Cloud Database Construction for the Expressway Design by the use of the Medical Information

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Abstract—**Your heart rate and blood pressure are respond to the curve, slope, lane width, and road surface friction coefficient of the expressway design. However, no report was reported concerning about the Expressway design from the viewpoint of medical information of the driver until now. To prevent the traffic accident, human factor is of course one of the most important factors. In this study, the Cloud Database Construction for the Expressway Design by the use of the Medical Information had been tried to carry out. HR response and PWV responses had been tried to be analyzed by the sensors in the car during driving. LF, HF and LF/HF of Heart rate variability had been calculated and tagged with expressway information including left and right curve, slope, lane width, and road surface friction coefficient. Furthermore, pulse of the descending aorta had been tried to be recorded from the sensor in a driver seat, so, the pulse wave velocity and blood pressure could be evaluated. Recording system of an Eye movement, pupil diameter, cerebral blood flow, and EEG are now under construction. So, all human driver's data will be combined in the Cloud of the Central office. this method will be useful for the development of the designing method the Expressway in near future**

I. Introduction

Traffic accidents on expressways are now becoming a major issue, especially in the advanced and elderly populations in some countries, including Japan (1-6), because driving ability, capacity for exercise, cognitive function, and cardiovascular function are decreased in the older population. If expressways are designed to prevent accidents based on medical information, it would be beneficial for elderly populations.

Heart rate and blood pressure respond to the curve, slope, lane width, and road surface friction coefficients of expressway design; however, no report has examined expressway design science from the viewpoint of the medical information of the driver until now. A review of Medline via PubMed showed that there is no scientific paper that has investigated expressway design along with the use of medical information.

In addition, no data has been gathered related to the human body's responses or medical responses to the left and right curve, up and down slope, lane width, or road surface friction coefficients of expressways until now. For the prevention of traffic accidents, human factors and medical information are important.

Evaluations of the electro-cardiogram (ECG)s, hemodynamic states, the autonomic nervous system, and brain functions during driving are most effective in ensuring driver safety and in determining the best expressway design (1-10).

In this study, the development of a methodology for the cloud database construction of expressway design using medical information was carried out. Heart rate (HR) and the pulse wave velocity (PWV) responses were analyzed during driving. The low frequency peak (LF), the high frequency peak (HF), and LF/HF of heart rate variability (HRV) were calculated and compared with expressway information, including left and right curve, slope, lane width, and road surface friction coefficients. Furthermore, the pulse of the descending aorta was recorded using a sensor in the driver's seat so the pulse wave velocity and blood pressure could be evaluated.

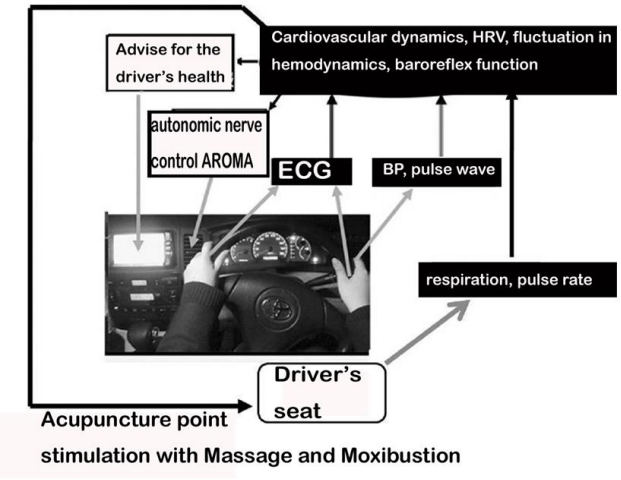

Figure 1 Schematic illustration of the biological signal monitoring system during driving in the expressway. ECG, pulse wave from finger tip of from driver seat, respiration had been easily obtained. And Advice in Navi system, intervention by the use of Aroma or Acupuncture stimuli will easy to be available (Japanese Patent 5390851, T.Yambe et al.)

