DEPARTMENT OF
ELECTRONICS AND COMMUNICATION ENGINEERING

Faculty of Engineering and Technology, SRM

DESIGN PROJECT SUMMARY FORM

Project Title : **Wideband spectrum sensing using subnyquist techniques for Cognitive Radio Networks**

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Background/Literature Review:

The electromagnetic radio frequency (RF) spectrum is a scarce natural resource, the use of which by transmitters and receivers is typically licensed by governments. Static spectrum access is the main policy for the current wireless communication technologies. Under this policy, fixed channels are assigned to licensed users or primary users (PUs) for exclusive use while unlicensed users or secondary users (SUs) are prohibited from accessing those channels even when they are unoccupied. Nowadays, it becomes obvious that this frequency allocation scheme cannot accommodate the constantly increasing demands of higher data rates. Cognitive radio (CR) has emerged as an innovative technology to solve this spectrum under-utilization problem in the next generation networks

References:

1. Advances on Spectrum Sensing for Cognitive Radio Networks: Theory and Applications Abdelmohsen Ali, Student Member, IEEE, and Walaa Hamouda, Senior Member, IEEE

2. Tianyi Xiong, Student Member, IEEE, Hongbin Li, Senior Member, IEEE, Peihan Qi, and Zan Li, Senior Member, IEEE- "Pre-Decision for Wideband Spectrum Sensing with Sub-Nyquist Sampling"

Objective:

To determine the unoccupied RF band by using wideband sensing and to use them in wireless communication to prevent spectral wastage.

Requirements:

1) Matlab R2017a

Technical Requirements:

Engineering standards and realistic constraints in these areas:

Area	Codes & Standards / Realistic Constraints
Economic	Targeted to reduce Spectral Wastage and hence helps in economic sustainability.
Environmental	This project is not expected to entail any particular environmental consequences.
Social	This project aims for making wireless communications more efficient , hence leads to the betterment of the society.
Ethical	This project is not expected to entail ethical constraints.
Health and Safety	This project is not expected to entail health and safety constraints except in the use of lead-bearing solder in its assembly .
Manufacturability	This project must be easily replicated. This requires *complete* schematics, *complete and documented* code listings, and use of the MATLAB (R2017a) software available in the networking Lab.
Sustainability	The Project uses only code listings in MATLAB and hence the software can be reused.

Realistic Constraints:

1)Sparsity levels may change . A primary user can occupy a band at any time. So unwanted changes in the signal level can occur.
2)If Channel State Information (CSI) is not known, then the presence of Primary Users cannot be detected.

Deliverables:

1)Wideband spectrum sensing will be executed and the result whether the primary user is presented or not in the spectrum will be shown in MATLAB

Standards Referred/used:

1)GSM (IEEE 802.21)
GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA)

2)WiMAX (IEEE 802.16e)
4G is the fourth generation of broadband cellular network technology, succeeding 3G. A 4G system must provide capabilities defined by ITU in IMT Advanced. Potential and current applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, and 3D television.

Abstract:

Cognitive radio(CR) communications have recently emerged as a reliable and effective solution due to underutilization problem in the given radio spectrum. Nowadays Cognitive radio networks are extensively used because of their ability to produce reliable and efficient service. Spectrum sensing provides the essential information to enable this interweave communications in which primary and secondary users are not allowed to access the medium concurrently. In this project, we will be implementing a model that can be used to sense the unused RF bands by measuring their energy levels using power spectral density techniques.We will be using wideband sensing techniques that uses sub nyquist frequencies (frequencies that are below the Nyquist frequency). In this way we can detect the unused spectrum and hence reduce spectral wastage and improve spectral efficiency by accommodating the licensed secondary users.

Additional Requirements:

(Multidisciplinary tasks –Mechanical, instrumentation, electrical, Computational /IT involved)

This project involves software works in Matlab R2017a version.

