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Detection of Secondary User in Cognitive Radio Environment Using Matched Filter Approach

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Abstract

This paper addresses to the detection of secondary user radio signal by proposed approach “Matched Filter” in a cognitive radio environment to ensure interference- free use for the primary user. Secondary user also run in unused spectrum bands that are licensed without interfering with the licensed user by doing so minimizing spectrum shortage and expanding the potency of spectrum utilization. Spectrum sensing has been noticed as being an important functionality of cognitive radio. Performance of proposed approach of spectrum sensing of this technique is based on false alarm and detection probability and sensing time is low as compared to other detectors and needs less time to achieve high processing gain.

Keywords: Cognitive radio network, Dynamic spectrum access, Spectrum overlay, Spectrum underlay, Transmitter Detection, Cooperative and Non-Cooperative Detection, Interference-based Detection, Spectrum holes, Digital Signal Processin1.

Introduction

Dependable and quick remote information transmission is developing as a worldwide marvel and is turning into a noteworthy thought in our lives. This has brought about an exponential increase in the interest for radio frequency spectrum. However, conservative range allotment approaches have made a deficiency of empty range groups, i.e. channels [1]. On the other hand, overdue reports have revealed that the regular usage within approved frequency bands is really as reduced as 5% (Federal Communications Commission (FCC), 2003).

In view of these estimates, FCC presumed that there are two fundamental situations where the range productivity of the authorized bands can be enhanced (Federal Communications Commission, 2005). In the situation where the range is entirely utilized, the range productivity can be improved by utilizing better radio access advancements. In the second situation where the range usage is generally low during some time periods, in this case, the range productivity can be increased by expanding the entrance effectiveness, i.e. permitting access of unlicensed (auxiliary) gadgets to the authorized (essential) frequency bands.

Cognitive radio [2, 3] appeared as the permitting technology for spectrum sharing, which uses its power to sense and realize the environment, and proactively alters its operational parameters to avoid interference with the primary user (Federal Communications Commission 2003). For future promising wireless devices, the key challenge is now on how to well deal with the radio spectrum to ensure its sustainability. For radio spectrum scarcity and under-usage, the observed contribution of strict allotment arrangement has been subjected to a considerable measure of feedback. Under current spectrum range access techniques, unlicensed user can run in unused licensed spectrum bands without interfering with the licensed user, so minimizing the spectrum shortage issue and expanding the potency of spectrum utilization [4].

Minimizing the spectrum shortage issue and expanding the potency of spectrum utilization many solutions have been proposed. In consequence, proposed approach“Matched Filter” user in a cognitive radio environment ensure interference- free use for the licensed user. Unlicensed user also can run in unused spectrum bands that are licensed without interfering with the licensed user by doing so minimizing spectrum shortage and expanding the potency of spectrum utilization.

The rest of this paper is organized as follows. In section II present taxonomy of CR environment which includes a review of spectrum sharing models to the effectiveness of CRN systems, classify operational modes of CR and analyze the CR key tasks of discovering spectrum holes for dynamic access to utilize these holes for communication. Next, in section III we present a bird’s eye view on approaches to broadcast information and in the last of section III present crucial bits of filters and filtering paradigms. Section VI describes implementation of propagation of unlicensed user in licensed bands with licensed user and performing the Matched Filter technique. In section V perform an analysis on licensed user signal that is result out after implementation of proposed technique. In section VI show the conclusions and describe the typical points popped out for proposed approach.

Taxonomy of CR Environment

Three exclusive models used-to talk to the spectrum sharing effectiveness in CRN systems which are (a) Public Commons Model, In this model radio spectrum is available to anyone for accessibility with equal rights; this model as of this moment relates to standards band that is wireless. (b) Exclusive Usage Model , In this model radio spectrum can be only authorized to a unique user; in any case, by permitting dynamic allotment and spectrum trading by the spectrum proprietor can enhances spectrum usage.(c) Private Commons Model, In this model various users in CRN that can have various priorities to share the spectrum. SU could possibly get towards the spectrum with different approach.

