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DRIVER'S ANGER STATE IDENTIFICATION BY USING FACIAL EXPRESSION IN COOPERATION WITH ARTIFICIAL INTELLIGENCE

M. Miyajia

Graduate School of Information Science and Technology, Aichi Prefectural University in Japan

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ABSTRACT

Preventive safety system of vehicle is highlighted to reduce the number of traffic accidents. Driver's state adaptive driving safety system may be one of candidates of the safety system. Identifying driver's psychosomatic states is indispensable to establish those safety systems. Anger of driver state is often seen in traffic congestion which may be involved in severe traffic accidents. This research adopted Kohonen neural network as classification algorithm to identify anger state of driver by using facial expression. We adopted six types of facial expression which are ordinary, drowsiness, anger, sorrow, delight and surprise according previous research. We classified six types of facial expressions by using KNN. Finally, this research proposes driver's anger state alert function by using facial expression classification in cooperation with artificial intelligence to prevent potential risks of traffic accidents.

Keywords: driver's anger; facial expression; Kohonen neural network; artificial intelligence.

Author Correspondence, e-mail: masahiro@toyota.ne.jp

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1. INTRODUCTION

One of high prioritized issues in the world is to reduce the number of traffic accidents. Although the number of traffic fatalities in Japan as of 2015 has declined under 4,200, the number of traffic injuries has still exceeded 0.6 million as shown in Fig.1 [1]. The number of traffic accidents should be reduced to establish sustainable mobile society. Recently preventive safety system of vehicle is expected to reduce the number of traffic accidents [2] [3]. Driver's state adaptive driving safety system may be one of candidates of the safety system which may reduce the number of traffic accidents. Looking upon development history of driver's state adaptive monitoring safety function, this research identified research direction to enhance performance of preventive safety functions. Previous research reported that around 90% of traffic accidents were occurred by human factors as shown in Table 1 [4] [5] [6]. We assumed that root cause of traffic accidents is same as that of traffic incidents. We revised results of real world experiences of traffic incidents done by Internet survey [7]. Then we identified root cause of traffic accidents by using analysis of traffic incidents including near-miss accidents. From analysis of the collected data, anger was important factor just before traffic incidents. Anger is often seen in traffic congestion situations [8] [9]. Therefore, we highlighted driver's anger which may result in severe traffic accidents. Human emotion may be expressed by six facial expressions [10], which are "ordinary", "drowsiness," "anger", "sorrow", "delight" and "surprise". According the previous research, facial expression is classified by using Kohonen neural network (hereinafter; KNN). Therefrom we classified six types of facial expressions by using KNN [11] [12] [13] [14]. Six types of facial expressions were adopted as alternative characteristics to classify driver's anger state. By using KNN, we defined six types of facial expressions as self-organized maps. As classification algorithm, this research adopted maximum similarity of facial expression and Mahalanobis' distance to identify classification accuracy. [15] In addition to classification accuracy by using KNN, we adopted subjective evaluation of six facial expressions. Then we established to classify anger state of driver in high accuracy. Finally, we proposed a novel driver's angry state adaptive driving safety function in cooperation with artificial intelligence (hereinafter: AI) as well as automatic emergency brake to reduce risks of traffic accidents [16] [17] [18] [19].

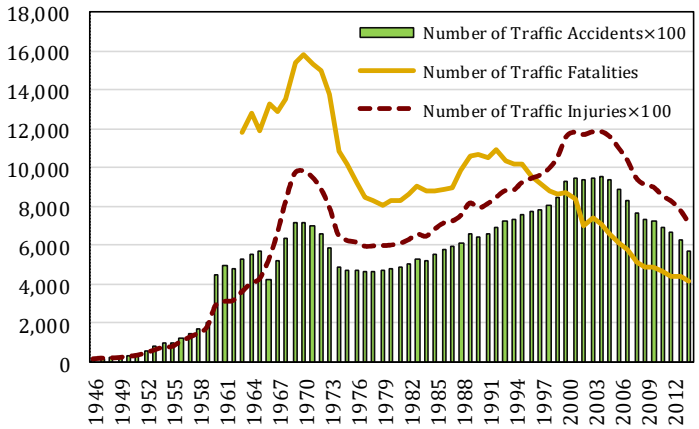

Fig.1. Traffic accidents trends in Japan as of 2015

Table 1. Human errors just before traffic accidents

Research Institute	Factor	Rate
Indiana Univ., USA (Treat, 1977)	General human error	90%
ITARDA in Japan (Traffic accident statistics, 2001)	Recognition error (Front-side Inattentiveness, Neglect checking safety)	71%
US DOT and Virginia Tech. (Klauer, 2006)	Inattention (including Distraction, Drowsy)	80%

