International Journal of Engineering Technology and Applied Science

(ISSN: 2395 3853), Vol. 3 Issue 6 June 2017

# Simulation Modelling and Analysis of Spectrum Sensing Mechanism using Hybrid Approach

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***Abstract-*** To identify the present or absent of licensed users, spectrum sensing techniques are used. Matched filter detection, Energy detection, and Cyclo-stationary feature detection are the three conventional methods used for spectrum sensing. Matched filter spectrum sensing technique needs prior knowledge about the received signal for every primary user. The performance of energy detector is susceptible to uncertainty in noise power. Cyclo-stationary feature detection requires a lot of computation effort and long observation time. This thesis discusses the conventional energy detection method and proposed improved energy detection method using double-squaring and addition of squaring operation. Mathematical description of energy detection based spectrum sensing techniques is also illustrated over fading channels.

**KEYWORDS: Additional Squaring, Cubic Operation, Squaring Operation, Energy Detection, AWGN Channel, Rayleigh Channel.**

## I INTRODUCTION

Increase in wireless devices and applications lead to the demand of effective utilization of radio spectrum and current radio spectrum is underutilized due to static allocation, as this allocation makes it inflexible to operate in a certain frequency band. So to remove underutilization of radio spectrum cognitive radio technology has been employed. Cognitive radio technology provides effective utilization of the radio spectrum and reliable communication among all the users of the network. Cognitive radios are made so intelligent that it has the capability to sense the external radio environment and change its parameters according to the situation. To improve the spectrum efficiency, it can also access underutilized radio spectrum dynamically without interfering the primary users. Spectrum sensing have a very prominent role in cognitive radio for efficient utilization of current radio spectrum. The primary task of every cognitive radio user is to keep track of primary users whether they are present or not and this process is known as spectrum sensing. Spectrum sensing techniques may be categorized as: Frequency domain approach and time domain approach.

In frequency `domain method, computation is carried out directly from signal whereas in time domain approach, computation is performed using autocorrelation of the signal.

## II COGNITIVE RADIO

Cognitive radio may be defined as part of radio systems that perform spectrum sensing in a continuous manner which identify spectrum holes (unused radio spectrum) dynamically and then perform operation in a time domain when it is not used by primary users. "A cognitive radio may be defined as a radio that is aware of its environment and the internal state and with knowledge of these elements and any stored pre-defined objectives can make and implement decisions about its behavior. Cognitive radio has four main functions which are: Spectrum sharing, Spectrum Management, Spectrum Mobility and Spectrum Sensing.

## III RELATED WORK

In this paper [1], the impact of varying the transmission power on the probability of false alarm of single CR has been investigated. The investigations have shown that increasing transmission power is not always effective to meet probability of false alarm target. To meet the target, designing an optimal energy efficient CBSS that satisfies the sensing accuracy metrics has been considered in this letter. The problem of design has been formulated and analysis has also been provided. An iterative algorithm with low computational complexity has been proposed to jointly determine the optimal design parameters of CBSS system that maximize the energy efficiency while satisfying all detection accuracy metrics.

In this paper [2] a new method was proposed to form all the subsets of sensors which can cooperatively provide the network with desired false alarm and detection probabilities. For each subset of sensors with such conditions, the average energy consumption for CSS per frame was computed. Then, a new heuristic algorithm was proposed to select the subset minimizing the average energy consumption for CSS in each frame. The simulation results show that the proposed algorithms have better performances in terms of maximum network lifetime, energy consumption for reporting the results to FC and CSS compared to other existing methods. It can be seen that the average energy consumption for CSS per frame is reduced up to 35% in comparison to the state-of-theart research works. In addition, the total reporting energy for CSS is reduced up to 67% compared to the existing methods. However, since the reporting energy is a part of energy consumption for CSS, the total energy consumption for CSS is decreased for at most 36%. Finally, the proposed algorithm increases the maximum network lifetime up to 39%. To reduce the complexity of the proposed algorithm, a sub-optimal algorithm was proposed which has the same performance from energy-efficiency point of view. However, the computational complexity of the suboptimal algorithm is significantly lower than the proposed heuristic algorithm.

In this paper [3], an FSCHT based entropy detection for spectrum sensing is presented. The results of histogram based Shannon entropy detection is compared with kernel based entropy detection. The detection performance of FSCHT based Shannon entropy is not promising. However, the FSCHT with Parzen entropy easily captures the randomness of the signal, stimulating the detection. The proposed detection technique depicts an exceptional performance in sensing the DVB-T signals at an SNR wall of -60 dB with the appropriate BIN size. In particular, this algorithm can be implemented in hardware that supports high-speed processing in real time applications.

