International Journal of New Technology and Research (IJNTR)
ISSN: 2454-4116, Volume-6, Issue-9, September 2020 Pages 13-17

Performance of Energy Detection in AWGN Channel and Rayleigh Fading Channel with Different Signal to Noise Ratio

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***Abstract*— This paper presents another look at the problem of detecting the power of detecting unknown signals on different faded channels. We do not start with a diversity case and present some alternative closure-form expressions for identification possibilities. We then investigate the performance of the system when various variation schemes are employed. It has been shown that the probability of detection does not improve much when the probability of a false alarm exceeds 0/1 or the scattering ratio (SNR) from the average signal exceeds 20 dB. Also, the receiver operating characteristic (ROC) curve is presented by comparing the performance of equal-gain combination, selection combination, and switch and stay combining. For example, the combination of equal-gain introduces the availability of two orders of magnitude from the probability of a missed perspective compared to different variations, while both selections combines and switches and combines together to achieve approximately one order quantity.**

***Index Terms*— Fading Channel, SNR,AWGN Channel, ROC, FCC, CR.**

I. INTRODUCTION

Modern years have seen a tremendous demand for wireless communication as the field of wireless communication expands, resulting in the need for more spectral resources to achieve our obligation. Spectral allocations are usually specified for the organization and management of today's spectrum is regulated by our government. However, this leads to a common problem with spectral loss [1]. A few licensed bands and companies are seen in spectrum deficits. The purpose of cognitive radio has been proposed as a way to overcome spectral deficiencies and appropriate spectral use in wireless communication. According to the Federal Communications Commission (FCC), many licensed users who are not used properly are starving. The FCC further states that spectrum use has rarely exceeded 35% at any given time in large populated urban areas [2]. The key concept behind "Cognitive Radio (CR)" is to ensure the proper use of those smaller spectra without interfering with the licensed primary user (PU). The CR system allows unlicensed users, also known as secondary users (SUs), to use temporarily unused spectrum that is not currently used by licensed primary users (PUs).

Spectrum sensing is a fundamental component of CR systems. Spectral sensing enables the ability to perceive PU presence and radio channel related parameters. There are several spectral sensing techniques used to determine the existence of PU, such as feature detection, energy detection, and matching filtering detection. The power detection technique is widely used because it does not require any prior knowledge about PU. Wireless channels have some basic features such as multipath fading, shading and noise uncertainty; a CR system may be unable to detect the presence of PU. To solve this problem, the cooperative spectrum has been proposed with the collaborative decision of several secondary users (SUs) for spectrum sensitization [3], and this is done at a fusion center (FC). Signals are received from the FC to unlicensed SUVs and combine these signals to make a final decision about the presence of PUs. There are currently three fusion rules for determining the readiness of the free spectrum: end-rule, OR-rule, and majority-rule. Of these three rules, energy detection gives improved sensing efficiency when using the OR-fusion rule.

II. METHODOLOGY

In the case of analog and digital communication, the signal-to-noise ratio (SNR) is defined as the ratio of the signal received by the sound signal. It indicates the intensity of the signal relative to the background sound. If the ratio is greater than 1: 1, it indicates more signals than words. The SNR is displayed as follows:

$$SNR = \frac{P_{signal}}{P_{noise}} \text{----------------------------(1)}$$

The ratio is usually measured in decibels (dB), P is the average power. If the signal and the noise are measured in the same resistance, the SNR can be obtained by squaring the amplitude ratio: At Eq. (2), this basically means square width. Since many signals have a very wide dynamic range, SNRs are often expressed on a logarithmic decibel scale.

$$SNR_{dB} = 10\log_{10}\left(\frac{P_{signal}}{P_{noise}}\right) \text{---------------(2)}$$

Eq. (2) can be written using amplitude as:

$$SNR_{dB} = 10\log_{10}\left(\frac{A_{signal}}{A_{noise}}\right)^2 = 20\log_{10}\left(\frac{A_{signal}}{A_{noise}}\right)$$