Other Department	Utilised for	Remarks
Basic Sciences		
Mechanical Engineering		
Instrumentation and Control Engineering		
Electrical and Electronics Engineering		
Computational/IT	Matlab R2017a	
Biomedical Engineering		
Purchase Section		
Maintenance Department		
Desktop publications	Report	

ABET Design Project Summary

Project Title	Objective of the Project	Realistic constraints imposed	Standards to be referred/followed	Multidisciplinary tasks involved
Wideband spectrum sensing using sub Nyquist techniques for cognitive radio networks	To determine the unoccupied band by using wideband sensing and cognitive radio and to use them in wireless communication to prevent spectral wastage.	1)Sparsity levels may change . A primary user can occupy a band at any time. So unwanted changes in the signal level can occur. 2) Channel State Information should be known	1)GSM (IEEE 802.21) 2)WiMAX (IEEE 802.16e)	1)Computational and IT field for MATLAB 2)Desktop publication for report.

RESULT

Input Signal with AWGN Noise

The input signal is taken and AWGN noise is added to it and then the input signal is plotted

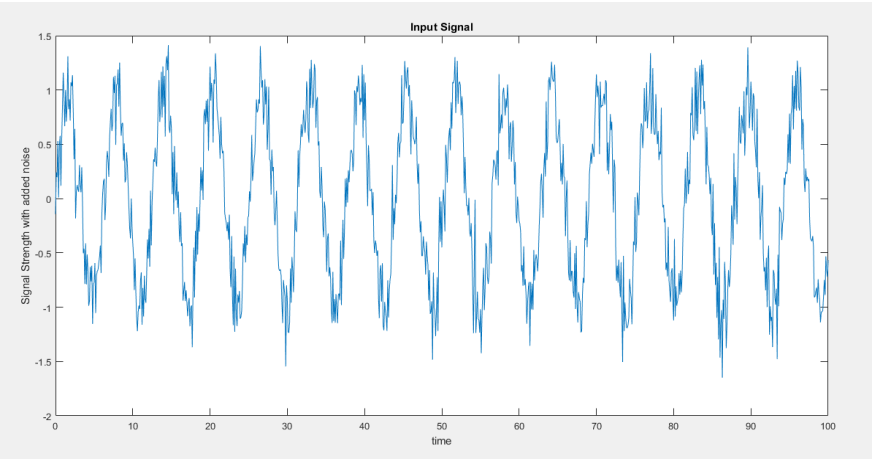
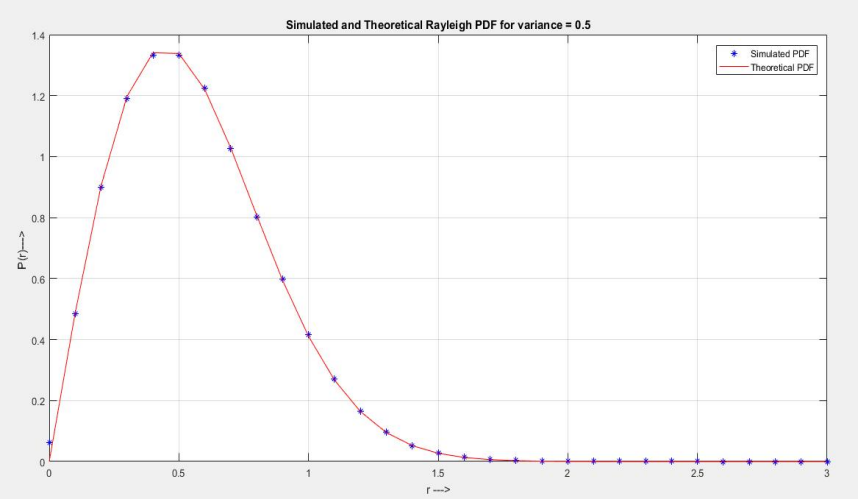


Figure : Input signal with noise

Rayleigh Fading Envelope applied to input signal



Rayleigh fading applied to input signal

The Rayleigh fading envelope is applied to the input signal and it has variance = 0.50.The red curve is obtained by considering the theoretical probability distribution function from the Rayleigh Fading equation.

r is the range of the signal

P(r) is the probability distribution function at range r

OPTIMIZATION IN WIDEBAND SPECTRUM SENSING IN COGNITIVE RADIO NETWORK.

