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Analysis of Communication Signals with Nonuniform Sampling Times

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ABSTRACT: Communication signals plays vital role in the automatic transmission of data over various applications and also in the various logistic and electrical activities of defence services. Analysis of communication signals is essential to ensure spectral efficiency and integrity of information. The main objective of the analysis is to minimize the noise present in the communication signals like voice, telegraphy, teletype writer and facsimile (FAX) etc. Non-uniform sampling occurs in many applications where uniform sampling either not possible or practically not achievable. This case relates to event based sampling in the time domain, such as queue process in routers, data networks and astronomical data processing etc. Non-uniform sampling signal can be estimated using FFT, Several methods to compute an approximate Fourier Transform for posterior analysis in terms of alias suppression and leakage. Though most of the work was focused on the development of posterior analysis of the signal a priori estimation of stochastic properties of the signal may result in better transformation approximation. In this way the frequency resolution of noise spectrum will be minimized. For optimum level minimizing purpose of frequency resolution, non-parametric power spectrum estimation methods are considered. The main focus of this paper is minimization of frequency resolution of noise spectrum and increasing frequency resolution of signal spectrum. For this purpose different non-parametric power spectrum estimation methods are used. In the non-parametric methods, periodogram is modified averaging and smoothing using different window techniques. This leads to the minimization of frequency resolution and variance with the help of non -parametric power spectrum estimation methods.

KEYWORDS: Fast Fourier Transform (FFT), Periodogram, Power Spectrum Estimation (PSE)

I.INTRODUCTION

Non linear signal processing involves the analysis and processing of signals produced from different systems and can be in the time, frequency or spatio-temporal domains. Similarly Non-uniform sampling occurs in many communication systems where uniform sampling is either not possible or practically not achievable. Nonuniform sampling technique is used in radar applications, medical applications, image processing and astronomical data processing. In uniform sampling, the sampling interval is fixed, uniform sampling is also known as periodic sampling. In no uniform sampling, the sampling time and amplitude are not predictable, non uniform sampling is also known as stochastic sampling.Nonuniform sampling signal spectrum plays an important role in signal detection and tracking. In many applications, much interest lies in narrow band signal detection which may be recorded in very noisy environment. Therefore signal detection and frequency estimation becomes non trial problems that require robust, high resolution spectrum estimation techniques [2].

This paper considers Fast Fourier transform method of spectrum estimation is most often used technique in spectral analysis. By using FFT, frequency resolution of noise spectrum is decrease and variance also reduced, but it may not be optimum level [3]. In order to obtain the optimum level non - parametric methods for spectrum estimation are used.
The non - parametric methods emphasize on obtaining consistent estimate of the power spectrum through some average or smoothing operations performed directly on the periodogram or on the auto correlation of the noisy data. Although variance of the modified periodogram estimates is decreased, the effect of the operations are performed are expenses of reducing the frequency resolution. In this paper since frequency resolution of noisy signal is the main focus. The problem of PSDE becomes two fold. First , it is necessary to denoise the signal from its interfering background and then, to compute its power spectrum estimation such that frequency resolution is not decreased due to further

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windowing of data [4]. Illustrating frequency resolution in non parametric methods averaging or modified periodogram for estimating power spectrum density. In comparison, the novel approach for power spectrum estimation is proposed to maintain frequency resolution close to the original spectrum compare to FFT method, which is also demonstrated in the results[4].

II.PROBLEM STATEMENT

Current scenario communication signals are sampled at a random period due to which linear estimation of signal not possible. To evaluate the signals at non - uniform sampling rate the frequency domain methods are used.

(i)Signal Model:

A signal is consider with non - uniform sampling rate with continuous time variance is defined as

$$s(t) = \int S(f) e^{i2\pi f t} df$$

Signal s(t) is non uniformly sampled N times. The sampling time t_m is stochastic variable with probability density function.

$$p_m(t) = \begin{cases} \frac{d}{dt} P(t_m \le t) & continous, \\ P(t_m = t) & discrete, \end{cases}$$

Continuous probability density function and continuous time signal s(t) give stochastic observation y_m of the corresponding deterministic sample value.

$$y_m = s(t_m).$$

(ii)Nonuniform sampling:

Nonuniform sampling is both deterministic and stochastic values. Depending on the type of sampling pdf can be deduced from the probability density function of sampling noise.