The operational modes of CR include [6] (a) Interleave, before transmission SUs has to carry out spectrum sensing to detect the unused channels. SU access for transmission only when there is no active PU in the channel, Spectrum sensing has to be performed to check during transmission whether or not the PU has returned. SU should vacate the current operating channel if presence of a PU is detected and sense another unused channel for transmission. This mode of CR also known as Interference Avoidance Mode. (b) Underlay, SU and PU simultaneously transmit data under the condition that interference at the primary receiver caused by the SU should be below a predefined threshold. It is major difference from the interleave mode, where interference completely avoided. This mode of CR also known as Interference Management Mode, (c) Overlay, in this mode both participants get benefits from cooperation. SU improve the PU's transmission performance in terms of throughput, reliability, and the like, and in return the PU awards an interval of time to the SU for its own transmission. This mode is actually based on mutual benefits.

Discovering spectrum holes are the major notion of dynamic spectrum access to utilize these holes for communication. Spectrum holes are modified with respect to time. CR dynamic spectrum access shifts from one portion to another portion of spectrum (US Federal Communications Commission et al., 2002). For accessing the spectrum CR key tasks are (1) Sensing of Spectrum, P [7] detects if licensed user is there on a band. Later than sensing, Detection results can be shared by CR to other CRs known as cooperative sensing. Cooperative sensing can be centralized or decentralized. In centralized cooperative sensing, identified spectrum holes, pointed out to the CRs by base station. Whereas in decentralized where to transmit is settled on by unlicensed users by swapping the dimensions. (2).Allocation of spectrum, the second step when it settles on which band to utilize. If numerous unlicensed users are there, they must share the existing spectrum. (3).Reconfiguration, finally CR reconfigures in term of adjusting carrier frequency, transmit power and scheme of modulation to transmit in the available band by itself [8]

Memorizing Elemental Precedent Assignments and Perceptions

Filtering Elemental Perceptions

In signal control, the filter's capability is always to leave undesirable elements of the signal, such as for instance arbitrary disturbance or to separate beneficial areas of the signal. There are two main manufacturers of filters. They're really unique within their physical framework and in addition to their performance. First is Analog filter and second is Digital filter. Digital filters have higher precedence over analog filter because of less computational issues, ease of transportation and reconfiguration, programmable and Non-autonomous change of temperature and multiple filtering flexibility.

Broadly two paradigms of digital filters are there. First Finite impulse response filter (FIR), i.e. a filter whose response is of finite duration identified as FIR filter. The reply of FIR filtering depends on previous and existing feedback designs. Second Infinite impulse response filter (IIR), the filter whose response is of infinite duration identified as IIR filter. The reply of FIR filtering depends on previous and existing feedback designs and past output designs. FIR filter mannerisms are stable, non-recursive, less efficient and of linear phase response. While in contrast IIR filter mannerisms are not stable, recursive, more efficient and of non-linear phase response.

The filter's characteristics could be seemed within an amplitude response filter plot. It is an amplitude plan that can occur at the yield of the filter for input frequencies. This really is referred to as filter frequency response. Filter responses are Low Pass Filter, High Pass Filter, Band Pass Filter and Band Stop Filter.

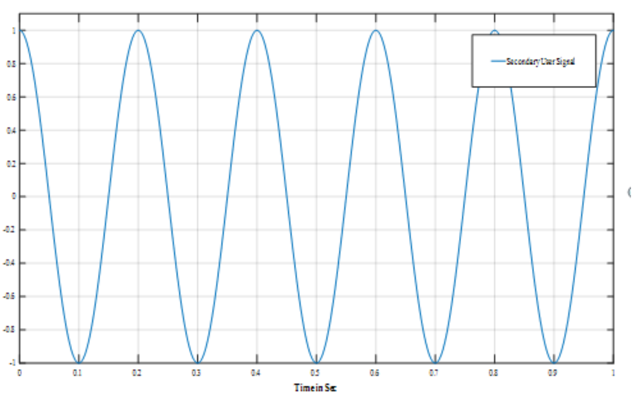
Implementation Approach

Now implementing the secondary user detection proposed techniques known as "Matched Filtering" and explore the results with the help of graphic representation and the steps involved are given below.