In this paper [4] the results show that the analysis matches the simulations well, and both of them verify that our proposed LRT and SLRT based NED-CS schemes can improve the sensing performance by taking the difference of each SU's sensing reliability into account. Specifically, the LRT and SLRT based NED-CS schemes can achieve substantially better sensing performance than EGC method and MNE detector in heterogeneous CR networks, where the differences of SU's sensing reliability are relatively large.

## IV PROPOSED METHODOLOGY

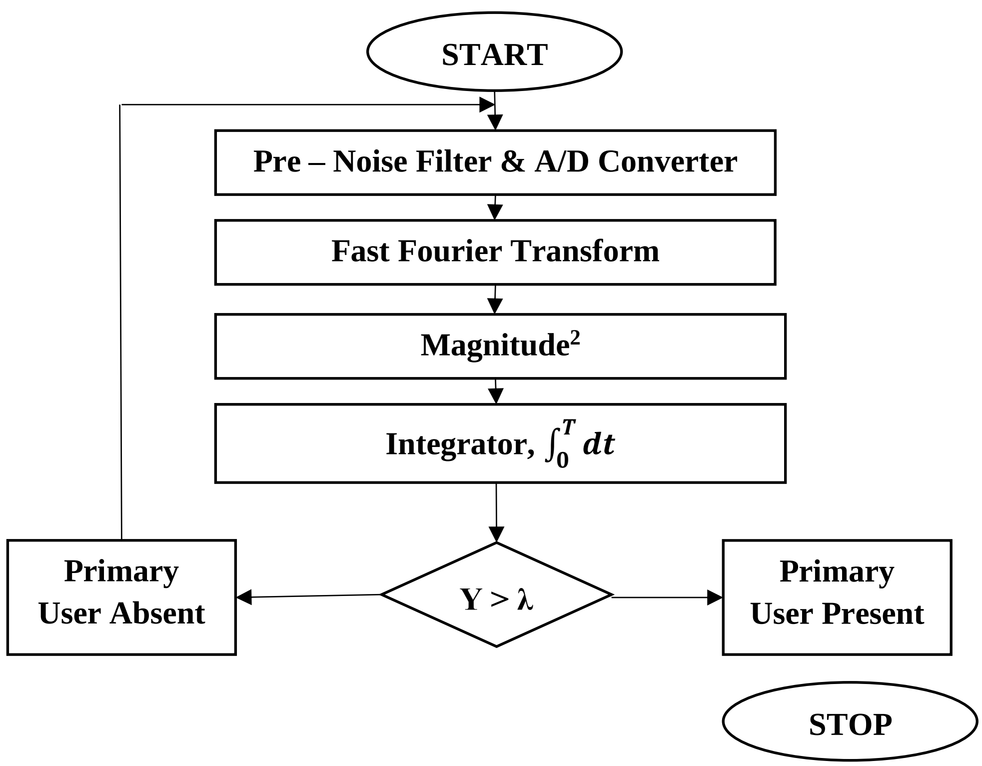


**Figure 1 Flow Chart of Energy Detector**

**Step 1:** First, the input signal is filtered with a Pre - Noise filter in order to limit the noise and to select the bandwidth of interest and A/D converted.

**Step 2:** The spectral component on each spectrum sub-band of interest is obtained from the Fast Fourier Transform (FFT) of the received signal.

**Step 3:** The power spectral density (PSD) is intended for continuous spectra. The integral of the PSD over a given frequency band computes the average power in the signal over that frequency band

**Step 4:** Finally the output of the integrator, Y is compared with a decision threshold value λ to decide whether primary user is present or not.

**V SIMULATION RESULTS**
**AWGN Channel**

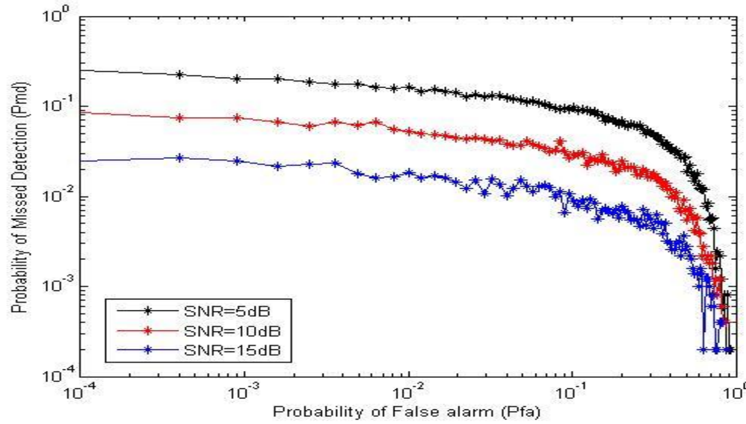


**Figure 2: ROC Curve for Double-Squaring Operation over AWGN Channel.**

Figure 2 illustrates the ROC (Receiver Operating Characteristics) curves i.e. $P_{md}$ versus $P_f$ using Energy detection method for spectrum sensing. This improved method uses double squaring operation. The graph is plotted for different SNR values over AWGN channel and it shows that with increase in SNR (Signal-to-Noise Ratio), the probability of detection increases and is quantified in Table 1.

