INTERNATIONAL JOURNAL OF ADVANCED STUDIES
IN COMPUTER SCIENCE AND ENGINEERING
IJASCSE VOLUME 6 ISSUE 5, 2017 05/31/2017

Driver's State Alert Function by Using Facial Expression Classification in Cooperation with Artificial Intelligence

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***Abstract*—Driver's non-normal psychosomatic states such as drowsiness and anger may cause severe traffic accidents. Driver's psychosomatic state adaptive driving support safety function may play important role to prevent being involved in a traffic accident. Therefore, detection technology of both drowsiness and anger is highly expected to enhance performance of the safety function. When driver's psychosomatic state adaptive driving support safety function detects driver's non-normal states in cooperation with artificial intelligence, the safety system delivers notice or alert of imminent risk of a traffic accident to a driver to prevent being involved in traffic accident in advance. This research firstly identified root cause of traffic incidents by means of refining data done by Internet survey. From statistical analysis of traffic incidents experiences, major psychosomatic state just before traffic incidents were haste, distraction, *drowsiness* and *anger*. This research focused both *drowsiness* and *anger* of a driver while driving. Facial expression was used as alternative characteristics of both driver's drowsiness and anger states. By means of using Kohonen neural network as classification algorithm, this research created a method to classify both drowsiness and anger states of a driver in high accuracy. Finally, this research proposes driver's psychosomatic state alert function by using facial expression classification in cooperation with artificial intelligence to prevent potential risks of traffic accidents.**

Keywords- Driver's psychosomatic state, drowsiness, anger, driving support safety system, artificial intelligence, facial expression, Kohonen neural network, autonomous driving

I. INTRODUCTION

The number of traffic fatalities in Japan as of 2016 has dropped below 4,000, however, the number of traffic injuries has still exceeded 0.6 million as shown in Figure 1 [1]. To build up sustainable mobile society, the number of traffic accident should be reduced as highly prioritized challenge. Recently driver's state adaptive driving support safety function may be highlighted as one of solutions to reduce the number of traffic accidents. By reviewing development of driver's state adaptive monitoring safety function, this research identified research direction to enhance safety performance of vehicle in preventive safety function field [2] [3]. Previous research reported that 71% to 90% of traffic accidents were occurred by human factors [4] [5]. Root cause of traffic accidents may be assumed same as that of traffic incidents including near-miss accidents.

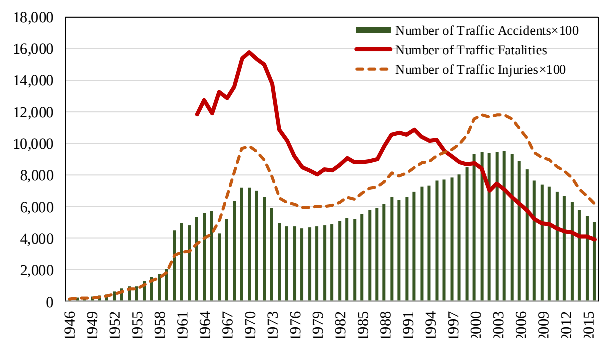

Figure1. Transition of road traffic accidents in Japan as of 2016

This research refined results of real world experiences of traffic incidents done by Internet survey to identify root cause of traffic accidents [6]. From analysis of the collected real world data, both *drowsiness* and *anger* are one of major factors just before traffic incidents. Drowsiness has sometimes seen in fatigue state of a driver, and anger has sometimes seen in traffic congestion situation [7] [8]. Therefore, this research focused both driver's drowsiness and anger which may result in severe traffic accidents.

Human emotion may be expressed by six facial expressions, which are "ordinary", "drowsiness," "anger", "sorrow", "delight" and "surprise" [9]. From previous research, facial expression is expressed by using Kohonen neural network (hereinafter; KNN) [10] [11]. In the previous research, six types of facial expressions were classified by using KNN [12]. Six types of facial expressions were adopted as alternative characteristics to identify driver's drowsiness and anger state. By using KNN, this research defined six types of facial expression as self-organized maps. As classification parameter, this research adopted location of similarity and Mahalanobis' distance [13]. Facial expression was judged by maximizing location of similarity and certain amount of Mahalanobis' distance. Then this research established to detect both drowsiness and anger of a driver in high accuracy [14]. Finally, this research proposed a novel driver's drowsiness and angry state adaptive driving support safety function in cooperation with artificial intelligence (hereinafter; AI) to prevent risks of being involved in traffic accidents [15]. This technology would be expected to evolve into autonomous driving including automatic emergency braking [16] [17] [18].

