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OFDM Synthetic Aperture Radar Imaging with Sufficient Cyclic Prefix

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ABSTRACT

In this paper, a novel approach is proposed for the orthogonal frequency-division multiplexing (OFDM) SAR imaging, where a sufficient cyclic prefix (CP) is added to each OFDM pulse. As the key in a wireless communications system, the sufficient CP insertion converts an inter symbol interference (ISI) channel from multi paths into multiple ISI-free sub channels. Analogously, it provides an inter-range-cell interference (IRCI)-free (high range resolution) SAR image in a SAR system. In the past second- and third-generation wireless communications, the existing linear-frequency-modulated (or step frequency) and random noise synthetic aperture radar (SAR) systems are corresponds to the frequency-hopping and direct-sequence spread spectrum systems. The sufficient CP insertion along with our newly proposed SAR imaging algorithm, particularly for the OFDM signals differentiates all the existing studies in the literature on OFDM radar signal processing. Simulation results are presented to illustrate the high-range-resolution performance ofour proposed CP-based OFDM SAR imaging algorithm.

KEYWORDS

OFDM, SAR imaging, cyclic prefix,inter symbol interference,Orthogonality.

I.INTRODUCTION

OFDM is a technique for transmitting data in parallel by using a large number of modulated sub-carriers. These sub-carriers (or sub-channels) divide the available bandwidth and are sufficiently separated in frequency (frequency spacing) so that they are orthogonal.

Synthetic aperture radar (SAR) can perform imaging well under almost all weather conditions, which, in the past decades, has received considerable attention. Several types of SAR systems using different transmitted signals have been well developed and analysed, such as the linear frequency modulated (LFM) chirp radar, linear/random step frequency radar, and random noise radar. Recently, orthogonal frequency-division multiplexing (OFDM) signals have been used in radar applications, which may provide opportunities to achieve ultra wideband radar[1].

The block diagram of OFDM Transmitter and Receiver model is shown in Fig1.

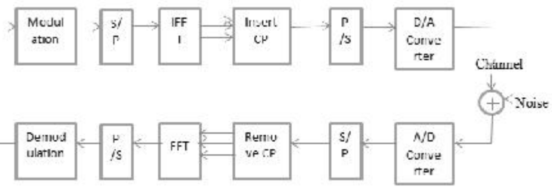

Fig1: Block diagram of OFDM Transmitter and Receiver model

OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers and the receiver is able to receive the whole signal to be able to successfully demodulate the data.Fourier Transform (IFFT /FFT) algorithms are used in the modulation and demodulation of the signal. The length of the IFFT/FFT vector determines the resistance of the system to errors caused by the multipath channel. The time span of this vector is chosen so that it is much larger than the maximum delay time of echoes in the received multipath signal. OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit[5]. The required amplitude and phase of the carrier is then calculated based on the 3 modulation scheme (typically differential BPSK, QPSK, or QAM). Then, the IFFT converts this spectrum into a time domain signal. The FFT transforms a cyclic time domain signal into its equivalent frequency spectrum. Finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components to find the amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal.

II.LITERATURE SURVEY

S. Sen and A. Nehorai, address the problem of detecting a target moving in clutter environment using an orthogonal frequency division multiplexing (OFDM) radar. The broadband OFDM signal provides frequency diversity to improve the performance of the system. S. Sen and A. Nehorai, propose an adaptive technique to design the spectrum of an orthogonal frequency division multiplexing (OFDM) waveform to improve the radar's wideband ambiguity function (WAF). The adaptive OFDM signal yields a better auto-correlation function (ACF) those results into an improved delay (range) resolution for the radar system. S. Sen and A. Nehorai, propose an information theoretic waveform design algorithm for target tracking in a low-grazing angle (LGA) scenario. V. Riche, S. Meric, J.-Y. Baudais, and E. Pottier, presents an opportunity to cancel range ambiguities in synthetic aperture radar (SAR) configuration. One of the limitations of SAR systems is the range ambiguity phenomenon that appears with long delayed echoes.J.-H. Kim, M. Younis, A. Moreira, and W. Wiesbeck, presented a new waveform technique for the use of multiple transmitters in synthetic aperture radar (SAR) data acquisition based on the principle of the orthogonal-frequency-division-multiplexing technique.

