ROLE OF PSO OPTIMIZED SINGULAR VALUE DETECTION TECHNIQUE IN RURAL DEVELOPMENT

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ABSTRACT

With the rapid development in wireless communications, the demand for the high data transmission require increases in spectrum resources because of fixed spectrum assignment policy is characterized in wireless network these lead to low spectrum utilization in many frequency bands but the availability of the spectrum resources is limited. Cognitive radio is key enabling technology for improving the utilization of electromagnetic spectrum. It senses the spectral environment over wide range of frequency band and exploits the unoccupied band. In this sense cognitive radio can play important role in the rural development by using the unused spectrum. So many T.V bands are not used in rural area these bands can be used there for broadband transmission by cognitive Radio. These frequency bands can also be used for giving online training, guidance and help in agriculture like modern techniques, organic farming, inspection of crops, identification of diseases in crops & their remedies etc.

One of the most challenging issues in cognitive radio system is to sense the spectrum environment accurately and determine whether the primary user is active, or not over a specific band reliably. So, there is need of good sensing algorithm have the property have low sensing time, ability to detect primary signal at low SNR Therefore, in this paper a PSO optimized singular value based detection methods is proposed to obtain improved result. Performance analysis and comparison of techniques are carried out and developed on MATLAB 2014 R.

1.Introduction

Currently, radio rapidly developing wireless communication systems, and increasing the intensity of their use, which leads to an increase in demand for radio spectrum. However, the radio-frequency spectrum (RFS) is a limited natural resource. Under these conditions it began to show a number of contradictions, the most urgent of which are:

- Contradiction between the increasing demand for services provided by wireless communication systems and the limited radio frequency spectrum.
- Contradiction between the Power Spectral Density (PSD) expansions represented in wireless communication systems and the ability to use the spectrum of each individual radio device 100%.

Virtually the entire frequency band allocated to the present time and is licensed, but the spectrum is a precious natural resource that is not used sufficiently effectively. Implementation and use of new services, for which the necessary availability of frequency bands, it becomes difficult, and in some cases even impossible. One of the possible solutions to this problem is to move to a new technology called cognitive radio.

An important way to increase spectrum efficiency allows dynamic spectrum management mechanism, according to which the secondary user (not assigned to the data of the frequency range) and the possibility to use the primary users ranges (assigned to this range) at a time, as long as this range is not used by the primary user.

The technology of cognitive radio (CR) intended for re-use of radio frequency spectrum, when the device on the network is automatically reconfigured for free frequencies. CR devices change their settings based on the information on the electromagnetic and the geographical environment, recognize the signals of all the images of the primary radio-electronic means (RES) and the frequency of use, when the primary distribution zone does not work. They are automatically reconfigured to free ranges while maintaining a stable connection.

Dynamic spectrum management algorithms are technically very complex, and can only be used in so-called smart radio systems. A distinctive feature of such systems, sets them in a separate group, is the ability to retrieve and analyze information from the surrounding radio space, to predict changes in the communication channel and optimally adjust their internal state parameters, adapting to changes in the radio environment.

In this work, we are interested in the problem of spectrum sensing, which is the detection of the presence of PU in a licensed spectrum in the context of intelligent radio. We are not interested in a particular band (GSM or TV, for example) or a particular system. The objective of this paper is to propose efficient detection methods with low complexity and / or low observation time using the minimum information a priori on the signal to detect.

Detection Techniques

The different methods that have been developed to achieve this objective can be categorized as

Matched Filter Detection, Energy Detection & Cyclostationary Feature Detection

The Energy detection method has shown its limits in the presence of a high level of interference. Indeed, the emitted signal preserves its spectral correlation but can no longer be detected with the Energy detection method because there is interference. So it is better to use the The Cyclostationary feature detection method has important advantages over other detection methods. Cyclostationary feature detection method when we have no information about the primary users. With these detection methods, a user of the cognitive radio network (which is also called a secondary user) will not be able to avoid interference due to lack of information on the licensed user. Indeed, the secondary user may not detect the presence of the primary user because of an obstacle between the two (the case of the hidden station) and thus generate interference at the receiver. Moreover, a single machine cannot constantly analyze the whole spectrum of frequencies in order to detect the unused portions of spectrum since this operation is very long.

