An Enhancement In QOS By Using Modified SVD algorithm For Spectrum Sensing In Cognitive Radio

Sumit Karedia[1], Er Deepak Pancholi[2]
[1]Dept ECE
[2]Asst. Professor, Dept ECE
[1, 2]Lakshmi Narain College of Technology (LNCT), Indore

Abstract- *Wireless communication is backbone of communication in today world, due to rapid development in wireless technology result a huge demand for radio spectrum resources. As we know, radio spectrdum is limited resources which is controlled by and the recognized authorities, such as the federal communications commission (FCC) in the US. Congitive radio is one of best solution which allows a group of users to identify & access to available spectrum resources for their optimum use. In this paper we work on the Singular Value Decomposition algorithm. The proposed detection method overcomes the drawback of other detection method and also, there will not require to know about noise parameter such as noise variance & other. Eigen ratio and Threshold is computed using random matrix theory (RMT) is exploited to formulate the detection method depending on sample covariance matrix of received signal. Simulation Result shows that SVD algorithm using Hankel matrix approach gives 0.067 to 0.103 better performance of detection at low SNR.*

Keywords- Spectrum Sensing, SVD, Hankel Matrix, Cognitve Radio, RMT,Probability of detection, probability of false alarm.

I. INTRODUCTION

Wireless communication is a hot growing topic for research works to the communication for ECE and computer engineers. Wireless devices are getting popularity everyday. It become a backbone of communication. As the demand for EMT Spectrum also increases day by day. As we know very well, the ways of availability of EMT Spectrum is Very complex and costly. As the outcome, availability of spectrum and its appropriate and proper use has been a major problem across the Globe. Allocation of frequencies are control by various agencies. Agencies such as International Telecommunication Union (ITU) [1][2] and other International agencies allocate spectrum frequencies to various countries for their use. Secondly, within each country the respective government allocates frequencies to various agencies for various purposes. A lot of costs are required at every stage of allocation and availability of electromagnetic Spectrum. Now, the main thing amoung all is that the most precious and valuable spectrum remail unutillized. As per Federal Communications Commission (FCC) survey report in the united states show that only 30% of the alloted spectrum are properly utilized, Office of Communication (Ofcom) of the United Kingdom [3] also involve in these survey.

Communication device such as traditional radio system capable to handle only fixed number of channels and multiple frequencies but the main problem exist as frequency and channel must be chosen at the time of design not at later stage because it is based on hardware there is no mechanish to bring andy post design adjustment at the time of actual requirement. To overcome these problem a comparatively new radio named as Software Defined radio is introduce[4]. The design based on traditional radio system but so many changes to its design. In SDR the physical layer behviour and various functionality are defined in software[5][6]. It is an enhancement version of traditional radio but it is not completely free fault. It mens it does not have its own intelligence so it can not take any kind of decision its own. Manully you have to input parameter using software. To make it intelligent, Cognitive radio is introduced. It has its own intelligence and it can take down decision. It remove the limitation if sdr. It introduce a new approch and solutionf or spectrum underutilization problem.

Cognitive radio is capable to sense the surrounding environment and contineously try to search electromagnetic spectrum that is not utilized to its optimum capicity. Ones it find the range of frequencies correspond to the EMT. Cognitive radio will utilize these in proper manner by allowing the secondary user to utilize it in the vaccum slots.