Furthermore, a recording system for eye movement, pupil diameter, cerebral blood flow, and EEGs is currently being developed. Thus, all human drivers' data will be combined in the cloud of the central officer to design an expressway in the near future.

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978-1-5386-1311-5/19/$31.00 ©2019 IEEE

II. MATERIAL AND METHODS

A. Medical information detection during driving

Human body responses are so sensitive that heart rate and blood pressure respond to the curve, slope, lane width, and road surface friction coefficients of expressway design; however, no medical scientific papers have addressed this phenomenon. No report has examined expressway design science from the viewpoint of the medical information of the driver until now. For example, fatal arrhythmia is a crucial issue when considering medical safety of the elderly people. If the ECG signals and hemodynamic parameters of the driver can be checked, it would be beneficial not only for drivers but also for pedestrians.

Figure 2 ECG sensors and Pulse wave sensor on the handle

Medical information detection is one of the most important issues when the elderly society is considered. An ECG monitoring device on the driver's handle was developed, which enabled a diagnosis with an autonomic function (Patent 5390851).

Using this system allows for evaluating ECG signals and tonus and balances of the autonomic nerves system during expressway driving. Noise is removed by the signal processing algorithm, and stable measurements are captured in the motorcar under development. This information will be useful when planning an expressway design.

Figure 3 Car navigation system and the position of this car

The position of a car while driving in Japan can be easily and accurately determined by a navigation system because Japan is a small country. Information regarding the position of the car can easily be tagged in relation to the information of the design elements of the expressway by the newly developed system. If the ECG signal, pulse wave, blood pressure, pulse wave velocity, and respiration data can be recorded, then this information can be tagged in relation to the design elements of the expressway as well. The medical information collected during expressway driving can be easily recorded because the driving speed on the expressway must be kept at almost the same range; however, precise medical signal recording may be difficult for other types of roads in towns. Thus, a mock simulator of driving with medical diagnosis equipment has been developed in the laboratory, and the measurements of the hemodynamic derivatives were carried out after the ethical committee granted permission (2017-1-1067).

B. Monitoring of the medical information and the relation to the design of the expressway

For the first time, the implementation of a cloud database to collect medical signals from the human body while driving on the expressway that can be submitted to the administrative office can be achieved by the newly developed system.

Each day, information can be collected for and can accumulate in the database. This is the first system of its kind in the world, and it will be useful for both motorcar development and expressway design.

This design methodology will be useful for all countries with an increasing elderly population.

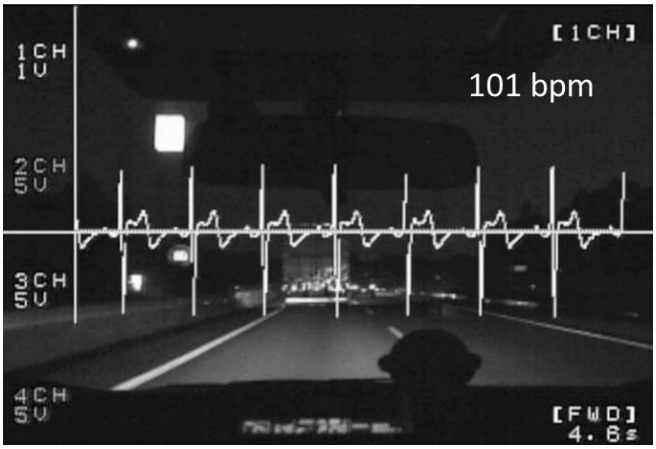


Figure 4 ECG signal superimpose in the Drive record during Tohoku Expressway drive

The medical information cloud database will be helpful when considering safety while driving on the expressway. The guidelines of expressway design can be improved based on the medical information collected by the newly developed system.