(a)Additive random sampling

The sampling times are constructed by adding the sampling noise to the previous sampling time.

$$t_m = t_{m-1} + \tau_m$$

(b)Stochastic jitter sampling:

The sampling noise is added to the expected sampling time.

$$t_m = mT + \tau_{m,}$$

(iii)Posterior analysis:

The posterior analysis is done using priori analysis.

$$Y(x) = \sum_{m=1}^{M} y_m e^{-x t_m}$$

(iv)Priori analysis:

the stochastic properties of the signals are developed by a priori analysis.

(v)Periodogram:

The periodogram of probability density spectrum of y(f)as

$$P_Y(f) = |y(f)|^2$$

Fundamentals of Existing PSDE Methods

Existing modifications to the periodogram that have been proposed to improve only the statistical properties of the spectrum estimate. The effects of these modifications on frequency resolution of spectrum are explained as follows: the Bartlett method also known as averaging periodogram, allow data to be subdivided into smaller segments prior to computing the periodogram. The effect of reducing the length of data into shorter segments results in a window whose spectral width has been increased by a certain factor. Consequently the frequency resolution is reduced by the same factor. Similarly, the Welch method, known as average modified periodogram, allow data segments to not only overlap but also applies a window for variance reduction .Resolution in this case is not only window dependent but also suffers from the same effect as Bartlett due to data segmentation. In the Black man Tuckey method, the auto correlation

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estimate is windowed first prior to spectrum estimation computation. The periodogram estimates and thus decreasing the variance in the estimate as a result. However, this is done at expense of reducing the resolution since a small number of estimates are used to form the estimate of the power spectrum

III.SIMULATION RESULTS

Case(i)
We work with one of set of noisy sinusoidal signal with noise W(n) using FFT.
Fs=1024Hz
F=5*sin(2*pi*t*100)+W(n)
Where W(n) is added white Gaussian noise with unit variance.

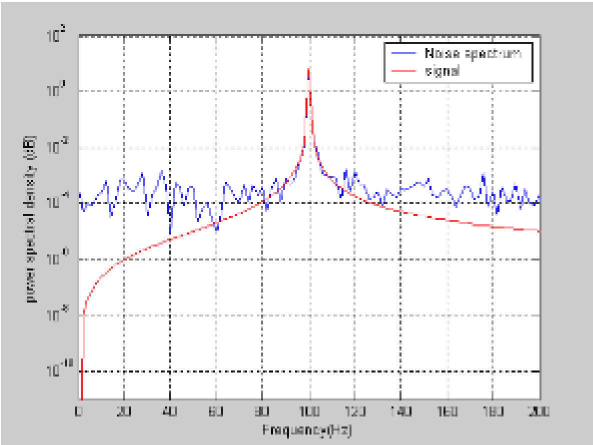

Fig.1. Single signal estimation using FFT with rectangular window

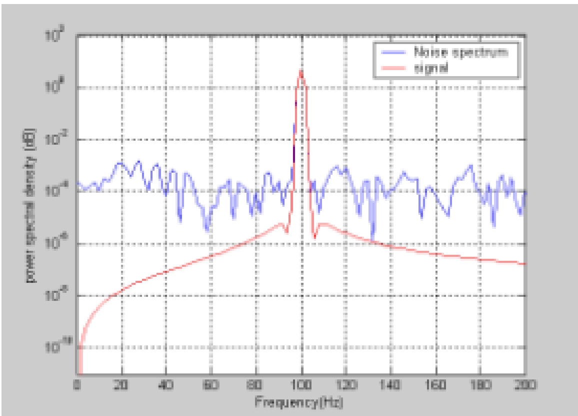

Fig.2. single signal estimation using FFT with Hamming window

Case(ii)
We work with two sets of noisy sinusoidal signals with noise W(n) using FFT
Fs=1024Hz
F1=5 sin (2*pi*t*50)+W(n)
F2=5 sin (2*pi*t*120)+W(n)
Y=F1+F2+2 W(n)
Where W(n) is additive white Gaussian noise

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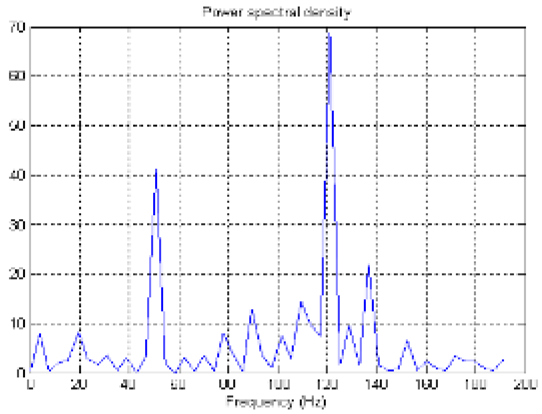