Signal Prompting and Conceptualization

First step involved in implementation approach is signal prompting and conceptualization. As a secondary user signal is prompted. The signal is prompted for 1sec with equation "cos (2*pi*t*f/2)".The representation of secondary user signal can be shown in figure 1.

Figure1: SU Continuous Time Signal.



If we view the secondary user signal is then it can be in time domain and in frequency domain. Both terms time domain and frequency domain view can be understood as. Time domain view is viewing the data over a time period.

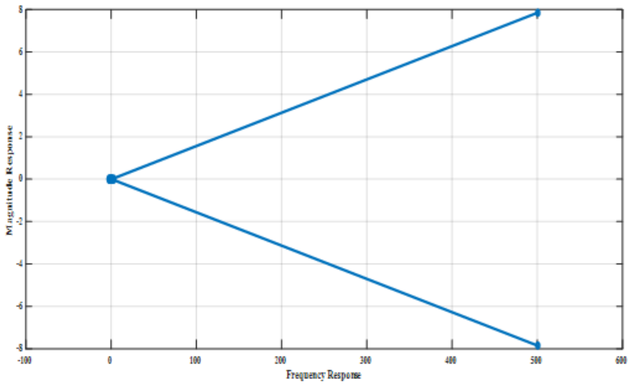
Frequency Domain view refers to viewing a mathematical function or a signal with respect to the frequency. Frequency domain view is good. Causes are to give precedence to frequency response analysis are given below.

- For the nonlinear control systems Frequency domain view can also be performed.
- In very quick time with no effort stability determination using a frequency response plot can be done
- To determine the behaviour of complicated transfer function experimentally, frequency response view can determine it. .

Transformation is used to convert a time domain function to a frequency domain function .The most common transformation used in the frequency domain is the Fourier transformations. Fourier transformation is used to convert a signal of any shape into a sum of infinite number of sinusoidal waves.

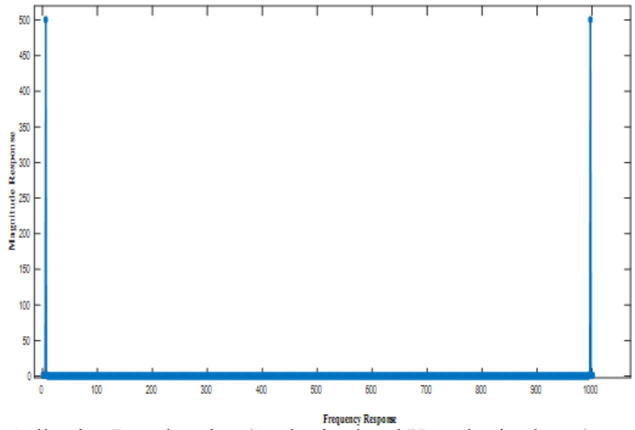
Since sinusoidal functions are easier than viewing general shaped functions, this method is very useful and widely used.

Figure2: SU Signal in Frequency Domain using FFT without Absolute values.



As negative values have no worth, so that values are ignorable. Redefine representation of SU signal in frequency domain can be viewed as in figure 3

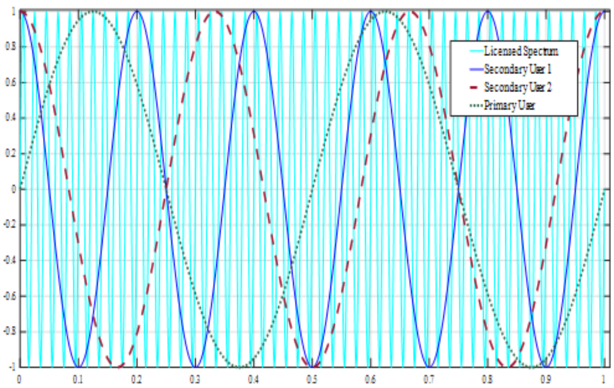
Figure3: SU Signal in Frequency Domain using FFT with Absolute values.