---(3)

In CR networks, to determine the spectrum availability,

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CR user need statistical information on the received primary signals, so the minimum SNR is the least signal level needed to decode the received signals [4].According to the spectrum usage spectrum sensing, one of the most important issues, monitors a govern port of the spectrum and makes binary decision. In spite of having sundry techniques are applied by diverse spectrum sensing approaches, the primary transmitted signal detecting based on energy detection is the most frequently used among them. It is because its structure is simple and not requires any signal knowledge in advance level [6][7]. The energy in a specified channel is studied by an energy detection strategy and comparison is done between the obtained value and the predefined threshold. As a result the spectrum will be considered idle if the energy level remains below the threshold. So, obviously, this spectrum will not be used by PUs. On the contrary, the spectrum is considered to be busy if energy revel remains above the threshold. As a result, this will be used by Pus [8][9]. But the noticeable factor here is that the first case works as a chance for CRUs to utilize the channel by avoiding the interference with PUs [7][10].

The signal-to-noise ratio (SNR) of the received signal is indicated by SNR = σ^2_s / σ^2_y. Essentially the decision about the channel usage is denoted as follows

E=$\sum_{m=0}^{n}|X[m]|^2$------------------------(4)

Where E is the decision statistics, m is the sample index, γ is a decision threshold formulated as in eq. (5) [11].

γ = $2\sqrt{N/2}(Q^{-1}P(fa)+\sqrt{N/2}$-----(5)

Where Q (•) is the common Marcum Q-function [12]. Pfa is the possibility that a CRU erroneously decides that a particular spectrum is used when a PU does not really use it. Pd is defined below using the given spectrum when the possibility of detecting a PU signal is actually present. It is defined as follows using Eq. (5) [13] [14] [15].

$$P_{d=}\quad e^{-\gamma/2}\sum_{n=0}^{c-2} {}^{1}\!/_{n!}\,\gamma/2^{n}+[\quad(\quad(\frac{1+SNR}{SNR})^{c-1}X\,(e^{\frac{\gamma}{2X(1+SNR)}}-e^{-\gamma/2}\sum_{n=0}^{c-2}(\frac{\gamma*SNR}{2X(1+SNR)})^{n}))]$$

---(6)

Where, c is the time bandwidth product. However, due to the complex structure of calculating the number of samples required according to SNR in faded channels is heavy to so, the number of samples required to meet the required Pd and Pfa is obtained by approximately [11]:

N = $(Q^{-1}(P_{fa})/-\log(P_d))^2(2*SNR)^{-2}$---(7)

Consequently, τ, the sensing time, is calculated by

τ=N/W-----------------------------------(8)

Where W is the channel bandwidth [16].

III. SIMULATION RESULTS

In following figures shows the comparison of probability of missed detection verses probability of false alarm when signal to noise ratio is varying over AWGN channel and Rayleigh Fading channel with simulated result are plotted.

Following Figures-1, 2 and 3 show the complementary ROC curve for energy detection over a non- fading AWGN channel (a case where the form of interference is only noise) and Rayleigh Fading channel.