**Table 1: Improvement in $P_d$ with increase in SNR using Double-Squaring**

| Probability of False Alarm ( $P_{fa}$) | Probability of Detection (SNR = 5 dB) | Probability of Detection (SNR = 10 dB) | Improvement (in times) |
|---|---|---|---|
| 0.0001 | 0.7502 | 0.9158 | 0.220 |
| 0.0121 | 0.8542 | 0.9498 | 0.111 |
| 0.1225 | 0.9098 | 0.9300 | 0.022 |
| 0.5776 | 0.9822 | 0.9942 | 0.012 |
| 0.8464 | 0.9994 | 0.9996 | 0.002 |

**Operation for AWGN Channel**.

Table 1 shows that 5 dB increase in Signal to Noise Ratio; increases the probability of detection (at SNR=10 dB) up to 0.22 times as compared to probability of detection (at SNR=5 dB) for AWGN Channel.

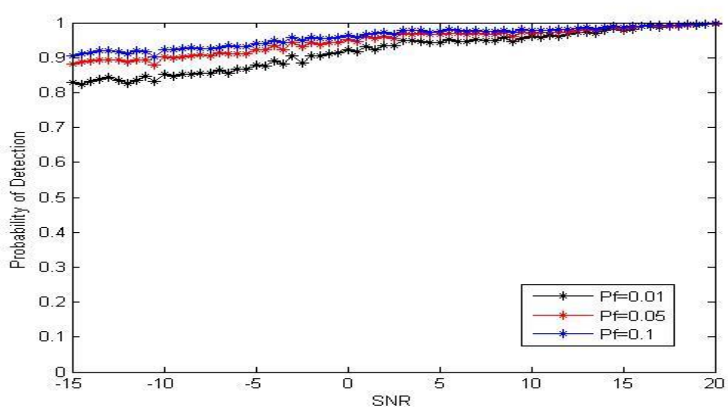


**Figure 3: $P_d$ *versus* SNR Curve for Double-Squaring Operation over AWGN Channel.**

Figure 3 shows the plot for probability of detection versus Signal-to-Noise Ratio over AWGN Channel using double-squaring operation in Energy detection. The graph is plotted for different values of Probability of False alarm and it shows that increasing the probability of false alarm, improves the probability of detection. Table 2 illustrates this improvement in performance.

**Table 2: Improvement in $P_d$ with increase in $P_f$ using Double - Squaring Operation for AWGN Channel**

| Signal to Noise Ratio (in dB) | Probability of Detection ( $P_f$ = 0.01) | Probability of Detection ( $P_f$ = 0.05) | Improvement (in times) |
|---|---|---|---|
| -15 | 0.8293 | 0.8817 | 0.063 |
| -10 | 0.8537 | 0.8832 | 0.034 |
| -5 | 0.8797 | 0.9227 | 0.048 |
| 0 | 0.9233 | 0.9521 | 0.031 |
| 5 | 0.9437 | 0.9760 | 0.034 |

Table 2 shows that 5 % increase in probability of false alarm; increases the probability of detection (for $P_f$ = 0.05) up to 0.063 times as compared to probability of detection (for $P_f$ = 0.01) over AWGN Channel.