2. DEVELOPMENT HISTRY OF DRIVER'S STATE ADAPTIVE MONITORING SAFETY FUNCTION

Research of psychosomatic states of driver had done in the middle of 1990's by ASV project in Japan, and, also AWAKE and AIDE project in EU Framework Program. Therefrom many research with regards to drowsiness as well as distraction has been conducted. Some of them has been introduced into production vehicle. For example, face direction detection and eye closing detection method have been introduced into production vehicle as well as attention assist system. With regards to anger state detection, few cases have been seen in production vehicle. This research intended to establish a novel system which classifies driver's anger state to comprise driver's states adaptive driving safety function in cooperation with AI. AI

function helps those functions to judge comprehensive driver's state, vehicle control status and road environment situation as well as risk of being involved in traffic accidents.

3. ROOT CAUSE OF TRAFFIC INCIDENTS IN REAL WORLD BY USING INTERNET SURVEY

We revised results of collected real world experiences of traffic incidents by Internet survey of our previous research. Then we figured out root cause of traffic incidents which may be same cause of traffic accidents. From the analysis of the collected data as shown in Fig.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 accident, we highlighted anger state to establish driver's psychosomatic state adaptive driving safety function in cooperation with AI.

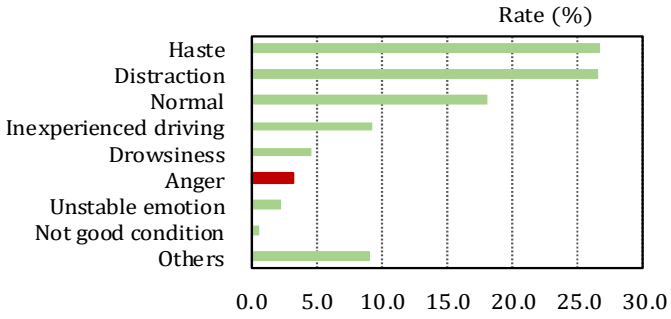

Fig.2. Psychosomatic states just before traffic incidents

4. CLASSIFICATION OF ANGER BY KOHONEN NEURAL NETWORK

Human emotion may be categorized by six facial expressions which were ordinary, drowsiness, "anger", sorrow, delight and surprise according the previous research. Because the aim of this research is to identify anger state of driver, we adopted six facial expressions as shown in Fig. 3. Six pictures were taken for each facial expression. One out of six of each facial expression was selected for a learning data of Kohonen neural network (hereinafter; KNN). 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 creates self-organized

map which expresses correlation among input data of facial expressions. Kohonen neural network generates complementary picture among each facial expression.

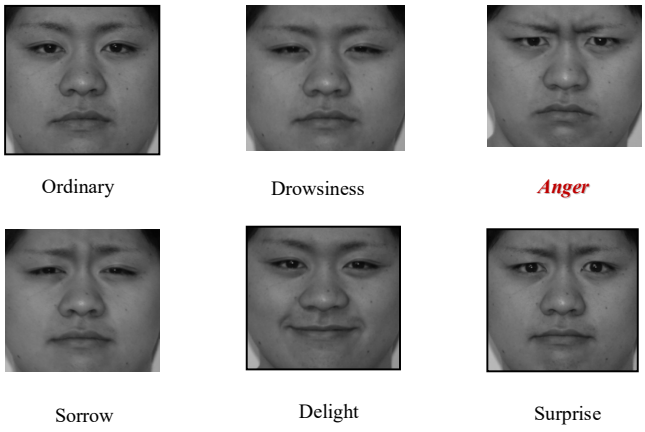

Fig.3. Six types of facial expressions

According the previous research, we used six facial expressions, which are ordinary, drowsiness, anger, sorrow, delight, surprise. Original face expression in 512× 512 pixel of 24 bit was gray-scaled as shown in Fig.4. Then both orientation and dimension of face were corrected by coordination 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.

