Compressive Sensing Approach to Detect Targets using Stepped-Frequency Continous-wave Radars

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1. Extended Abstract

Contactless detection of targets in motion has been receiving much attention in numerous applications, such as disaster search-and-rescue, healthcare, law enforcement, and urban warfare [1]. For instance, it is essential to search for human beings trapped in debris, wreckage of collapsed buildings after an earthquake or trapped in buildings on fire. It is also important to perform non-invasive measurements of the vital parameters of a patient in clinics or event at home.

There are different radar systems for these purposes, namely continuous wave (CW) Doppler radar [1], ultra-wideband (UWB) radar [2], and stepped-frequency (SF) CW radar [3]. UWB and SFCW radar systems are both preferable over CW radar systems due to their capability of localization and multiple object monitoring. Nevertheless, SFCW radar possess several advantages over the UWB radars such as high reliability, stability, and relatively easy implementation. SFCW radars, however, suffer from long data acquisition time, which can lead to aliasing while capturing scattered signals [4].

In this paper, we present a generic system for detection of targets using stepped frequency radar with a CS-based approach. CS technique is employed to compress both measurement frequencies and slow-time samples to resolve range profiles, enabling a significant decrease in data acquisition time, and reducing the amount of data to be processed. For simulation results, the full-wave numerical method – Multilevel Fast Multipole Algorithm (MLFMA) is implemented to calculate the scattered fields received at a radar. Because targets are electrically large, MLFMA is implemented on hybrid CPU-GPU platforms not only to speed up computations but also to solve larger problem sizes.

2. References

1. C. Li, J. Ling, J. Li, and J. Lin, "Accurate Doppler radar noncontact vital sign detection using the RELAX algorithm," *IEEE Trans. Instrum. Meas.*, vol. 59, no. 3, pp. 687-695, March 2010.

2. Y. Wang, Q. Liu, and A. E. Fathy, "CW and pulse-Doppler radar processing based on FPGA for human sensing applications," *IEEE Trans. Geosci. Remote Sens.*, vol. 51, no. 5, pp. 3097-3107, May 2013.

3. L. Liu and S. Liu, "Remote detection of human vital sign with stepped-frequency continuous wave radar," *IEEE J. Sel. Topics Appl. Earth Observ.*, vol. 7, no. 3, pp. 775-782, March 2014.

4. A. Gurbuz, J. McClellan, and W. Scott, "A compressive sensing data acquisition and imaging method for stepped frequency GPRs," *IEEE Trans. Signal Process.*, vol.57, no.7, pp.2640–2650, July 2009.