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Distributed Soft Decision Weighted Cooperative Spectrum Sensing in Cognitive Radio

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Abstract— *In cognitive radio transceiver can smartly recognize which communication channels are in used. CR is a type of wireless communication. The unused channels are used instead of used channels. Cognitive radio enhances the use of vacant radio-frequency range while reducing interference to additional users. Spectrum recognition is a significant purpose of cognitive radio to stop the destructive interfering with certified users and recognize the vacant spectrum for improving the range's consumption. In a cooperative cognitive radio spectrum recognizing scheme, recognizing will be commenced by an amount of dissimilar radios inside a cognitive radio network. The weighted average distributed consensus-based combination allows each SU to pick out a weight permitting to the measurement situation, and the comprehensive attached measurement is a soft weighted linking reflecting the measurement superiority without consolidated fusion point. We proposed soft decision weighted distributed cooperative spectrum sensing with the help off Particle Swarm Optimization method in CR. We have implemented proposed algorithm in MATLAB and outcome represents that suggested method is the finest for distributed cooperative sensing. Experimental outcomes represents that our system is also best appropriate for energy detection in CR.*

Keywords— Cognitive radio, Spectrum sensing, weighted average consensus, Soft decision, Signal detection

I. INTRODUCTION

Cognitive Radio [1] is a radio system that is capable of sensing its operating environment and dynamically utilizing the available radio resources. CRNs are fully programmable wireless set of devices that be able to sense their surroundings and energetically adjust their channel access method, transmission waveform, networking protocols and spectrum use, as desired for decent application and network performance. In conventional spectrum allocation schemes, fixed frequency bands are statically assigned to Primary Users (PU) or licensed users and due to most of the available spectrum statically allocated, frequency regulation bodies fall short to provide vacant bands to new wireless applications and services. Thus, it becomes very complex to get spectrum for moreover expanding the existing wireless services or new services. In present scenario government schemes do not permit the right to use of licensed spectrum by unlicensed customers, restricting them instead to use several densely occupied and interference affected frequency bands, which results in a massive spectrum scarcity difficulty in certain ranges. During scanning the radio spectrum system may discover that some frequency spectrum are existing for some of the period, and numerous frequency bands are merely incompletely in use, whereas in [2] the remaining frequency bands are deeply used. The problem of spectrum scarcity is getting inferior due to the appearance of new wireless applications and services. To improve spectrum utilization [3] by allowing secondary users to access under-utilized licensed bands dynamically whenever licensed users are not present. Inside a cooperative cognitive wireless spectrum recognizing radio system, sensing will be commenced by a numeral of unalike radios within a cognitive radio network. The main challenge of radio spectrum recognizing is the receiver uncertainty problem such as practical multipath fading and shadowing, which compromise the detecting performance significantly. The explosion of wireless device applications generates an ever-increasing request for extra radio spectrum. Present distributed consent based procedures only make sure like gain merging of local measurements, whose concert may be unmatched to numerous centralized soft merging systems. With the evolution of new and eternally growing wireless services and, applications spectrum sensing resources are facing enormous demands. The actual licensed spectrum is not in use maximum of the time and this unused part of the radio spectrum is acknowledged as Spectrum holes' or 'White Spaces' [4] of available spectrum. CR as an intellectual radio communication scheme is conscious of the radio frequency environment choose the communication parameters (such as transmission power, frequency of carrier signal, modulation technique, available bandwidth and) to enhance increase the spectrum usage and adjusts its reception and transmission as per requirements. The Particle Swarm Optimization (PSO) has ability to solve efficiently plenty of problems in engineering and science. We proposed soft decision weighted distributed cooperative spectrum sensing with the help of PSO method in cognitive radio. Paper is organized as follows. Section II provides background of cognitive radio. Section III provides proposed work in cooperative spectrum sensing in cognitive radio network. Section IV provides implementation and result analysis. Section V concludes the paper.