Fig.3.Two sinusoidal signals estimating using FFT with rectangular window

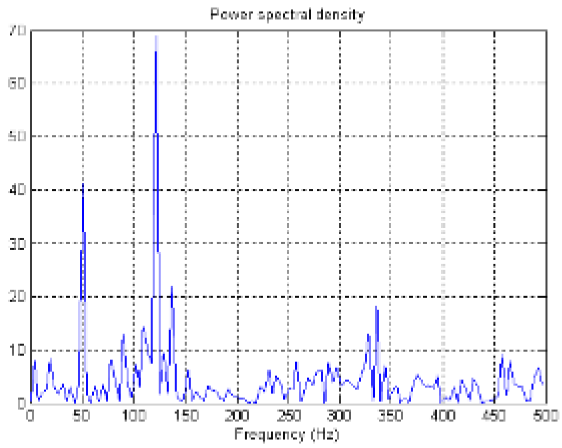

Fig.4. Two sinusoidal signals estimating using FFT with hamming window

Case(iii)

We work with three sets noisy sinusoidal signals with noise W(n) using nonparametric power spectrum estimation methods.

Fs=1024Hz

F1=5*sin(2*pi*t*100)+W(n)

F2=5*sin(2*pi*t*300)+W(n)

F3=5*sin(2*pi*t*500)+W(n)

Y=F1+F2+F3+3W(n) , Where W(n) is an additive white Gaussian noise.

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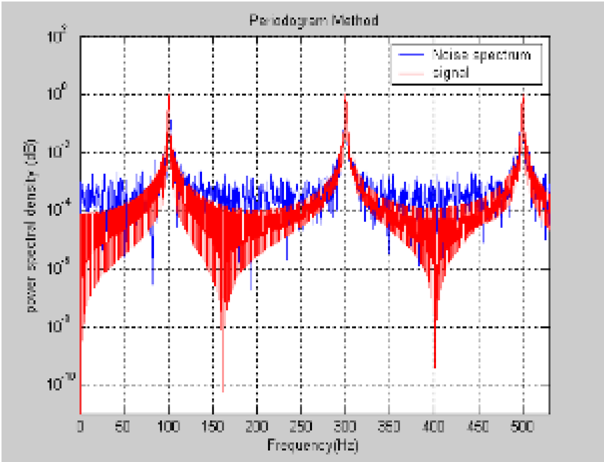