II. Root Cause of Traffic Incidents

This research refined results of real world experiences of traffic incidents collected by Internet survey to identify cause of traffic accidents [6]. From analysis of the collected real world data as shown in Figure 2, top four non-normal psychosomatic states just before traffic incidents were "haste" (26.6%), "distraction" (26.5%), *drowsiness* (4.6%) and *anger* (3.1%). Because identifying driver's non-normal psychosomatic state just before traffic incidents is indispensable for establishing countermeasures to reduce the number of traffic accidents, this research focused both *drowsiness* and *anger* to build up driver's psychosomatic state adaptive driving safety function in cooperation with artificial intelligence (AI) [15].

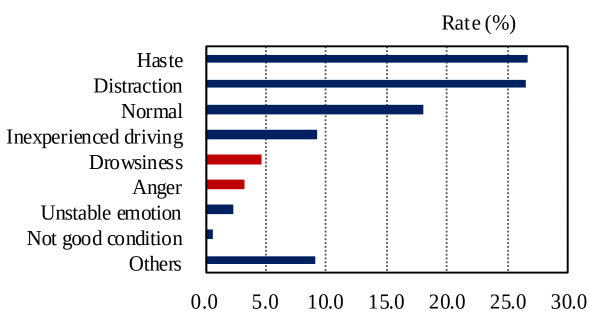

Figure 2. Psychosomatic states just before traffic incidents (Units: %)

III. Review of Driver's State Adative Monitoring Safety Function

Research of drowsiness and distraction of driver's state has started in the middle of 1990's by ASV project in Japan, and, also AWAKE and AIDE project in EU Framework Program. After that many research with regards to drowsiness has been executed, many practical drowsiness detection methods has been introduced into production vehicle. Several cases as to face direction detection and eye closing detection method have been introduced into production vehicle [2] [3] as well as attention assist system.

As to anger state detection, few case has been seen in production vehicle. Therefrom this research intended to build up a novel system to classify driver's *drowsiness* and *anger* state for establishing driver's states adaptive driving support safety function in cooperation with artificial intelligence (AI). Recently many automakers have developed autonomous vehicle by using AI technology as shown in Figure 2. AI function in autonomous vehicle may help the safety function to judge comprehensive driver's state, vehicle control status and road environment situation as well as alerting risk information to a driver.

TABLE I. DEVELOPMENT OF DRIVER'S MONITORING SAFETY FUNCTION

Proto type system	Phase 1, 2 ASV Project in Japan	(1) Drowsiness warning (heart rate, eye opening) [1994]
	EU-FP5 and 6 AWAKE / AIDE	(2) Driver's distraction and drowsiness warning (blinking, gaze direction, head movement, other) [1996]
	Saab	(3) Driver attention warning (gaze direction, blinking) [November 2007]
Production system	Toyota	(4) PCS with face direction detection [May 2006] PCS with eye opening and closing detection [February 2008]
	Mercedes Benz	(5) Attention Assist including drowsiness detection [May 2009]

Verification test on the freeway of USA by experimental vehicle

Smart cockpit of autonomous vehicle

Figure 3. Example of test scene of autonomous vehicle [19]

IV. Classification of Drowsiness and Anger by Kohonen Neural Network (KNN)

Kohonen neural network (KNN) is known as one of competitive learning type neural network which only winning neuron can learn input data set in learning stage. This learning may have feature to create self-organized map which expresses correlation among input data of facial expression. Kohonen neural network may generate complementary picture among each facial expression. Facial expressions were categorized in six types, which were ordinary, drowsiness, anger, sorrow, delight, surprise as shown in Figure 4. Original facial expression in 512× 512 pixel of 24 bit was gray-scaled. Then both orientation and dimension of face were corrected by coordination of eyes. A picture in 256 × 256 pixel of facial expression was extracted by referring central point of nose. Then this picture was compressed in 64 × 64 pixel. Accordingly, self-organized map was created as input vector of Kohonen neural network. Output picture of Kohonen neural network unit was in 32 × 32 pixel as shown in Figure 5.

