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Analysis of Human Kinetics using Millimeter-wave Micro-Doppler Radar

Ashish Kumar Singh[a], Yong Hoon Kim[a,b,*]

[a]School of Mechatronics, Gwangju Institute of Science and Technology, Gwangju 500-712, Republic of Korea
[b]Millisys Inc., Gwangju 500-470, Republic of Korea

Abstract

In this paper, we presented a millimeter wave micro-Doppler radar for human motion detection. The concept of micro-Doppler is used to identify the motion of different body parts. Recently, the human detection using radar has number of application like surveillance, tracking and security. We have analyzed the received radar signals from pendulum and human as targets using spectrogram (time-frequency representation).

Keywords: Micro-Doppler radar; millimeter wave radar; human kinetics; human detection.

1. Introduction

In recent years, several papers related to the detection, classification and tracking of human using Doppler radar for surveillance, security and civil applications have been published[1-8]. The main advantage of using radar that it can efficiently operate in the darkness, at long range and almost all climate situations.

The micro-Doppler signature from human body parts are different for walking, running, jumping and other activities. So it is easy to determine the human activity using micro-Doppler radar[2].

By analyzing the Doppler signature, one can also get information such as velocity of different body parts, stride length, etc. of the target. Also, it is possible to classify the target is either human or animal because the stride length and velocity of animal are unlike to that of human[2, 3].

* Corresponding author. Tel.: +82-62-715-2412; fax: +82-62-715-2384.
E-mail address: yhkim@gist.ac.kr

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The received radar signal can also be used to determine the target is either rigid body or non-rigid body. The rigid body having body with a fixed size, whereas non-rigid body is having a deformable body parts. Thus, Doppler information for both types are different[4, 5].

Rest of paper is structured as follows: Basic concepts of the micro-Doppler radar is given in Section 2. Section 3 describes millimeter micro-Doppler radar. Experiments and micro-Doppler analysis are presented in Section 4. Finally, Section 5 summaries and concludes the work presented in this paper.

2. Basic concepts of micro-Doppler radar

Doppler Effect is the effect due to the motion of either source or observer, which causes change in the frequency. This frequency shift depends on the direction of motion and the relative radial velocity. The transmitted wave may be sound or electromagnetic wave. For example, the frequency of siren on the car gradually increases as moving towards than when the car is moving away from observer. In radar technology, the wave travels 2-way: from the transmitter to the target and then from the target to the receiver that results. Thus, the Doppler Effect occurs twice in case of a radar. The change or shift in frequency due to the relative radial speed is given as Doppler frequency[6]:

$$f_{Doppler} = \frac{2.Ve}{\lambda}.Cos\theta \quad (1)$$

where, $f_{Doppler}$ = Doppler Frequency (Hz)
λ = wavelength (m)
Ve = velocity (m/s)
θ = angle of arrival.

In radar, the Doppler frequency can be used to calculate speed of target (Doppler radar), or to identify moving target (MTI radar).

The micro-Doppler effect is the additional frequency modulation due to the motion or rotation of a target which generates side bands about the main Doppler frequency. The main Doppler frequency corresponds to speed of the core body part. The target characteristics can be identify by the micro-Doppler signatures[7, 8].

Micro-Doppler is sensitive to the carrier frequency of the radar signal and Doppler Effect will be more for higher frequency band. Doppler bandwidth and Doppler resolution is better for millimeter-wave radar, and it is easier to distinguish the micro-Doppler signature from different targets. The kinetics properties of human can determined using Doppler frequency. The simulation results[1] of typical micro-Doppler radar with pendulum and human as target shown in Fig. 1 and Fig. 2.

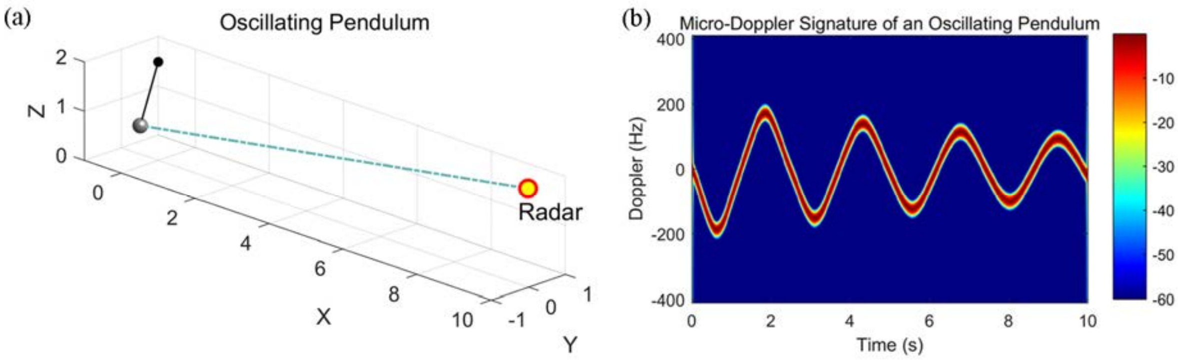

Fig. 1. (a) Pendulum as a target; (b) micro-Doppler signature of an oscillating pendulum.