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EMG Feature Extraction for Driver's Drowsiness Using RF Wireless Power Transmission Method

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***Abstract:** Various methods are being considered to prevent driver's drowsiness. Recently, a method for preventing driver's drowsiness by measuring physical changes such as electromyogram (EMG), electrocardiogram (ECG), and electroencephalogram (EEG) has been considered. In this paper, we proposed simple EMG sensor system for preventing driver's drowsiness with radio frequency (RF) wireless power transmission method. It is designed to reduce the disturbance to the driver because it is supplied with continuous RF power. Also, we have analyzed the body position suitable for determining the degree of drowsiness by measuring the EMG signals at various body positions. From the measured EMG signal at various parts of the body, the wrist area is the most sensitive to driver's drowsiness by spectrum analysis.*

***Keywords** - driver's drowsiness; electromyogram (EMG); radio frequency (RF) wireless power transmission method; spectrum analysis*

I. INTRODUCTION

Of the deaths from traffic accidents in the last three years, almost 30 % is due to drowsiness driving. It is necessary to introduce an auxiliary device to prevent sleepy driving for the safety of citizens. However, the drowsiness prevention devices that are currently being developed do not interfere with the driver's operation, impair the convenience of the driver, fail to provide reliable sensing technology, or are inaccurate [1-4]. It is necessary to develop a drowsiness prevention module that is reliable, compact, low power, and does not interfere with the operation of the driver.

With respect to the drowsiness driving prevention technique, there is an attempt to detect the movement of the driver's eyes by using eye movements, the muscle behavior, and the changes in heart rate. Also, a system for detecting an automobile motion and giving an alarm to the driver is being developed. Among them, many developments have been made to prevent drowsiness using bio signals such as electromyogram (EMG), electrocardiogram (ECG), and electroencephalogram (EEG) [5-7]. These bio signals have recently been applied to various classifications through signal analysis using deep learning techniques [8-10]. In this paper, we propose an EMG sensor system using radio frequency (RF) wireless power transmission method which is reliable, low power, and does not interfere with the operation of the driver. Through EMG signal analysis of various body parts, the correlation between EMG signal and the drowsiness level is verified.

II. PROPOSED EMG SYSTEM

The configuration of the EMG measurement system is similar to the previous paper in reference [11]. The EMG sensor system used "myoware" as the EMG sensor to occupy a small area and Arduino pro mini for control and analysis of the EMG signals. The RF power receiver is configured using watch shaped battery recharging board and Bluetooth module is used to give alarm to the driver using HC-06. This small, compact EMG measurement system gives less interference to the driver and can easily analyze the measurement results. Figure 1 shows the overall structure of the configured EMG sensor system. Continuous power supply is possible by installing a transmitter near the driver.

In this paper, we focus on the extraction of important parameters related to the appropriate body part to analyze the driver's drowsiness. This can be a great help if you use EMG signals to classify them by direct method or by specific parameters using deep learning techniques.

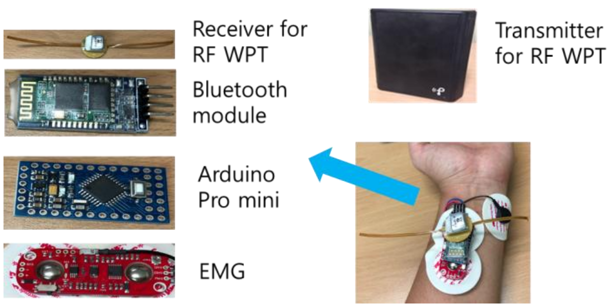

Figure 1. EMG sensor system using RF wireless power transmission method.

III. EMG SIGNAL FEATURE

Attempts to analyze drivers' drowsiness using the EMG signal are observed in some references [1-4]. Typical measurement methods for driver's drowsiness are maximum amplitude, median amplitude, and median frequency.

