A STUDY OF AGE DETECTION SYSTEM FOR APPLICATION TO ELDERLY OCCUPANT PROTECTION

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Paper Number 19-0235

ABSTRACT

Recently, the number of injuries and fatalities in traffic accidents tend to decline. However, the proportion of elderly citizens involved in traffic accidents is tending to increase in Japan and other developed countries. The elderly is known to be less resistant to impacts than younger people due to the deterioration of physical structures, such as bones and muscles. In order to improve safety performance for elderly vehicle occupants, it is necessary to know the age of the drivers in advance. However, actual age of drivers does not always correspond to the representative age because the level of resistance of the elderly has large differences in individuals. It would be necessary to detect not only the driver's age, but also the aging level of the individual differences. In addition, in order to take convenience for the drivers into consideration, it would be necessary to use simply. Therefore, this research focused on the age of the blood vessels which can be measured easily.

The age of the blood vessels expresses the aging level of physical composition, such as the blood vessels and muscle fibers. It is calculated from the acceleration pulse wave of the blood flow. The characteristic points observed in the acceleration pulse wave are classified according to the age. Usually, the blood vessel age is measured by a contact-type photoelectric sensor. This research developed a noncontact measuring method based on an RGB camera. Evaluate accuracy of the blood vessel age with proposed method, moreover examined applicability of the method to onboard use.

In order to verify that the camera device developed in this research, measurements of proposal method were compared with that used the conventional method. The evaluation test was held on in indoor. The test subjects were thirty men aged from 20s to 60s. Proposal method is achieved that accuracy is comparable to that of the conventional method.

It should be considered that the proposed method will apply for a variety of adverse conditions when fitted in a vehicle. For example, use at night, use under backlight conditions, intrusion of the driver's arm operating the steering wheel and movement of the captured area due to vibration. It must be necessary for the method to perform detecting the age of the blood vessels accurately even under these conditions.

This paper has discussed about a noncontact method of detecting a driver's age, focusing on the age of the blood vessels, with the aim of improving safety of the occupant protection system. The experimental testing was verified as the basic concept of a noncontact blood vessel age detection system based on camera images. In order to proceed with research for fitting actual vehicle, it will be necessary to research not only improving system accuracy but also improving its robustness under onboard conditions.

INTRODUCTION

It is tending to decline about fatalities in traffic accidents according to report of traffic accidents in Japan (See Figure 1). Otherwise, population of driver above 75 years old is increasing as background of aging society (See Figure 2). Therefore, it is significant to improve the safety for elderly drivers in recent years.

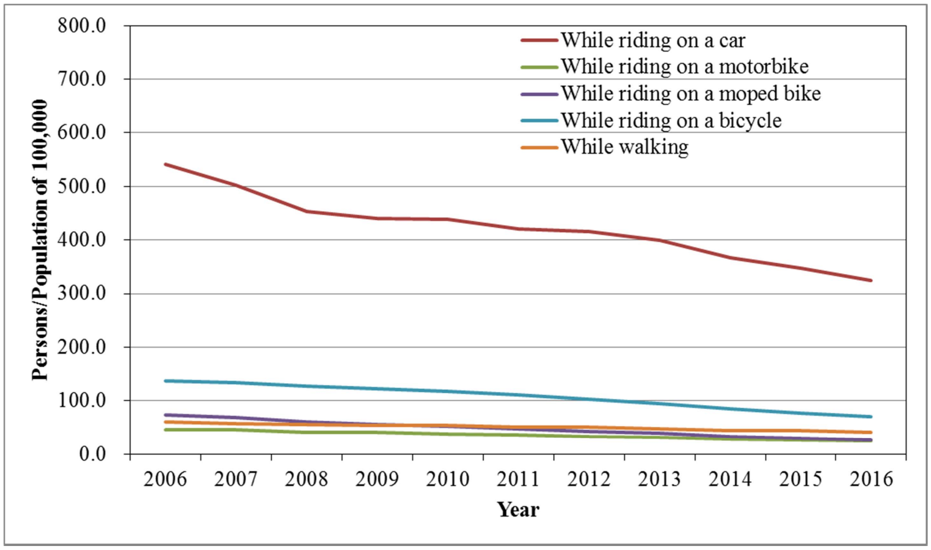

Figure 1. Changes in the number of fatalities in traffic accidents by state per a population of 100,000 WHITE PAPER ON TRAFFIC SAFETY IN JAPAN 2017 (https://www8.cao.go.jp)

