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An Optimised SVD with ABC for Spectrum Sensing in Cognitive Radio

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Abstract –**The aim of this study is to focus on spectrum sensing in cognitive radio which is a recently introduced technology in order to increase the spectrum efficiency. We studied the Singular value decomposition based signal detector and its advantages over the energy based signal detection. Soft thresholding technique for spectrum sensing is optimized using Ant Bee Colony algorithm. Results shows that ABC outperforms then SVD based signal detector to improve its performance, especially under low SNR simulation.**

Keywords – **Ant Bee Colony Algorithm, Cognitive Radio, SNR, Spectrum Sensing, SVD.**

I. Introduction

The requirement for higher data rates is growing as an effect of evolution from voice to multimedia transmission. Since the spectrum is scarce and static frequency allocation schemes cannot fulfil the demand of increasing number of high data rate devices. Hence innovative concepts which can offer new ways to utilize the available spectrum are needed. Cognitive radio has emerged as tempting solution of the aforementioned problem which allows opportunistic usage of frequency bands that are not occupied by the licensed users [1]. Cognitive Radios use the radio spectrum owned by other users. They perform radio environment examination, identify the unutilized bands and assigns these spectrum holes to unlicensed secondary users ([2] [3]). In cognitive radio terminology Primary user refers to a user who is allocated the rights to use the spectrum. Secondary user refers to the users who try to use the frequency bands allocated to the primary user when the primary user is not using it. Spectrum Sensing, an essential component of the Cognitive Radio technology involves,

- Identifying spectrum holes (white space) and,
- When an identified spectrum hole is being used by the secondary users, to quickly detect the onset of primary transmission.

Cognitive radio extends the software radio with radio-domain model-based reasoning about radio etiquettes. Radio etiquette is the set of RF bands, air interfaces, protocols, and spatial and temporal patterns that moderate the use of the radio spectrum [1]. Software radios are emerging as platforms for multiband multimode personal communications systems. It also provides an ideal platform for the realization of cognitive radio. Cognitive radio is a novel approach for improving the utilization of a precious natural resource: the radio electromagnetic spectrum [2]. The cognitive radio, built on a software-defined radio, is defined as an intelligent wireless communication system that is aware of its environment and uses the methodology of understanding-by-building to learn from the environment and adapt to statistical variations in the input stimuli, with two primary objectives in mind: highly reliable communication whenever and wherever needed; efficient utilization of the radio spectrum. The spectrum sensing problem has gained new aspects with cognitive radio and opportunistic spectrum access concepts.

Spectrum sensing is one of the most challenging issues in cognitive radio systems. There are various spectrum sensing methods for cognitive radio such as, Energy detection, Eigenvalue based detection, Feature based detection, Cyclostationarity-based detection, and SVD based detection. Discussions about the above techniques and algorithms can be found in [3], [4].Energy based detection method is a classical method of detection but it requires knowledge of noise power for signal detection and it gives poor performance under low SNR. Eigenvalue based detection method achieve both high probability of detection and low probability of false alarm with minimal knowledge of primary signal, [5]. The SVD based detection method is quite similar to Eigenvalue decomposition method. Among them SVD is very general that it can applied to any m×n matrix, while Eigenvalue decomposition method can only be applied to certain classes of square matrix. SVD has got several advantages compared to other decomposition methods [6] as it is more robust to numerical error; it exposes the geometric structure of a matrix an important aspect of many calculations.

II. Proposed SVD Algorithm

SVD plays an important role in signal processing and statistics, particularly in the area of a linear system. For a time series $y(n)$ with $n = 1, 2 . . . N$,

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commonly, we can construct a Henkel matrix with M = N -L+1 row and L columns as follows:

$$R = \begin{bmatrix} y(1) & y(2) & & y(L) \\ y(2) & y(3) & \cdots & y(L+1) \\ \vdots & \vdots & & \vdots \\ y(N-L+1) & y(N-L+2) & & y(N) \end{bmatrix} \quad (1)$$

Then R is an M × L matrix. Its elements can be found by substituting of y (n)
R_{ml} = y (m+l-1), m = 1, 2…M and l = 1, 2…L Using SVD, R can be factorized as:

$$R = U\Sigma V^H \quad (2)$$

U and V is an M × M and L × L unitary matrix, respectively. The columns of U and V are called left and right singular vectors, respectively. The Σ = diag $(\lambda_1, \lambda_2 \ldots \lambda_m)$ is a diagonal matrix whose nonnegative entries are the square roots of the positive eigenvalue of $R^H R$ or RR^H. These nonnegative entries are called the singular values of R and they are arranged in a decreasing manner with the largest number in the upper left-hand corner of the matrix. The $[\,]^H$ denotes the Hermitian transpose of a matrix.

Whenever no primary signal or other signal is present, the received signal y (n) includes only AWGN contribution such that its singular values are similar and close to zero. When other signals are active whose power is higher than a threshold, there will exist several dominant singular values to represent these signals. As a result, the signal can be detected by examining the presence of dominant singular values [7].