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The reason for using the EMG signal for drowsy operation is that the measurement is relatively simple compared to other biological signals. However, there is a disadvantage that the measurement accuracy is low for drowsy operation than for other biological signals. In this paper, we try to analyze the most reliable signal feature for preventing drowsiness by measuring and analyzing EMG in various parts of the body. In order to minimize the inconvenience of the driver, these parts of the body are limited to the position where the attachment of EMG sensor system is easy. These are a wrist, a hand, a forearm, and an ankle.

The acquisition signals for the wrist are shown in Figure 2. This is a raw signal for signal processing. These raw EMG signals move rapidly around the centerline when there is muscle movement. It records the electrical activity of the muscle and is used to diagnose the condition of the muscle. EMG signals refer to the action potential of the muscles. In other words, when the EMG sensor is used, the degree of muscle contraction and relaxation by numerical value can be checked. These activations of muscles are transformed to maximum amplitude, median amplitude, and median frequency using mathematical analysis.

The maximum amplitude is measured as the difference between the electrical signal at the highest point and the lowest point when the muscle is active. This maximum amplitude gradually decreases with the fatigue of the muscle. In the case of median amplitudes, when the muscle is activated, the root-mean-square (RMS) values are taken from the EMG signal. The median amplitude is determined from the most centrally located data in order of RMS magnitude. To get the median frequency, the measured EMG signals in time domain must be converted to the signals in frequency domain using fast Fourier transform (FFT). These are calculated using Arduino Pro mini. In the case of the median frequency, the frequency component is lowered as the fatigue of the muscle is increased. The maximum amplitude, median amplitude, and median frequency of the EMG signal at the wrist measured in Figure 2 are 0.29 V, 1.65 V, and 92 Hz, respectively. The sampling time is about 5 ms. To observe the change of EMG signal before and after the driving operation, the EMG signals are measured after 2 hours driving operation. The measured EMG signals after 2 hours driving operation are shown in Fig. 3. The calculated maximum amplitude, median amplitude, and median frequency using Arduino Pro mini are 0.27 V, 1.64 V, and 86 Hz, respectively. The maximum amplitude, median amplitude, and median frequency are reduced by the muscle fatigue after 2 hours driving operation.

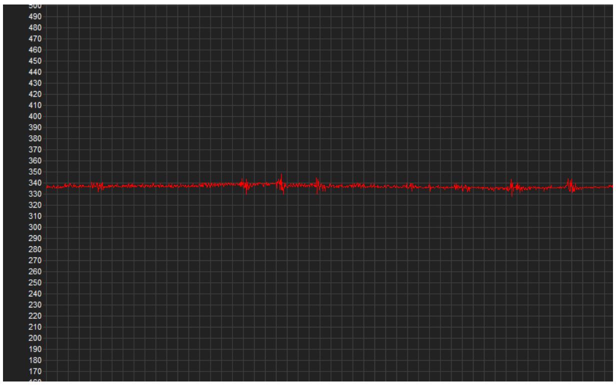

Figure 2. EMG raw signal at the wrist.

Figure 3. EMG signal at the wrist after 2 hours driving operation.

IV. RESULTS & DISCUSSIONS

The maximum amplitude, median amplitude, and median frequency obtained from the EMG measurement system are shown in Figure 4 according to the operating time to determine the feature to judge driver's drowsiness level. For scale adjustment, the maximum amplitude is taken three times. In this case, the driving operations are performed for 10 persons and the measurement site is a wrist. The graph shows only changes in maximum amplitude, median amplitude, and median frequency for one driver, representatively. To find body parts sensitive to drowsiness, the measurement results for a wrist, a hand, a forearm, and an ankle are shown in Figures 4, 5, 6, and 7, respectively. Each characteristic represents the muscle fatigue of the driver according to the driving time. Additional criteria for drowsiness driving decisions are determined by eye blinking through the small camera. These reference times are represented by red dotted lines in Figs. 4, 5, 6, and 7. From this, it can be seen that the most sensitive value among the features is the median frequency at all measurement sites. Also, at the measured median frequency, the wrist of the body parts shows the largest change. In order to determine the drowsiness of the driver using the EMG measurement signals, it is most effective to attach the EMG measurement system to the wrist area and observe the change of the median frequency. This EMG measurement system uses the RF WPT method, has a small size, is the least obstructive to the driver's operation, and has the advantage of being able to measure at every moment..