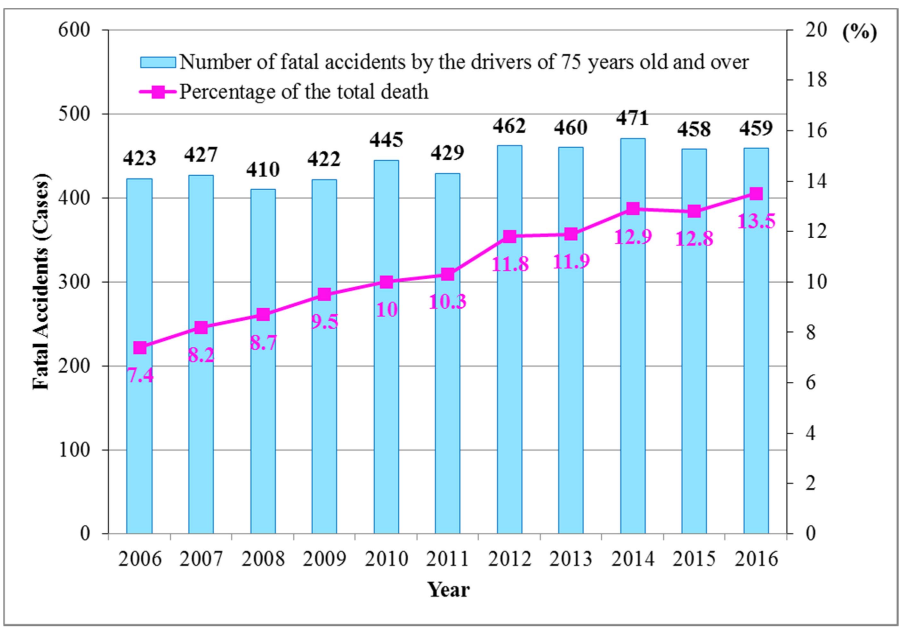

Figure 2. The number and percentage of fatal accidents caused by drivers of 75years and above WHITE PAPER ON TRAFFIC SAFETY IN JAPAN 2017

Because of this social background, research for the elderly protection has been conducted in the past. Kent et al. [1] reported that changes of the elderly chest characteristics caused by aging. Ito et al. [2] constructed the elderly FE model and proposed an injury evaluation method for the elderly. Gunji et al. [3] studied that restraint device focused on the elderly by the method of Ito et al. According to Gunji et al., it is significant that adjusting restraint force

depending on status of elderly physical resistance to prevent fatality of the elderly. Adults and the elderly are identified with actual age generally. But it is difficult to represent physical resistance with only actual age because of individual difference of physical resistance. For example, there is sturdy elderly person or frail young adult. Therefore, we decided that studying some parameters to represent physical condition and developing a system to recognize the physical parameter.
There are two types of parameters for representing physical condition which are “bone age” and “blood vessel age”. According to Suzuki et al [4], it is difficult to measure the bone age correctly without medical X-ray apparatus. Due to this reason, the authors judged that the bone age is inappropriate parameter for measuring in a vehicle. On the other hand, the blood vessel age can be measured easily using portable measuring system (See Figure 3). There is a possibility that the blood vessel age measuring system can be mounted on a vehicle. Therefore, this research focused on the blood vessel age to recognize driver’s physical aging level.

Figure 3. Portable blood vessel age measuring system (U-medica Artett2 PDU-M200)

METHODOLOGY

This study proposed non-contact measuring system to measure the blood vessel age of driver. This paper reports that accuracy of proposed method with evaluation test.

