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Analysis of Human's Motions Based on Local Mean Decomposition in Through-wall Radar Detection

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Observation of human motions through a wall is an important issue in security applications and search-and rescue. Radar has advantages in looking through walls where other sensors give low performance or cannot be used at all. Ultrawideband (UWB) radar has high spatial resolution as a result of employment of ultranarrow pulses. It has abilities to distinguish the closely positioned targets and provide time-lapse information of targets. Moreover, the UWB radar shows good performance in wall penetration when the inherently short pulses spread their energy over a broad frequency range.

Human's motions show periodic features including respiration, swing arms and legs, fluctuations of the torso. Detection of human targets is based on the fact that there is always periodic motion due to breathing or other body movements like walking. The radar can gain the reflections from each human body parts and add the reflections at each time sample. The periodic movements will cause micro-Doppler modulation in the reflected radar signals. Time-frequency analysis methods are consider as the effective tools to analysis and extract micro-Doppler effects caused by the periodic movements in the reflected radar signal, such as short-time Fourier transform (STFT), wavelet transform (WT), and Hilbert-Huang transform (HHT).The local mean decomposition (LMD), initially developed by Smith (2005), is to decomposed amplitude and frequency modulated signals into a small set of product functions (PFs), each of which is the product of an envelope signal and a frequency modulated signal from which a time-vary instantaneous phase and instantaneous frequency can be derived. As bypassing the Hilbert transform, the LMD has no demodulation error coming from window effect and involves no negative frequency without physical sense. Also, the instantaneous attributes obtained by LMD are more stable and precise than those obtained by the empirical mode decomposition (EMD) because LMD uses smoothed local means and local magnitudes that facilitate a more natural decomposition than that using the cubic spline approach of EMD.

In this paper, we apply the UWB radar system in through-wall human detections and present a method to characterize human's motions. We start with a walker's motion model and periodic motion features are given the analysis of the experimental data based on the combination of the LMT and fast Fourier Transform (FFT). The characteristics of human's motions including respiration, swing arms and legs, and fluctuations of the torso are extracted. At last, we calculate the actual distance between the human and the wall.

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