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Development of a Step Frequency Continuous Wave Radar for Detection and Tracking of Objects in Motion

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1. Extended Abstract

There are various types of ultra wide band radars that are suitable for detection and tracking of objects in motion [1,2]. High resolution imaging can be achieved by using ultra wide band impulse radars. The higher the bandwidth the better the resolution along the range, while the higher the operating frequency the higher the resolution in the cross range too. But, impulse radars operate in time domain and require very fast and expensive analog to digital converters (ADCs) to retrieve picosecond pulses. Alternatively, frequency modulated continuous wave radars “FMCW”, or step frequency continuous wave radars “SFCW” operate in the frequency domain. They provide ultra wide operation, and utilize relatively low cost ADCs with moderate to low speeds.

SFCW radars operate in the frequency domain, and cover a given set of frequencies. They can be designed to cover ultra wide bandwidth for high-resolution detection, and only random number of frequencies can be selected to speed up data processing. They can be used for detecting and tracking targets moving with medium speeds, e.g. walking humans, because of their current capability of limited number of frames per second. This paper discusses methods to speed up their data acquisition and the possibilities of increasing the number of frames per second, which is required for tracking fast objects in real time.

SFCW radars provide a wide bandwidth, a high signal to noise ratio, a simple control circuitry, and capability of random frequency hopping. Typically, SFCW radars are slow in data acquisition, but using random sampling based on compressive sensing, and operating multiple channels in parallel can speed up data acquisition and processing as well.

The developed SFCW is comprised of four blocks: the first block is a customized digital signal synthesizer (DDS) controlled by a complex programmable logic device (CPLD) and connected to multi-channel multiplexer, the second block a power amplifier and followed by an ultra wide band transmitting antenna. At the receiver side, the signal is received by an ultra wideband antenna that is followed by a de-multiplexer, and LNA as the third block, the fourth block is an I/Q demodulator for each channel and data acquisition units “DAQs units” [2]. The system is used for imaging, detection, and tracking for relatively low speed targets such as walking targets. Examples of ranging, and object identification based on simulated and measured results and implementation of compressive sensing will be presented.

Currently, the data acquisition speed is limited by the time required to step through all frequencies, but compressive sensing would require processing of only a fraction of the sub-Nyquist number of samples; algorithms were developed to efficiently retrieve the signals. Additionally, we have developed SFCW with two channels that operate in parallel, however more channels can be added to provide faster parallel processing scheme. Meanwhile, currently we are using 5kb/s DAQs; but much faster units in the few MB/s range are available (e.g. by National Instruments) and could be utilized for tracking of fast moving objects. SFCW operation limitations will be detailed in our presentation.

2. References

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[2] H. Wang, V. Dang, L. Ren, Q. Liu, L. Ren, E. Mao*, et al.*, "An Elegant Solution: An Alternative Ultra-Wideband Transceiver Based on Stepped-Frequency Continuous-Wave Operation and Compressive Sensing," *IEEE Microwave Magazine,* vol. 17, pp. 53-63, 2016.

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