III.PROPOSED METHODOLOGY

The most important feature of OFDM signals in communications systems, namely, converting an inter symbol interference (ISI) channel to multiple ISI-free sub channels. When a sufficient cyclic prefix (CP) is inserted.This feature of the OFDM signals into account to propose OFDM SAR imaging, where a sufficient CP is added to each OFDM pulse, as the next-generation high-range-resolution SAR imaging. In our proposed SAR imaging algorithm, not only the transmission side but also the receiver side is also different from the existing SAR imaging methods[2][4].

The main features of a practical OFDM system are as follows:

1. Some processing is done on the source data, such as coding for correcting errors, interleaving and mapping of bits onto symbols. An example of mapping used is QAM.

2. The symbols are modulated onto orthogonal sub-carriers. This is done by using IFFT.

3.Orthogonalityis maintained during channel transmission. This is achieved by adding a cyclic prefix to the OFDM frame to be sent. The cyclic prefix consists of the L last samples of the frame, which are copied and placed in the beginning of the frame. It must be longer than the channel impulse response.

4. Synchronization: the introduced cyclic prefix can be used to detect the start of each frame. This is done by using the fact that the L first and last samples are the same and therefore correlated. This works under the assumption that one OFDM frame can be considered to be stationary.

5. Demodulation of the received signal by using FFT.

6. Channel equalization: the channel can be estimated either by using a training sequence or sending known so-called pilot symbols at predefined sub-carriers.

7. Decoding and de-interleaving.

OFDM has been used in many high data rate wireless systems because of the many advantages it provides. It is immunity to selective fading. One of the main advantages of OFDM is that is more resistant to frequency selective fading than single carrier systems because it divides the overall channel into multiple narrowband signals that are affected individually as flat fading sub-channels[2].

Resilience to interference: Interference appearing on a channel may be bandwidth limited and in this way will not affect all the sub-channels. This means that not all the data is lost.Spectrum efficiency: Using close-spaced overlapping sub-carriers, a significant OFDM advantage is that it makes efficient use of the available spectrum.

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Resilient to ISI: Another advantage of OFDM is that it is very resilient to inter-symbol and inter-frame interference. This results from the low data rate on each of the sub-channels.

OFDM SYSTEMS — CYCLIC PREFIX

The details of OFDM transmitter and receiver structure are succinctly presented in the block diagram below. We note that the OFDM systems basically involve transmission of a cyclic prefixed signal over a fading multipath channel. The prime goal of this tutorial is to explain the significance of Cyclic Prefix [3].

Synthetic aperture radar (SAR) can perform imaging well under almost all weather conditions. Recently, orthogonal frequency-division multiplexing (OFDM) signals have been used in radar applications, which may provide opportunities to achieve ultra wideband radar [2].

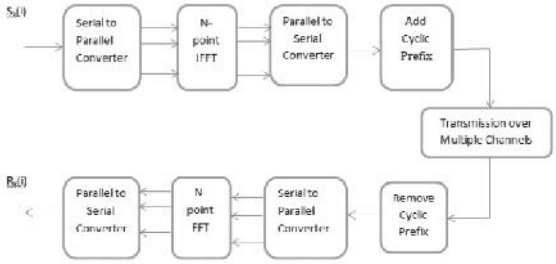

Fig2: Block diagram of OFDM system with prefix coding

The most important feature of OFDM signals in communications systems, When a sufficient cyclic prefix (CP) is inserted it converts an inter symbol interference (ISI) channel to multiple ISI-free sub channels.

IV.IMPLEMENTATION

Adaptive OFDM radar was investigated for moving target detection and low-grazing angle target tracking. Using OFDM signals for SAR applications was proposed. In adaptive OFDM signal design was studied for range ambiguity suppression in SAR imaging. The reconstruction of the cross-range profiles is studied.

V.RESULTS AND DISCUSSION

The tracking of Synthetic Aperture Position of the radar is calculated with a long track FFT before the phase and is shown in Fig3. This figure shows that the image of Track FFT is not having well in resolution. This figure is completely an assumption of how tracking is done.