**Rayleigh Channel:**

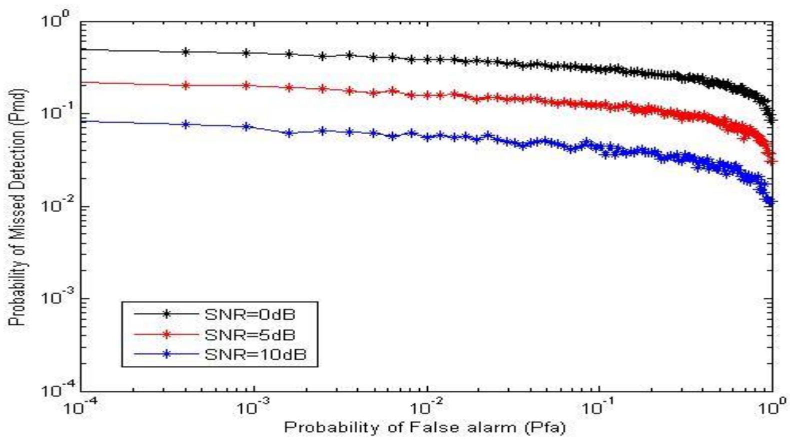


**Figure 4: ROC Curve for Double-Squaring Operation over Rayleigh Channel.**

Figure 4 illustrates the ROC (Receiver Operating Characteristics) curves i.e. $P_{md}$ versus $P_f$ using Energy detection method for spectrum sensing. This improved method uses double squaring operation. The graph is plotted for different SNR values over Rayleigh channel and it shows that with increase in SNR (Signal to Noise Ratio), the probability of detection increases and is quantified in Table 3.

**Table 3: Improvement in $P_d$ with increase in SNR using double - Squaring Operation for Rayleigh Channel**

| Probability of False Alarm ( Pfa) | Probability of Detection (SNR = 5 dB) | Probability of Detection (SNR = 10 dB) | Improvement (in times) |
|---|---|---|---|
| 0.0001 | 0.5034 | 0.7818 | 0.553 |
| 0.0121 | 0.6160 | 0.8426 | 0.367 |
| 0.1225 | 0.6962 | 0.8830 | 0.226 |
| 0.5776 | 0.7892 | 0.9110 | 0.154 |
| 0.8464 | 0.8620 | 0.9532 | 0.105 |

Table 3 shows that 5 dB increase in Signal to Noise Ratio; increases the probability of detection (at SNR=10 dB) up to 0.55 times as compared to probability of detection (at SNR=5dB) for Rayleigh Channel.

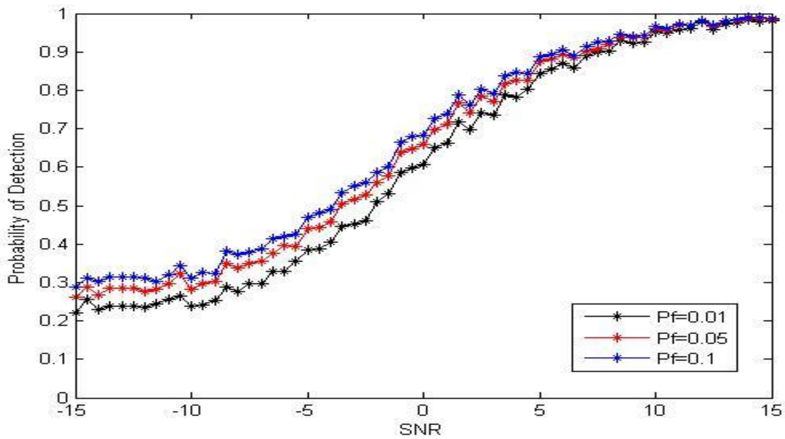


**Figure 5:** $Pd$ **versus SNR Curve for Double-Squaring Operation over Rayleigh Channel**

Figure 5 shows the plot for probability of detection versus Signal-to-Noise Ratio over Rayleigh Channel using double-squaring operation in Energy detection. The graph is plotted for different values of Probability of False alarm and it shows that increasing the probability of false alarm improves the probability of detection. Table 13 illustrates this improvement in performance.

**Table 4: Improvement in** $P\,d$ **with increase in** $Pf$ **using Double-Squaring operation for Rayleigh Channel**

| **Signal to Noise Ratio (in dB)** | **Probability of Detection ( $P_f$ = 0.01)** | **Probability of Detection ( $P_f$ = 0.05)** | **Improvement (in times)** |
|---|---|---|---|
| -15 | 0.2200 | 0.2630 | 0.195 |
| -10 | 0.2371 | 0.2831 | 0.194 |
| -5 | 0.3840 | 0.4392 | 0.143 |
| 0 | 0.6082 | 0.6630 | 0.090 |
| 5 | 0.8443 | 0.8867 | 0.050 |

Table 4 shows that 5 % increase in probability of false alarm; increases the probability of detection (for $P_f$ = 0.05) up to 0.2 times as compared to probability of detection (for $P_f$ = 0.01) over AWGN Channel.

## VI CONCLUSION

It has also been observed that increase in probability of false alarm improves the probability of detection of a particular spectrum sensing method. 5% increase in probability of false alarm increases the probability of detection up to 2.8 times for AWGN Channel and 0.6 times for Rayleigh Channel in case of conventional energy detection method (i.e. using squaring operation). While in case of cubing operation, this improvement is up to 0.29 times for AWGN Channel and 0.25 times for Rayleigh Channel. And if we use double-squaring operation, this improvement is up to 0.07 times for AWGN Channel and 0.2 times for Rayleigh Channel.

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