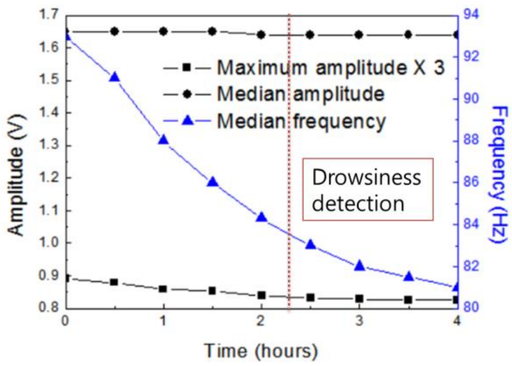

Figure 4. EMG measurement result at the wrist during driving operation.

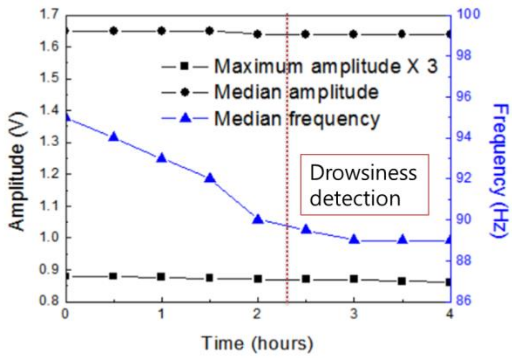

Figure 5. EMG measurement result at the hand during driving operation.

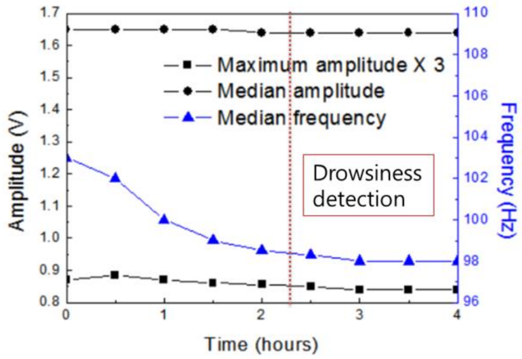

Figure 6. EMG measurement result at the forearm during driving operation.

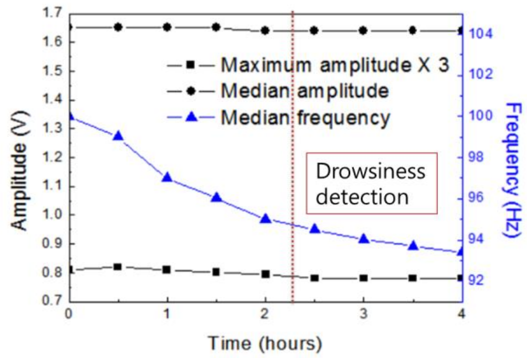

Figure 7. EMG measurement result at the ankle during driving operation.

V. DRIVER'S DROWSINESS DETECTION

In order to observe driver's drowsiness prevention function through actual EMG measurements, the change of EMG signal through driving operation is performed for two additional drivers. The EMG measurement results are converted to median frequency at the wrist. The method to determine the drowsiness level according to the driver can be done more effectively by using deep learning algorithm, but in this paper, we have selected the point where the initial value of median frequency is reduced to 90 % from the analysis results for simplicity. If the median frequency of EMG signals determines that the driver is sleepy, the result is sent to the driver through the Bluetooth module as an alarm. It is expected that the EMG signal from the wrist will be continuously measured through the RF WPT method, so that the drowsiness level of the driver can be determined using the median frequency. This system is small, it can be judged by using a simple EMG measurement system for the drowsy operation of the driver. This EMG measurement system is small, less disturbing to the driver, and able to make accurate judgments.

