze movements of a driver before and after near-miss events involving the sudden appearance of a bicyclist at an intersection, we attempt to analyze the causal relations between the distinctive safety verification behaviors, and interview .

According to statistics, about 3/4 of the human errors in crossing collisions in nonregulated intersections where many crossing collisions have occurred involve cognitive distraction states. However, cognitive distraction depends on changes in a driver's internal state, and external observation of the distraction is difficult. A method of estimating distraction has not yet been established.

Several methods of detecting distraction have been proposed by Dong et al. [3] and classified into four types based on the modalities of measurement [4]. The application of what Dong et al. defined as "subjective evaluation" and "physiological information" for actual driving situations is not realistic because of the burden these methods place on the driver. Furthermore, the "operation information" that the authors defined as steering or braking lead to accidents directly, and when the distracted state appears in the operation information, there is a possibility to miss the accidents avoiding.

In related studies of the estimation of driver distraction, Abe et al. [5] examined what they referred to as the driver's "thinking state", and Honma et al. [6] discussed what they referred to as the "blank states". These studies not only have confirmed the basic characteristic scene wherein discovery delay occurs but also overlooked changes in ambient conditions. In this study, we focus on the following three types of distraction states, i.e., thinking states and blank states reflecting how attention resources are distributed, and "impatience and frustration states" where the driving task occurs under time constraints.

In Section II, experimental procedure is described. In Section III, we show the experimental results focusing on facial orientation and eye-gaze movements. Section IV concludes this study and indicates the future plans.

II. EXPERIMENTAL PROCEDURE

A. *Experimental system*

This study employs a driving simulator (DS), which is able to freely design load environments and traffic conditions and to measure driving behaviors under different environments.

Fig. 1 illustrates the experimental system architecture. The DS used for these experiments is composed of a control device, the size of which is equal to a standard-sized vehicle,

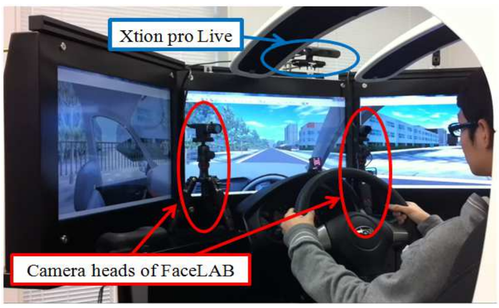


Figure 1. Experimental system for measuring driver behaviors.

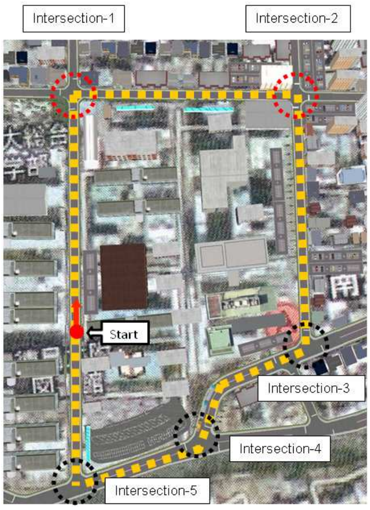
 ISBN: 978-1-61208-356-8

and a compact 6-axis motion platform (SUBARU design). The system includes three color liquid crystal displays (LCD) at the front of the cabin, and these are capable of freely displaying the horizontal viewing angle and driving environments. To achieve unconstrained monitoring and measuring of the driver's head motions, facial orientations, and eye-gaze movements, we set two camera heads on the right and left side of the center LCD, and an infrared pod at the upper center front of the cabin, as shown in Fig. 1.