Algorithm of Proposed Method

Figure 4 shows the algorithm flow of our proposed method. According to Nakaya et al. [5], a parameter as some kind of age is required to calculate a vascular age. The authors used the facial age and the actual age for the input parameter. Firstly, the method detects facial area of a driver from an image recorded by driver camera. Next, the method predicts a facial age by deep learning from the facial image. This deep leering architecture was implemented by “Azure” cloud service provided by Microsoft Corporation. And then, proposed algorithm measures a blood pulse wave from facial color fluctuation. The algorithm was created by Uchida et al [7]. A status of blood vessel age is calculated from blood pulse wave. This calculation method was proposed by Nakaya et al [5]. Finally, blood vessel age is estimated from both statuses of blood vessel and age parameters. This paper proposed two kinds of blood vessel age “Proposed_A” and “Proposed_F”. “Proposed_A” was based on actual age. “Proposed_F” was based on facial age.

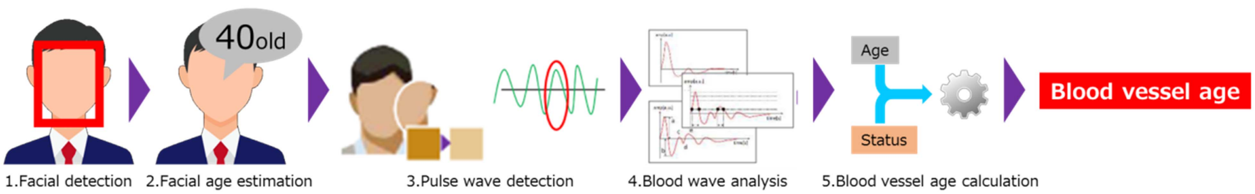

Figure 4. System flow of the proposed algorithm

Accuracy Evaluation of Proposed Method

In order to confirm the accuracy of proposed method, we prepared the reference age which is calculated by the conventional contact type sensor. The target correlation coefficient was set to 0.8 or more and the vessel age error was set within 10 years old. Evaluation test was carried out with the condition of Table 1.

Table 1.
Conditions for evaluation

Environment	Indoor
Illuminance	640 [lx]
Ambient temperature	25 [°C]
Number of subjects	30 persons
Sexuality	Male
Body temperature	From 26.0 to 27.3[°C]

Proposed system was developed as a smart phone application with portable devices (See Figure 5). Reference value of vessel age was measured with conventional measuring system (See Figure 6). Measuring equipment of each value was show in below (See Table 2). Each blood vessel age was evaluated by an average value calculated from values measured three times.

Table 2.
Equipment for each value

Measurement value	**Equipment**
Blood vessel age (Proposed_F)	Proposed system
Blood vessel age (Proposed_A)	Proposed system
Blood vessel age (Reference)	PDU-M200
Facial age	Proposed system
Body temperature	CISE 01 TE

Figure 5. Components for proposed system

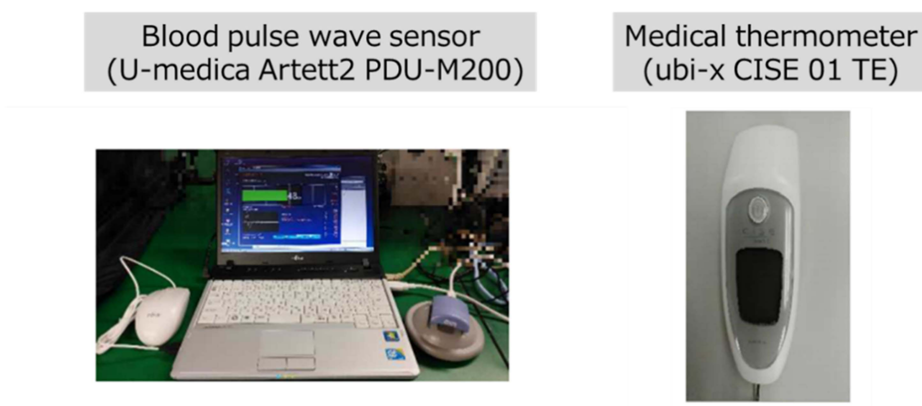

Figure 6. Equipment for reference data

RESULTS

The mean error of Proposed_A was 4.1 years old and Proposed_F was 7.6 years old. The maximum error was Proposed_A of 18.0 years old and Proposed_F of 28.0 years old. The plot (See Figure 7) was relation of the blood vessel age between proposed method and conventional method. The correlation factor of “Proposed_A” was 0.87, “Proposed_F” was 0.63.