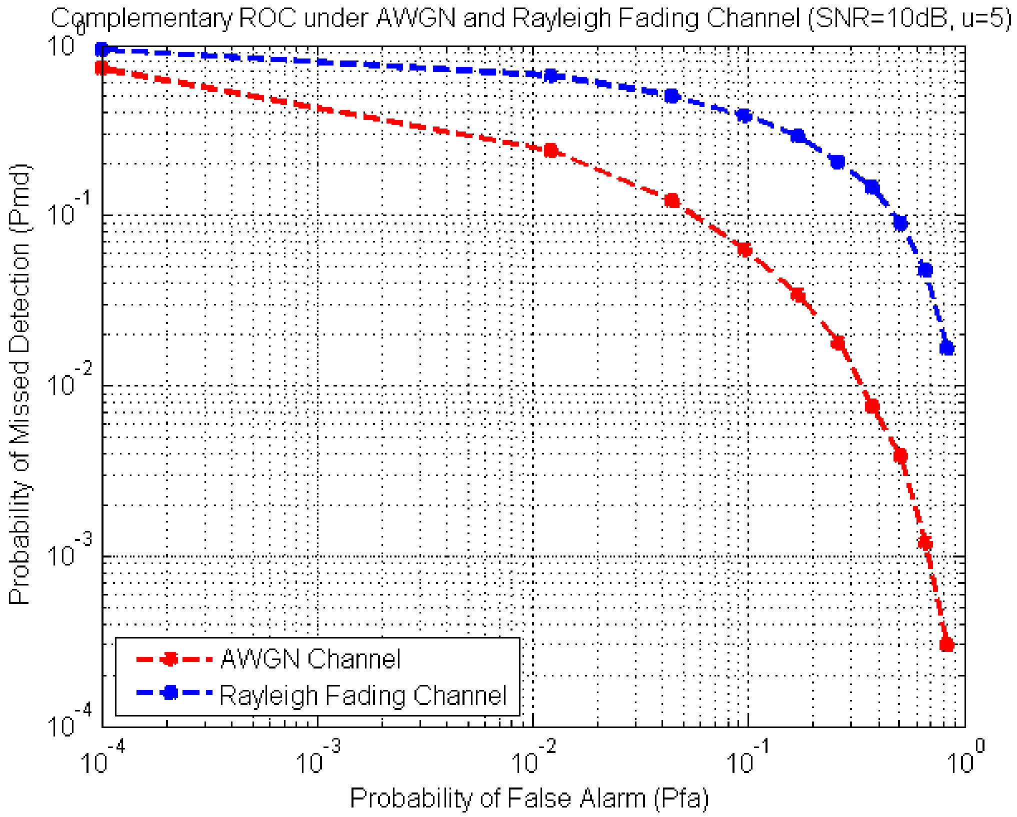

Figure-1:Complementary ROC under AWGN and Rayleigh Fading Channel (SNR=10dB, u=5).

It can be seen that as values of P_{fa} increases; there is drastic decrease in P_{md}. Similarly, as values of SNR are varying there is still decrease in values of P_{md}. It is apparent that energy detection executed over a Rayleigh channel exhibits a tough detection performance, compared to that of AWGN. This is not far- fetched, since the fading severity is more in a Rayleigh channel compared to that of AWGN.