Threshold Determination

Decision threshold and probability of false alarm are derived based on limiting distribution of eigenvalues based on random matrix theory. The decision statistic for the maximum minimum eigenvalue (MME) detection is defined as the ratio of maximum to minimum eigenvalues of received signal covariance matrix as follows:

$$T_Y = \lambda_{max}/\lambda_{min}$$

Based on decision statistic as in the above equation, the detection threshold, g, must be estimated for a required probability of false alarm. To define the threshold in terms of P_{fa} or vice versa, the density of the test statistic, T_Y, is required. The density can be found asymptotically i.e. both the threshold values and the probabilities of detection and false alarm are derived based on asymptotical (limiting) distributions of eigenvalues that is mathematically tractable and less complicated.

An asymptotic formula of signal detection threshold in term of desired probability of false alarm for MME has been proposed in. The detection threshold in terms of desired probability of false alarm is calculated by using the results of the theorem in and, as follows (in our case, M = 1):

$$\gamma_{mme} = \left((\sqrt{N_s} + \sqrt{L})^2/(\sqrt{N_s} + \sqrt{L})^2\right) \times \left(1 + \frac{(\sqrt{N_s}+\sqrt{L})^{\frac{2}{3}}}{(N_s L)} . F_1^{-1}(1 - P_{fa})\right) \quad (3)$$

Where F_1^{-1} 1 denotes the inverse of cumulative distribution function (CDF) of the Tracy-Widom distribution of order 1.

The threshold definition is formulated based on deterministic asymptotic values of the minimum and maximum eigenvalues of the covariance matrix, R, when the number of samples, Ns is very large. As shown in the equation, it is defined only in terms of number of samples, N_s, level of covariance matrix, L and the desired probability of false alarm, P_{fa}.

Pseudo code of the ABC Algorithm

1. Initialize the population of solutions x_{ij}
2. Evaluate the population
3. Cycle=1
4. Repeat
5. Produce new solutions (food source positions) v_{ij} in the neighbourhood of x_{ij} for the employed bees and evaluate them.
6. Put on the greedy selection process between xi and v_i
7. Compute the probability values Pi for the solutions xi by means of their fitness values. In order to calculate the fitness values of solutions

$$\begin{bmatrix} \frac{1}{1+f_i} & if\ f_i \geq 0 \\ 1 + abs(f_i) & if\ f_i < 0 \end{bmatrix} \quad (4)$$

   Normalize p_i values into [0, 1]
8. Produce the new solutions (new positions) v_i for the onlookers from the solutions x_i, selected depending on p_i, and evaluate them
9. Put on the greedy selection process for the onlookers between x_i and v_i
10. Determine the abandoned solution (source), if exists, and replace it with a new randomly produced solution xi for the scout using the equation

$$x_{ij} = min_j + rand(0,1) * (max_j - min_j) \quad (5)$$

11. Memorize the best food source position (solution) achieved so far
12. cycle=cycle+1

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13. Until cycle= Maximum Cycle Number (MCN)

Optimization with SFLA Algorithm

1. Optimize the value of L by ABC and SFLA.
2. Factorized the covariance matrix.
3. Obtain the maximum and minimum eigenvalue of the covariance matrix which are $\lambda_{\max}$ and $\lambda_{\min}$.
4. Compute threshold valueγ. The threshold value determination will be highlighted in the next section.
5. Compare the ratio with the threshold. If $\lambda_{\max}/\lambda_{\min} > \gamma$, the signal is present, otherwise, the signal is not present.

III. Simulation And Results

Simulation Parameters:
Modulation Scheme:- MPSK:M=8
Signals:-

1. Rectangular Pulse
2. Raised cosine
3. Root Raised cosine

SNR Range: - -16 to -4 db
P_{fa}:- 0.01-0.1
Environment: - AWGN.

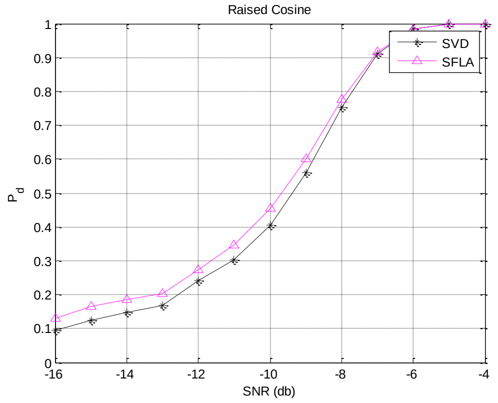

Fig. 1: simulation result of SVD and Shuffled Frog Leaping for Raised cosine pulse