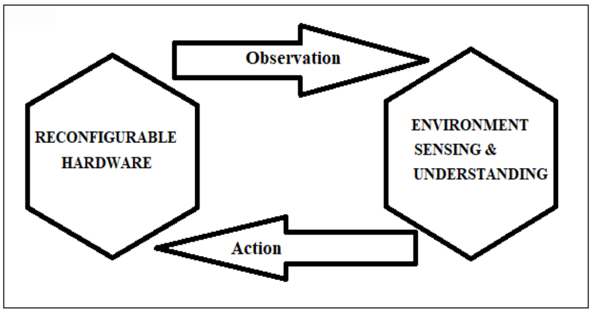

Figure 1: Sensing the environment & make required changes

Cognitive Radio is fully reconfigurable[8] and it defined by software. Software is used to in Cognitive radio to implement all the logics. It can able to change its behaviour and requirement based in the information sensed by CR. It can be done through software instructions as well as physical changes[8][9]. CR hardware support reconfigurability. Different reconfigurable hardwares are easily available in the market for commercial use like FPGA3 and ASIC2.IEEE 802.22 working Group was formed in 2004 [9]. IEEE 802.22 standard is known as Cognitive radio standard, because it contains cognitive features. Cognitive radio network provide high bandwidth to mobile user via dynamic spectrum access techniques and heterogeneous wireless architecture. The goal can dbe achieve throw efficient spectrum management techniques, impose unique challenges dute to high fluctuation in the available spectrum, and also all the diverse quality of servic(QoS) need to various application.

In order to address these challenges, every Cognitive radio user int CRN must have :

- Determine which portions of the spectrum are available
- Select the best available channel
- Coordinate access to this channel with other users
- Vacate the channel when licensed user is detected [10]

This paper is organized as follows. Section I has been used as introduction. In section II we discussed different related work for spectrum sensing in Cognitive Radio. In section III System model In section IV complexity analysis of these methods were done also resut. Section V concludes the paper.

II. RELATED WORK

The concept of software defined radios (SDRs) firstly, introduced by Joseph Mitola [5] In early 1990s,. Software Defined Radio is used to minimize hardware requirements; it gives user a cheaper and reliable solution also remove the limitation of traditional radio. In, 2000 . Mitola introduce the concept of CR. As the CR is the new version of SDR and later, he investigated the concept of dynamic spectrum sensing [7]. . In particular, need for antennas that can make a cognitive radio (CR) system work with other devices across multi-bands, multi-standards or multi-channels was also described. Since these new devices must both learn and adapt to their RF environment for the purpose of establishing seamless communication with other RF devices according the need. That defined characteristics of the cognitive radio as :

a) apability
b) Reconfigurability[9]

Cognitive radio can able to utilise spectrum these new approach for efficient utilization of electromagnetic spectrum concept is given by S. Haykins [11].

In 2015, Min Jia, Xue Wang, Fang Ben, Qing Guo and Xuemai Gu developed the concept of Energy detection and Covariance Detection [14][15], proposed a new method (An improved spectrum sensing algorithm) which overcome the limitation of both method and give better performance in term of probability of detection at low SNR as well as improved method result as comparing to detection result of each method. So we can say that the proposed method find the balance point with computation complexity and detection performance at same time, this introduce more reliability in detect results. The concept Eigen value is use for spectrum sensing in CR is first proposed by Y. Zeng and Y.-C. Liang in 2007, in method the ratio of Maximum-minimum eigenvalue is used for detection [16][17] further more implementation in 2009, concept of maximum eigenvalue for spectrum sensing in CR [18]. Basically, in this method the correlation among the received signal is catches by the covariance matrix. Result show performance of MED is better than energy detection for correlated signals. To set the threshold and obtain the probability of false alarm Random matrix theorise is used. They performed verification and simulation of this technique by use of wireless microphone signal and independent and identically distributed signal. Singular value decomposition (SVD) method is used to detect the presence of wireless signal this concept is implement by Mohd. Hasbullah Omar, Suhaidi Hassan, Angela Amphawan, and Shahrudin Awang Nor in 2011 [19][20]. SVD method is used to find maximum and minimum eigenvalues. On comparing with ED, it gives the better result in low SNR. CR must avoid the interference from primary user and any other signal. SVD of data matrix is help to obtain dominant singular values in which the existence of other signal can also be detected.

III. SYSTEM MODEL

Spectrum sensing is one of the most useful processes performed by cognitive radio systems. It give permission to the Second Users to learn about and sens the radio environment by detecting the existance of the licence users signals by using using one or multiple techniques and decide to transmit or not in its frequency band [5].