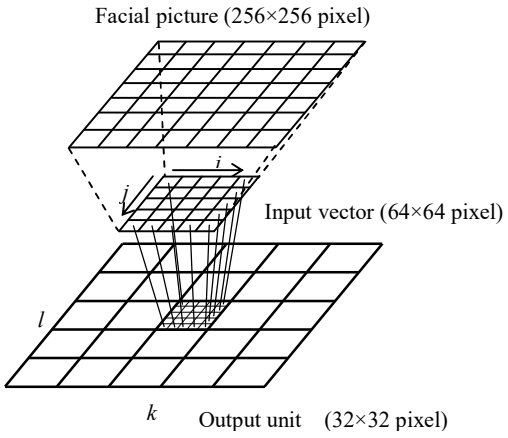

Fig.4. Basic structure of Kohonen neural network (KNN)

KNN learned by being given four types of random numbers in initial stage. KNN learned each facial expression map of six facial expressions, where u_{ij} was defined as similarity factor in equation (1). x_{ij} was input vector and w_{ijkl} is combined load of KNN. Similarity factor between

generated facial expression and unknown input facial expression was calculated by (1).

$$u_{ij} = \frac{\sum xijw_{ijkl}}{\sqrt{\sum x_{ij}^2 \sum w_{ijkl}^2}} \quad (1)$$

We estimated accuracy of anger of 8 voluntarily joined subjects, who consented to execute the experiment. Distribution degree of similarity was acquired from generated map. Learning of facial expression map was done by 100 times. Location of maximum similarity was determined as classified facial expression.

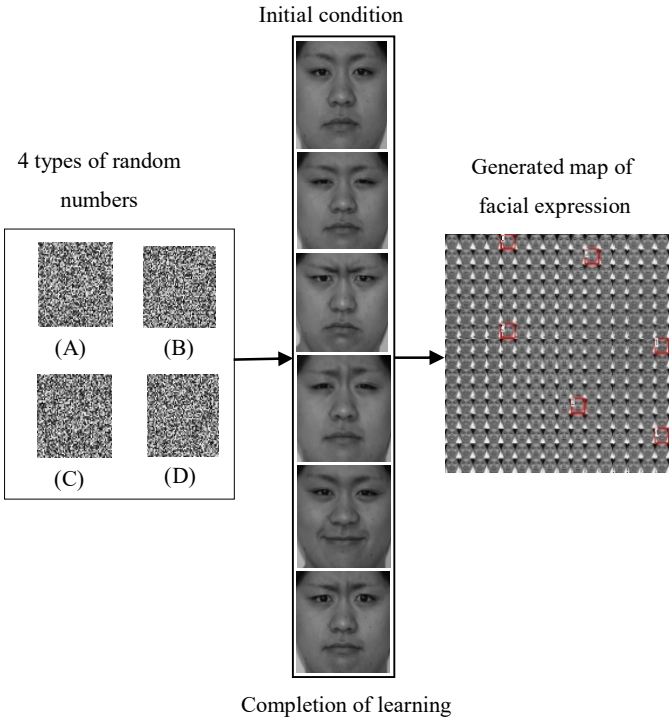

Fig.5. Learning process by KNN

By means of using location of similarity and Mahalanobis' distance as classification algorithm, we estimated accuracy of state of anger. Strongly reacted portion to a maximum similarity data was extracted by a certain amount of Mahalanobis' distance. Then classification was done following equation (2).

$$D_i = (x_i - u_i) S_i^{-1} (x_i - u_i)^i \quad (2)$$

In equation (2), D_i denotes Mahalanobis' distance between portion of maximum similarity of similarity map (x_i) and centroid position of facial expression area i (u_i). S_i denotes variance-covariance matrix of facial expression area i. When D_i is minimum for a facial expression, the area must be judged as expected facial expression (anger). Classification procedure was done following Fig. 6.

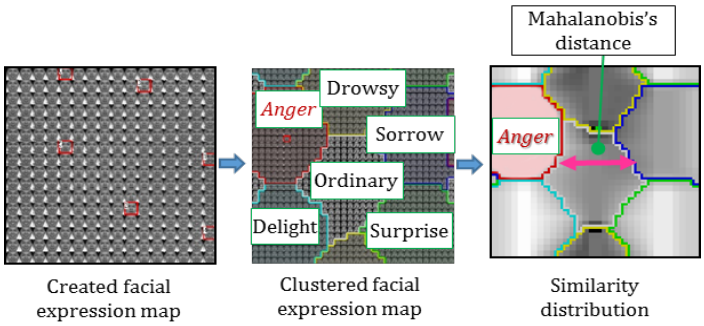

Fig.6. Classification by Mahalanobis's distance and similarity

3. RESULTS OF CLASSIFICATION OF ANGER BY KOHONEN NEURAL NETWORK (KNN)

We took 6 pictures for 6 facial expressions per one subject of eight. 240 pictures of facial expressions were selected. 40 facial expressions were allocated for each facial expression. Classification experiment was done by means of using Kohonen neural network. Likewise, subjective evaluation by six facial expressions was done by the same participant. Accordingly, average classification accuracy of facial expression was obtained as shown in Table 2. Classification accuracy of anger was 80.0%, which was fourth in top common among 6 facial expressions. However, amount of subjective evaluation of anger was 91.7%, which was third in top common. Because average value of accuracy between classification of facial expression and subjective evaluation were almost same, this classification method by means of using Kohonen neural network was judged as applicable to detect a state of anger of driver. Consequently, we selected 85.9% as average anger detection accuracy between facial expression and subjective evaluation. This method of detecting driver's anger state may be applicable to driver's psychosomatic adaptive driving safety function which should be included one of contents of artificial intelligence (hereinafter; AI) unit being used in near future vehicle.