If the feature extracted from this system is determined by using the deep learning classification criterion suitable for the user, more sophisticated system construction become possible.

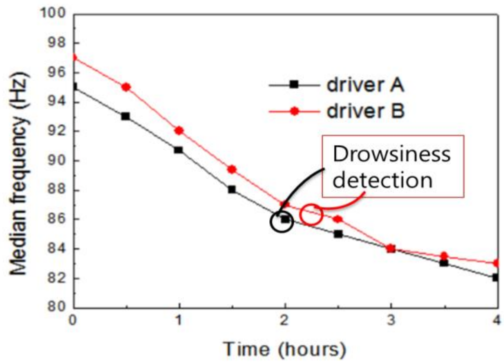

Figure 8. Median frequency changes at the wrist during driving operation.

VI. CONCLUSIONS

The median frequency in the wrist is selected as a parameter with a relatively high sensitivity so that the drowsiness level can be judged by the EMG signal measurements. The drowsiness level can be determined based on the change of about 90 % of the previous median frequency after the driving operation. The measurement system uses the RF WPT method to enable continuous power supply. This system is also small, has fewer disturbances to the driver, is continuously operational, and is a relatively accurate.

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REFERENCES

1. A. Chowdhury, R. Shankaran, M. Kavakli, and Md. M. Haque, "Sensor Applications and Physiological Features in Drivers' Drowsiness Detection: A Review," IEEE Sensors Journal, vol. 18, no. 8, pp. 3055-3067, Apr. 2018.
2. A. Sahayadhas, K. Sundaraj, and M. Murugappan, "Detecting Driver Drowsiness Based on Sensors: A Review," Sensors, vol. 12, pp. 16937-16953, Nov. 2012.
3. B.-L. Lee, B.-G. Lee, and W.-Y. Chung, "Standalone Wearable Driver Drowsiness Detec-tion System in a Smartwatch," IEEE Sensors Journal, vol. 16, no. 13, pp. 5444-5451, Jul. 2016.
4. A. G. Correa, L. Orosco, and E. Laciar, "Automatic detection of drowsiness in EEG rec-ords based on multimodal analysis," Medical Engineering & Physics, vol. 36, no.1, pp. 244-299, Jul. 2014.
5. M. Akin, M. B. Kurt, N. Sezgin, M. Bayram, "Estimating vigilance level by using EEG and EMG signals," Neural Computation and Applications, vol. 17, no. 1, pp. 227-236, Jul. 2008.
6. R. Fu and H. Wang, "Detection of driving fatigue by using noncontact EMG and ECG signals measurements system," International Journal of Neural Systems, vol. 24, no. 3, p. 1450006, Nov. 2014.
7. L.-L. Chen, Y. Zhao, J. Zhang, and J.-Z. Zou, "Automatic detection of alert-ness/drowsiness form physiological signals using wavelet-based nonlinear features and machine learning," Expert Systems with Applications, vol. 42, no. 1, pp. 7344-7355, May 2015.
8. M. B. Kurt, N. Sezgin, M. Akin, G. Kirbas, and M. Bayram, "The ANN-based computing of drowsy level," Expert Systems with Applications, vol. 36, no. 1, pp. 2534-2542, Nov. 2009.
9. S. Park, F. Pan, S. Kang, and C. D. Yoo, "Driver Drowsiness Detection System Based on Feature Representation Learning Using Various Deep Networks," in Asian Conference on Computer Vision (ACCV), 2016, pp. 154-164.
10. B. Reddy, Y.-H. Kim, S. Yun, C. Seo, and J. Jang, "Real-Time Driver Drowsiness De-tection for Embedded System Using Model Compression of Deep Neural Networks," in IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), 2017, pp. 438-445.
11. H.-S. Choi, "EMG sensor system for neck fatigue assessment using RF wireless power transmission," in international conference on computational intelligence and applications (ICCIA), 2018, p. 60.

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