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FREQUENCY ESTIMATION BASED ON DIFFERENT TECHNIQUIS

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frequency estimation;LFM ;NLFM;deep learning .

ABSTRACT

The technique of estimating the complex frequency components of a signal in the presence of noise based on assumptions about the number of components is known as frequency estimation. The problem of frequency estimation appears when we receive a signal from a transmitter with a known frequency, and it is often in radar, sonar, etc. applications. This problem has been dealt with by various techniques and algorithms. This research shows the methods used by researchers to estimate the frequency, which is better and more accurate in two cases when the transmitter and receiver are fixed and the other when the transmitter is fixed. The recipient is moving at a constant or variable speed.

1. INTRODUCTION

In the past years, the problem of frequency estimation was present and it was addressed by researchers in different ways, including the old classics[1]using discrete Fourier transform (DFT) and using the s-transform[2] to obtain a frequency estimate in which there is noise and noise that can be eliminated by another step, which is the use of non-linear least squares(NLS) to remove noise from the signal and obtain a more accurate estimate despite its computational complexity. Solving the nonlinear functions yields the proposed estimator. [3] The new estimator has an analytical formulation based on three DFT samples and an interpolation approach to estimate the frequency of a complex exponential sine waveform observed under additive white Gaussian noise (AWGN). NumericalThe suggested estimator has a lower SNR threshold than the Cramer-Rao estimator, demonstrating that its performance is near to that of the Cramer-Rao estimator. bound (CRB) in the low-SNR , as well as its performanceIn the high SNR area. In terms of its performance in the high SNR area, it beats earlier estimates. Because of the linear approach, the linear least-squares algorithm (LLS) should be used [4] to estimate the frequency of a single-tone noisy signal, which is more efficient than the nonlinear least-squares algorithm (NLS). This algorithm's methodology entails linearizing the frequency estimation problem by fitting a waveform with a similar but wrong frequency. Surprisingly, the right frequency can then be derived by doing so. When the signal frequency was known ahead of time within a 10% or greater range, excellent performance was achieved. The standard deviation of the estimator, for example, matched that of NLS when employing the batch version of the technique. Because LLS is non-recursive, it is substantially more computationally efficient than the recursive NLS. There are several methods used to estimate the frequency of a complex sinusoidal complex under white Gaussian noise, including the autocorrelation (Corr) method and the maximum likelihood (ML) method by fast Fourier transform (FFT). [8]. We notice that FFT is more efficient than (Corr), as the SNR of the correlation is (-15db) and the SNR of FFT is (-30db). That is, the difference between them is (15db) On the other hand, the approach of instantaneous frequency (IF) can be found in many applications like communication, speech, and music processing. (IF) estimator [5] was estimated using the Winger distribution method based on the length of the window. The results were improved [6] by using an adaptive-short time Fourier transform, which provides the best rejection of co-channel interference. The S-transform technique was used in a white Gaussian noise environment [7], which was implemented through simulation, which showed that the bias and change depended on the signal. [9]. The second-order statistics are reconstructed from compressed observations of a single sinusoid in MA colored noise for the purpose of frequency estimation of the original uncompressed noisy sinusoid using compressive covariance sensing. For moderate compression ratios, estimation accuracy is good, but it degrades for lower (better) compression ratios, resulting in a skewed estimate.

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2. MATERIALS and methode

2.1. MATERIALS

Frequency estimation when transmitter and receiver are constan we designed model in MATLAB to implement etimation process as fig(1) we us PID controller and frequency response estimation block in this block use two mod of signal and evrey mod use type of frequency estimation algorithm such as sinestream signal use correlation method and superposition using recursive least squares algorithm ,plant that is close loop configration with input of controller .

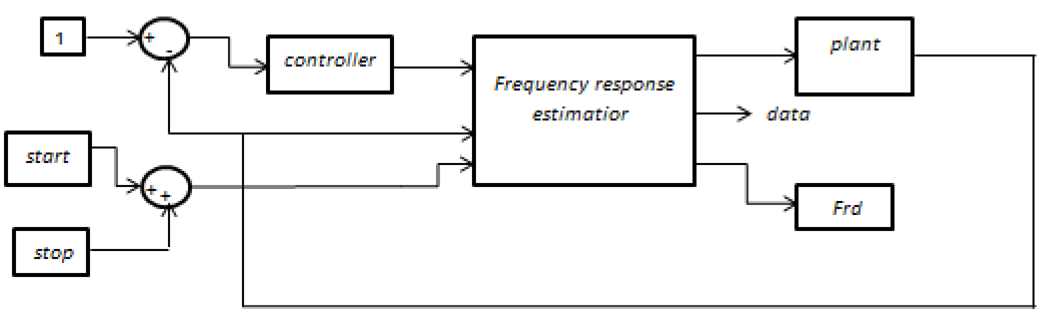


Fig (1) frequency estimation block diagram

2.2. METHODS

Frequency response estimation mainly includes four steps 1) starting 2) controller 3) plant 4)frequency estimation .