Here local spectrum sensing technique is Energy Detection and the SNR=10dB and n=10 samples are used for this spectrum sensing. From figure 3(b) shown the threshold vs. total error rate using ED technique.

From figure 3(b), shows the total error probability versus threshold for different number of n=1, 2, 3, 4 ….10. We observe there are difference in the performance through using n=1 to 10.

Actually energy detection sets a threshold according to the noise and comparing with input of the energy detection data stream.. The ED mainly do the presence of a signal comparing the received energy with a known threshold derives the noise of signal

In this figure, we get the optimum value of ‘n’ out of ‘K’ CRs. We vary threshold value from 10 to 40.n=5 by modelling signifies that for that particular band there is an error every 5 seconds.

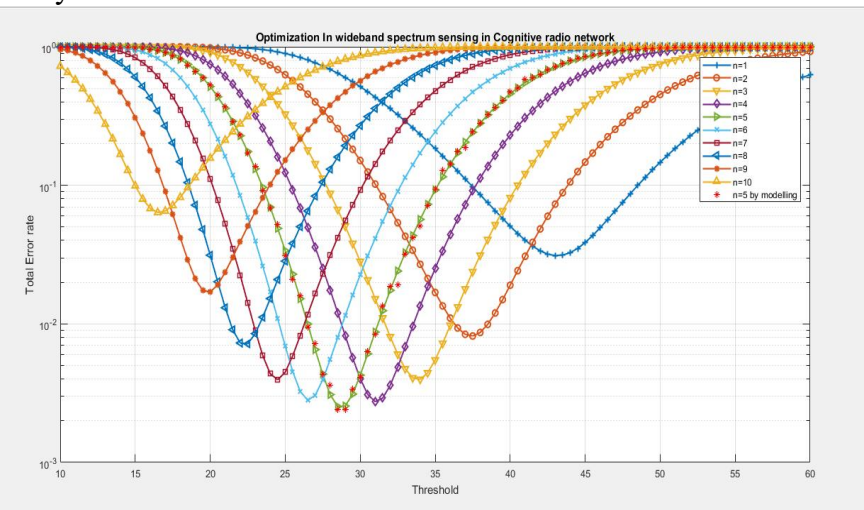
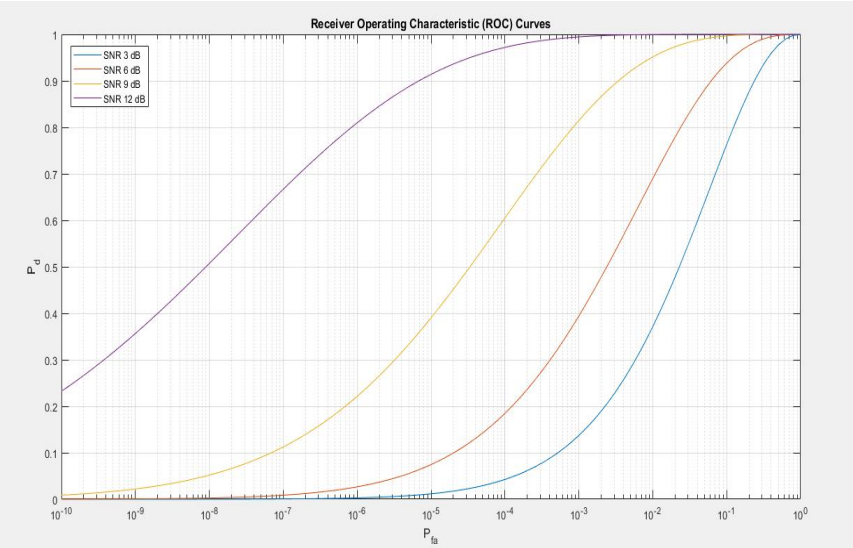


Figure : plot of total error rate vs threshold

ROC Curve for Probability of Detection vs Probability of False Alarm

The probability of False Alarm is the probability of falsely detecting the Primary Signal when the primary user is actually silent in the scanned frequency band.
Probability of Detection is the Probability that the Primary User present in the specified band is correctly detected and the band is shown to be occupied.