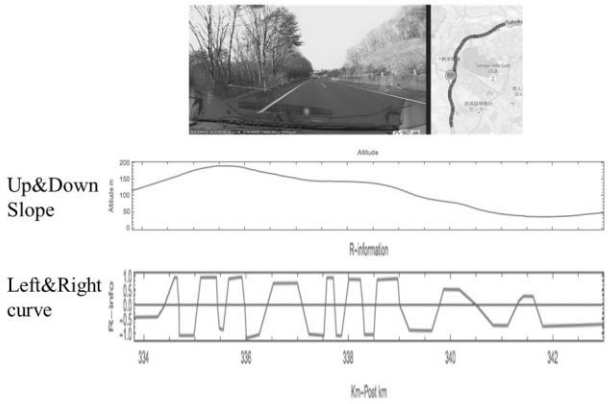


Figure 5 Position of the car in the navigation system and the information of the expressway design. Up & down slope and Right and left curve were shown in the figure

At Tohoku University, various types of medical information detection units are now under development by the Graduate School of Biomedical Engineering, and these sensors can be used for drivers in a non-invasive way (11-15).

First, heart rate responses to expressway driving must be detected. Therefore, the Holter ECG recording was used for the experiments, and the recorded data were compared with the expressway design components.

III. Results

After the ethical committee granted permission, the clinical experiments began with healthy volunteers. Various types of medical equipment were used in this study in various driving situations. An example is shown in fig.6.

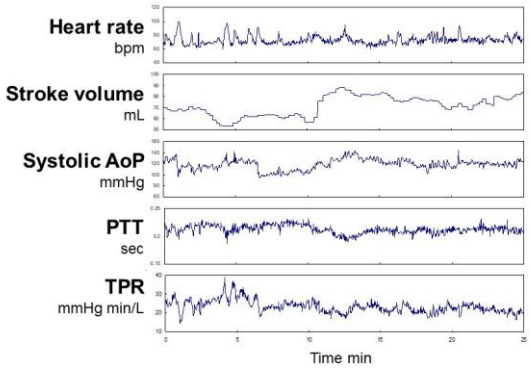


Figure 6 An example of the hemodynamic parameters was recorded during driving with simulator. Heart rate, stroke volume, systolic blood pressure, pulse transfer time, ant total peripheral resistance had been recorded.

It was difficult for the feeling for the volunteers, because the diagnosis system were troublesome and noisy. So, simple equipment may be desirable for the design plan for an expressway. For this reason, we moved to the highway with simple Holter ECG system.

An example of the time series data of the hemodynamic parameters is shown in fig.7. Stable measurements were collected.

HR and hemodynamic parameter information while driving on the expressway should be tagged to the driveway point for the evaluation of expressway design.

As is shown in lower, the X axis was the time series, and HR was the Y axis. The time series was converted to the expressway position. These calculations were related to the car's navigation sensor.

$$HR(x) = f(HR(t))$$

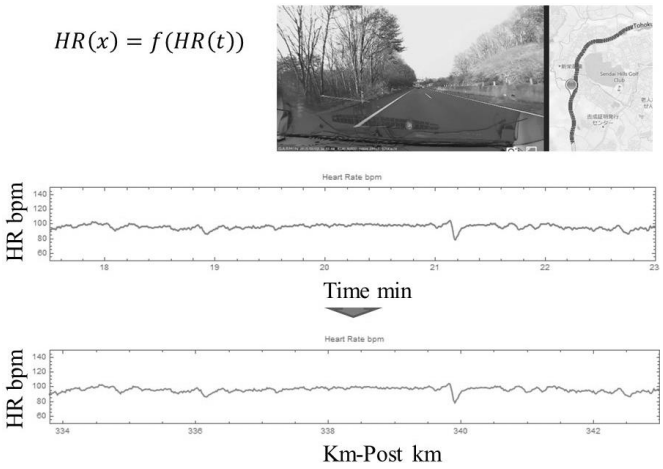


Figure 7 Time series data of the heart rate at the point. HR during drive was tagged to the Km-post from Tokyo central. So, we can evaluate the driver's behavior at the specific point in the expressway

Fig.7 shows the time series data for heart rate at this point. HR data while driving was tagged to the Km-post from Tokyo central. Thus, driver's behaviors at specific time points on the expressway were evaluated. All medical data from the human body must be tagged to the position on the expressway for the ideal design of an expressway for safe driving. Heart rate variability was checked while driving at different positions on the expressway. These types of data are the first of their kind to be collected when considering expressway design, and thus a patent was submited (p2016191985, Jpn Pt. 5390851).