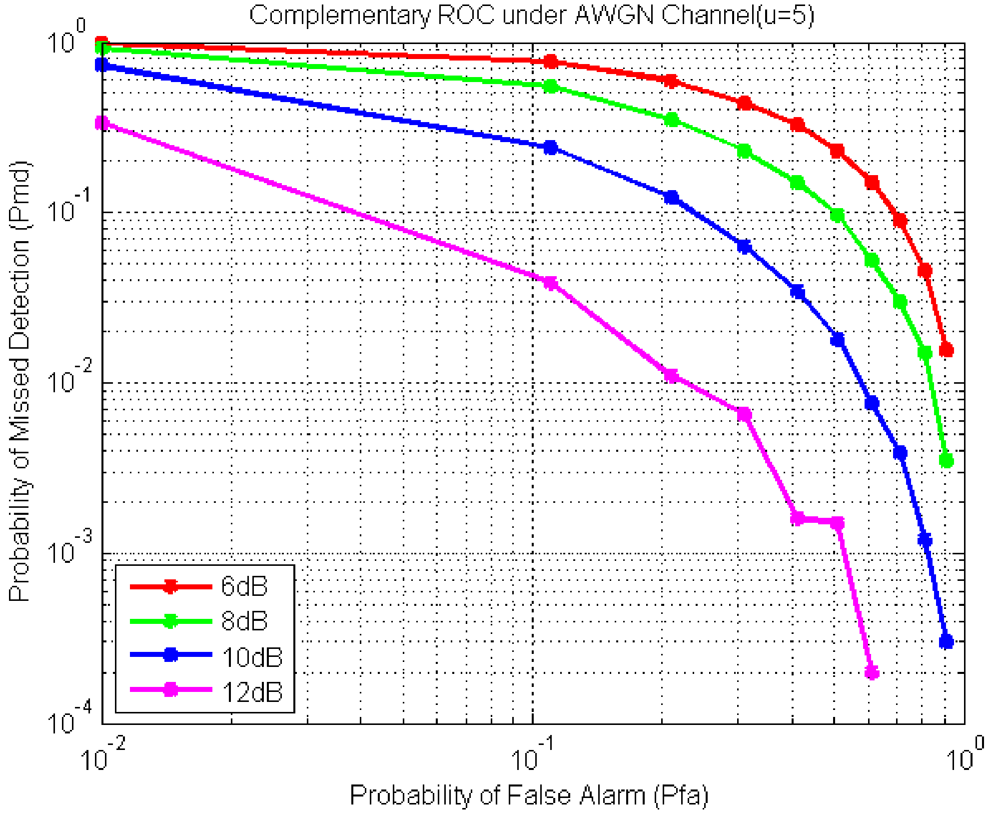

Figure-2: Complementary ROC under AWGN Channel (u=5)

Figure-2 shows the probability of missed detection for energy detection under AWGN for various SNR (SNR=6dB, 8dB, 10dB, 12dB).

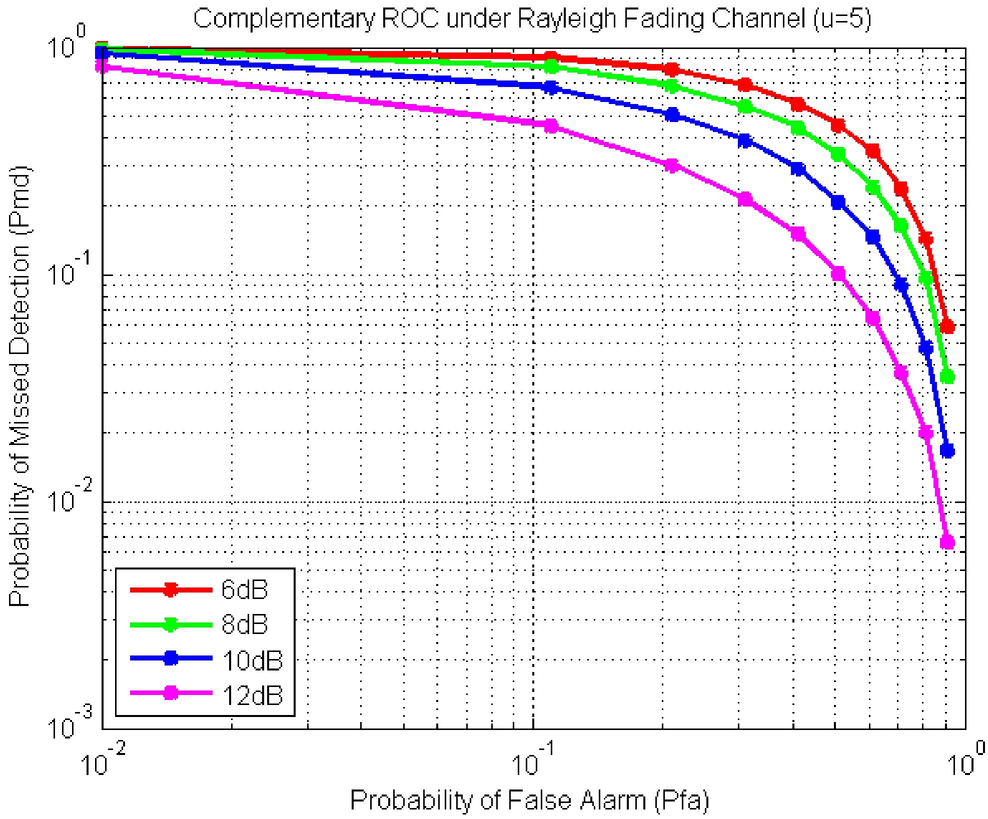

Figure-3: Complementary ROC under Rayleigh Fading Channel (u=5).