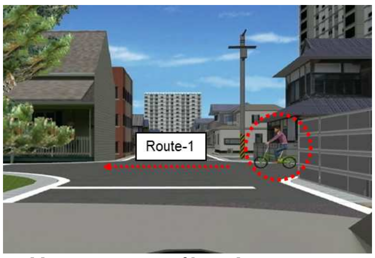
B. Near-miss events and running scenarios

Fig. 2 depicts the driving route and the two definitions of near-miss events due to the sudden appearance of a bicyclist at an intersection. At intersection-1, a bicyclist suddenly appears from the right front of the vehicle and passes through sthe intersection (route-1). At intersection-2, a bicyclist appears suddenly from the left front side of the vehicle and interferes directly in the vehicle's path (route-2).

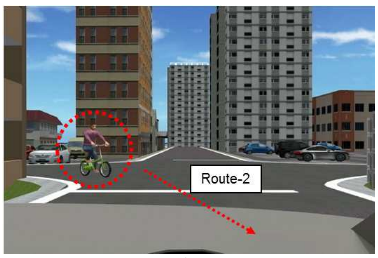
Subsequently, an overview of the various running scenarios is as follows. The fundamental scenario is to run three laps of the driving route described in Fig. 2-(a). We performed a control of the near-miss events as follows. The first lap is made without near-miss events at intersections. During the second lap, the driver encounters the crossing bicyclist indicative of route-1 at intersection-1, in addition to the bicyclist defined by route-2 at intersection-2. Specifically, we constructed four types of running scenarios at varying



(a) Running route for simulation

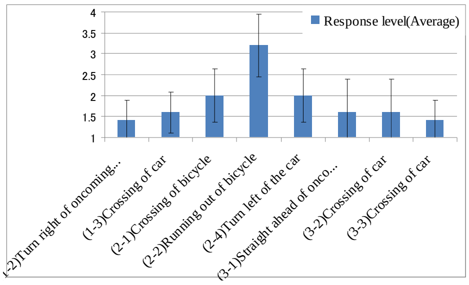


(b) Sudden appearance of bicyclist at intersection-1

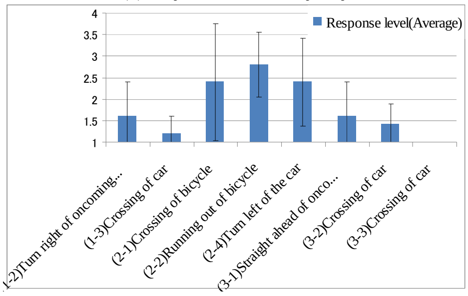


(c) Sudden appearance of bicyclist at intersection-2

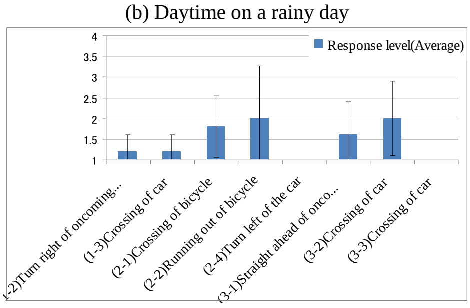
Figure 2. Simulation course with two types of near-miss events (Route-1/Route-2).



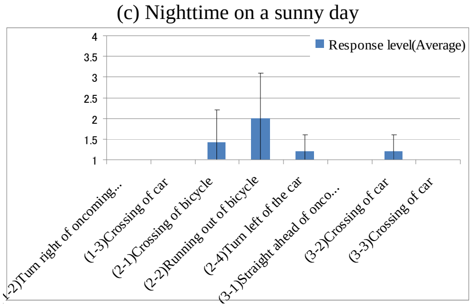
(a) Daytime on a sunny day



(b) Daytime on a rainy day



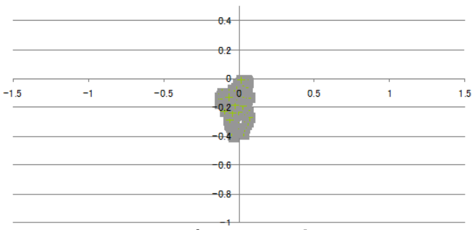
(c) Nighttime on a sunny day



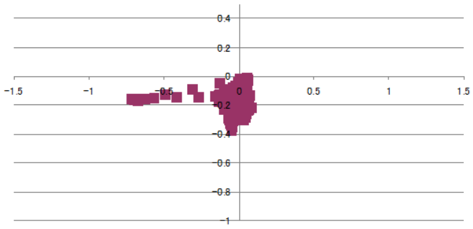
(d) Nighttime on a rainy day

Figure 3. Interview results of traffic events at intersections (1, 2, and 3).

