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SVD Based Gesture Detection using Cultural Algorithm for Spectrum Sensing

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Abstract- **Spectrum sensing has been identified as a key enabling functionality to ensure that cognitive radios would not interfere with primary users, by reliably detecting primary user signals. Recent research studied spectrum sensing using energy detection and network cooperation via modeling and simulations. However, there is a lack of experimental study that shows the feasibility and practical performance limits of this approach under real noise and interference sources in wireless channels. This paper presents the development of efficient and reliable spectrum sensing algorithm for cognitive radio network with the help of soft computing techniques. A Cultural Algorithm (CA) optimized model for conventional SVD based spectrum sensing algorithm has been presented.**

Keywords **– CA, CR, QoS, Spectrum Sensing, SVD.**

I. INTRODUCTION

The frequency lies in the range of 3 Hz to 3 THz are referred as the radio frequencies. Radio spectrum is utilized in various wireless communication frameworks and services as satellite-based, mobile, fixed and low power communication systems. Generally, wireless communication operates on frequency that lies in the frequency band of 3MHz to 30GHz. Radio spectrum is very precious and limited natural resources so spectrum management, controlling issues and monitoring are the primary objective of wireless communication worlds worldwide and countrywide.

Most nations have their own particular administrative organizations and which is upheld by respective governments that are responsible for the utilization of the spectrum. Radio spectrum bands basically, classified into two type i.e., licensed and unlicensed bands. The spectrum authority gives specific licensed band to operate radio device, licence is based on some parameter as availability of free frequency, technical operation condition and the users have to pay for the spectrum usage. Whereas some radio device does not require licence from spectrum authority to operate it in certain band, as the uses of that band is totally free. i.e., the free bands are known as unlicensed band.

The rapid growth in wireless communications has contributed to a huge demand on the deployment of new wireless services in both the licensed and unlicensed frequency spectrum. However, recent studies show that the fixed spectrum assignment policy enforced today results in poor spectrum utilization. To address this problem, cognitive radio (CR) has emerged as a promising technology to enable the access of the intermittent periods of unoccupied frequency bands, called white space or spectrum holes, and thereby increase the spectral efficiency. The fundamental task of each CR user in CR networks, in the most primitive sense, is to detect the licensed users, also known as primary users (PUs), if they are present and identify the available spectrum if they are absent. This is usually achieved by sensing the RF environment, a process called spectrum sensing.

The objectives of spectrum sensing are twofold: first, CR users should not cause harmful interference to Pus by either switching to an available band or limiting its interference with PUs at an acceptable level and, second, CR users should efficiently identify and exploit the spectrum holes for required throughput and quality-of-service (QoS). Thus, the detection performance in spectrum sensing is crucial to the performance of both primary and CR networks. The detection performance can be primarily determined on the basis of two metrics: probability of false alarm, which denotes the probability of a CR user declaring that a PU is present when the spectrum is actually free, and probability of detection, which denotes the probability of a CR user declaring that a PU is present when the spectrum is indeed occupied by the PU.

Since a miss in the detection will cause the interference with the PU and a false alarm will reduce the spectral efficiency, it is usually required for optimal detection performance that the probability of detection is maximized subject to the constraint of the probability of false alarm. Many factors in practice such as multipath fading, shadowing, and the receiver uncertainty problem may significantly compromise the detection performance in spectrum sensing.

The main objective of this paper is to implement a Cultural Algorithm (CA) optimized model for conventional SVD based spectrum sensing.

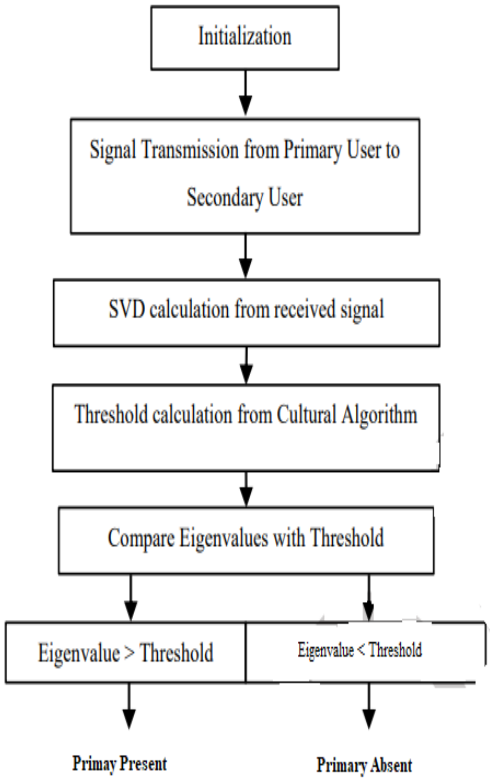

Figure 1: Flow chart for proposed approach.

