Respiratory Signal Estimation of a Stationary Target Based on UWB Radar

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ABSTRACT

This article presents a method to estimate and monitor the breathing rate of a stationary target using UWB radar. Due to lack of equipment, we proposed a UWB radar system using MATLAB-Simulinkwith a center frequency of 2 GHz. Respiratory rate is estimated using the Fourier transform. Experimental results showed that our proposed model achieves high performance, especially accuracy.

Keywords: UWB radar, Non-contact, Respiratory rate

1 Introduction

Respiratory sign is one of the important physiological markers that reflect human health and that help in evaluating and monitoring body functions, as well as in diagnosing disease and monitoring its progress. Measuring signs of respiration is critical in the medical field and healthcare, for example, a difference in respiratory rate may indicate a disease problem that needs immediate treatment, such as respiratory failure. Remote health monitoring is of paramount importance in medical field. UWB radar has receivedprominent attention and become a popular research topic in the field due to its high penetrating ability,high range accuracy and low power consumption. UWB radar has been used in several applications suchas Medical imaging for cancer detection [1], vital sign detection [2], vital signs monitoring [3].

During this paper, we will highlight the estimation and monitoring of the breathing rate of a stationary target using UWB radar. The remainder of this paper is organized as follows. In Section 2, the proposed method is presented by introducing the UWB system, experiment setup, and data collection. Section 3 discusses the results. Finally, Section 4 concludes the paper.

2 Methodology

2.1 UWB System

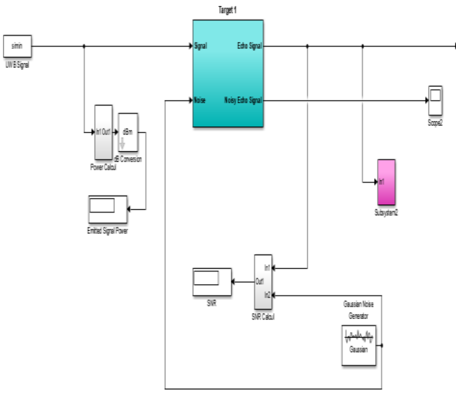

Figure 1: *UWB radar*

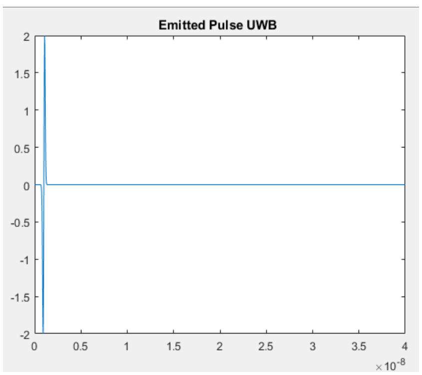

Figure 2: *Emitted Pulse UWB*

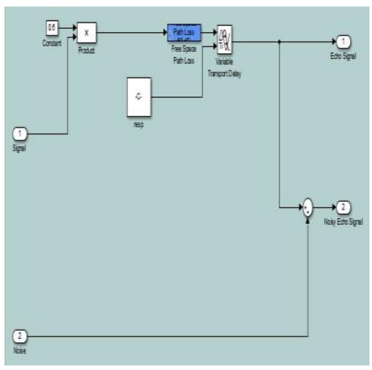

Figure 3: *Target Model*

Our model is simulated under Matlab/Simulink contains three essential parts: the radar, a Gaussian channel and the target as shown in figure 1. The main components of the UWB radar system are the transmitter, receiver and signal processing [4]. The transmitter generates and transmits a series of pulses UWB 'simin'

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(figure 2), the receiver receives the reflected echo containing the breathing information, signal processing algorithms are used to generate a series of pulses UWB and process the echo signal by determining the breathing rate [4]. The propagation channel must be designed in such a way that free- space attenuation, propagation delay and noise are taken into account [4]. The target is presented by a simple model corresponding to the inflection point at a distance d(t) [4] (figure 3).

2.2 Experiment Setup

The UWB radar consists of a transmitter and a receiver, simulated using MATLAB-Simulink softwar (figure 1). The signals generated are Gaussian monocycle impulses with a central frequency of 2 GHz which is equivalent to Bandwidth equal to 500 MHz, the sampling rate is 50GHz. The target was simulated by simulating the thoracic cavity with a simple model corresponding to the inflection with theability to determine its range and frequency. The respiratory rate was set at 0.27 Hz. The experiment was conducted at a distance of 4 m.

2.3 Data Collection

In slow-time, the data was collected for 48 seconds, the sampling period is T_S= 0.046875 seconds, whichis equivalent to a sampling frequency of F_S =21.3 Hz so the number of samples is M=48/0.046875=1024 frames. In fast-time, the frequency sampling for measuring each received waveform is F_f= 50 GHZ., so the time resolution is T_f = 20 PS. The wavelength is L= 40 ns so, each recorded waveform has N = L /T_f = 2000 sample points. These values are stored in a MxN Matrix , where M is the number of samples in slow time and N is the number of samples points in fast time.

3 Results and Discussion

After collecting the data, we applied the correlation between the received signal and the emitted signal,and then searched for the column with the maximum value, whose maximum value represents the location of human motion. A discrete Fourier transform is applied to this column in slow time to extractthe respiratory rate and heart rate. Respiration is a strong peak usually between 0.2 and 0.8 Hz. Figure 4 shows the estimation of respiratory rate.

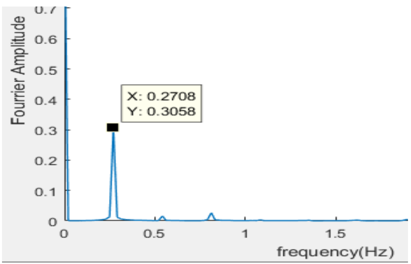

Figure 4: *Estimating the respiratory rate*

Table 1 presents the statistical results for the signs of respiration and heart rate

Table 1: *Respiratory rate, error rate and relative error*

Value\ Rate	Set value	Estimated value	Error rate	Relative error
Respiratory rate	0.27 Hz	0.2708 Hz	0.0008	0.296%

Figure 4 shows that the respiratory rate was estimated to be 0.2708 Hz. Table 1 represents the simulated breathing rate, and compares it with the set values in order to obtain the errors and relative error according to the simulation results and set values. The breathing error rate is 0.296%. These results indicate that the

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accuracy of measuring the human body's respiration rate by the proposed method is precise. The results showed that vital signs can be estimated using the proposed method even with longdistances of "4 m".

4 Conclusion

In this article, the respiratory rate of a human target was successfully estimated using UWB radar, operating at a center frequency of 2 GHz, and a bandwidth of 500 MHz. We used the Fourier Transformto extract the vital signals from the target. The proposed method is robust for long distances. The UWBradar has the ability to detect vital signs due to its high accuracy and wide frequency range.

How to Cite

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