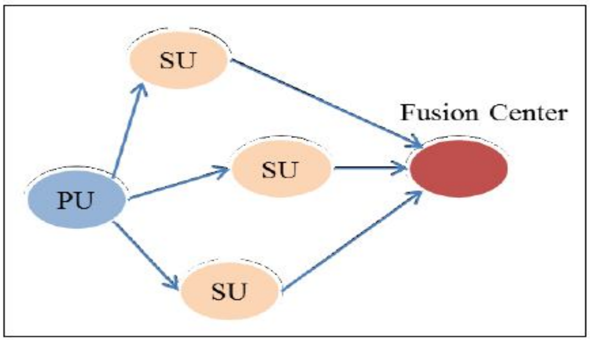

Figure 2: Spectrum sensing Module

For system model, We consider a system of one cognitive radio (CR), one primary user (PU) and fusion center (FC).When a signal from PU is transmitted, the received signal by the CR for the detection of PU can be modeled under two hypotheses (H0 & H1), is gives as follows

The two hypotheses are given respectively by formula as follows:

H_0: y(*k*) = n(k) : PU is Absent (3.1)
H_1: y(*k*) = h*s(*k*) + n(k) : PU is Present (3.2)

Where y(k) the received signal by secondary users is ,s(k) is the transmitted signal of the primary user, h is the channel coefficient and n(k) is AWGN with zero mean and σ2 variance (i.e. N (0,σ2)).The output is considered as the test statistic to test the two hypotheses H0 and H1 [13].

- H_0: corresponds to the absence of the signal and presence of only noise.
- H_1: corresponds to the presence of both signal and noise

We can define three possible cases for the detected signal:

1) H1 turns out to be TRUE in case of presence of primary user i.e. P (H_1 / H_1) is known as Probability of Detection (Pd).
2) H0 turns out to be TRUE in case of presence of primary user i.e. P (H_0 / H_1) is known as Probability of Missed-Detection (Pm)
3) H1 turns out to be TRUE in case of absence of primary user i.e. P (H_1 / H_0) is known as Probability of False Alarm (Pf).

The PU signal detection is performed using one of the spectrum sensing techniques to decide between the two hypotheses *H0* and *H1*.

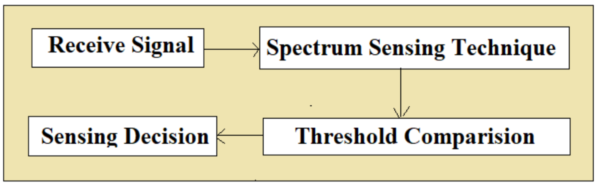

Figure 3: General model of spectrum sensing.

The detector output, also called thetest statistic, is then compared to a threshold in order to make the sensing decision about the PU signal presence. The sensing decision is performed as:

$$\text{if } T \geq \gamma, H_1 \quad (3.3)$$
$$\text{if } T < \gamma, H_0 \quad (3.4)$$

where T denotes the test statistic of the detector and γ denotes the sensing threshold. If the PU signalis absent, SU can access to the PU channel. Otherwise, it cannot access to that channel at that time.Figure 4 presents the general model of the spectrum sensing.

III. METHODOLOGY

The Modified SVD technique is used as he samples of received signal comes from system interference to build Hankel matrix or the covariance matrix, the Eigenvalue is matrix are calculated by using a specific algorithm to make the ratio of maximum to minimum, and also threshold computation is based on user interface and comparator give the output in the term of hypothesis test.