II. BACKGROUND

Cognitive radio (CR) is a technique of communication into which a transceiver can sagaciously make a distinction which communication stations are in usage and which are not, and suddenly move into unoccupied channels while circumventing engaged ones. Cognitive radio optimizes the use of available radio-frequency (RF) [5] spectrum while minimizing interference to other users. Cognitive radios have the capability to sense, observe, and detect the conditions of operating environment, and then dynamically re-configure their own individualities to finest match those conditions. Unlike their traditional counterparts, they can view their environment in great detail to identify spectrum that is not being used, and quickly tune to that frequency to transmit and/or receive signals. They also have the ability to instantly find other spectrum if interference is detected on the frequencies being used. Probable functions [6] of cognitive radio comprise the capability of a transceiver to decide its identify, geographic location, and authorize its user, decrypt or encrypt signals, sense neighboring wireless devices in operation, and correct output modulation and power characteristics. There are two main types of cognitive radio, full cognitive radio and spectrum-sensing cognitive radio. Full cognitive wireless takings into account all constraints that a wireless network or node can be cognizant of. Spectrum-sensing [8] in cognitive radio is used to sense channels in the radio frequency spectrum. In common the cognitive radio might be predictable to look at parameters such as free channels, channel occupancy, the kind of data to be communicated and the modulation styles that may be used. It must similarly look at the directing necessities. The usage of a cognitive radio network make available [7] a numeral of advantages when related to cognitive radios functioning decently autonomously: (1)Improved spectrum sensing: By means of using cognitive radio networks, it is probable to expand noteworthy benefits in relations of spectrum sensing. Improved coverage: (2) by setting up cognitive radio network, it is probable to convey data from one node to the subsequent. In this means power stages can be condensed and performance is sustained. The impression for cognitive radio has derived out of the requirement to consume the radio spectrum additional efficiently, and to be able to sustain the furthermost well-organized form of communication for the predominant conditions. By means of the stages of processing that are accessible nowadays, it is imaginable to develop a radio that is able to aspect at the spectrum, perceive which frequencies are clear, and then implement the best form of communication for the required conditions. In this way cognitive radio technology is able to select the frequency band, the type of modulation, and power levels most suited to the requirements, prevailing conditions and the geographic regulatory requirements. In a lot of areas cognitive radio structures cohabit with other radio systems, with the identical spectrum but without initiating unnecessary interfering. When detecting the spectrum occupancy, the cognitive radio system need accommodate a variability of contemplations: Continuous spectrum sensing: It is compulsory for the cognitive radio system to uninterruptedly sense the spectrum possession. Normally a cognitive radio system will use the spectrum on a non-interference base to the primary user. Consequently it is compulsory for the Cognitive radio system to uninterruptedly sense the spectrum in situation the primary user returns. Monitor for alternate hollow spectrum: In condition if the primary user returns to the spectrum being used, the cognitive radio system essentially have alternate spectrum accessible to which it can change should the requirement arise. Monitor nature of communication: It is compulsory for the cognitive radio to sense the nature of transmission actuality received. The cognitive radio system should be capable to determine the method of data transmission used by the primary user so that counterfeit interference and transmissions are disregarded as well as transmissions completed by the cognitive radio system itself. There are numerals of methods in which cognitive radios are capable to perform spectrum sensing. The ways in which cognitive radio spectrum sensing can be performed falls into one of two categories: ***Non-cooperative spectrum sensing [8]:*** This method of spectrum sensing, happens when a cognitive radio acts on its personal. The cognitive radio will organize itself permitting to the signals it can identify and the information with which it is pre-loaded. ***Cooperative spectrum sensing [9]:*** In a co-operative cognitive wireless spectrum sensing approach a system, sensing will be instigated by a numeral of dissimilar radios within a cognitive radio network. Typically an essential station will receive information of indications from a variability of radios in the system network and correct the complete cognitive radio network to suit.

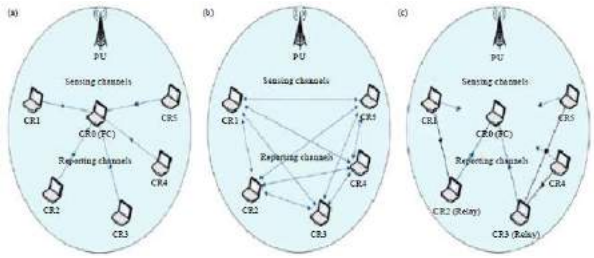

Figure 1: Classification of cooperative sensing (a) Centralized (b) Distributed (c) relay-assisted.