To compensate for the lack of frequencies, researchers have designed cognitive radio technology. It involves exploiting the under-used frequency spectrum without interfering with licensed users. The first task of cognitive radio networks is to detect the presence of licensed users in the frequency spectrum to identify portions of unused frequency spectrum and to allow users of cognitive radio networks (also called secondary users) to Release frequencies used by primary users.

In the presence of several distinct cognitive radio networks, the detection of primary users is more difficult because it will be more difficult to distinguish the signals emitted by secondary users from those emitted by primary users. In protocol 802.22 a period of silence has been set up during which secondary users are not allowed to transmit a signal in order to better detect the presence of primary users. It will be necessary to synchronize the beginning of this period of silence between the different cognitive radio networks in order to increase the efficiency in the detection of a primary user.

Proposed Pso Optimized Singular Value Based Detection

The proposed method can be used for various signal detection and applications without knowledge of the signal, channel, and noise power. The received signal samples under the two hypotheses are therefore respectively as follows:

$H_0: x\ (n)\ =\ \eta\ (n)$

$H_1: x\ (n)\ =\ s\ (n)\ +\ \eta\ (n)$

Let $f(k), k = 0,1, \dots K$ be normalized band pass filter applied to the signal.

Let

$x^{'}(n) = x(n) * f(n)$

$s^{'}(n) = s(n) * f(n)$

$\eta^{'}(n) = \eta(n) * f(n)$

Then,

$H_0\ :\ x'(n) =\ \eta'(n)$

$H_1\ :\ x'(n)\ =\ s'(n)\ +\ \eta'(n)$

Consider L samples and let

$X(n)\ =\ [x'(n), x'(n-1), \dots\dots x'(n-L+1)]^T$

$S(n)\ =\ [s'(n), s'(n-1), \dots\dots s'(n-L+1)]^T$

$\eta(n)\ =\ [\eta'(n), \eta'(n-1), \dots\dots \eta'(n-L+1)]^T$

Define a L x (L+K) matrix

$$H = \begin{bmatrix} f(0) & f(1) & \cdots & f(k) & 0 & \cdots & 0 \\ 0 & f(0) & \cdots & f(k-1) & f(k) & \cdots & 0 \\ \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & f(0) & f(1) & \cdots & 0 \end{bmatrix}$$

If G = H $(H^*)^H = Q^2$ then define $R_x^{'} = Q^{-1}R_xQ^{-1}$. (Rx is the correlation matrix of x (n)). If there is no signal, then $R_x^{'} = 0$. Hence the off diagonal elements of $R_x^{'}$ are all zeros. If there is signal and the signal samples are correlated, $R_x^{'}$ is not a diagonal matrix.

Let r_{nm} be the elements of$R_x^{'}$. Let:

$K_1 = \frac{1}{L}\sum_{n=1}^{L}\sum_{m=1}^{L}|r_{nm}|$

$K_2 = \frac{1}{L}\sum_{n=1}^{L}|r_{nn}|$

$K_3 = \frac{1}{L}\sum_{n=1}^{L}\sum_{m=1}^{L}|r_{nm}|^2$

$K_4 = \frac{1}{L}\sum_{n=1}^{L}|r_{nn}|^2$

The primary signal is considered to be present if $K_1 > \gamma K_2$. Covariance absolute value (CAV) detection or if $K_3 > \gamma K_4$. Covariance Frobenius Norm (CFN) detection where γ is an appropriate value based on P_f.

Particle Swarm Optimization

This approach is a heuristic method. The evaluation of candidate solution of current search space is done on the basis of iteration process.