Table 2. Classification accuracy of anger state

Type of Facial Expression	Classification Accuracy (%)	Subjective Evaluation (%)
Ordinary	77.5	97.9
Anger	***80.0***	***91.7***
Sorrow	67.5	39.6
Drowsiness	92.5	81.3
Delight	97.5	89.6
Surprise	90.0	93.8
Average	**84.2**	**82.3**

3. DRIVER'S PSYCHOSOMATIC STATE ADAPTIVE DRIVING SAFETY FUNCTION IN COOPERATION WITH ARTIFICIAL INTELLIGENCE (AI)

We proposed a novel driver's anger state adaptive driving safety function in cooperation with artificial intelligence as well as an autonomous driving unit as shown in Fig. 7. Composition of the system are the followings;

1. AI unit connected with infrastructure by mobile communication network including driver's anger detection function. It always watches driver's condition as well as vehicle peripheral conditions.
2. Driver's anger detection is consisting of KNN-based classification function for detecting anger state.
3. Automatic emergency braking. It receives intervene signals by AI when in an emergency occasion.

The operation of the system is described the following.;

A. The function always watches driver's psychosomatic state as well as surrounding road traffic condition in cooperation with an AI unit. AI units always collects road traffic conditions ahead by means of using road information provision service such as VICS in Japan through mobile communication networks.

B. When AI unit detects driver's anger state, it delivers related information or alert to a driver to be calm down.

C. If AI judges potential risk to be involved in traffic accidents because of driver's immature operation, it may intervene driver's operation by using automatic emergency braking.

D. This operation of AL may reduce the risk of encountering traffic accidents.

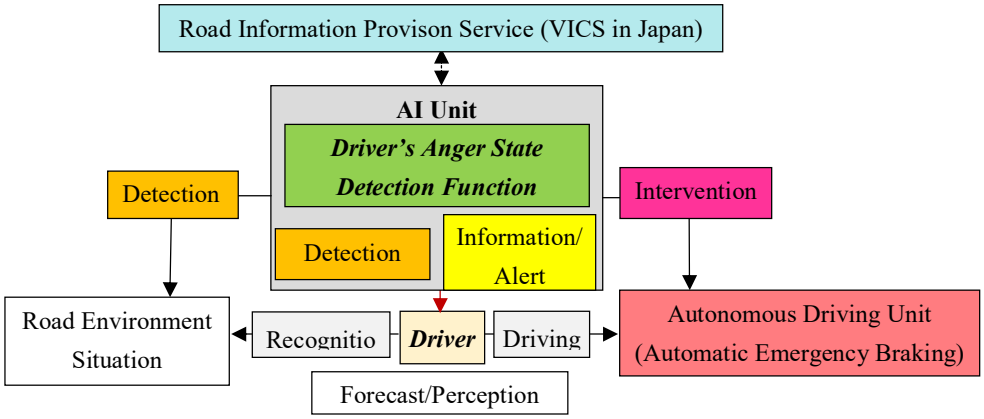

Fig.7. Concept of driver's anger state adaptive driving safety function

7. CONCLUSION

By revising real world experiences of traffic incidents collected through Internet, this research identified important root cause of traffic accidents. Therefrom this research introduced KNN as classification algorithm which identify anger states of a driver. Finally, this research proposed a concept of a driver's psychosomatic states adaptive driving safety function in cooperation with artificial intelligence unit, which could reduce risk of being involved in the traffic accidents. Major conclusions are as follows;

1. Driver's anger state is one of dominant cause which has risk of severe traffic accidents.
2. Internet survey of traffic incidents as well as traffic accidents may be effective means to collect real world experiences on a big data basis.
3. Kohonen neural network may be effective means to classify anger state. This method may be applicable to build up driver's state adoptive driving safety function.
4. Driver's state adaptive driving support safety function in cooperation with artificial intelligence may have potential to prevent risks to be involved in traffic accidents.

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