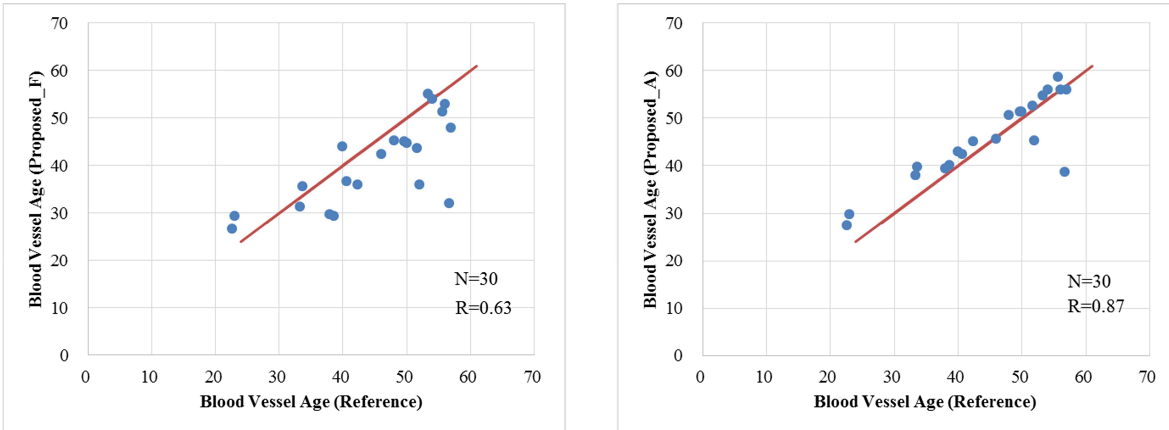

Figure 7. Relation of blood vessel age between proposed and reference

Figure 8 shows the plot between the actual age and the facial age. The correlation factor was 0.86. Mean error was 7.5 years old. Maximum error was 28.0 years old. There were 28 subjects with a facial age lower than the actual age. 2 subjects showed a higher age than the actual age. All values were shown in Table 3.

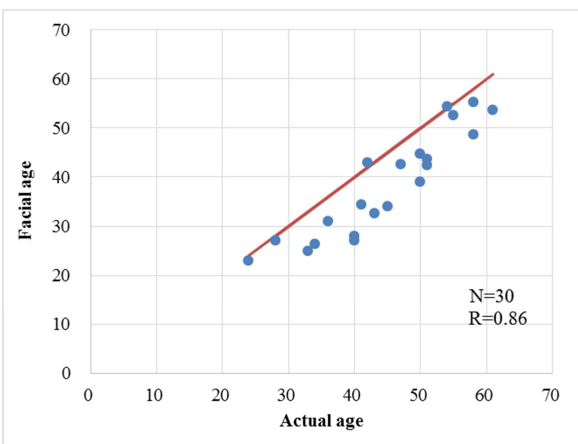

Figure 8. Relation between Actual age and Facial age

Table 3.
Blood vessel ages measured in evaluation test

ID	Age	Facial Age	Reference Age	Proposed_F		Proposed_A	
				Average	Difference from reference	Average	Difference from reference
1	28	27.0	23.0	29.3	6.3	29.7	6.7
2	51	43.7	49.7	45.0	4.7	51.3	1.7
3	40	12.0	44.3	16.3	28.0	42.0	2.3
4	40	28.0	38.0	29.7	8.3	39.3	1.3
5	40	32.3	36.7	35.0	1.7	41.3	4.7
6	60	56.0	63.3	57.0	6.3	60.3	3.0
7	54	54.3	53.3	55.0	1.7	54.7	1.3
8	42	36.3	36.3	38.3	2.0	42.7	6.3
9	36	31.0	33.7	35.7	2.0	39.7	6.0

