Estimation of DOA of Wide Band LFM Signals Using Few Snapshots

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Abstract : - The wideband linear frequency modulation (LFM) signals are widely used in information systems. The conventional direction-of arrival (DOA) estimation algorithms of LFM signals rely on a large number of snapshots, some of which are not reliable in numerous practical applications such as underwater array processing. To solve the above problem, we present a modified sparse iterative covariance (MSPICE)-based estimation method in fractional Fourier transform (FrFT) domain to estimate the DOA of wideband LFM signals. First, we extend the original SPICE algorithm in FrFT domain with a specific transform order for wideband LFM signals. Then, we utilize the energy centrobaric modification method to make the original SPICE more accurate without adding more computational complexity. The simulation results demonstrate the effectiveness of the proposed method.

Index Terms - Direction of arrival, Fractional Fourier transform, Iterative approach, Wideband LFM.

I. INTRODUCTION

Radar is an acronym for Radio Detection and Ranging. It is an electromagnetic system used for detecting and locating objects by transmitting the signals and receiving the transmitted signals from the objects within its range. The echoes received are used to extract information about the target such as range, angular position, velocity and other characteristics. The reflected energy that is returned to the radar not only indicates the presence of a target, but by comparing the received echo signal with the transmitted signal, various information can be extracted regarding the target[4].

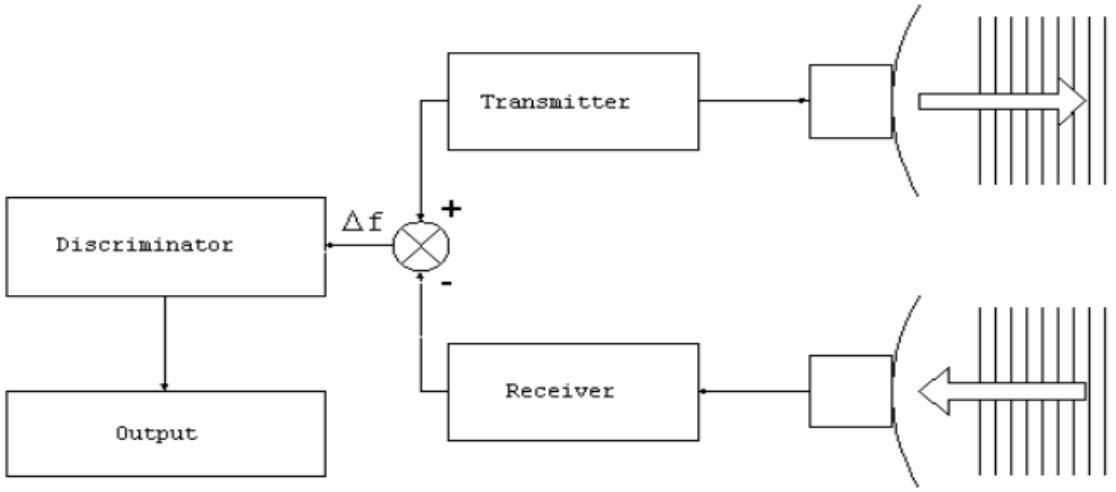

Fig 1.1- Basic Principle of Radar

LITERATURE REVIEW:

[1] Fang Ye, Yibing Li, Shenyuan Yang:

This paper puts forward a new technique for LFM signal process, which has practical applied importance.,Linear frequency modulation (LFM or chirp) signals are widely used in information systems, how to detect and estimate LFM signals is an important problem.However,using traditional array signal process couldn't commendably estimate DOA of LFM signal,because which is an non stationary signal.

Summary:

This paper combines the time-frequency analysis method with array process algorithm to process LFM signals. It puts forward a new method to separate the LFM signals in time-frequency domain as well as estimate DOA. In the method, a time-frequency represented array data model is formed by FRFT ofthe output of a reference sensor and those of two sub-arrays, then the subspace based methods are applied to get DOA estimates of

[2] Deliang Liu,Xiwei Guo,Peng He,Shen Zhao:

This paper Conventional DOA estimation approaches suffer from low-angular resolution or relying on a large number of snapshots which are unavailable in numerous practical applications such as underwater array processing. The sparsity-based IAA can work with a few snapshots and has high resolution and low sidelobe levels, but it is only applied to narrowband signals. To solve the above problem, a new FrFT-IAA method was proposed to estimate the DOA of wideband chirp signals with high resolution based on a few snapshots. First, the wideband chirp signal was taken on the Fractional Fourier Transform (FrFT) under a specific order so that the chirp wave in time domain could be converted into sine wave with a single frequency in FrFT do **Summary:** Here,the wideband chirp signal was taken on the Fractional Fourier Transform (FrFT) under a specific order so that the chirp wave in time domain could be converted into sine wave with a single frequency in FrFT domain. Then the steering vector of the received signal can be obtained in FrFT domain. Finally, IAA algorithm was utilized with the obtained steering vector to estimate the DOA of the wideband chirp with a few snapshots