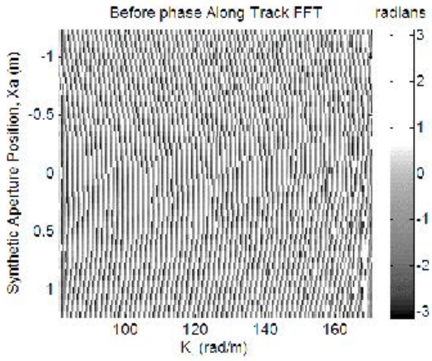

Fig3: Phase Response of Synthetic aperture position before phase

The Magnitude of the Synthetic Aperture Position of the radar with a long track FFT before the phase is calculated and is plotted in Fig4. This figure contains the data which is related to the image part.

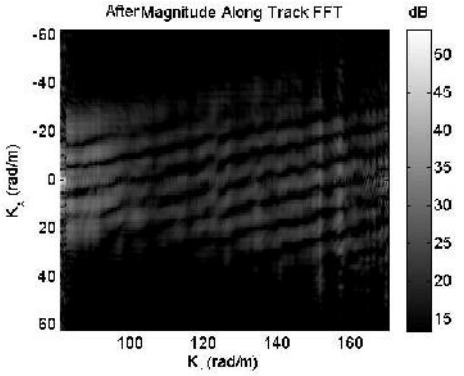

Fig4:Magnitude Response of Synthetic aperture position before phase

The tracking of Synthetic Aperture Position of the radar is calculated with a long track

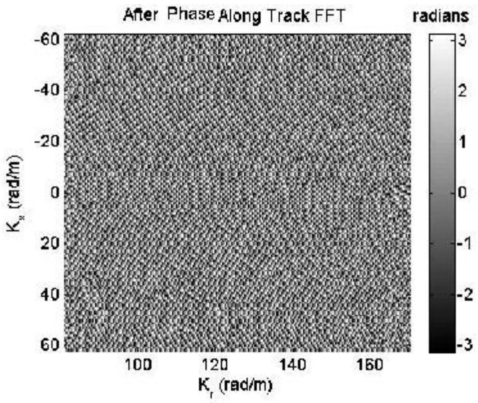

Fig5: Phase Response of Synthetic aperture position after phase

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FFT after the phase and is shown in Fig5. The Fig is processed image which is having good resolution when compared to beforePhase a long Track FFT as there will be change in radians of degrees.

The Magnitude of the Synthetic Aperture Position of the radar with a long track FFT after the phase is calculated using 2-D FFT and is plotted in Fig6.

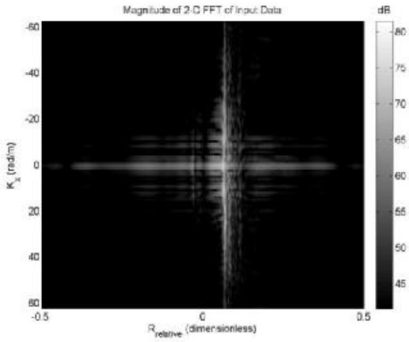

Fig6: Magnitude Response of Synthetic aperture position after phase

The Matched filter outputs of Phase response and magnitude responses of radar before phase are calculated using 2-D FFT with the introduction of CP and are given in Fig7 and Fig8. Tracking with matched filter with CP gives the perfect tracking position.

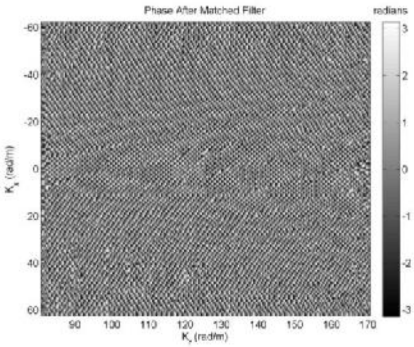

Fig7:Phase response of Match filter

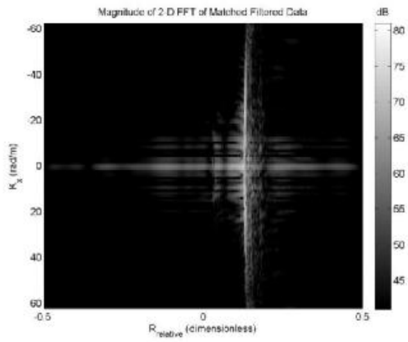

Fig8:Magnitude of 2-D FFT Matched filter

In this image matrix is interpolated that is rows are changed with columns and columns with rows. The phase of radar is calculated with the Slot interpolation and is shown in Fig 9.