Firstly,starting the model the output of plant gives frequency response and return feed back to controller to start frequency estimation in block of frequency response estimation and transfer it to Frd block .

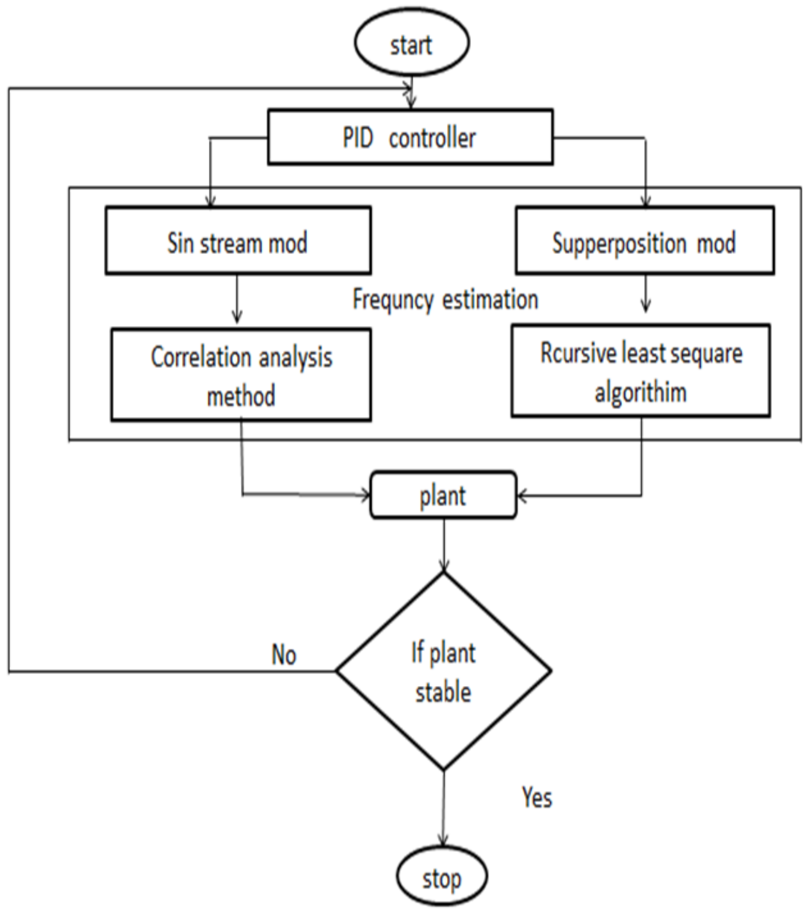


Fig (2) flow chart algorithm for estimation

2.3.LFM AND NLFM ESTIMATION

The Linear Frequency Modulation (LFM) signal is a non-stationary signal that is used in radar and communication systems. For radar electronic reconnaissance and resistance, it is critical to quickly recognize and estimate the parameters of LFM signals.there are many method such as[10] use short-time fouier transform(STFT). One of the advantages of non-linear frequency modulation(NLFM) used in radar systems [14]is that it naturally reduces the level of the side lobes, as if it retains the transmission energy completely, and these features are not found in LFM Researchers have been active in finding ways to improve the performance and efficiency of the radar in detecting small targets over long distances[11] using the pulse compression technique, which was previously generated in different ways[12]also deep learning techniques were used in target detection and frequency estimation. The linear chirp rate is the most widely used waveform in radar systems because of its ease of generation and also that it is more tolerant to the Doppler effect and has a good range accuracy than NLFM. [13] and fig(3) shows How does it change linearly over the duration of the signal pulse, either with an increase, called the up chirp rate, or with a decrease in the down chirp rate.