The received signal at receiver can be given as:

$$x(n) = \sum_{k=0}^{N} h(k)s_j(n-k) + \eta(n)$$

At receiver the discrete signal denoted by $x(n)$, s(n) is the source signal, $h(k)$ is channel response and order of the channel is N.η(n) are the noise samples.
Considering a subsample L of consecutive outputs are as follow

$$X(n) = [x(n), x(n-1), \ldots\ldots, x(n-L+1)]^T \quad (4.1)$$
$$\eta(n) = [\eta(n), \eta(n-1), \ldots\ldots, \eta(n-L+1)]^T \quad (4.2)$$
$$S(n) = [s(n), sx(n-1), \ldots\ldots, s(n-L+1)]^T \quad (4.3)$$

As we get,

$$X(n) = H\,S(n) + \eta(n) \quad (4.4)$$

Where H is matrix of row L and column is N+L.

$$H = \begin{bmatrix} h(o) & \cdots & h(N) & \cdots & 0 \\ \vdots & \ddots & & \ddots & \\ 0 & \cdots & h(0) & \cdots & h(N) \end{bmatrix} \quad (4.5)$$

The following assumption is to be assumed on the basis of statistical properties of transmitted symbols a channel noise

1) Noise is white
2) transmitted signal and Noise are uncorrelated

As $R_x(N_s)$ is the sample covariance matrix of the received signal

$$R_x(N_s) = \frac{1}{N_s}\sum_{n=L-1}^{L-2+N_s} \hat{x}(n)\hat{x}^{\dagger H}(n) \quad (4.6)$$

Where L is the smoothing factor, N_s is the number of samples Factorization of matrix is the help of singular value decomposition; SVD determines original data in a coordinate system in which covariance matrix is diagonal. In SVD, Q can be factorized as

$$Q = U \sum V^T \quad (4.7)$$

Where

$$U^T U = I_{M\times M} \quad (4.8)$$

$$VV^H = I_{L\times L} \quad (4.9)$$

Therefore, U and V is orthogonal matrix. As U and V are M×M and L×L unitary matrix, as M is the N-L+1. U is left singular vector for Q and column matrix V is right singular vector for Q. ∑ is the rectangular matrix with same dimension. ∑ is the diagonal matrix whose non negative entries are the square root of positive Eigenvalues of QQ^T.

IV. THRESHOLD DETERMINATION

The detection threshold in terms of desired probability of false alarm is calculated by using the results of the theorem in [22] and [23], as follows (in our case, M = l)

$$\gamma = ((\sqrt{N_s}+\sqrt{L})^2/(\sqrt{N_s}+\sqrt{L})^2) \times \left(1 + \frac{(\sqrt{N_s}+\sqrt{L})^{\frac{2}{3}}}{(N_s L)} \cdot F_1^{-1}(1-P_f)\right)$$

Where

N_s	=	Number of Samples
L	=	Smoothing factor
P_f	=	Probability of false alarm
P_d	=	Probability of detection
γ	=	Threshold value

F^{-1} Represent the inverse of cumulative distribution function (CDF) of Tracy widom distribution of order 1. Tracy widom distribution is Probability distribution function of the largest Eigenvalues of random Hermitian matrix.

V. ALGORITHM

Algorithm for Modified SVD are as follow :

1) Initialization of Parameter which include Number of samples (N), Smoothing factor (L) and Probability of false alarm (Pf).
2) Construct Covariance matrix, Q given in equation (4.7).
3) Decomposition of matrix, as given in equation (4.9), by using Singular Value Decomposition (SVD), to form equation Q = U ∑VT.
4) After decomposition, Obtain Maximum and minimum Eigenvalue of matrix as represent as λ_{max} and λ_{min}.
5) Compute threshold value, γ by using equation (4.10)
6) Calculate the ratio of maximum Eigenvalue to minimum Eigenvalue and compare it with the threshold. If $(\lambda_{\_max})/(\lambda_{\_min}) > \gamma$ it means primary signal is present otherwise the signal is absent.

VI. RESULT

All Simulation was done on MATLAB version R2016aThe results are averaged over minimum 1500 test using Monte-Carlo Simulation. Simulation results are taken using BPSK modulated random primary signal. Independent and identically distributed noise samples with Gaussian distribution are used.We use complementary receiver operating characteristic (ROC) for analysis performance analysis of energy detection technique.