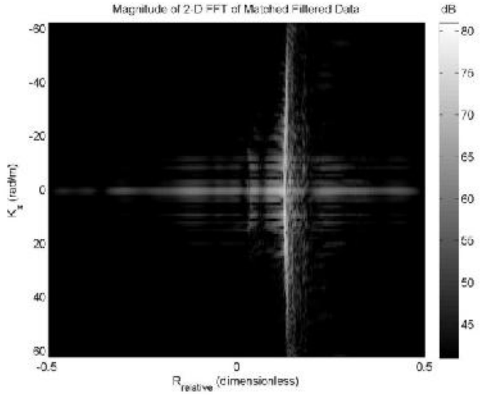

Fig8: Magnitude of 2-D FFT Matched filter

In this image matrix is interpolated that is rows are changed with columns and columns with rows.

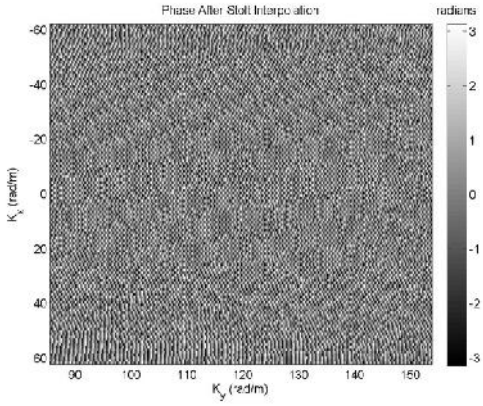

Fig9: Phase response with Slot interpolation

The exact tracking of the image will be calculated with the cross range and down range.This image shows the exact tracking part of the image with the help of temperature and is shown in Fig10.

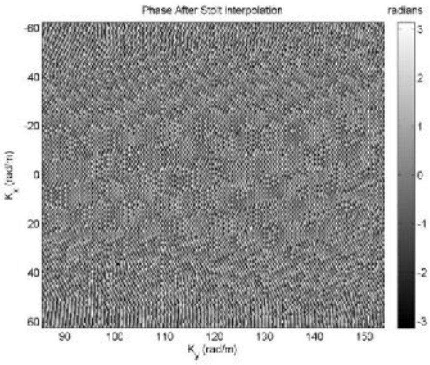

Fig9:Phase response withSlot interpolation

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The exact tracking of the image will be calculated with the cross range and down range.This image shows the exact tracking part of the image with the help of temperature and is shown in Fig10.

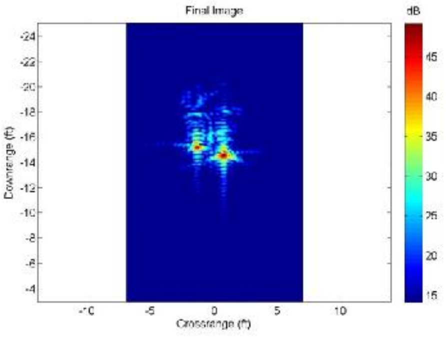

Fig10:Final image of cross range and down range

VI.CONCLUSION

In this paper a novel approach of SAR imaging using OFDM signals with sufficient CP has been proposed. The sufficient CP insertion provides an IRCI-free (high range resolution) SAR image. We first established the CP-based OFDM SAR imaging system model and then derived the CP-based OFDM SAR imaging algorithm with sufficient CP. We then showed that this algorithm has zero IRCI (or IRCI free) for each cross range. By comparing with the LFM SAR and the random noise SAR imaging methods, we thenfinally provided some simulations to illustrate the high-range resolution property of the proposed CP-based OFDM SAR imaging and also the necessity of a sufficient CP insertion in an OFDM signal.

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