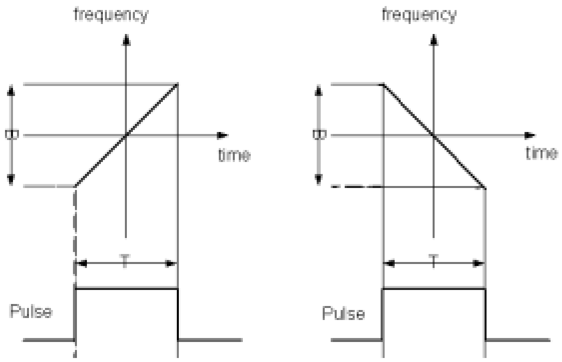
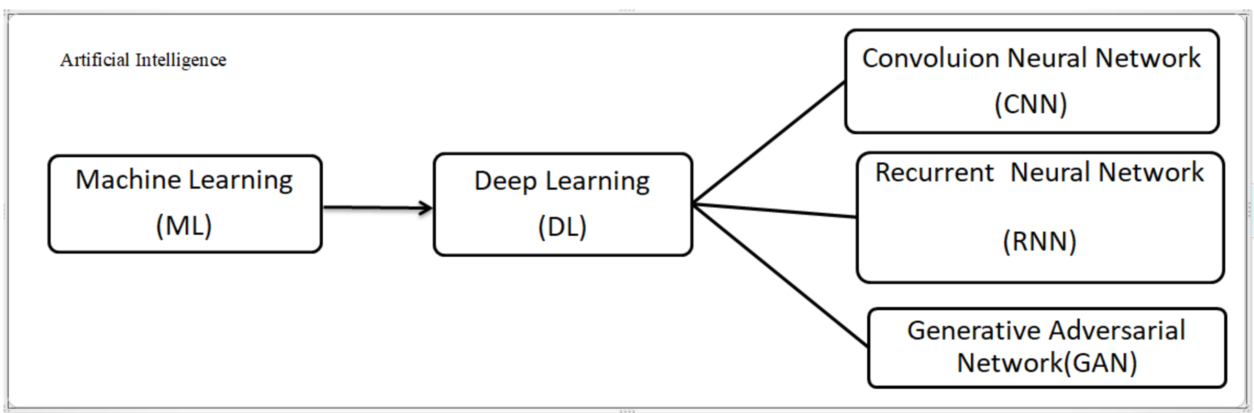


Fig (3) typical iinear wave form (a)up-chirp (b)down-chirp.

2.4 ESTIMATION BY DEEP LEARNING

Artificial intelligence has recently made a great revolution in the development of applications and its ease, as it simulates and imitates human intelligence, and through knowledge of human features, multiple techniques have been developed for artificial intelligence, such as signal processing, feature extraction, image processing, image classification, etc. Machine learning is part of artificial intelligence, and deep learning is part of the latter. Each of us has multiple algorithms, but there is a difference between them. Fig.4.



Fig(4)family of Artificial Intelligence

The deep learning mechanism was used to estimate the frequency for a single bit of a complex single sinusoidal signal within the noise used in GSM,[15] and we found that the result is more efficient than using FFT, especially by using convolutional methods .Although artificial intelligence and machine learning have made great advances in all fields, there is very little work on frequency estimation of single tones[16] Previous problems and gaps when using classical DFT methods in this field have been addressed by using deep learning mechanism and despite the use of one or two hidden layers With one or two nodes each, but it showed efficiency and error performance much better than the classic methods. A system for evaluating the unknown input frequency[17] of a sinusoidal signal is provided that is accurate, efficient, and stable. The suggested approach addresses the fundamental shortcoming of the existing phase-based estimator, also known as a derivative estimator, which is reliant on deep learning. The proposed estimator's accuracy is the result of splitting the dynamic range of estimating into three sections (low frequencies, medium frequencies, and high frequencies), each with its own method for calculating the estimated frequency. Eachzregion's boundaries are: The optimal option was chosen using the azGrey wolf optimizer (GWO), which trains bidirectional recurrent neural networks (BRNN). The frequency of sinusoidal waves that had been blended[18] with white noise at a signal-to-
noise ratio of 25 dB was extracted using a three-layer neural network. It has recently been found that the best algorithm for frequency estimation in the case of radar when the target is moving is the convolution neural network instead of the fractional fourier transform[19], which showed high accuracy and good performance for signal recognition even at low signal-to-noise ratio. The algorithm was trained on a different data set consisting of three Kinds of signal(single signal ,chirp rate,LFM). There are types of convolutional neural networks such as LetNet which is a primitive entity ,AlexNet which is the best deepest in object recognition and GoogleNet is the network in the network that reduces computational burden and is considered highly efficient.the common AlexNet has been used which and consists of :

- multiple convolutional layers

- pooling layers
- fully connected layers
- softmax classification layer

2.5 RADAR MODELING OF MOVING TARGET SIGNAL

For LFM signal detection and estimation, we use radar moving target detection as an example. Moving target recognition with radar is a critical subject in both military and civilian applications.fields. The signal's mobility state is inextricably linked.Doppler. And the target echo's Doppler spectrum reflects this.the change in instantaneous velocity of the target Taking the assumption that the target and the radar are both in the same horizontal plane. The radar sends out an LFM signal

$$S_t(t)=rect(\frac{t}{tp})exp\{2\pi j[f_c t+\frac{1}{2}\alpha t^2]\} \qquad (1)$$