EXISTING METHOD:

IAA is a nonparametric adaptive algorithm recently proposed for array processing applications.The Iterative Adaptive Approach is a spectral estimation technique that is based on a weighted least squares minimization. The method was originally proposed for source localization, but has found other applications in imaging, pulse compression, and missing data estimation .IAA assumes that the following general signal model is valid for the data:

$$\mathbf{y} = \mathbf{A}\boldsymbol{\alpha} + \mathbf{e}.$$

Here $\mathbf{y} \in \mathbb{C}^{N\times 1}$ is our measured data vector, and A = $[\mathbf{a}(\theta_1), \mathbf{a}(\theta_2), \ldots, \mathbf{a}(\theta_K)]$ is our steering matrix. Here K represents the grid size in the frequency domain and a steering vector of A can be written as

$$\mathbf{a}(\theta_k) = [e^{-j(2\pi f/c)x_1 \sin(\theta_k)}, \ldots, e^{-j(2\pi f/c)x_N \sin(\theta_k)}]^T.$$

PROPOSED METHOD:

Let us consider an active radar system as shown in Fig.. The linear array of the radar has M sensors uniformly placed along the x axis. The transmitter is located at the origin point. The distance between two adjacent sensors is d. T1, T2, …, TK are K Farfield targets at θ, where θ = [θ1, θ2,…, θK]. Here K is usually unknown, so it is considered to be the amount of potential targets (scanning points) in the region, and it is much larger than the amount of actual ones. Only a few signal power estimates of the potential targets will be non-zero, so sparsity-based algorithm can be used in array processing applications. The transmitter emits a LFM signal that can be

expressed as

$$x(t) = a\exp\left(j2\pi f_0 t + j\pi\mu t^2\right)$$

where a is the signal amplitude, f0 is the centre frequency, and μ is the chirp rate.

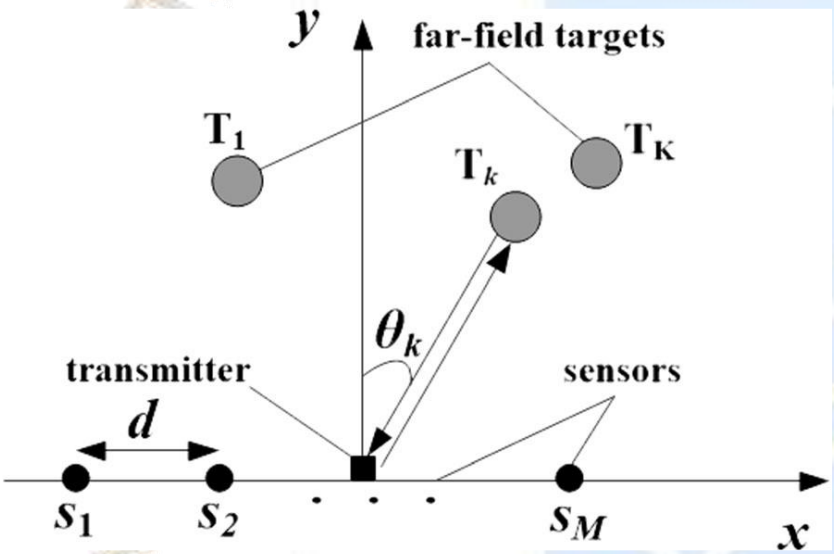

Fig:The geometry of the array system

The received signals at the sensors can be written in

matrix form as

$$x(t) = as(t) + e(t)$$

where s(t) = [s1(t), s2(t), … , sK(t)]T is the waveform vector, a = [a(θ1), a(θ2),…, a(θK)]T is the steering vector.

HARDWARE & SOFTWARE REQUIREMENTS:

Software:

- Matlab R2018a.

