WIDEBAND SPECTRUM SENSING USING SUBNYQUIST TECHNIQUES FOR COGNITIVE RADIO NETWORKS

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Abstract

- Cognitive radio communications have emerged as reliable solution to underutilization problem in given radio network
- Spectrum sensing provides essential information to enable this interweave communications in which primary and secondary users aren't allowed to access medium concurrently
- In this project, we will be implementing a model that can be used to sensed 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
- The presence of Primary Users in the signal can be detected. If PU is not present then the Secondary Users (SU) will be allowed to access the spectrum band.
- In this way we will be reducing spectral wastage and improve spectral efficiencies by accommodating licensed secondary users.

Flowchart

Generation of wideband signal that contains many narrowband

MWC module. The signal is first sampled and then passed through low-pass filter

PCER module. Comparing energies of consecutive narrowband

Support Recovery Module. If noise is present in the signal then the SR module is used to determine the occupied bands. If noise absent then the SR Module is bypassed.

Finally determine if the particular narrowband is empty or occupied.If it is empty, then it can be assigned to a Secondary licensed user.

Figure 1: Flow Chart

Methodology

- MWC- Modulated Waveform Converter: The MWC first multiplies the analog signal by a bank of periodic waveforms. Then the product is low pass filtered and sampled uniformly at a low rate. The waveform period and the uniform rate can be made as low as the expected width of each band, which is orders of magnitude smaller than the Nyquist rate.
- PCER- Pairwise channel energy ratio detector : It compares the energies of the consecutive narrow bands and thus by comparing energy levels we can detect the presence of Primary Users.
- SR – Support Recovery Module : Based on the PCER hypothesis it determines the presence of Primary Users.

Block Diagram

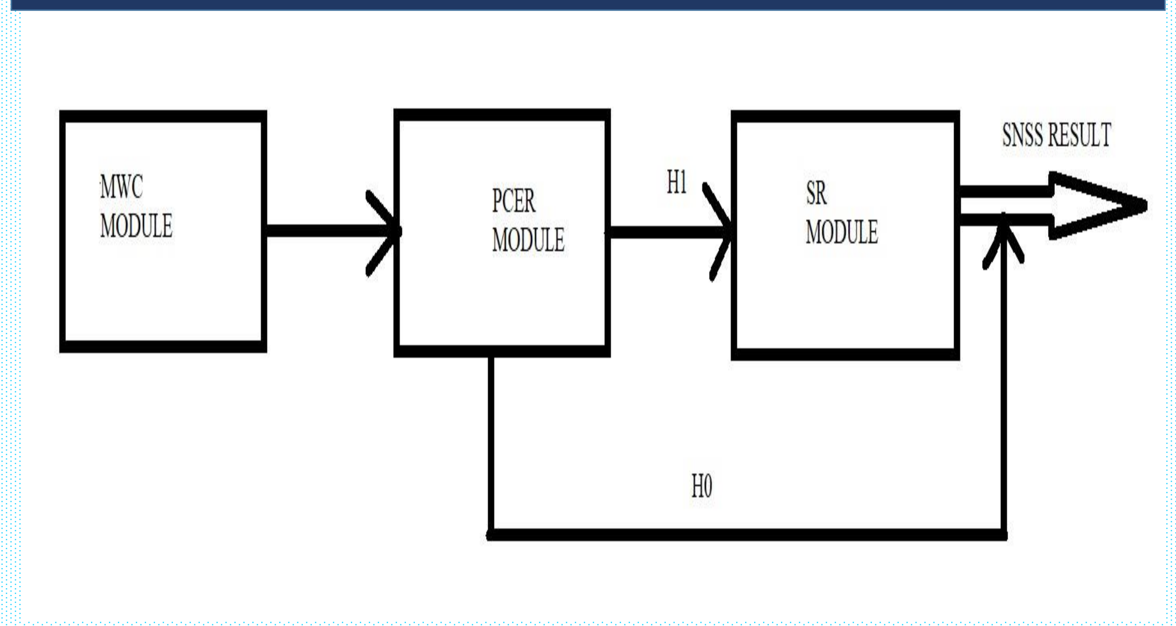


Figure 2: Subnyquist spectrum sensing Framework

Input Signal with Added Noise

- A wideband signal is created with many narrowbands
- AWGN (Additive White Gaussian Noise) is added to that signal and then the signal iis plotted against time