10	58	55.3	56.0	53.0	3.0	56.0	0.0
11	47	42.7	46.0	42.3	3.7	45.7	0.3
12	41	34.3	40.7	36.7	4.0	42.3	1.7
13	58	48.7	57.0	48.0	9.0	56.0	1.0
14	45	42.7	50.3	43.3	7.0	45.0	5.3
15	61	53.7	55.7	51.3	4.3	58.7	3.0
16	43	32.7	42.3	36.0	6.3	45.0	2.7
17	50	44.7	48.0	45.3	2.7	50.7	2.7
18	40	27.0	38.7	29.3	9.3	40.0	1.3
19	44	28.3	58.0	30.3	27.7	44.0	14.0
20	50	39.0	51.7	43.7	8.0	52.7	1.0
21	33	25.0	33.3	31.3	2.0	38.0	4.7
22	42	43.0	40.0	44.0	4.0	43.0	3.0
23	43	25.0	49.7	30.3	19.3	45.7	4.0
24	34	26.3	56.7	32.0	24.7	38.7	18.0
25	24	23.0	22.7	26.7	4.0	27.3	4.7
26	25	19.0	27.3	29.0	1.7	33.7	6.3
27	45	34.0	52.0	36.0	16.0	45.3	6.7
28	29	28.0	24.0	30.0	6.0	31.0	7.0
29	55	52.7	54.0	54.0	0.0	56.0	2.0
30	51	42.3	50.0	44.7	5.3	51.3	1.3

DISCUSSION

From the evaluation test, the correlation coefficient of the Proposed_F was 0.63. It is considered that the facial age used when calculating the vessel age contains an error. From Figure 8 as well, we can see that the facial age tends to be lower than the actual age. By improving the estimation accuracy of the facial age, Proposed_F can be detected with high accuracy.

As for Proposed_A, the correlation coefficient with the vessel age of the reference machine exceeds the target value by 0.87. The authors confirmed that the proposed method is effective as a noncontact method that can replace contact type blood vessel age measuring instrument. However, looking at the experimental results, there were two subjects who exceeded the target error of 10 years old. For ID No. 19, since the measurement results at the reference machine were 69, 45 and 60 years old, there were many variations in measurements and there is a possibility that the accurate blood vessel age cannot be measured with the reference machine, so further investigation is necessary. Next, we consider subjects with ID 24. His vessel age measured by the reference machine was 56.7 years for the actual age of 34 years. There was a large difference between vessel age and actual age. There is possibility that the proposed method is not able to measure vessel age which is different from actual age largely. Therefore, it is necessary to improve the method so that we can respond to subjects who's the vessel age is remarkably high (low) in the future. We were concerned that these two measurements are unreliable. The correlation coefficient was 0.90 except these two subjects.

LIMITATION

Proposed_A method requires input procedure of actual age and it cannot be said that it is a perfect noncontact method. In the future, in order to replace the actual age with the face age, it is necessary to improve further the estimation accuracy of the facial age. Subjects in this paper were limited to healthy Japanese men from 20s to 60s. In order to make this method available to people all over the world, it is necessary to evaluate accuracy over 60 years old, accuracy for women, and correspondence to races other than Japanese. In the proposed method, the target is limited to drivers, therefore this method is assumed to use a driver camera. Considering that the elderly also sits on seats other than driver's seat, it is necessary to apply this method to all the seats in the future. In that case, a sensor has to be able to detect the entire interior of the passenger compartment.

CONCLUSIONS

In this research, the authors examined the age detection method necessary for improving the safety of elderly drivers at the time of a vehicle crash accident.

The authors proposed the blood vessel age as an index to measure the aging level of the driver. In addition, a noncontact measurement method replacing the conventional contact type was newly constructed and the accuracy was validated.

In order to make the proposed method completely noncontact, it is necessary to reduce the error from actual age to within 1 year by improving accuracy of the facial age detection algorithm.

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