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NON-CONTACTING SYSTEM FOR DRIVER STATE MONITORING USING UWB RADAR

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Abstract—This paper, describes a novel technique that detects a driver's state using Ultra Wide Band(UWB) radar. UWB radar can measure both human vital signs and movement simultaneously with just one device. It is an improvement on existing Driver State Monitoring(DSM) systems because is much cheaper and lighter. And UWB radar can be used all day and night in all weather conditions without contacting the driver. The experiment's result shows the possibility of using UWB radar for monitoring driver state.

Index Terms—DSM, UWB, Radar, Vital Signs, Respiration

I. INTRODUCTION

Drowsy driving is a major cause of automobile crashes, and much research is being done to reduce it. Previous studies have investigated parameters for detecting sleepiness, and the majority of research has progressed to estimating these parameters, which include head movement, respiration rate, and heartbeat rate [1].

Most systems that have been developed thus far rely on image processing using optical/infrared camera to detecting motion or estimating vital signs using a system that requires contact with the driver via sensors [2], [3]. Some systems combine these methods but must have two or more sensors [4].

This paper describes a novel technique for using UWB radar for estimating movement and vital signs with just one sensor.

II. MEASUREMENT SETUP

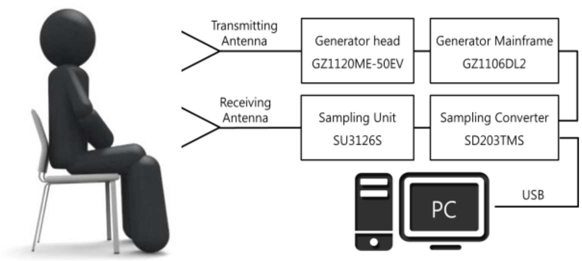
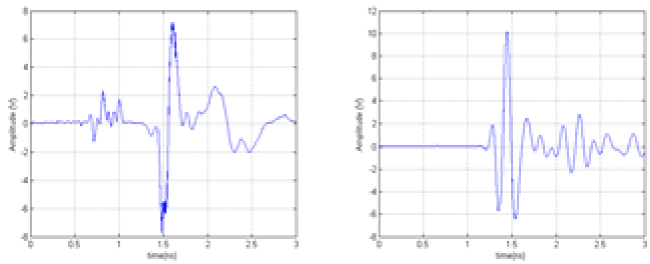


Fig. 1. **UWB Measurement Schema**

The UWB measurement system setup is shown in Fig 1. All equipment is made by Geozondas except the computer. Transmitting and receiving antennas are targeting the object (the driver). The GZ1120ME-EV generates a monocycle pulse with an amplitude ±7 V, a center frequency of 4.8MHz, and a pulse repetition frequency of 250KHz. Generated pulse is radiated by the transmitting antenna. Its frequency range is from 3.1 GHz to 10.6 GHz. The received signal is sampled by the SU3126S and the SD203TMS. The generator mainframe GZ1106DL2 triggers the generator head GZ1120ME-50EV. Figure 2 shows the generated pulse waveform by generator head and radiated pulse waveform by antenna.



(a) **(b)**

Fig. 2. **(a) Waveform of the generated pulse by generator head, (b) Waveform of radiated pulse by antenna**

III. EXPERIMENT

A. Respiration rate test

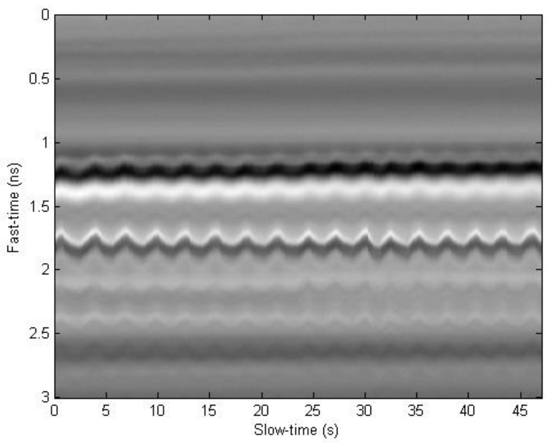


Fig. 3. **Received Raw Data**

The transmitted pulse train signals are received by the receiver and recorded as shown in Fig 3. Each column of Fig 3 corresponds to one received pulse signal. Background clutter in the raw data is eliminated by subtracting the average of each row from all samples in the row [5]. Figure 4 shows the signal after background clutter is removed.

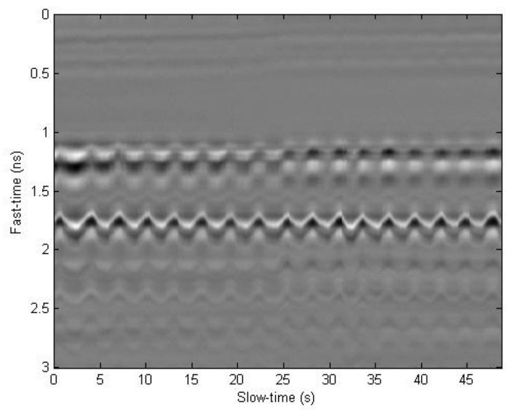


Fig. 4. **Signal with Background Clutter Removed**

Figure 5 shows the respiration signal acquired from Moving Target Indicator(MTI) processing. Figure 5(a) shows the detected signal in the time domain. Figure 5(b) is the Fast Fourier transform(FFT) of the detected signal, and Figure 5(c) is the filtered signal in the frequency domain. Constant False Alarm Rate(CFAR) and a zero-crossing algorithm were used to improve detection probability. Figure 6 shows the filtered respiration signal in the time domain.