Fig.5 periodogram method plot

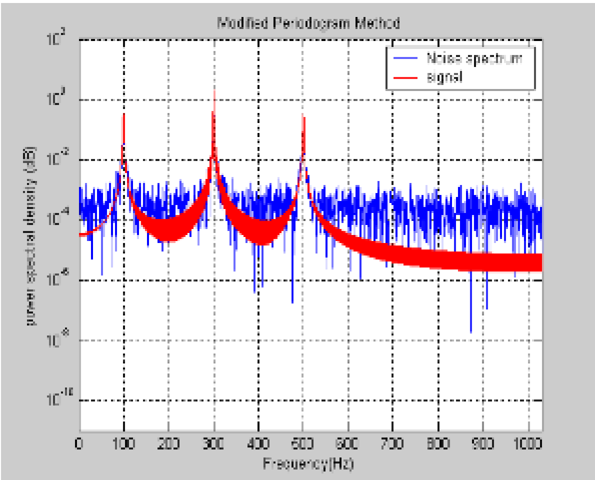

Fig.6. Modified periodogram method plot

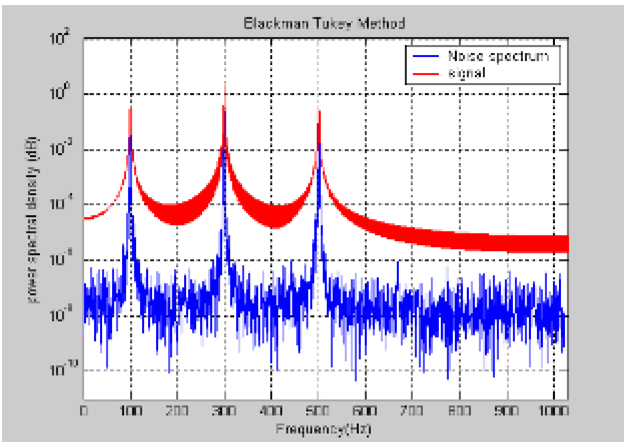

Fig.7.Blackman Tuckey method plot

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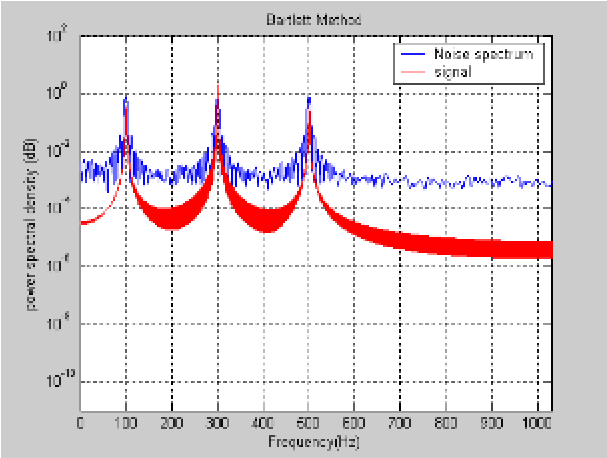

Fig.8.Bartlett method plot

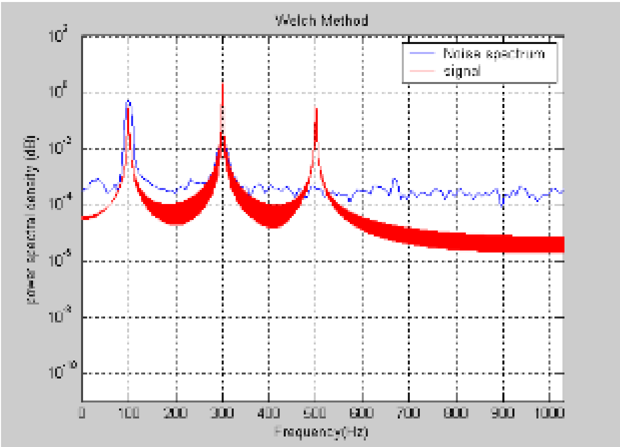

Fig.9.Welch method plot

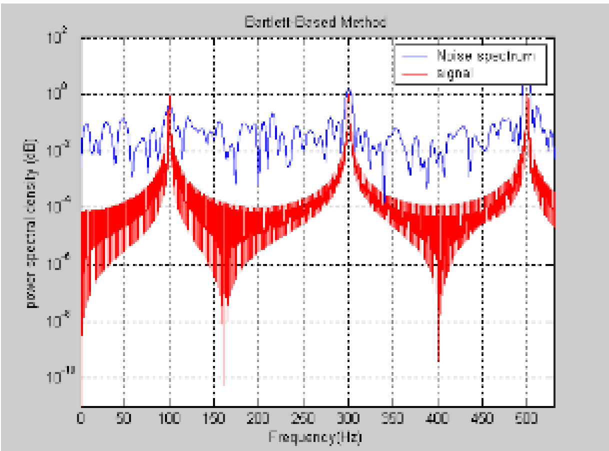

Fig.10. Bartlett based method plot

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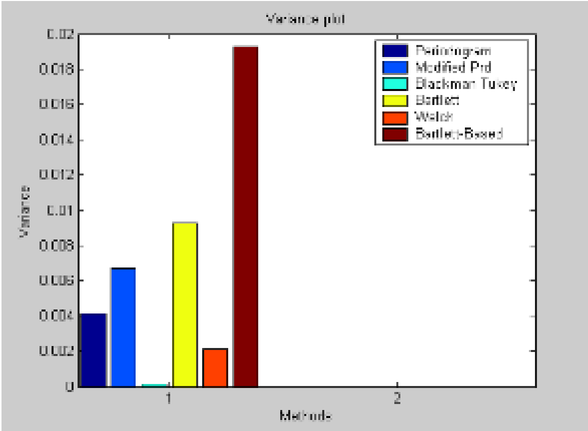

Fig.11. Variance plot

IV.CONCLUSION

In this paper, we acknowledged and imposed a problem, a signal estimation algorithm for non - uniform sampling rate is developed. Various power spectrum estimation density approaches were evaluated for estimation accuracy. It is observed that apriori estimation with PSDE calculation results in higher denoising compare to posterior analysis.
Further, we observed that problem of existing modification on the periodogram that have been proposed to improve only the statistical properties of the spectrum estimate at the cost of frequency resolution Moreover the communication signals will be analyzed with the combination of Nonuniform sampling technique with FFT and power spectrum estimation method.

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