ROC Curve for Probability of detection vs Probability of false alarm for a fixed SNR

The graph shows the Probability of detection vs Probability of false alarm for fixed SNR values.

Signal-to-noise ratio (abbreviated SNR or *S/N*) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise.

SNR is defined as the ratio of signal power to the noise power, often expressed in decibels. A ratio higher than 1:1 (greater than 0 dB) indicates more signal than noise.

SNR=Power of signal/Power of noise

From the graph we can confer the following table :

SI no.	SNR	Probability of detection	Probability of False Alarm	False Alarm Rate	Probability of missed detection
1	3 dB	0.75	10^{-1}	1 false Alarm in every 10 samples.	0.25
2	6 dB	0.70	10^{-2}	1 false Alarm in 100 samples.	0.30

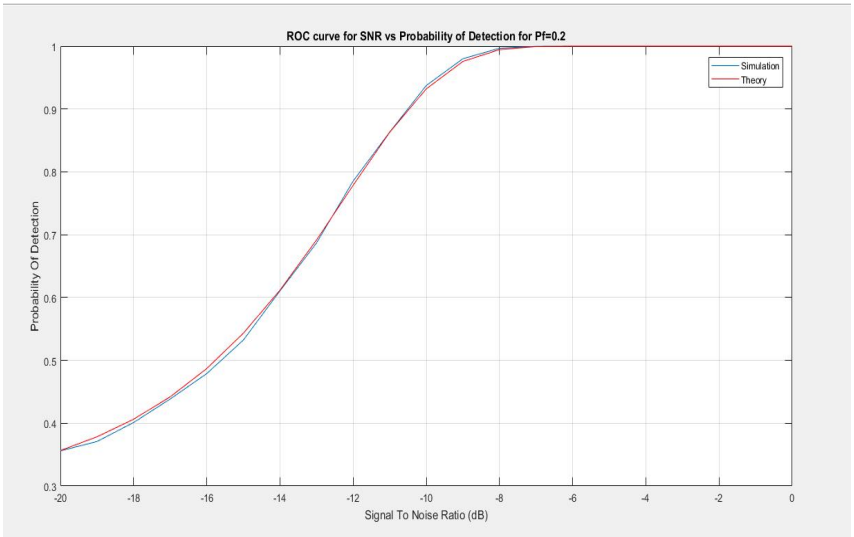
3	9 dB	0.23	10^{-6}	1 false alarm every 1000000 samples.	0.77
4	12 dB	0.24	10^{-10}	1 false alarm every 10000000000 samples.	0.76

Values obtained from the probability of detection vs probability of false alarm curve

So the false alarm and the probability of detection can be correlated and it is shown in the table.

ROC CURVE FOR SNR vs PROBABILITY OF DETECTION

Here we will plot Probability of Detection vs SNR for a constant false alarm rate. Lets assume Probability of False alarm rate= 0.20, and study the graph obtained as below.



Curve of probability of detection vs SNR for constant Probability of false alarm rate

Here we are calculating the theoretical value of Probability of Detection and then comparing it with the simulated value.

Pd_the = Q(((threshold - (snr + 1)).* $(L)^{0.5}$)./$((2)^{0.5}$ * (snr + 1)));
% probability detection theoretical value.
Where snr= signal to noise ratio.
Thresh=threshold value that is fixed based on the input energy stream

Analysis of the graph :

Probability of false alarm= 0.20

SI no.	SNR in Decibels	Probability of Detection Pd	Probability of Missed Detection
1	-4	1	0
2	-8	0.99	0.01
3	-12	0.78	0.22
4	-16	0.48	0.52

Values obtained from the probability of detection vs SNR curve

Using these graphs, the presence or the absence of Primary users can be detected.

FUTURE ENHANCEMENT

The work done in this project can be enhanced in numerous ways in the future for even better results. This can be achieved in various ways:

- Detecting the presence of Primary Users
- Accomodating Secondary licensed Users in the bands unoccupied by Primary Users
- Improving Spectral efficiency by accommodating more number of wireless users.