Table 1: Specification of Parameter

Parameter	Values
Bandwidth	1e6
Sample Time	1e-5
SNR	-5,-10,-20,-30
Modulation	BPSK
Noise Variance	0.4
Replica of Signal	4

The Figure shows, the receiver operating characteristic (ROC), (Pd versus Pf) curve for different value of SNR (SNR=-5dB, SNR=-10dB, SNR=-20dB & SNR=-30dB), Specification of parameter are in Table 1.

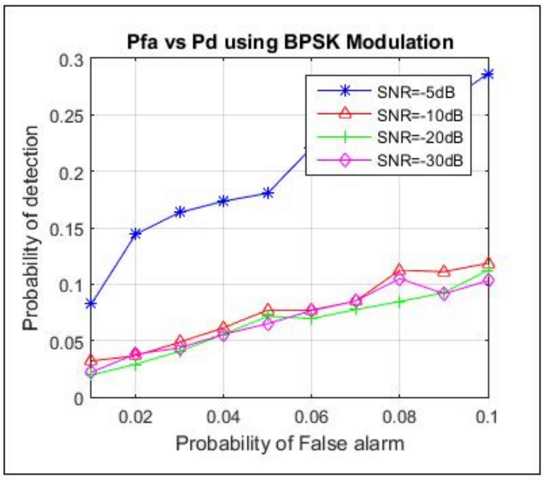

Figure 4: ROC at different value of SNR

So by analyzing of figure 4, it clears that varying the value of SNR as shown in figure SNR value at -5dB give the best result as it will give better probability of detection.

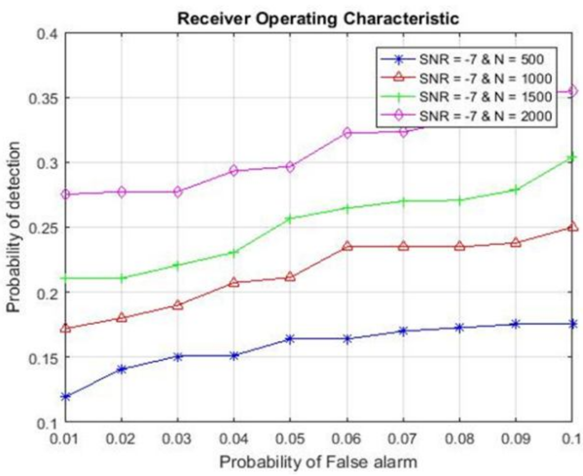

Figure 5 : ROC at different value of SNR& No. of Sample

Figure 5 depicts Receiver operating characteristic (ROC) curve of SVD method with Probability of detection versus Probability of false alarm at different Number of Samples (N =500, N =1000, N =1500 & N =2000), For Smoothing factor = 16, Signal to noise ratio = -10dB. that the values probability of detection at 2000. samples is approximately 0.132 to 0.178 greater than the probability of detection at 500 samples at different points. The values P_d at 2000 samples is approximately 0.854 to 0.114 greater than the P_d at 1000 samples at different points.From ROC, it is clear that P_d values is higher at 2000 samples as compare to varying numbers of samples in decreasing order having a difference of 500 (500, 1000, 1500) which proves good performance of SVD method at higher number of samples.

VII. CONCLUSION

Spectrum is a very precious resource and backbone in wireless communication systems but it become a limited due to increase in huge demand of radio spectrum day by day and licensed bands are used inefficiently. So it has become a center point for research and development that how we can efficient utilize spectrum band. In our work, We use Software Tool MATLAB 2015a for Simulation Various ROC (Receiver Operating Characteristics) curves i.e. plot of Pd versus Pf has been plotted over different value of SNR values.