Collective Broadcasting (Authorized and Unauthorized user)

One of the situation to enhance the range productivity of the authorized bands, where the range use is generally low after some time, the range productivity can be enhanced by permitting access of unlicensed user to the authorized frequency bands.

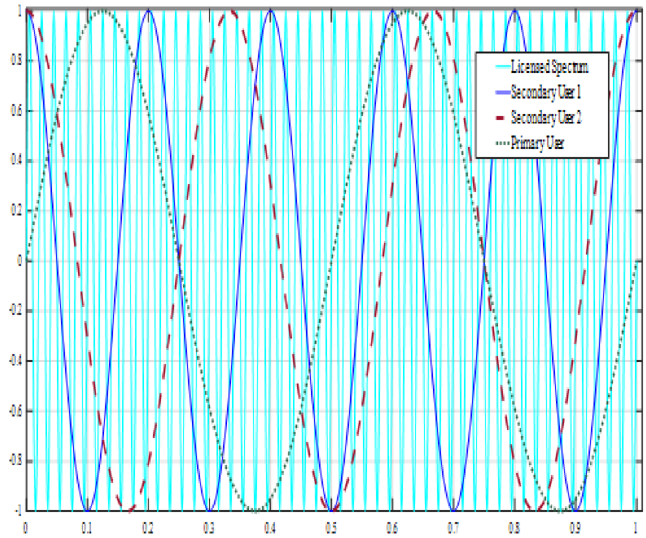
Figure4: SU signal Propagation with Licensed User.



Filter Remarkable Signal from Spectrum

By permitting access of unlicensed user to the authorized frequency bands, the process of filtering is performed. Now basic task is to filter out secondary user signal. The demonstration of this phenomenon can be seen in the figure 5

Figure5: Filter Remarkable signal From Spectrum.



In figure 5 black dotted lines represent primary user signal, continuous distorted lines represent our secondary user plus noise whereas dotted blue line depict our filtered secondary user signal.

Analyzing the Filtered Signal

Now it's time to analyzing the signal as a secondary user signal that prompted in section IV and allow it to propagate in licensed band with licensed user with signal that result out after the implementation of proposed technique. Analyze the both signals terms of spectral power density, correlation.

Spectral Power Density

Power spectral density is a very valuable tool. Power spectral density demonstrates which frequencies alterations are intense and at which frequencies alterations are feeble, utilizing the strength of the alterations (energy) as a function of frequency.

By integrating PSD within frequency range, energy within that specific frequency range can be gained. Inspection of alteration in frequency domain is just one more way to noticing variations of time series data, as frequency is a transformation of time.

PSD demonstrates which frequency ranges alteration are intense and for further analysis that might be quite useful. Calculated PSD of both signals filtered signal and original signal at different frequencies listed in table 1 and table 2.

Table 1: Filtered Secondary User Signal PSD.

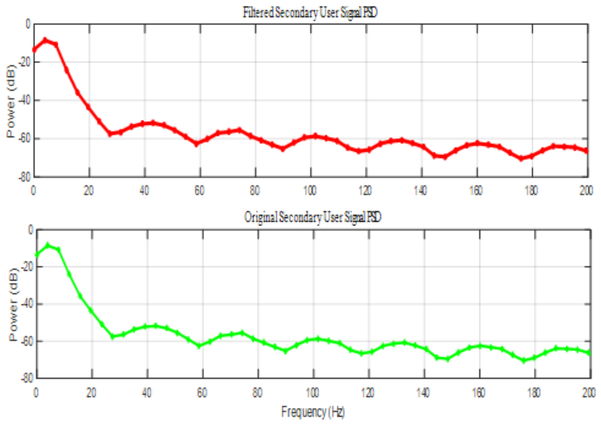
Frequency	Power	Power
(Hz)	**(dB)**	**MilliWatts**
10	-18.83	13.0918
20	-44.61	0.03459
40	-52.14	0.006109
60	-61.7	0.000676
80	-59.75	0.001059
100	-58.98	0.00127