Figure 1 shows the flow diagram for proposed spectrum sensing approach using CA-SVD. Rest of methodology is as follows: The purpose of signal detection is to test the existence of primary user's signal in receiver. For the signal detection, there are two kinds of hypothesis: $H0$, which means primary user's signal does not exist; $H1$, which means primary user's signal exists. The two hypotheses are given respectively by formula as follows: y by formula as follows:

$$H_0: x(n) = \eta(n) \quad (1)$$
$$H_1: x(n) = \bar{s}(n) + \eta(n) \quad (2)$$

Where $\bar{s}(n)$ is the received signal samples including the effects of path loss, multipath fading and time dispersion, and $\eta(n)$ is the received white noise assumed to be identically distributed signal, and with mean zero and variance $\sigma\eta 2$.

The received signal at receiver can be given as:

$$x(n) = \sum_{j=1}^{P} \sum_{k=0}^{N_{ij}} h_j(k) s_j(n-k) + \eta(n) \quad (3)$$

Where, P is the number of source signals i.e., number of transmitters, $h\,j\ (k)$ is channel response and Nij is the order of the channel. The detection techniques performance can determine through two probabilities: probability of false alarm (Pf) is probability of incorrectly detection of primary user in the frequency band that is case $H0$ and probability of detection (Pd) is probability of correctly detection primary user in frequency band that is case $H1$. 2 Singular Value based Detection (SVD) In linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. Formally, the singular value decomposition of a $M \times L$ real or complex matrix R is a factorization of the form:

$$R = U \Sigma V^* \quad (4)$$

Where U is a $M \times M$ real or complex unitary matrix, Σ is a $M \times L$ rectangular diagonal matrix with nonnegative real numbers on the diagonal, and $V*$ (the conjugate transpose of V) is a $L \times L$ real or complex unitary matrix. The diagonal entries Σi, i of Σ are known as the singular values of R. The M columns of U and the L columns of V are called the left-singular vectors and right-singular vectors of R, respectively. Steps to SVD algorithm: Step 1: Select number of columns of a covariance matrix, L such that $k<L<N-k$, where N is the number of sampling points and k is the number of dominant singular values. here, $k = 2$ and $L = 14$. Step 2: Factorized the covariance matrix. Step 3: Obtain the maximum and minimum eigenvalue of the covariance matrix which are λmax and λmin. Step 4: Compute threshold value γ. Step 5: Compare the ratio with the threshold. If λmax/ λmin $>\gamma$, the signal is present, otherwise, the signal is not present.

Threshold Determination using Cultural Algorithm
Here the singular value decomposition (SVD) is applied for the acknowledgement of received signal whether it is correlated to primary user or not. Here the received signal is changed into matrix form then its SVD is calculated. The proposed research work uses two algorithms for the optimization of the matrix prior to the SVD. Finally, SVD is applied on the optimized value of L i. e. size of matrix. Threshold optimization is performed using Cultural Algorithm which is explained as follows.

Cultural Algorithm (CA): Inspired by the process of social and cultural changes, the CA was developed to enhance evolutionary computation. Besides the population component that evolutionary computation approaches have, there is an additional peer component belief space and a supporting communication protocol between these two components, which makes CAs perform better in some special optimal cases than other evolutionary algorithms (EAs). The following figure presents the basic CA framework.

As Figure 2 shows, the population space and the belief space can evolve respectively. The population space consists of the autonomous solution agents and the belief space is considered as a global knowledge repository. The evolutionary knowledge that stored in belief space can affect the agents in population space through influence function and the knowledge extracted from population space can be passed to belief space by the acceptance function. In the process of the CA evolution, the population space is initialized with candidate solution agents at random, meanwhile, the initial knowledge sources in the belief space are built. At first the two spaces evolve independently. Then the selected agents from the population space are used to update the belief space.

