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Accident Risk Prediction Using Autonomic Nerve Functions Measured During Driving

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***Abstract*—Truck accidents caused by health-related conditions such as fatigue are increasing. Therefore, we are developing technology that uses autonomic nervous functions to monitor the health condition of active drivers and detect dangerous conditions that lead to accidents. To handle autonomic nerve functions (ANF) in the dynamic environment of driving, we propose a time-series accident risk prediction method that shortens the time range for calculation, normalizes to eliminate individual differences, and indexes environmental factors. We achieved an 88.8% accuracy of Recall and a 0.84 area under the curve (AUC).**

I. Introduction

Factors such as labor shortages and long working hours have adversely affected driver fatigue and stress, and the number of traffic accidents related to driver health is increasing yearly [1]. With prevention in mind, we focus on the autonomic nerve function (ANF) index obtained by heart rate variability (HRV) analysis that reflects physical and mental health [2]. However, it is difficult to use an ANF for driving scenarios because HRV analysis is generally premised on static measurement scenes. Therefore, we aim to adapt it to a dynamic driving environment.

II. Methods

We propose technology that performs highly accurate accident risk prediction using an ANF and a time-series deep learning model. Figure 1 shows the outline of our method. We used three-months' worth of R-R interval (RRI) data from 20 drivers. We calculated the ANF from RRI data using HRV analysis. In the preprocessing, we performed HRV analysis with an optimized time window that corresponded to the dynamic environment and normalization processing that eliminated individual differences in data distribution. Aside from health factors, we focused on environmental factors (ENVs) that affected the ANF and risk of accidents; we indexed several of them for input into the prediction model. Thirty minutes after measurement, the prediction model outputs whether high-risk driving situations will occur as "accident risk." The model contains one long short-term memory and four dense layers. Following receipt of written informed consent, we obtained the volunteers' data according to the internal review board standards of the Research & Development Group, Hitachi, Ltd.

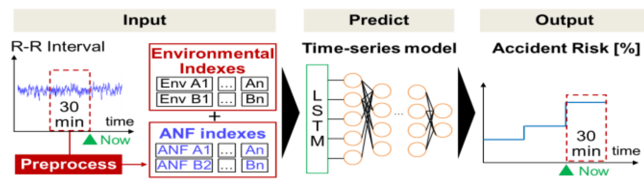

Figure 1. Outline of the proposed method.

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TABLE I. APPLICATION RESULTS OF THE PROPOSALS

Input index	Model	Recall	AUC
ANFs	Non-time series	65.9%	0.57
Preprocessed ANFs	Time series	82.8%	0.74
Preprocessed ANFs + ENVs	Time series	88.8%	0.84

We utilized three-fold cross-validation, and all the drivers and all their measurement data were randomly split. We used the measured 30-minute RRI as an input and predicted the accident risk as the probability that a high-risk scenario would occur within 30 minutes after measurement. For comparison, we used ANFs without preprocessing and a non-time series model (five dense layers).

III. Results

We used data from 20 drivers for learning and evaluation. TABLE I shows the prediction accuracy when the proposed processes were applied. We achieved an 88.8% Recall accuracy and a 0.84 area under the curve (AUC).

IV. Discussion & Conclusion

We determined that each of the proposed processes contributed to the prediction. As future tasks, we aim to improve the interpretability of the models and to optimize the time width of the input data and prediction targets.

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