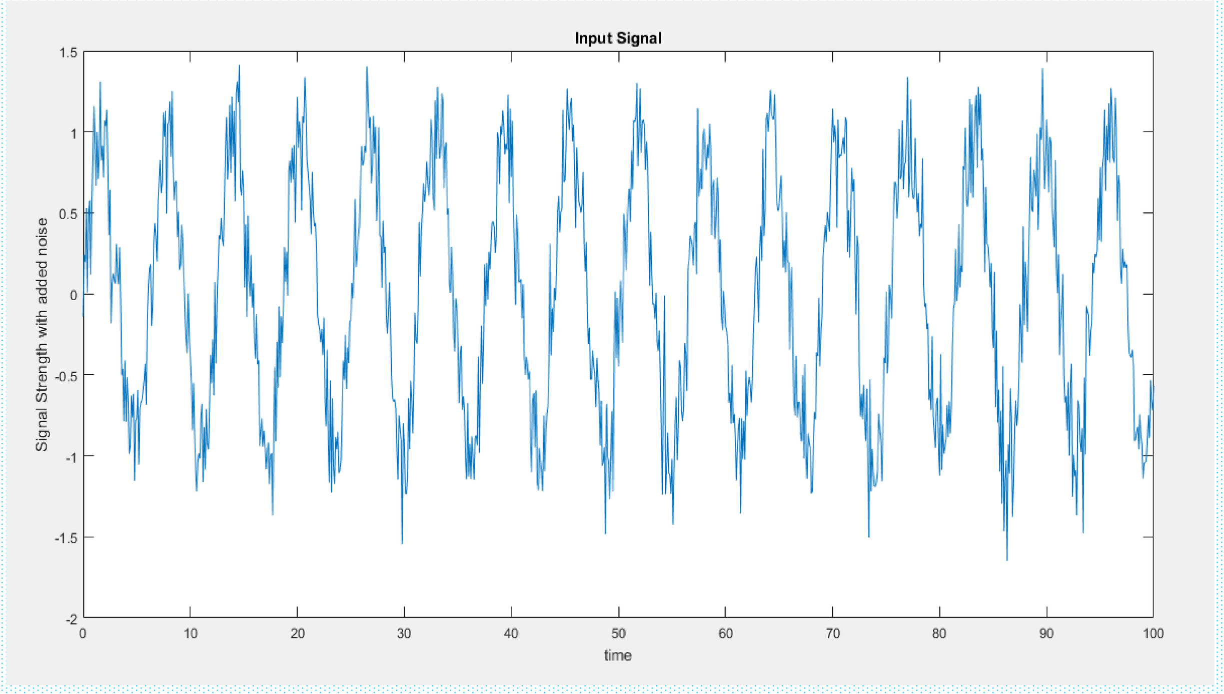


Figure 3: Signal with AWGN Noise

Realistic Constraints

- The Channel State Information is a constraint in this project
- The CSI should be known to detect the Primary Users present in the channel.

Standards Used

- GSM (IEEE 802.21)
- WiMAX (IEEE 802.16e)