Cognitive wireless cooperation condenses hitches of interfering where a on its own cognitive radio cannot hear a primary user because of issues such as shading from the primary user, but a second primary user acting as a receiver may be able to hear both the primary user and the signal from the cognitive radio system. The cooperative sensing is classified as distributed sensing, centralized sensing and relay-assisted sensing. Distributed cooperative sensing does not rely on a fusion central for making the cooperative decision. In centralized cooperative sensing fusion essential controls the process of cooperative sensing. In distributed cooperative sensing cognitive radio user interconnect amongst them and converge to a combined conclusion on the absence or presence or of Pus [10] by iterations. In relay supported cooperative sensing CR user witnessing a weak sensing communication channel and a resilient report channel and a CR user with a weak report channel, and durable sensing channel a for example, can cooperate and accompaniment with individually other to advance the performance of cooperative sensing.

Figure 2: Conventional radio spectrum view

Conventional radio opinion of unlicensed spectrum shows radio spectrum as a wall of interfering [11]. This spectrum analyzer reading shows how conventional radios show congested radio spectrum with heavy interference, and essentially unusable. Cognitive radio view of unlicensed spectrum sees radio spectrum as a window of opportunity. Cognitive radio can view the same radio spectrum in deeper detail, allowing them to identify unused gaps to transmit signals. The open challenges regarding cooperation models include the following: Modeling of cooperation overhead: Most existing models for cooperative sensing are centered at the detection performance that is cooperative gain. Merely a rare cooperation overhead concerns have been conversed in proposed schemes. For example, in [12], only the numeral of cooperating CR users and the sensing time throughput adjustment are measured in founding utility functions.

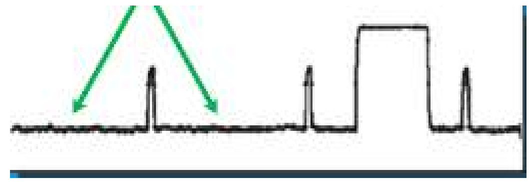

Figure 3: Cognitive radio spectrum view

While cooperative expansion is important in the model, appropriate modeling of cooperation overhead can disclose faithful achievable cooperative improvement. Thus, the modeling of cooperation overhead is quiet an open challenge [13] into the modeling for cooperative sensing. Modeling of primary user collaboration: Furthermost present models for cooperative sensing concentration on the recognition of a single large-scale PU such as a TV system base station and take up that the PUs do not collaborate with CR users. However, in definite applications such as military [15] CR networks, these conventions may not be accurate, since the PUs may be encouraged to cooperate with CR users and the PUs may be associated in an ad hoc routine. As an outcome, novel models that model the cooperation between CR users and PUs and for cooperative communications and cooperative sensing such as the one in [16] are preferred. In addition, the recognition of small-scale mobile PUs such as radio wireless microphones is a recognized open challenging research difficulty, which will need a novel model for cooperative sensing.

III. PROPOSED WORK

The Proposed algorithm

The PSO represents a good trade-off between complexity and reliability from the point of views of implementation and quality of the found solution respectively. PSO based weight determination in which the values of parameters are upgraded by optimizing trained weights from by PSO based weight optimization. PSO algorithm uses population of neighbors which can be subset of global best value, value can be smaller.

Algorithm

PSO is initialized with a collection of random elements (solutions).

The first best solution is called pbest.

Additional "finest" value a global best.

The global best value is called gbest.

When an element takes part of the populace as its topological neighbors, the finest value is a local best. This native finest significance called lbest.

Select randomize weight value

Set the initial value for the weight.

Determine the weight value for initialization of the procedure.

Over a number of repetitions, a cluster of variables have used their values.

In each repetition, each element is updated by subsequent two "best" values.

The value is compared with the target value.

If value is closer than the value is updated accordingly.

Determine the value of the winner from the repeated steps.

Correct the value of weight and neighborhood.

Set the value of p from best value to present value. Set the value of q as global best.