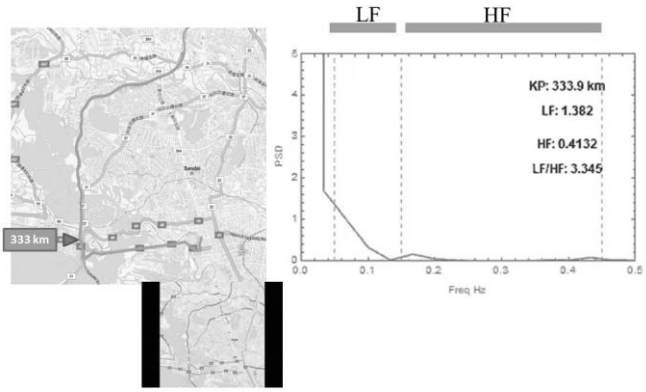
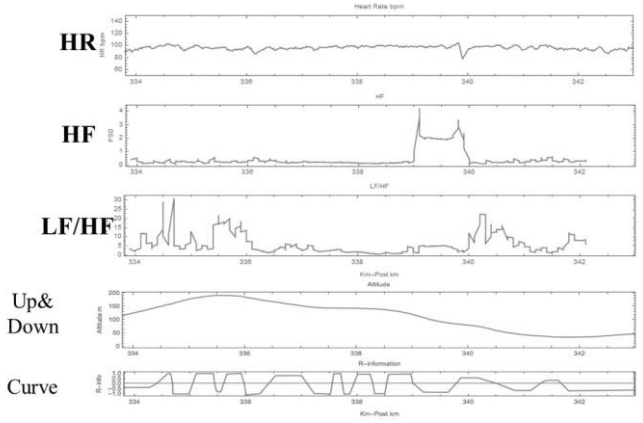


Figure 8 Spectral analysis of the heart rate variability of the driver tagged to the point in the Tohoku Expressway

Of course, a driver can feel the slope and curve and road friction of the expressway while driving. The autonomic nervous system can sense these changes.

Every day, you drive a car by the blood supply from your heart, which is controlled by an autonomic nervous system.

If the slope is too steep, the heart rate will respond to the road slope. If the driver makes a sharp turn, blood pressure may rise. Thus, an ideal expressway should be designed for driver safety.



Fogure 9 HR and HRV response of the human body during driving in the Expressway. Heart rate, High frequency peak, and low frequency/high frequency ratio were compared with the information of the up and down slope with left and right curve information

The information related to expressway design was reported from the East Japan Nippon Expressway Company Limited (East Japan NEXCO) and was compared with the data collected from the human body.

IV. DISCUSSION

This study is the first to demonstrate the usefulness of collecting medical information from drivers to apply it to the design elements of an expressway. Traffic accidents on expressways are now becoming a major issue, especially in countries with large elderly populations.

Medical information detection for drivers will become increasingly important, especially for expressways due to high speed driving. When designing expressways, medical information must be considered in the near future.

A cloud database for drivers will become a crucial factor when considering driver safety on expressways.

Information related to the driver must be collected and tagged in relation to information regarding expressway design elements.

Further studies are needed to collect additional medical information to improve driver safety and expressway design.

V. CONCLUSION

In this study, the development of a methodology for the cloud database construction of expressway design using medical information was carried out.

This study is the first to demonstrate the usefulness of collecting medical information from drivers to apply it to the design elements of an expressway. A cloud database for drivers will become a crucial factor when considering driver safety on expressways.

ACKNOWLEDGMENT

This study were partly supported by the Grant in aid by JSPS KAKENHI Grant Number 25282125, and 25560188 and Grant in aid for Scientific research from East Japan Nippon EXpressway COmpany Limited and NEXCO related companies

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