The minima and maxima of objective function is determined by the candidate's solution as it fits the task's requirements. Since PSO algorithm do not accept the objective function data as its inputs hence

The fitness function is:

$(minimize\ f(L) = 1 - P_D)$

Where, $P_D = prob.of\ detection$ & L = size of matrix

The best value of fitness is recorded by PSO for an individual record. The other individuals reaching this value are taken as the individual best position and solution for given problem. The individuals reaching this value are known as global best candidate solution with global best position. The up-gradation of global and individual best fitness value is carried out and if there is a requirement then global and local best fitness values for every individual $f(L)$ are replaced. For PSO's optimization capability, the updation of speed and position is necessary. Each particle's velocity is updated with the help of subsequent formula:

$$v_i(t+1) = Wv_i(t) + c_1r_1[\hat{x}_i(t) - x_i(t)] + c_2r_2[g(t) - x_i(t)]$$

Where, $v_i(t+1)$=velocity of i^{th} particle at $t+1$ iteration, c_1 and c_2 are acceleration coefficients & r_1 and r_2 are random and uniform elements of a sequence in the range of (0, 1)

The position of particle is calculated as : $p_i(g+1) = p_i(g) + v_i(g+1)$

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. PSO optimizes the matrix prior to the SVD. Finally SVD is applied on the optimized value of L i. e. size of matrix.

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:

$$R = U \sum V^*$$

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 $\Sigma_{i,i}$ 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.

Algorithm for Singular Value based Detection

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 $\lambda_{\max}$ and $\lambda_{\min}$.

Step 4: Compute threshold value γ.

Step 5: Compare the ratio with the threshold. If $\lambda_{\max}/\lambda_{\min} > \gamma$, the signal is present, otherwise, the signal is not present.