Figure 4. Six type of facial expressions

Learning of facial expression map was done by 100 times as shown in Figure 6. By using both location of similarity and Mahalanobis' distance as classification algorithm, this research classified accuracy of detecting drowsiness and anger. The number of participants was eight, who have consented to join in this research. Location of similarity was acquired from generated map. Strongly reacted portion to a maximum similarity data was extracted by a certain amount of Mahalanobis' distance.

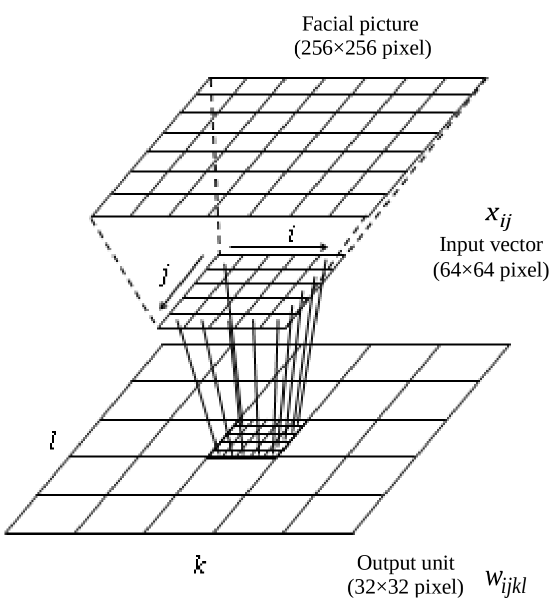

Figure 5. Basic structure of Kohonen neural network (KNN)

Then classification was executed if related portion was included following equation (1).

$$P_i = \sum_{k}^{N_i} (x_{ik} - x_{\min}) \quad (1)$$

In equation (1), N_i denotes class of facial expression, P_i denotes similarity of class of facial expression in the same location, x_{ik} denotes similarity of data k in i class of facial expression, x_{min} denotes minimum similarity on similarity map. Accuracy of facial expression was defined by maximum value of facial expression class derived from equation (1).

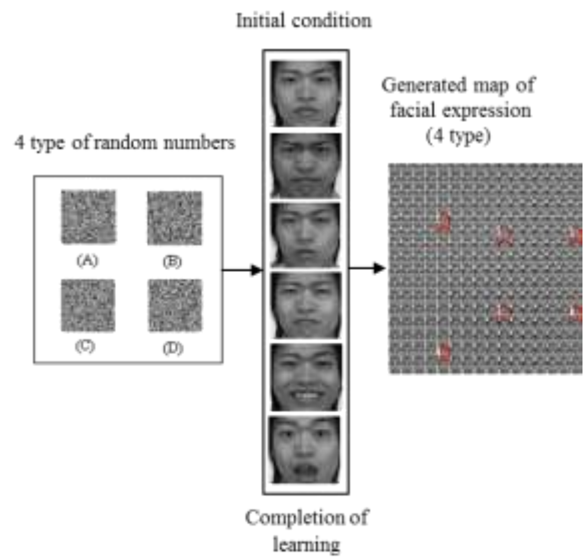

Figure 6. Learning process

V. CLASSIFICATION RESULTS

This research took 6 pictures for 6 facial expressions per one participant. 240 picture of facial expression were selected. 40 facial expressions were allocated for each facial expression. Then classification by means of using Kohonen neural network was examined. At the same time subjective evaluation by six facial expressions were done by the same participant. Accordingly, average classification accuracy was obtained as shown in TABLE I.

Classification accuracy of drowsiness 93.8% which was second top in common among 6 facial expressions. However, amount of subjective evaluation of drowsiness was 81.3% which was fourth top in common. Classification accuracy of anger was 83.3%, which was fourth top in common among 6 facial expressions. Amount of subjective evaluation of anger was 91.7%, which was third top in common. Therefore, this examination by means of using Kohonen neural network was said as practical to classify states of both drowsiness and anger.

