Abstract—This paper describes a non-contact heart rate monitoring system using a 24-GHz microwave Doppler sensor for driver health monitoring. The objective of this work is to detect an instantaneously heart rate using this non-contact system in a car. The instantaneously heart rate can contribute to prevent heart disasters and to detect mental stress state. However, the Doppler sensor system is very sensitive and it can be easily contaminated by a motion artifact especially while driving. To address this problem, time frequency analysis and autocorrelation method are employed. Measurement results show that the Doppler sensor, which is pasted on the clothing surface, can successfully extract the heart rate through clothes. The proposed method achieves 13.1-ms RMS error in heart rate measurement with 11 subjects and 40km/h driving speed on average.

I. INTRODUCTION

Heart attack during driving has been a social problem because it causes serious accident. The number of patients with cardiovascular disease increases with progress of an aging society. Therefore, this paper focuses on an instantaneous heart rate (IHR) monitoring in a car using a wearable sensor. The IHR is particularly important for human beings. Analyses of the instantaneous heart rate variability can reveal a person’s stress state and signs of heart disease.

A lot of wearable sensor devices have been developed for ECG and heart rate measurement. However, these systems require pasting of wet electrodes directly onto the skin. It presents shortcomings in terms of usability. Therefore, the motivation of this work is non-contact IHR monitoring. We employed a 24-GHz microwave Doppler sensor to realize a non-contact and non-invasive IHR monitoring system.

II. IHR MONITORING USING MICROWAVE DOPPLER SENSOR

The microwave Doppler sensor can detect heartbeats from an imperceptible vibration of human body surface, which is caused by cardiac vibration. On the other hand, the Doppler sensor is very sensitive and it can be easily contaminated by a body motion artifact especially in a car while driving.

To prevent the motion artifact, the Doppler sensor board and its antenna are pasted on the clothing surface in this work as shown in Fig. 1. Furthermore, we used time-frequency analysis using a parametric (Burg’s) method [1]. Because the heartbeat and body motion have different velocity, it can be separated in frequency domain.

Fig. 2 shows an example of IHR measurement result in a car while driving. The average driving speed is 40 km/h. As shown in Fig. 2(a), the IHR can be extracted from time-frequency domain, although it contains body motion artifact. The RMS error of IHR is 13.1 ms on average of 11 subjects. This error is 75-% smaller than a prior work of heart beat detection using the microwave Doppler sensor [2].

REFERENCES


This research was supported by JSPS KAKENHI Grant Number JP16H05868.

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Figure 1. Experimental setup.

Figure 2. Example of measurement result; (a) Time-Frequency analysis result, (b) Extracted heart rate using autocorrelation.