Where $rect(u)=\begin{cases}1, & |u|\le\frac{1}{2}\\ 0, & |u|>\frac{1}{2}\end{cases}$ *,*f_c *is the carrier frequency of radar, tp is the pulse width ,* $\alpha=\frac{B}{tp}$ *is the transmitted signal's chirp rate, Bis the bandwidth*

The recived echo signal at time t is:

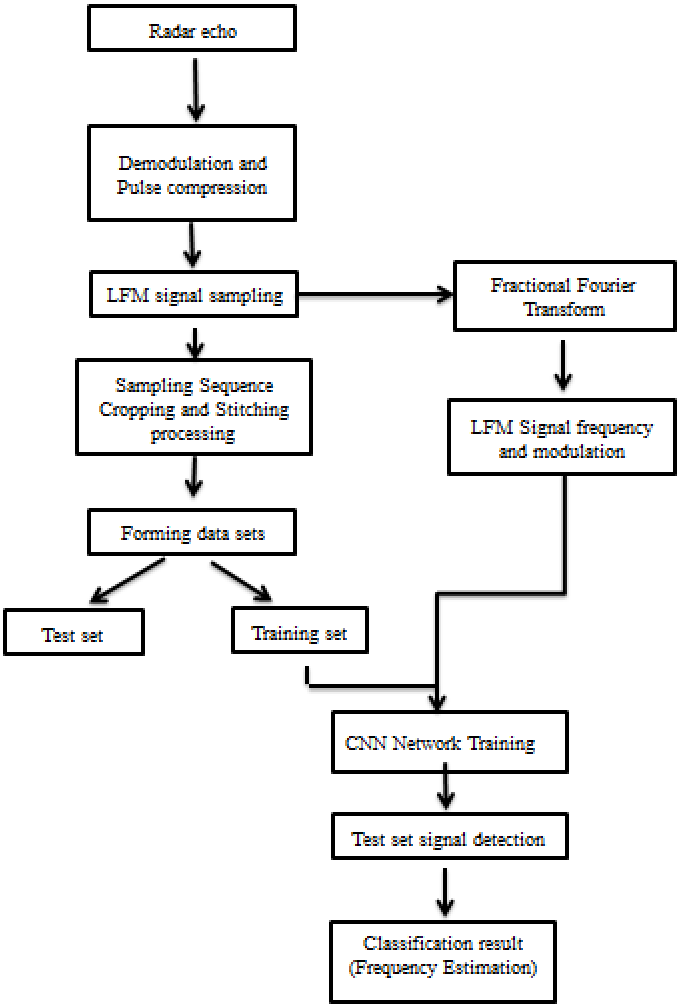
$$S_r(t)=\sigma_r rect(\frac{t-\dot{\tau}}{tp})exp\{2\pi j(f_c[t-\dot{\tau}]+\frac{1}{2}\alpha[t-\tau])\} \qquad (2)$$

Where σ_r *is the cross − sectional area of the target ,* $\tau=2\pi R_s(t_m)/c$ *where c is the speed of light and* τ *is the time delay , The radar's line-of-sight distance from the target is* R_s *, and the slow time between the pulse and the pulse is* t_m *,after demodulation process the intermediate frequency signal is obtained as[20]*

$$S_{IF}(t)=S_r(t)\,.\,S_t{}^*(t)$$
$$=\sigma_r\, rect(\frac{t-\dot{\tau}}{tp})exp(-2\pi j\alpha t\tau)exp(-2\pi j f_c\tau) \qquad (3)$$

*Where * denote the complex conjugate . after the pulse compression [21] , (3) can be rewritten*

$$S_{pc}(t,t_m)=A_r sinc(B[t-\tau])exp(-2\pi j f_c\tau) \qquad (4)$$



Fig(5)Algorithm flowchart for LFM signal detection and frequency estimation by CNN

3. DISCUSSION

After looking at many studies related to frequency estimation for different systems, we found that some methods are better than others in terms of accuracy and computational burden. The application and enhancement of this algorithm in detecting moving radar targets and estimating the frequency of the received signal in complex environments such as clutter backgrounds.

4. CONCLUSIONS

Many algorithms have been used in previous years to solve the problem of frequency estimation through different systems, and the classic methods used have poor accuracy. A review of many of them shows that in various cases and systems of fixed and mobile systems, the radar represents a moving target. The mathematical model and algorithm that achieve the detection of the radar signal and the estimation of the frequency of the signal received from it when the target is moving at fixed or variable speeds were presented using the convolutional neural network algorithm, which is one of the best methods for accuracy and efficiency

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