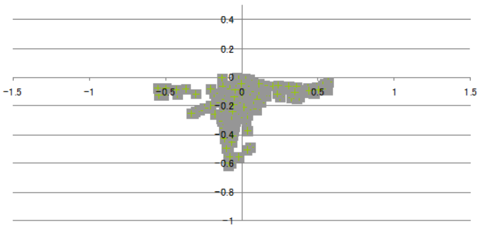
ISBN: 978-1-61208-356-8



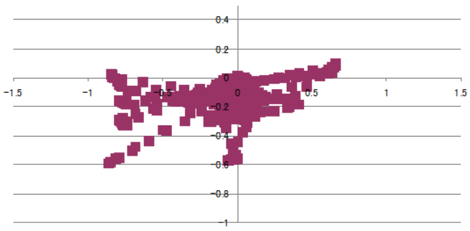
(a) Eye-gaze movements from approach to intersection-1 to pause



(b) Facial orientations from approach to intersection-1 to pause

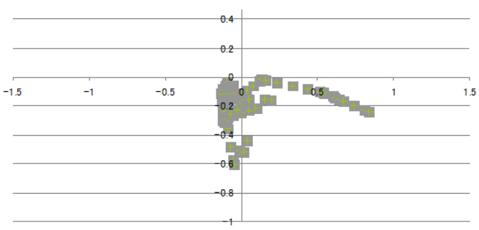


(c) Eye-gaze movements from safety check to turn right

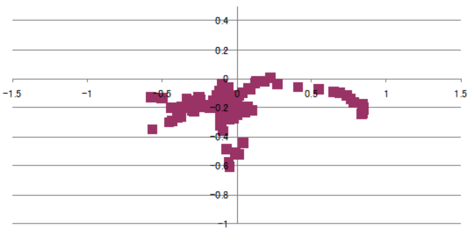


(d) Facial orientations from safety check to turn right

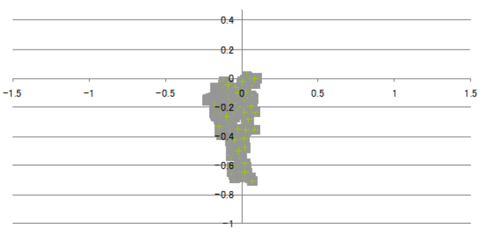
Figure 4. Sudden appearance of bicyclist crossing right to left at intersection-1 (subject C: daytime on a sunny day).



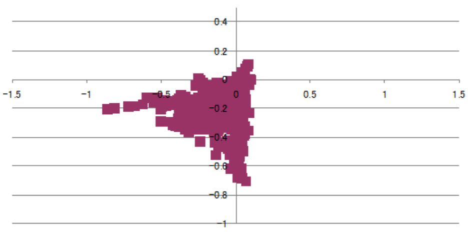
(a) Eye-gaze movements from approach to intersection-2 to pause



(b) Facial orientations from approach to intersection-2 to pause



(c) Eye-gaze movements from safety check to turn right



(d) Facial orientations from safety check to turn right

Figure 5. Sudden appearance of bicyclist interfering with the vehicle path at intersection-2 (subject C: daytime on a sunny day).

times of the day (i.e., day or night) and under various weather conditions (i.e., sunny or rainy) by designing near-miss events involving the two intersection types, which control the timing and routes for suddenly appearing bicyclists.