Table 2: Original Secondary User Signal PSD.

Frequency	Power	Power
(Hz)	**(dB)**	**MilliWatts**
10	-18.81	13.1522
20	-44.61	0.03459
40	-52.14	0.006109
60	-61.9	0.00065
80	-59.75	0.001059
100	-58.96	0.00127

Both filtered secondary user signal PSD and original secondary user signal PSD graphical representation can be view in figure 6 which depict that secondary user that is propagating in licensed band after implementation of proposed technique PSD of it remain same without interfering primary user

Figure6: Comparative Analysis of Power Spectral Density.



Auto Correlation and Cross Correlation

Correlation is a relationship that exists between signals. Correlation procedures are broadly utilized as a part of in signal processing with numerous applications in media communications, material science, stargazing, geophysics and so forth.

Numerous valuable properties correlation has, giving for example the ability to

- Perceive designs within analogue, discrete-time or digital signals.
- Correlation is an examination procedure
- The correlation between two functions is a measure of their comparability.

For periodic functions, with period T, the correlation function is given by

$$R_{12}(\tau) = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} V_1(t)V_2(t-\tau)dt$$

R12 (t) is the correlation function and is a measure of the similarity between the functions v1(t) and v2(t). The measure of correlation is a function of a new variable,t which represents a time delay or time shift between the two functions. That correlation is decided by multiplying one signal, v1 (t), by someone else shifted in time, v2 (t-τ), and finding the integral of the product, in this fashion correlation concerns multiplication, time shifting (or delay) and integration

Autocorrelation action of signal suggests the generic dependence of codes of samples at one time on codes of sample at someone else time. Informally, it is similarity between considerations as a function of the time lag between them. The ACF, R (t) is noticed as by (Fabrice Gens et al., 2000)

$$R(\tau) = \frac{1}{T}\int_{-T/2}^{T/2} V(t)V(t-\tau)dt$$

When measuring the correlation between two functions, the result is often expressed as a correlation coefficient, r, with r in the range –1 to +1.

$\rho = -1$	$\rho = 0$	$\rho = +1$
Similar but opposite	No similarity	Exactly similar

For auto correlation, the correlation coefficient is given by:

$$\rho = \frac{R(\tau)}{\sqrt{R(0).R(0)}} = \frac{R(\tau)}{R(0)}$$

Resultant correlation coefficient of original secondary user signal and filtered secondary user signal are computed in MATLAB, which are given below

$$\rho = \begin{vmatrix} 1.000 & 0.7932 \\ 0.7932 & 1.000 \end{vmatrix}$$

As all calculated correlation coefficients are close to 1, so there is a strong positive correlation between each pair of data which depict that secondary user signal filtered from licensed band is similar to original signal prompted in section VI.

Conclusion

Sensing time of this technique is low as compared to other detectors and needs less time to achieve high processing gain. The accuracy of this can be reduced if information about the secondary user signal is not accurate. This leads to distortion of the CR concept may cause low quality of service for the licensed users.

If has the just right knowledge then this technique performs better in terms of accuracy and requires a short time to achieve a particular probability of detection.

However, perfect information is typically not feasible in most realistic applications, which restricts the robustness of this approach. In CR environment, this approach would call for a dedicated receiver for every kind of SU. Since large numbers of receivers are needed, so different algorithms are required to be evaluated and thus power utilization is large and computational complexity is also high

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