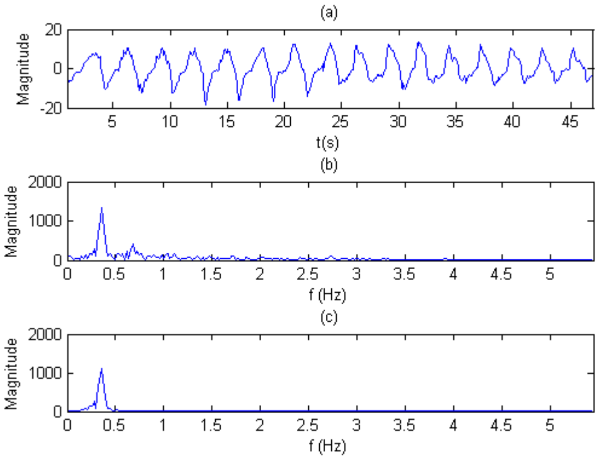


Fig. 5. **(a) Respiration Signal, (b) FFT of Noisy Signal, (c) FFT of Filtered Signal**

The method of detecting movement is almost same as that of estimating respiration rate, except the threshold value of MTI processes. The threshold value is small when estimating respiration because the chest movement when a human breathes is small. Therefore, if the threshold value is higher than the thorax movement, we can detect head movement. Figure 6(a) shows received raw data of head movement. Figure 6(b) shows the movement signal using a larger threshold.

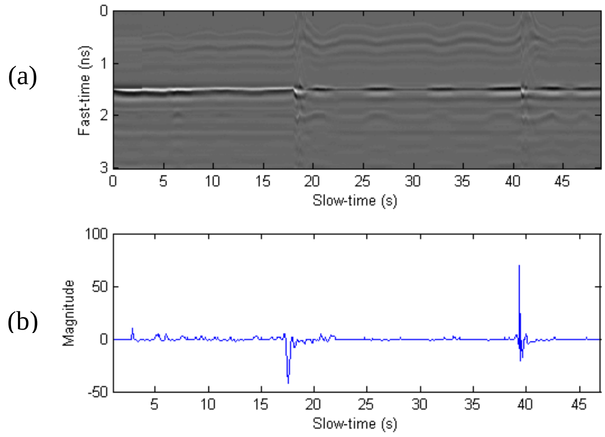


Fig. 6. **(a) Received Raw Data, (b) Movement Signal after Operating Detection Algorithm**

IV. Result

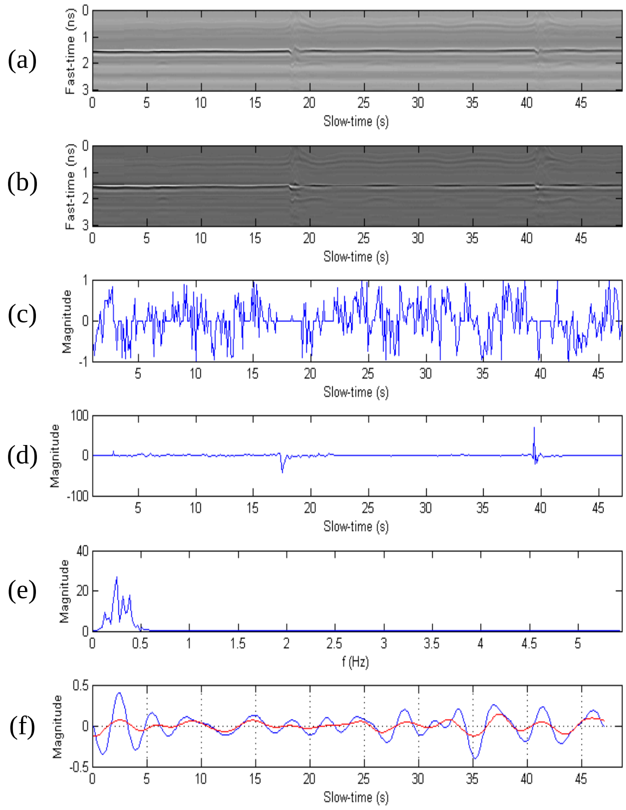


Fig. 7. **(a) Raw Data, (b) Signal after Clutter Removal, (c) Respiration Signal in Time Domain, (d) Movement Signal in Time Domain, (e) FFT of Filtered Signal, (f) Filtered Respiration Signal in Time Domain (blue), and CFAR Threshold (red)**

The goal of this experiment is to estimate vital signs and head movement concurrently using just one device. Thus, the above two experiments were performed simultaneously. The human target sat on a chair for 48 seconds moving his head intermittently. The result is as follows: Figure 7(a) shows received raw data, Figure 7(b) shows the data after the clutter was removed, Figure 7(c) shows the detected respiration signal, and Figure 7(d) shows the detected movement signal in the time domain. The detected movement signal almost matches up to the real movement (shown in the red box). Figure 7(e) is the filtered signal in the frequency domain; Figure 7(f) is the processed respiration signal in the time domain. Respiration is well-detected by the UWB radar.

V. Conclusion

This study demonstrates the possibility of estimating the change in respiration rate and head movement simultaneously by using UWB radar. This result signifies that monitoring driver's state using UWB radar is possible.

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