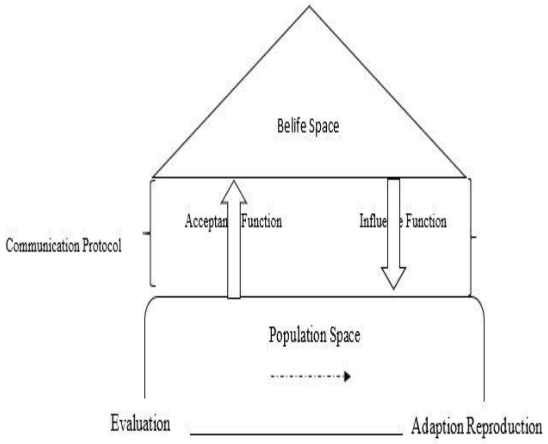

Figure 2 CA framework [10].

After the knowledge sources being updated, the belief space will reversely guide the evolution of the population space. These procedures repeat till a termination condition has been reached.

II.SIMULATION RESULTS

A randomly generated BPSK signal is taken as the primary signal through Rician fading channel, and then the Gaussian noise is added to achieve probability of detection at different SNR values. The performance of proposed algorithms has been studied by means of MATLAB simulation.

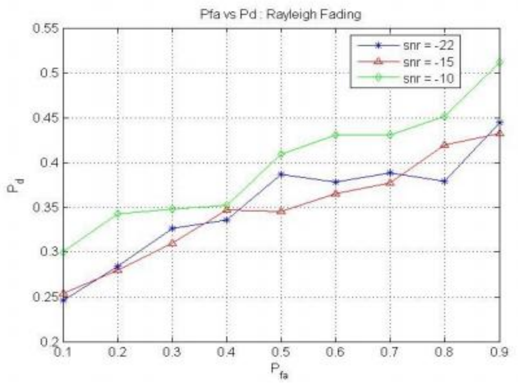

Figure 3 Pf v/s Pd graph.

for CA optimized SVD based detection for different values of SNR Figure 3 depicts Receiver operating characteristic (ROC) curve of CA optimized SVD based detection method with probability of detection versus probability of false alarm at different value of SNR (SNR =-10dB, SNR=-15dB, & SNR=-22dB). The probability of detection Pd is plotted under $H1$ against probability of false alarm Pf under $H1$.So, from the ROC curve in Figure 5.1, it clear that the value of Pd is higher at -10dB SNR level when compare with different SNR level (-10dB, -15dB and -22dB) which proves the good performance of CA-SVD detection method at higher SNR.

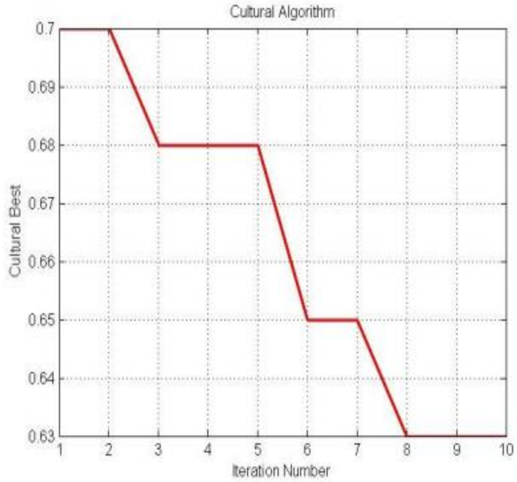

Figure 4: Iteration count for cultural algorithm.

IV. CONCLUSION

This paper presented the performance analysis of Singular Value based Detection (SVD) using Cultural Algorithm (CA) for spectrum sensing. Here the CA is used to select a value of smoothening factor with objective of highest probability of detection. The fitness function comprises of full scenario where we generate a random standard signal (modulated and filtered) and transmitted it to channel of defined SNR, we have taken lowest SNR value, signal received at each cognitive secondary user is collected and arranged in Hankel matrix with a random value of smoothening factor and detection probability has been calculated.

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