In our work. Good performance SVD method at higher number of samples and also, the good performance of SVD method at higher SNR. The brief simulated result show that SVD algorithm using Hankel matrix approach gives 0.067 to 0.103 better performance of detection at low.

REFERENCE

[1] The International Telecommunication Unionhttp://www.itu.int.
[2] Federal Communication commission http://www.fcc.gov.
[3] Office of the Communication http://www.ofcom.org.uk
[4] Mitola J., III; Maguire, G. Q., Jr., “Cognitive Radio: making software radios more personal,” Personal Communications, IEEE, vol.6, no 4 pp. 13 – 18, Aug 1999.
[5] J. Mitola III, “Cognitive Radio: An Integrated Agent Architecture for Software Defined Radio”. PhD Dissertation, Royal Institute of Technology (KTH), Sweden, May 2000.
[6] FCC ET Docket No. 03-108, “Facilitating Opportunities for Flexible, Efficient and Reliable Spectrum Use Employing Cognitive Radio Technologies”, December 2003.

[7] S. haykin, “Cognitive Radio: brain-empowered wireless communication,” IEEE J. Select Areas Communication, Vol: 23, No:2, Feb. 2005.
[8] Q. Zhang, A B J Kokkeler and G. J. M. Smit, “A Reconfigurable Radio architecture for Cognitive Radio in Emergency Networks”, September 2006, Manchester U K.
[9] Q Zhang, G J M smit, L T Smit, A Kokkeler, F W Hoeksema, M Heskmp “A Reconfigurable Platform for Cognitive Radio”.
[10] John G. Proakis and Masoud Salehi, Digital Communication, McGraw-Hill, New York, Fifth Edition, 2001.
[11] S. Haykin, “Cognitive Radio: brain-empowered wireless communications,” IEEE Journal on Selected Areas in Communications, Volume 23, Issue 2, February 2005, pp.201– 220.
[12] D.D. Ariananda, M.K.Lakshmanan, H. Nikookar, “A survey on spectrim sensing techniques for Cognotive radio”, IEEE, International Research center for Telecommuniaction and radar, 2009.
[13] Ankit Dobariaa, Sagar Sodhatarb "A Literature Survey on Efficient Spectrum Utilization: Cognitive Radio Technology" International Journal of Innovative and Emerging Research in Engineering, Volume 2, Issue 1, 2015.
[14] F. F. Digham, M. S Alouini and M.K Simon, “On the energy detection of unknown signals over fading channels”, Proc. IEEE International Conference on Communication (ICC003), pp. 3575-3579, May 2003.
[15] Urkowitz, H. 1967. Energy detection of unknown deterministic signals, Proceedings of the IEEE 55(4): 523 - 531.
[16] Y. Zeng and Y.-C. Liang, "Covariance based signal detections for cognitive radio, " in Proc. IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks, Dublin, Ireland, Apr. 2007, pp. 202-207
[17] Y. Zeng, Choo Leng Koh, and Y. Liang, "Maximum eigenvalue detection: theory and application," IEEE International Conference on Communications, Beijing, 2008, pp. 4160-4164.
[18] Syed Sajjad Ali, Chang Liu, Minglu Jin, ―Minimum Eigenvalue Detection for Spectrum Sensing in Cognitive Radio‖, International Journal of Electrical and Computer Engineering (IJECE), Vol. 4, No. 4, August 2014, pp. 623~630.
[19] Mohd. Hasbullah Omar, Suhaidi Hassan, Angela Amphawan and Shahrudin Awang Nor, “SVD-Based Signal Detector for Cognitive Radio Networks”, in Proceedings of 2011 UK Sim 13th International Conference on Modelling and Simulation, University of Cambridge (Emmanuel College), United Kingdom, 30 March - 1 April 2011, pp. 513 – 517
[20] Z. Han, R. Fan, and H. Jiang, “Replacement of spectrum sensing in cognitive radio," Wireless Communications, IEEE Transactions on, vol. 8, no. 6, pp. 2819-2826, 2009.