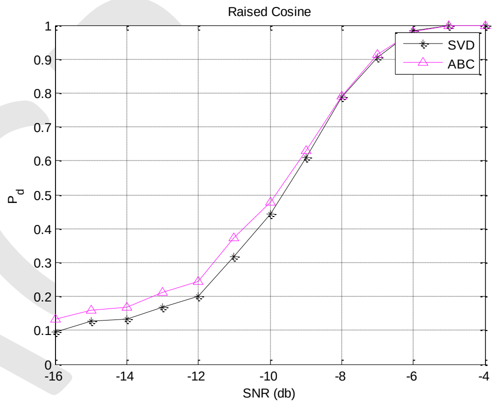

Fig. 2. Simulation result of SVD and ABC for Raised cosine pulse

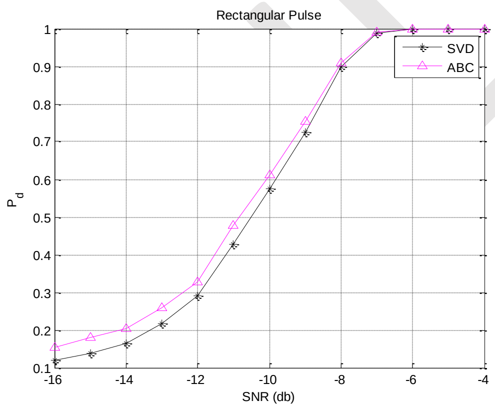

Fig. 5: Simulation result of SVD and ABC for Rectangular pulse

IV. Conclusion

Spectrum is a very valuable resource in wireless communication systems, and it has been a focal point for research and development efforts over the last several decades. Cognitive radio, which is one of the efforts to utilize the available spectrum more efficiently through opportunistic spectrum usage, has become an exciting and promising concept. One of the important elements of cognitive radio is sensing the available spectrum opportunities. In this paper, we implemented an ABC-SVD-based approach to detect common signals in today's digital communication system. As expected genetic algorithm has shown its effectiveness on the entire work. The simulation results show the impact of ABC on the SVD based method. The detection probability is improved in low SNR zone of simulation which conclude itself that the implementation of this work in reality may make the system more reliable and effective.

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REFERENCE

[1] Farrukh Aziz Bhatti, Gerard B. Rowe and Kevin W. "Spectrum Sensing using Principal Component Analysis", ISSN : 1525-3511, IEEE, 1-4 April 2012.
[2] Tanuja Satish Dhope (Shendkar), Dina Simunic, "Performance Analysis of Covariance Based Detection in Cognitive Radio", Print ISBN: 978-1-4673-2577-6, IEEE, 21-25 May 2012.
[3] Mohd. Hasbullah Omar, Suhaidi Hassan, Angela Amphawan, and Shahrudin Awang Nor, "SVD-Based Signal Detector for Cognitive Radio Networks", E-ISBN : 978-0-7695-4376-5, IEEE, 2011.
[4] Laiti Apoorva, "Introducing the concepts of swarm intelligence and genetic algorithms in cognitive networks", 2011.
[5] T. Yucek and H. Arslan, "A survey of spectrum sensing algorithms for cognitive radio applications," IEEE Communications Surveys & Tutorials, vol. 11, no. 1, pp. 116–130, 2009.
[6] Y. Zeng and Y. C. Liang, "Eigenvalue-based spectrum sensing algorithms for cognitive radio," IEEE Transactions on Communications, vol. 57, no. 6, pp. 1784 –1793, 2009.
[7] S. Xu, Y. Shang, and H. Wang, "Svd based sensing of a wireless microphone signal in cognitive radio networks," in 11th IEEE Singapore International Conference on Communication Systems, 2008 (ICCS 2008), 2008, pp. 222 –226.
[8] R. Chen and J.-M. Park, "Ensuring trustworthy spectrum sensing in cognitive radio networks," in Proc. IEEE Workshop on Networking Technologies for Software Defined Radio Networks (held in conjunction with IEEE SECON 2006), Sept. 2006.
[9] I.F Akyildiz,W Lee, M.C Vuran, S Mohanty,"Next Generation/ Dynamic spectrum access/cognitive radio wireless networks: A survey" Computer Networks 50(2006) 2127-2159, May 2006.
[10] S. Haykin, "Cognitive radio: brain-empowered wireless communications," IEEE J. Select. Areas Commun., vol. 3, no. 2, pp. 201–220, Feb. 2005.
[11] "A. Sahai, N. Hoven, and R. Tandra, "Some fundamental limits on cognitive radio," in Proc. Allerton Conf. on Commun., Control, and Computing, Monticello, Illinois, Oct. 2004.
[12] "F. Digham, M. Alouini, and M. Simon, "On the energy detection of unknown signals over fading channels," in Proc. IEEE Int. Conf. Commun., vol. 5, Seattle, Washington, USA, May 2003, pp. 3575–3579.
[13] D. Cabric, S. Mishra, and R. Brodersen, "Implementation issues in spectrum sensing for cognitive radios," in Proc. Asilomar Conf. on Signals, Systems and Computers, vol. 1, Pacific Grove, California, USA, Nov. 2004, pp. 772–776.

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