TABLE II. CLASSIFICATION RESULTS

Type of facial expression	Classification Accuracy (%)	Subjective Evaluation (%)
Ordinary	81.3	97.9
Drowsiness	93.8	81.3
Anger	83.3	91.7
Sorrow	72.9	39.6
Delight	97.8	89.6
Surprise	91.7	93.8
Average	86.8	82.3

Accordingly, this examination adopted two kinds of classification accuracy between facial expression and subjective evaluation for states of drowsiness and anger. This method of classifying both driver's drowsiness and anger states may be applicable to driver's psychosomatic states adaptive driving support safety function which should be included one of contents of artificial intelligence (AI) unit in near future.

VI. DRIVER'S PSYCHOSOMATIC STATES ADAPTIVE DRIVING SUPPORT SAFETY FUNCTION

This research proposed a potential driver's states adaptive driving support safety function in cooperation with artificial intelligence unit as shown in Figure 7. The unit always checking driver's psychosomatic states such as "drowsiness and anger" as well as surrounding road conditions in cooperation with an artificial intelligence unit.

AI unit always observes driver's condition, vehicle condition and road conditions ahead of a vehicle by means of using mobile communication between road infrastructure of road information service. Driver usually looks frontal road condition as well as peripheral of vehicle to execute driving safely.

When driver's drowsiness or anger detection function judges that driver should be fallen in those states, or be noticed imminent risk of danger situation from the AI unit, driver's psychosomatic states adaptive driving support safety function could deliver notice or alert to the driver. When the driving safety function judges that an imminent danger may be unavoidable, the AI unit could intervene instead of the driver by activating an automatic emergency braking of an autonomous driving unit to prevent being involved in a traffic accident.

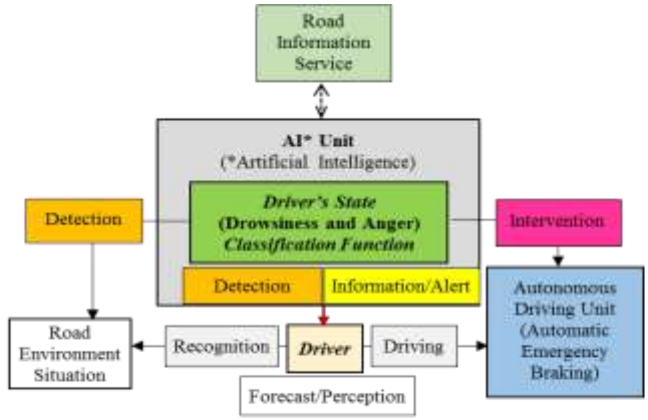

Figure 7. Concept of driver's psychosomatic states adaptive driving support safety function

VII. CONCLUSION

By refining real world experiences of Internet survey, this research identified root cause of traffic incidents which is assumed same as traffic accidents. Then this research introduced KNN as classification algorithm which identify both drowsiness and anger states of a driver. Finally, this research proposed a concept of a driver's psychosomatic states adaptive driving support safety function in cooperation with artificial intelligence unit, which would corporate with autonomous driving function. Therefrom those comprehensive functions could reduce the number of traffic accidents. Major conclusions are as follows;

A. *Driver's drowsiness and anger are one of important psychosomatic states which may be involved in severe traffic accidents.*

B. *Internet survey of traffic incidents as well as traffic accidents may be effective means to collect real world experiences on a big data basis.*

C. *Kohonen neural network may be effective means to classify drowsiness and anger state on facial expression basis. This method can be applicable to build up driver's state adoptive driving support safety function.*

D. *Driver's state adaptive driving support safety function in cooperation with an artificial intelligence may have potential to prevent risks of traffic accidents.*

VIII. FUTURE ISSUE

Future issue includes researches to identify reduction effect of traffic accidents by means of using detection function of both drowsiness and anger states. Furthermore, statistical investigation to identify reduction rate of the number of traffic accidents in real world be highly expected. It may bring wider promotion of introduction of new kind of vehicle safety devices to reduce the number of traffic accidents.

ACKNOWLEDGMENT

Hearty appreciation for the dedicated support from T. UMEZAKI, Professor of the Graduate School of Engineering, Nagoya Institute of Technology and also Project Professor of Interfaculty Initiative in Information Studies of the University of Tokyo in Japan, and, K. OGURI, Professor of the Graduate School of Information Science and Technology, Aichi Prefectural University in Japan, and H. KAWANAKA, Associate Professor of the Graduate School of Information Science and Technology, Aichi Prefectural University in Japan.

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