Experimental Setup & Results

Simulations are carried out in MATLAB environment

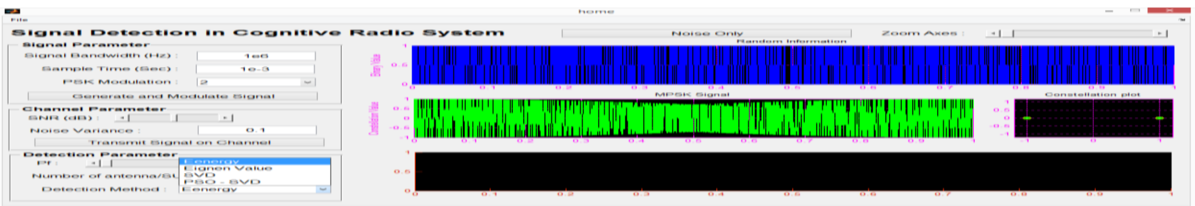

Figure 1. GUI of proposed research work

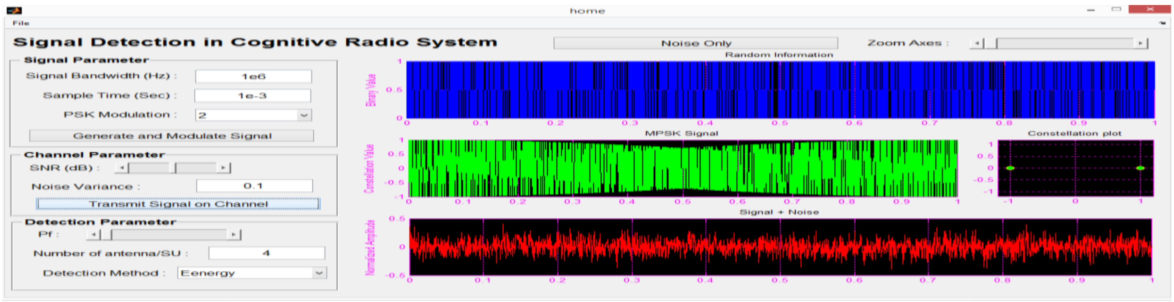

Figure 2. Selection of signal detection method

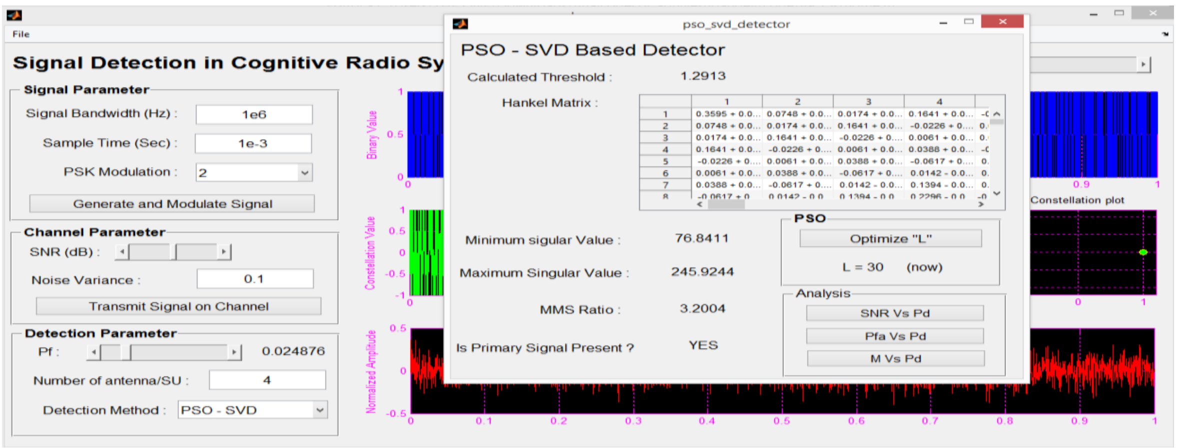

Figure 3. Performance analysis of PSO-SVD method

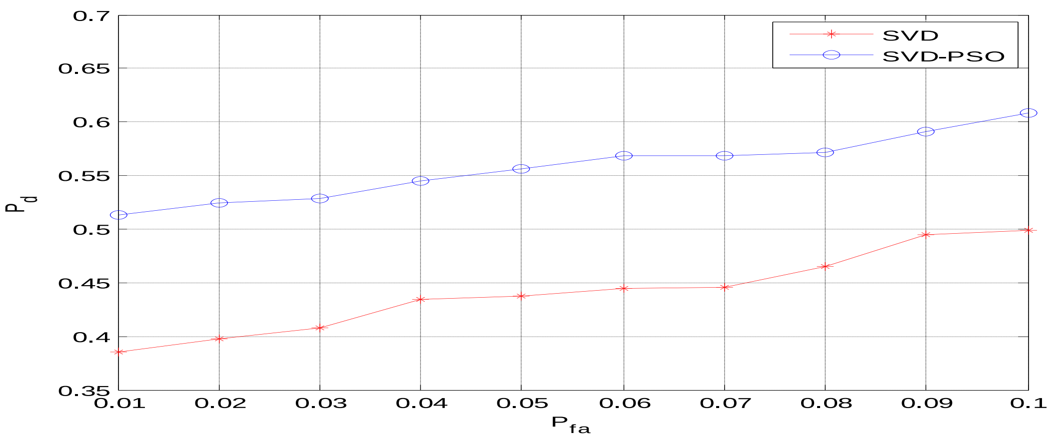

Figure 4. Comparative graph for probability of detection vs. probability of false alarm for SVD and SVD-PSO based detection algorithms

2.Conclusion

Signal detection in cognitive radio has been performed in this research with various detection methods and its enhancement with particle swarm optimization. A brief simulation shows that detection probability increases with PSO in noisy environment. PSO actually modified the size of Hankel matrix with respect to fitness function which evaluates probability of detection. Simulation also shows that results significantly improve when evaluating effect of false alarm probability. This paper adds consistency to the cognitive radio framework therefore it is improving the performance. Proposed method is suitable for all common digital signals but it is an iterative process thus needs proper knowledge of system, any change in system will need re-optimization in order work efficiently. This efficient detection of idle spectrum made it possible to use this spectrum for rural development related services.

3.References

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