Optimization Curve

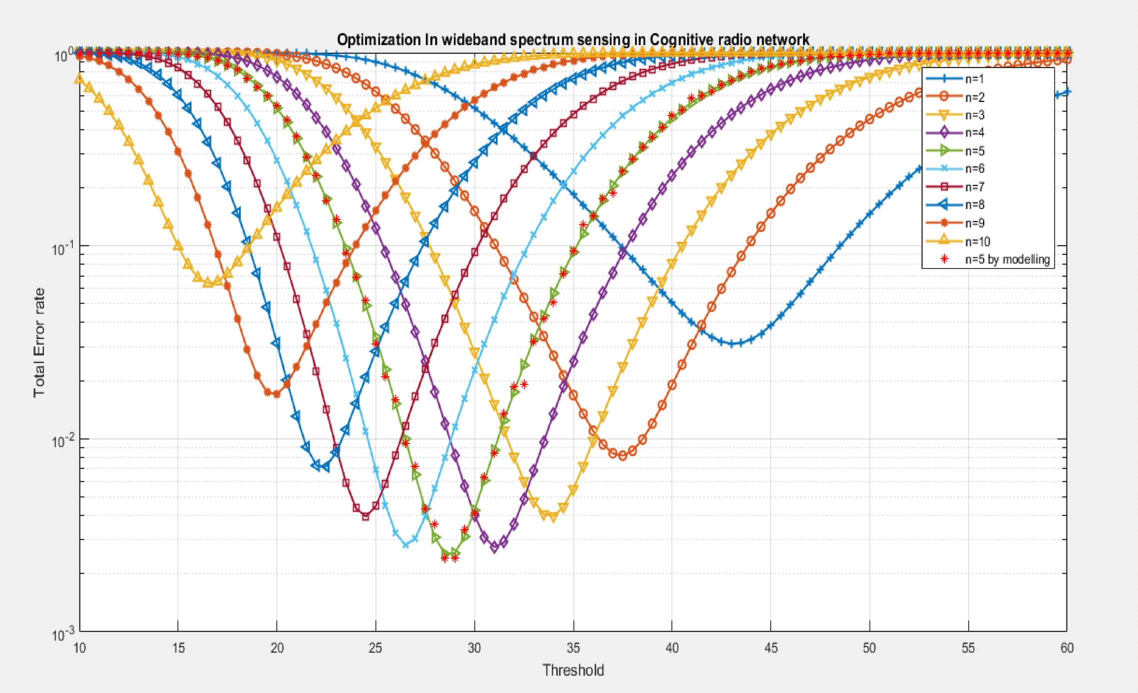


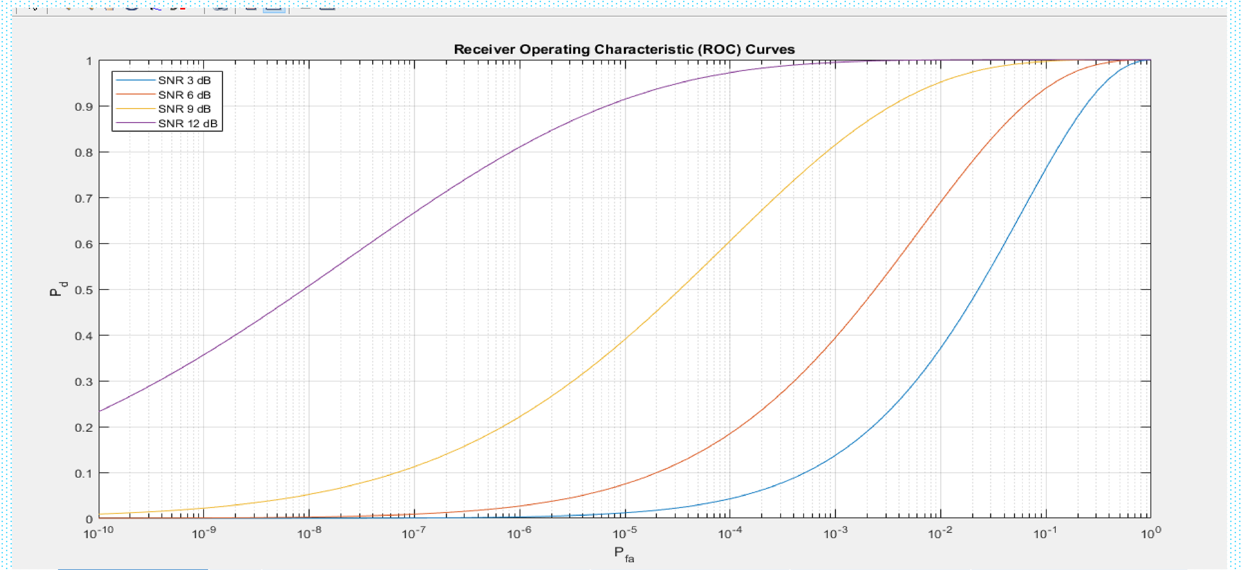
Figure 5: Bessel function showing total error rate VS threshold

- Here local spectrum sensing technique is Energy Detection and the SNR=10dB and n=10 samples are used for this spectrum sensing. From figure 5 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.

Multidisciplinary Components

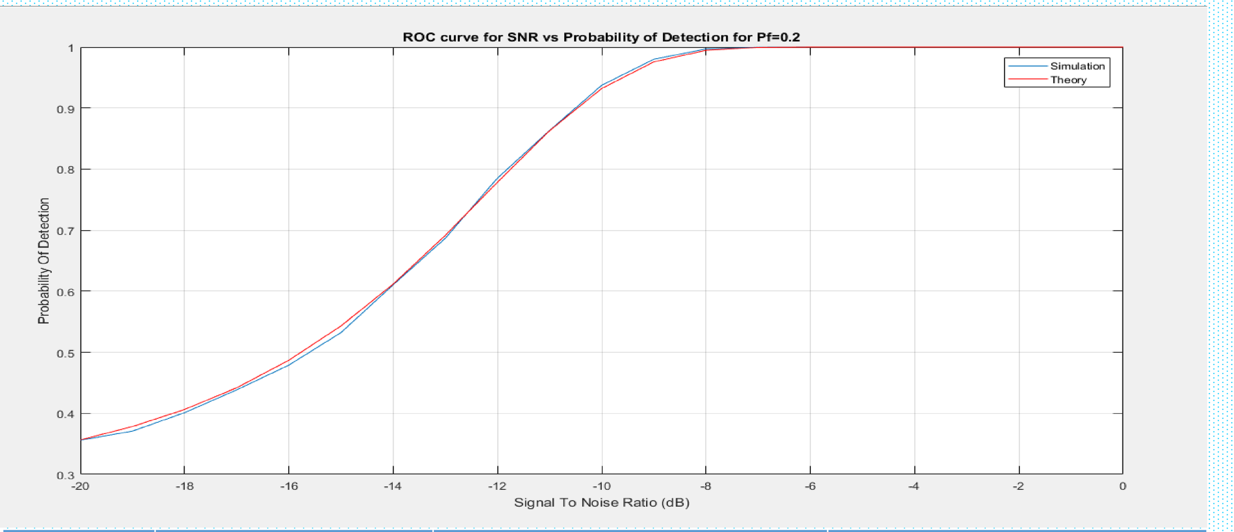
MATLAB Version R2017a

Results/Analysis



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

Figure 6: ROC curve for probability of detection VS probability of False alarm



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

Figure 7: ROC curve for SNR VS Probability of Detection

Future Directions

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 Users
- Improving Spectral efficiency by accommodating more number of wireless users.

References

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2.) Z. Tian and G. B. Giannakis, "Compressed Sensing for Wideband Cognitive Radios," in 2007 IEEE International Conference on Acoustics, Speech and Signal Processing – ICASSP '07, vol. 4, April 2007, pp. IV– 1357–IV–1360.
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