Sensing of wideband spectrum using Stockwell-Transform

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Abstract: Due to the rapid growth of wireless communications more and more spectrum resources are needed. Within the current spectrum framework most of the spectrum bands are exclusively allocated to specific licensed services. However, a lot of licensed bands such as those for TV broadcasting are underutilized, resulting in spectrum wastage. Cognitive radio (CR) can successfully deal with the growing demand and scarcity of the wireless spectrum. To exploit limited spectrum efficiently CR technology allows unlicensed users to access licensed spectrum bands.

For implementation of CR network, foremost step is spectrum sensing. Most of spectrum sensing techniques follow different methodologies like channel state prediction and spectral detection. In cooperative network, a centralized spectrum sensing unit scans the entire channel and identifies the spectrum holes. Based on spectrum sensing result, centralized unit take care the allocation of available frequencies to SUs. Under the fading conditions, these conventional methods give more false alarms. To overcome the limitations of conventional methods this work will mainly focus on a new wideband sensing algorithm using Stockwell-Transform. Using this method, it is possible to visualize entire spectrum scenario at any instant of time.

Key Words: Cognitive radio, Spectrum sensing, channel state prediction, Spectral detection, Stockwell-transform

I. INTRODUCTION

Wireless communication is one of the fastest growing areas of communication in the past decade. Static spectrum allotment is the major problem in the existing spectrum scarcity. Due to fixed allocation, it is very hard to drive new users; this shortage of spectrum creates various challenges to researchers. Cognitive Radio (CR) is one of the emerging technologies, which gives the best solution for the existing underutilization of spectrum. The centralized cooperative CR network allows Secondary Users (SUs) to access unused spectrum by primary users (PUs) .For the implementation of CR network, the foremost step is spectrum sensing. Most spectrum sensing techniques follow different methodologies like channel state prediction and spectral detection. Here fixed carriers/channels are allotted to PUs. Using these fixed carriers, PUs send their information through the common communication channel. In a cooperative network, a centralized spectrum sensing unit scans the entire channel and identifies the spectrum holes. Based on spectrum sensing result, the centralized unit takes care the allocation of available frequencies to SUs. Different techniques like matched filter detection, cyclostationary detection and energy detection schemes are narrowband spectrum sensing techniques. These narrowband sensing algorithms find the availability of a single channel with the prior information of PU. For wideband sensing, these techniques are not suitable. Under non-cooperative conditions these techniques give more false alarm. These techniques give poor performance in noisy conditions and also the mother wavelet function significantly affects the performance of sensing. Based on motivations, a novel narrowband and wideband spectrum sensing methods using Stockwell-Transform(S-Transform) is presented in this chapter. For wideband sensing, the sensed composite signal is applied to Modified S-Transform (MST).The rest of the chapter is organized as follows: Wideband signal analysis using Modified S-Transform is described in chapter.

Cognitive radio:

A Cognitive Radio (CR) is a newer version of SDR in which all the transmitter parameters change like SDR, but it will also change the parameters according to the spectrum availability. Cognitive Radio can smartly senses and adapts with the changing environment by altering its transmitting parameters, such as modulation, frequency, frame format etc. In the early days of communication there were fixed radios in which the transmitter parameters were fixed and set up by their operators.

II. OBJECTIVES

To develop an Automatic Modulation Classification (AMC) algorithm for design of intelligent receivers.

To develop Narrowband and Wideband Spectrum Sensing using Time-Frequency Analysis and analyse the performance under different noisy conditions.

III. SIGNAL ANALYSIS WITH MODIFIED S-TRANSFORM

S-Transform:
S-Transform (ST) is an extension of the STFT in the Time domain.
The ST of a time series x(t) is defined as

$$s(t,f)=\int_{-\infty}^{\infty}x(\tau)w(t-\tau,f)e^{-2i\pi f\tau}d\tau$$

where w(t, f) is a Gaussian windowing function and it is given by

$$w(t,f) = \frac{1}{\sigma(f)\sqrt{2\pi}} e^{\frac{-t^2}{2\sigma(f)^2}}$$

Here σ (f) is the standard deviation of the window w(t,f) and it is given by

$$\sigma(f) = 1/|f|$$

Modified S-Transform:

Modified S-Transform is a time–frequency transform which analyzes the signal in Time and frequency domain simultaneously. MST converts time domain sequence into time–frequency domain. For a signal z(t) the S-transform output s(t, f) is given by

Modified Gaussian window

The standard deviation of the modified Gaussian window is

$$\sigma(f) = k/(a + b/\sqrt{f})$$

Where ɑ, b are positive constants, f is signal fundamental frequency and

$$k \le \sqrt{a^2 + b^2}$$

Therefore the new modified Gaussian window can be

$$w(t,f) = \frac{a + b\sqrt{|f|}}{k\sqrt{2\pi}} e^{-\frac{(a+b\sqrt{f})^2 t^2}{2k^2}}, k > 0$$

Here f is the frequency, t and T are the time variables and k, b are scaling factors that control the number of oscillations in the window; ɑ is a constant.

The Generalized S-Transform with modified Gaussian window (Modified S-Transform) is represented as

$$S(\tau,f) = \int_{-\infty}^{\infty} X(\alpha + f) e^{(-2\pi^2\alpha^2K^2)/(a+b\sqrt{|f|})^2} e^{2i\pi\alpha\tau} d\alpha$$

The discrete version of the Modified S-Transform of a signal is obtained as

$$S[j,n] = \sum_{m=0}^{N-1} X[m+n] e^{(-2\pi^2 m^2 K^2/(a+b\sqrt{|f|})^2)} e^{i\frac{2\pi mj}{N}}$$

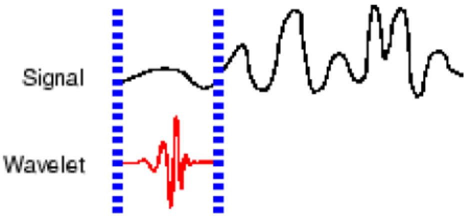
Where X[m + n] is obtained by shifting the discrete Fourier Transform (DFT) of x(k) by n.

