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Use Times New Roman

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000 Method for Evaluating Motorcycle by Measuring Driver's Physiological Reactions (Second Report)*

1-3-digit Presentation Number

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Author's Name: Centering with 9-10 pt. bold

Abstract : Centering with 100 words with 9-10 pt.

Driving a motorcycle on expressway at high speeds would increase the mental tension of a driver as the physiological condition of a bus driver is assumed to be affected by the handling of the bus. In this study, quantifying driver's tension as a function of the physiology of the3 human, HRV, was tried. Specifically, how certain differences in handling, particularly suspension characteristics, would contribute to driver's tension, were attempted to find, and feasibility of evaluating the handling of a vehicle as a man-machine system were determined. The results of this study indicate significant correspondence between HRV indices and suspension characteristics

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Keywords: **Human Engineering, Vehicle Dynamics, Maneuverability/Ignition Delay, Mixture Formation⑥**

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1. INTRODUCTION

The number of customers using expressway motorcycle has been increasing, along with those who use chartered buses to go to tourist resorts, as expressway network in Japan has been extended and improved.

As a means of long-distance transportation of passengers from Tokyo area, most people have used airplanes and railways, such as Shinkansen Lines (Bullet Train). However , the number of people using expressway motorcycles has been increasing because of convenient services such as reasonable fares, a variety of routes thinking many cities, short time required to reach destination after getting off, comfortable leg room, night service, etc.

The utmost concern for along-distance driver operating on expressway is to scour the safety of passengers, and thus it is important to reduce physiological load on the driver to prevent accidents.

In this study, possibilities of evaluating difference in the suspension characteristics of bus were studied by using lane changing pattern the bus driver (subject) at high speeds as an assumed index for mental tension, and processing the measured data.

Conventionally, the evaluation of vehicle behavior ...istics has depended on sub-jective rating of feel- ...xperienced lately attracted people's attention in ...cal field, was used to study possibility of quanti- ...expressing difference in driver's tension due to ...pension characteristics by using a lane changing pat- ...n, according to which a driver changed lanes quickly at ordinary us expressway speeds.

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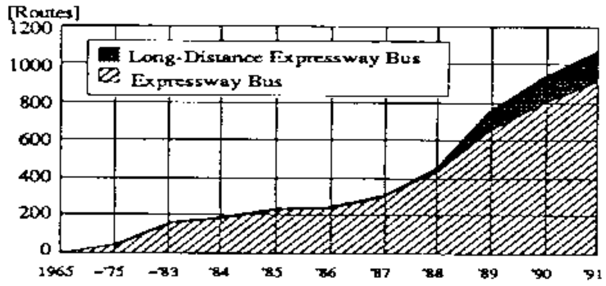
HRV is an index expressed by the periodic components included in heartbeat fluctuation wave-low frequency (LF) harmonic component, for which one periodic cycle appears in approximately 10 heartbeats, and high frequency (HF) harmonic component, for which one periodic cycle appears in approximately 3 to 4 heartbeats to estimate the activity in sympathetic and parasympathetic nervous systems. Hence, HRV is an index for quantifying our mental tension as well as mental and physical load,



* Expressway Bus: Transit bus for which no less than half of its route is expressway
* Long-Distance Expressway Bus: 'Expressway Bus' with a 300 km or longer bus route

Fig.1 Change in the Number of Expressway Bus Routes

etc.

Rec...ly attention has been focused on HRV as a potential non-invas... index for the activity in autonomic nervous systems, and there ... been many reports that HRV is a possible index for mental loa... ...h was confirmed in our laboratory tests. Howev... this method to the evaluation of vehi... teristics failed.