Hardware:

Operating Systems:

• Windows 10

• Windows 7 Service Pack 1

• Windows Server 2019

• Windows Server 2016

Processors:

Minimum: Any Intel or AMD x86-64 processor

Recommended: Any Intel or AMD x86-64 processor with four logical cores and AVX2 instruction set support

Disk:

Minimum: 2.9 GB of HDD space for MATLAB only, 5-8 GB for a typical installation

Recommended: An SSD is recommended a full installation of all Math Works products may take up to 29 GB of disk space

RAM:

Minimum: 4 GB

Recommended: 8

RESULTS:

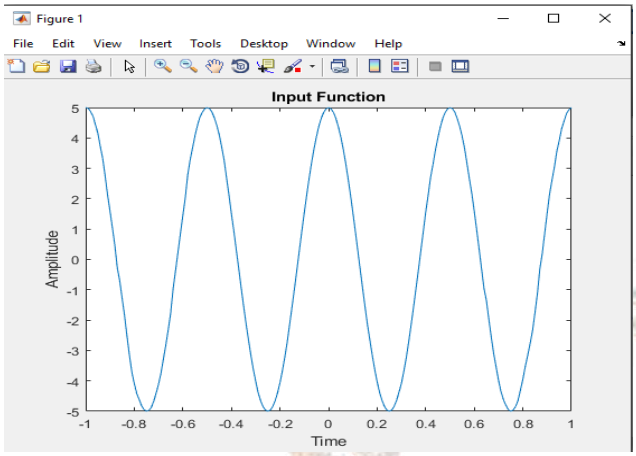

Figure 1:Input Function

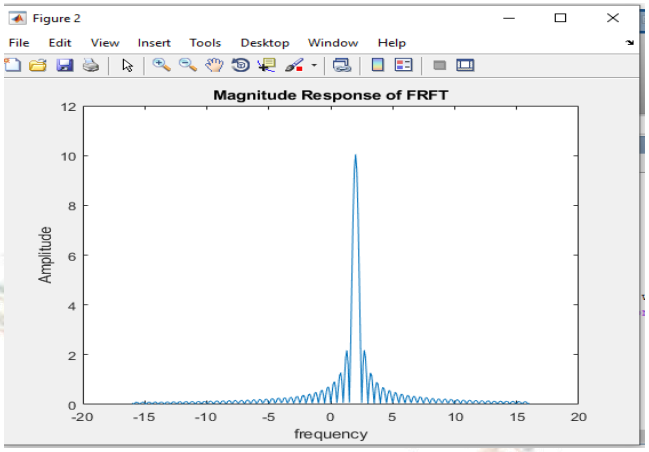

Figure 2: Magnitude Response of FRFT

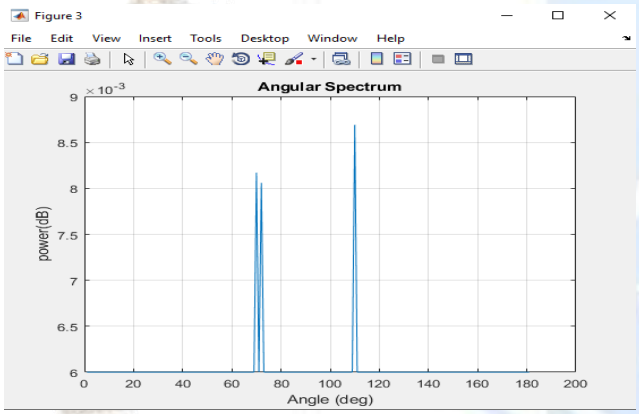

Figure 4:Angular Spectrurm

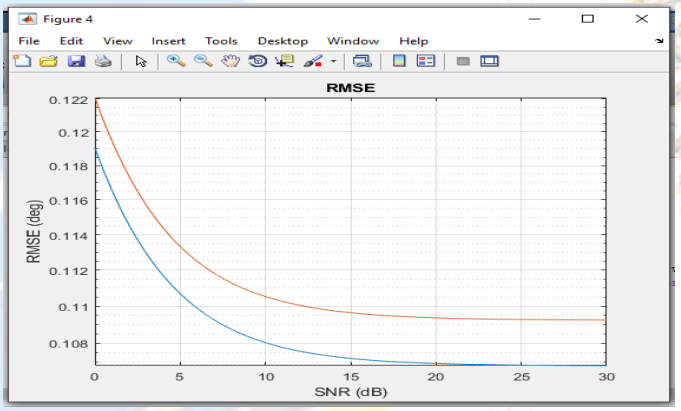

Figure 5:RMSE

CONCLUSION:

We presented a FrFT-MSPICE method for the DOA estimation of wideband LFM signal. We extend the SPICE algorithm in FrFT domain so that the DOA of wideband LFM signals can be estimated with a few snapshots. The proposed method has high angular resolution and low sidelobe levels. We also utilize the energy centrobaric modification method in order to increase the accuracy of the SPICE algorithm without imposing too much additional computational burden. The simulation results have demonstrated the effectiveness of the proposed method.

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