IV.TIME-FREQUENCY ANALYSIS

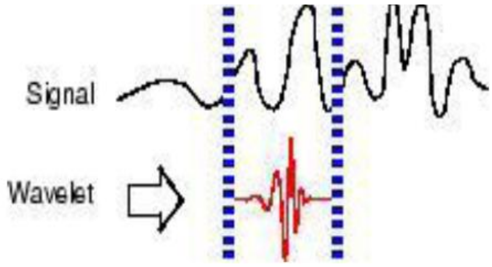
Time-frequency analysis involves splitting a signal into different parts and then analyzing these parts separately.

Time-Frequency Distributions (TFDs) map a one-dimensional signal into a two-dimensional function of time and frequency, and describe how the spectral content of signal changes with time.

Step1:



Step2:



IV.SENSING RESULTS:

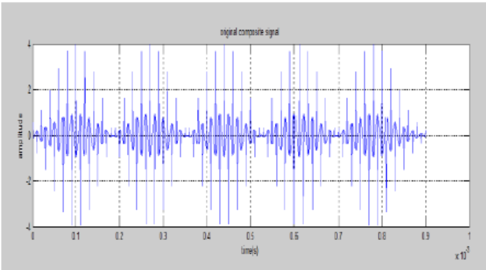


Fig 1. Original composite signal

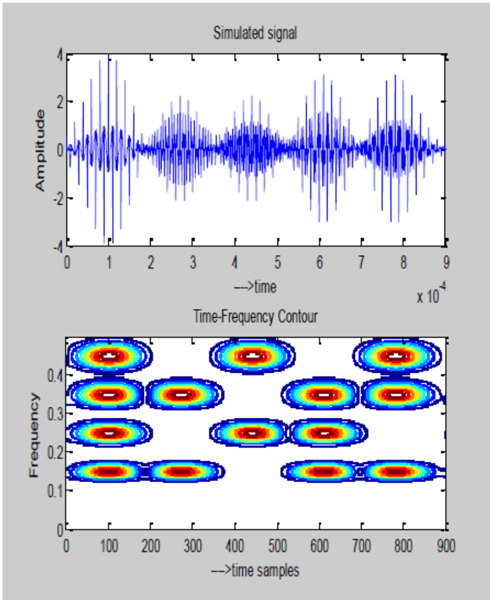


Fig 2. Signal with noise

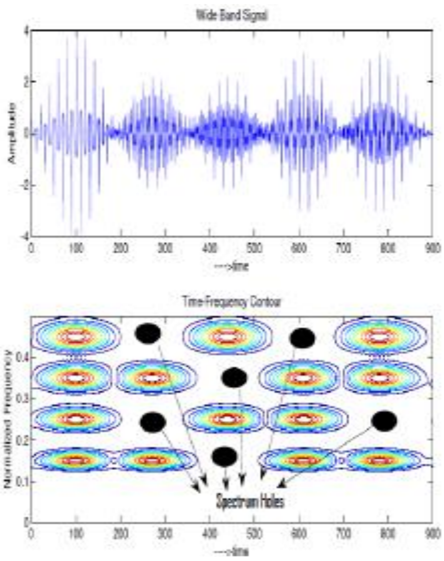


Fig 3. Signal without noise

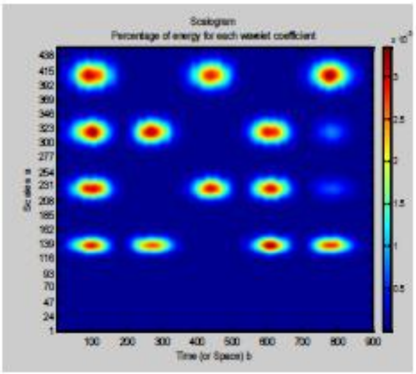


Fig 4. Signal with 10db noise

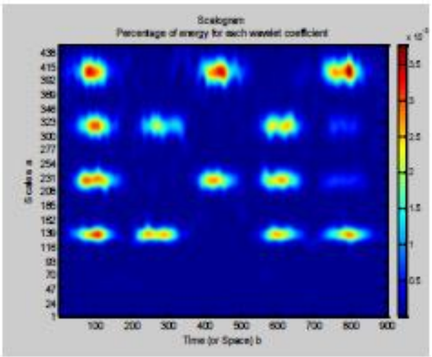


Fig 5. Signal with 5db noise

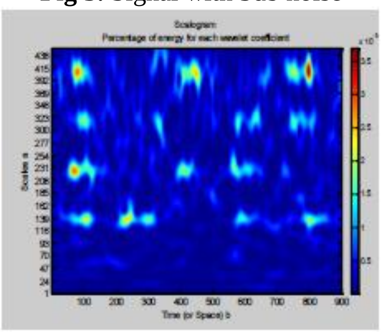


Fig 6. Signal with 0db noise:

IV. CONCLUSION

This project presents a new approach for wide band spectrum sensing in cognitive networks. This work introduced a new spectrum sensing algorithm called Time Frequency Analysis using S-Transform. All the existing methods for spectrum sensing are applicable only for narrow band sensing. But the proposed works proved, Wide band sensing is possible with Time Frequency Analysis. Under the noisy environment all the existing methods does not gave the better results. The proposed method gives the best results even under high noisy conditions.

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