Figure-3 shows the probability of missed detection for energy detection under Rayleigh fading channel for various SNR (SNR=6dB, 8dB, 10dB, 12dB)

In simulation experiment we have studied spectrum sensing error is low when SNR value is 10dB or 12dB. Figure-2 and 3show the comparison of the miss detection schemes for different mean SNR values. This shows the relationship between the probability of missed detection P_{md} , and false alarm probability P_{fa}, for 6dB to 12dB average SNR, time bandwidth product u = 5, sample size N = $2*u$ respectively. The probability of missed detection is a complement of detection probability.

We noticed in the both channel, the probability of miss improves rapidly with increasing $\bar{\gamma}$. It shows that an increase in SNR produces greater detection performance for both channels.

From this $P_{fa}\, vs\, P_{md}$ plot, it is observed that the slopes are low for P_{fa} < 0.1, and a 6 dB increase in SNR (from 6dB to 12dB), has an increase in missed detection probability (reduced Pd).

IV. Discussion

We have discussed a radio or system that is sensitive and aware of its operational environment and can be trained to adjust its radio operating parameters dynamically and autonomously accordingly. This radio is known as cognitive radio. A common misconception about cognitive radio, however, is that they are unlicensed spectrum users who should avoid interfering with licensedprimary users. Effective identification of the primary user is the main problem of cognitive radio, which uses the traditionally allocated spectrum in an opportunistic way. Thus, one of the most important components of cognitive radio is identifying opportunities in the available spectrum. In general, we have discussed cognitive radio and issues related to spectrum detection performance of detector algorithms under both AWGN and Rayleigh fading channels to reduce interference between primary users and cognitive users [13].

Spectrum is an extremely valuable resource for wireless systems and applications and has become a focal point of research over the past few decades. Cognitive radio is an innovative technology that could potentially improve the use of the radio spectrum. In this project, several spectrum sensitive techniques have been reviewed and a comparison has been made. However, due to the low computer complexity and special attention paid to energy detection, it requires no prior knowledge of PE signal and co-operative spectrum sensing as it improves detection efficiency due to severe fading and hidden terminal problems. Cooperative spectrum sensing is good because it eliminates the hidden node problem, reduces false alarms and gives more accurate signal detection. Draw and evaluate the effectiveness of energy detection algorithms for spectral sensing in cognitive radio via complementary ROC curves between ROC (receiver operating characteristics) and complementary ROC curves between detection probability, SNR vs. detection probability, error probability, etc. We analyzed the effectiveness of energy detection by the AWGN channel and the more faded environment (Rayleigh). We considered the challenge of multipath fading and hidden terminal problems. To overcome this we have presented the co-op spermatozoa sensation and research with a strict combination on the AWGN channel and the Rayleigh faded channel. Finally the Cooperative Energy Spectrum Sensing has been evaluated on the basis of rigorous decision-making and regulation with identification which shows better results in different situations. A simulation comparison of AND & OR cooperative decision fusion rules was undertaken and results show that OR rule (corresponding to considering the decision of at least one detector out of k available detectors) out-performs the AND & OR rule combining rules [14].

V. CONCLUSION

We have studied spectral sensitive performance in both the non-fading AWGN channel and the Rayleigh fading channel in a cooperative and non-cooperative environment. We used the energy detection method to detect PU. We have also used the OR fusion rule here. We have seen that energy detection performs better in non-fading channels than in non-collaborative environments. We further noted that when CSS was considered, the sensing performance was better than that of a Rayleigh fading channel compared to the AWGN channel.

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