III. EXPERIMENTAL RESULTS AND DISCUSSION

The subjects were 5 men (Subject D and Subject E were 21 years old, whereas subjects A, B, and C were 22) and one woman (Subject F was 23 years old), all of whom were university students and had driver's licenses for ordinary vehicles. During test runs, we instructed all subjects to maintain standard speeds and traffic rules, such as pause, etc.

A. *Interview results of near-miss events*

We interviewed all subjects to assess the response level of surprising near-miss events occurring in nonregulated intersections (i.e., intersection-1, intersection-2, and intersection-3) using a method including four scenarios. The interview results in sunny-daytime, rainy-daytime, sunny-nighttime, and rainy-nighttime are shown in Fig. 3-(a), Fig. 3-(b), Fig. 3-(c), and Fig. 3-(d), respectively. The results indicate that the route-2 near-miss event in which a bicyclist

 ISBN: 978-1-61208-356-8

suddenly appears in the path of the vehicle, as shown in Fig. 2-(c), was confirmed as the most effective for all subjects.

B. Analysis of facial orientation and eye-gaze movements

We targeted near-miss events at nonregulated intersection-1 and intersection-2 with poor visibility, and classified driver behavior according to two segments. The first and the second segments are defined as the period from the approach to the intersection to pausing for the oncoming bicyclist and the period from the safety verification to turning right to avoid collision, respectively. Focusing on the gaze movements and facial orientation measured by the head-gaze tracking device (FaceLAB), we portray the results of intersection-1 and intersection-2 for Subject C driving on a sunny day as scatter diagrams, as shown in Fig. 4 and Fig. 5, respectively.

First, we focus on the eye-gaze movements and facial orientations in the case of encountering the sudden appearance of the bicyclist defined by route-1, as shown in Fig. 4. In the first segment, the driver is aware of the stop position of intersection-1, gazing toward the front of vehicle path. The scatter diagrams of gaze movements and facial orientation are concentrated in the center of the screen, as shown in Fig. 4-(a) and Fig. 4-(b). In the second segment, the driver visually confirmed the crossing bicyclist by safety verification after a pause, and then the driver was tracking the bicycle route. The scatter points of the facial orientations are distributed to the left and right of the screen, as shown in Fig. 4-(c) and Fig. 4-(d). We believe that these results quantitatively support the safety verification behavior against the near-miss event defined by route-1.

Next, Fig. 5 shows the scatter diagrams of eye-gaze movements and facial orientations in the case of encountering the sudden appearance of the bicyclist defined by route-2. During the first segment, the driver visually confirmed that a bicyclist suddenly appeared from the front left of the vehicle path, and then the driver was tracking the bicycle route. The scatter diagrams of gaze movements and facial orientations form trajectories that are continuous from the center of the screen to the right side, as presented in Fig. 5-(a) and Fig. 5-(b). In the second segment, safety verification behavior after a pause is concentrated on the left side of the intersection where the sudden appearance of the bicyclist has occurred. The scatter points of the facial orientations formed a trajectory that is continuous to the left side while concentrating on the center of the screen, as shown in Fig. 5-(d). This result quantitatively supports the safety verification behavior against the near-miss event involving the sudden appearance of a bicycle along route-2.

IV. CONCLUSION

In this study, we concentrated on the facial orientation and eye-gaze movements of a driver before and after near-miss events involving the sudden appearance of a bicyclist at a nonregulated intersection. Our results provide the following points.

1) The sudden appearance of bicyclists in a vehicle’s path indicates that the probability of a near-miss event is likely to be high.

2) The trajectory characterized by the eye-gaze movements and facial orientations of the driver before and after near-miss events show close correlation with the interview results of daytime on a sunny day.

In future work, we will add the number of subjects and experiments, and a quantitative analysis of relation between the near-miss event and the safety verification behavior will be carried out. Moreover, we are planning analysis of influence of the driving style and the workload sensitivity for driving behaviors.

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 ISBN: 978-1-61208-356-8