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2. THEORETICAL MODEL

Test driver, and physiological load on a driver has never been clearly quantified. Hence, in this study the heart rate variability (HRV) analysis method, which has

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3. EVALUATION

Recently attention has been focused on HRV as a potential non-invasive index for the activity in autonomic nervous systems, and there have been many reports that HRV is a possible index for mental load which was confirmed in our laboratory tests. However, attempts to apply this method to the evaluation of vehicle dynamic characteristics failed.

$$a_{mm} = -\frac{2\sum_{i=1}^{N-m} b_{mi}\, b'_{mi}}{\sum_{i=1}^{N-m} \left(b_{mi}^{2} + b'^{2}_{mi}\right)} \qquad (1)$$

$$b_{mi} = b_{m-1\,i} + a_{m-1\,m-1} \cdot b'_{m-1\,i} \qquad (2)$$

One presumable cause of the failure is an evident difference in the manner of heartbeat behavior between the laboratory test and the actual vehicle test. Fig.3 shows a typical example of R-R intervals (RRI) as heartbeat fluctuation waves in the case of a low subjective union. Obviously there is a large difference in the manner of heartbeat behavior between the actual driving of a vehicle and the simulation of driving a vehicle in the laboratory (tracking operation). When the heart rate fluctuation wave is seen as a signal wave, this difference is due to the ratio of non-stationary components, or so-called “1/f-fluctuating components” contained in the heart rate fluctuation wave. Far more non-stationary components exist in the heart rate fluctuation wave in driving an actual vehicle than in carrying out a set of task in the laboratory. Since these

are non-stationary components, the errors (or plain mistake) in the analysis due to these components are probably the causes of the failure in studying the possibilities of HRV in the vehicle conditions.

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4. METHOD

4.1 Fluctuation Wave

Hence a method for removing the non-stationary components from the heart rate fluctuation wave was studied, and the following method was suggested as a better one in terms of filtering characteristics: Estimate non-stationary components by using smoothing filters, thus causing the low-pass filter effects, and then subtract those components from the original wave. The filtering characteristics were verified by means of F.I.R. digital filters, differential filters, smoothing filters, etc. and by using the data, such as heart rate data taken in an actual vehicle, white noise data and the data in which harmonic components are synthesized by calculation. Fig.4 shows the concept of the method for removing non-stationary components by the smoothing filters which are used in the experiment explained later. Fig.5 shows the results of simulating frequency into the vehicle damping characteristics by using this method. As shown in Fig.5, the components at very low frequencies (VLF), lower then those for the general study of HRV, are suppressed.

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4.2 Fluctuating Component Analysis

One presumable cause of the failure is an evident difference in the manner of heartbeat behavior between the laboratory test and the actual vehicle test. Fig.3 shows a typical example of R-R intervals (RRI) as heartbeat fluctuation waves in the case of a low subjective union. Obviously there is a large difference in the manner of heartbeat behavior between the actual driving of a vehicle and the simulation of driving a vehicle in the laboratory (tracking operation). When the heart rate fluctuation wave is seen as a signal wave, this difference is due to the ratio of non-stationary components, or so-called “1/f-fluctuating components” contained in the heart rate fluctuation wave. Far more non-stationary components exist in the heart rate fluctuation wave in driving an actual vehicle than in carrying out a set of task in the laboratory. Since these are non-stationary components, the errors (or plain mistake) in the analysis due to these components are probably the causes of the failure in studying the possibilities of HRV in the vehicle conditions.

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5. VEHICLE TEST

The following tests were conducted to study possibility of quantifying difference in vehicle dynamics due to suspension characteristics by means of HRV.

5-1. Vehicle Specifications

The test was conducted using a test vehicle shown in Fig.6 Table 1 shows basic specifications for the test vehicle. In this vehicle, a switch box for selecting the suspension characteristics was provided on the passenger side so that a driver would not notice the selection of either suspension specification A or B ('Spec. A, B') shown in Table 2:

5-2. Results of HRV

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Weight	Front	6000 (kgf)
	Rear	9800 (kgf)
Wheelbase		6150 (mm)
Tread	Front	2065 (mm)
	Rear	1840 (mm)

Table 1. Basic Specifications fo Test Vehicle

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6. OBSERVATIONS

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7. CONCLUSIONS

(1) The study shows that the difference in drivers' tension in lane changing tests due to suspension characteristics can be evaluated on the basis of the physiological reaction of a driver. This difference is due to the ratio of non-stationary components, or so-called "1/f-fluctuating components" contained in the heart rate fluctuation wave. Far more non-stationary components exist in the heart rate fluctuation wave in driving an actual vehicle than in carrying out a set.

(2) It also shows that a noticeable difference corresponding to suspension characteristics appears in qualified physiological phenomena, not only of the driver skilled at evaluation but also of the other ordinary drivers.

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