N as the number of sensing nodes and as the energy output of the kth sensing node (SU's), the average weight linear cooperative spectrum sensing algorithm is as follows:

$$\overline{T} = \begin{cases} \frac{1}{N}\sum_{k=1}^{N} T_k < \eta, \ H_0 \\ \frac{1}{N}\sum_{k=1}^{N} T_k \geq \eta, H_1 \end{cases}$$

On increasing the weight factors of the sensing nodes with higher received SNR can improve the performance of CSS. For weight based SNR above equation will be written as

$$\overline{T} = \begin{cases} \frac{1}{N}\sum_{k=1}^{N} T_k . w_k < \eta, \quad H_0 \\ \frac{1}{N}\sum_{k=1}^{N} T_k . w_k \geq \eta, \ H_1 \end{cases}$$

Where

$$w_k = \frac{SNR_k}{\sum_{r=1}^{N} SNR_r}$$

Where SNR is Signal to Noise Ration, N is number of sensing nodes. K is the sensing node. Wk is the weight of K node.

IV. IMPLEMENTATION

For simulation we have used PIV 3.0 GHz machine with 4GB RAM. The program is developed in MATLAB language. In this section we have performed the analysis of result with hard combination using AND rule as we have discussed the different challenges of Spectrum sensing. In figure we did the analysis of the sensing performance under the target probability of miss detection and probability of false alarm at SNR=15dB.

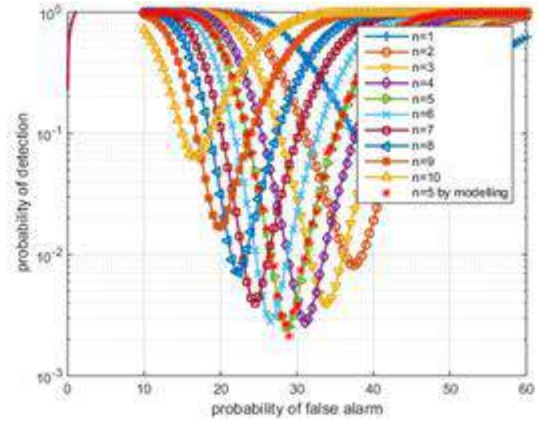

Figure 4: Probability of detection Vs Probability of false alarm at 15dB SNR

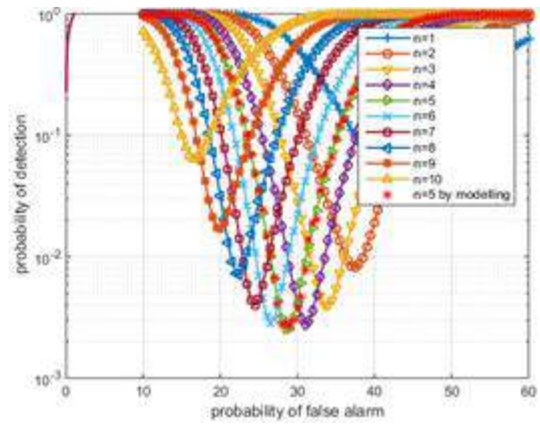

Figure 5: Probability of detection Vs Probability of false alarm at 10dB SNR

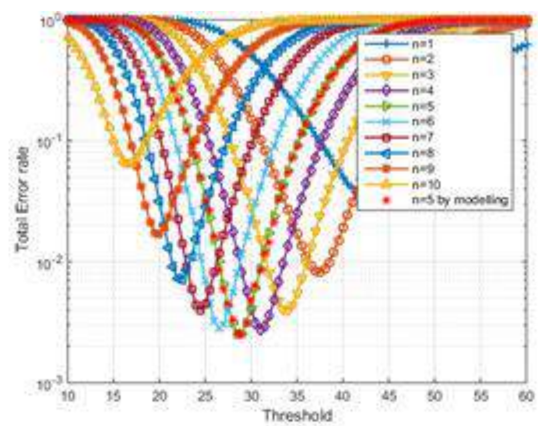

Figure 6: Threshold Vs Probability of total error rate at -10dB SNR

Figure above represents the probability of detection and probability of false alarm at 10dB. For a particular value of SNR, high Pfa results in a low probability of miss detection because of the reduced threshold. For a particular value of SNR, high P_{fa} results in a low probability of miss detection because of the reduced threshold. Now, further we take some plots for the complementary ROC of Probability of Miss detection and Probability of false alarm at SNR=-10dB with N=1000 as shown in figure 5 for channel. Thus we can say that the curves we are getting has been similar following the methods proposed in previous chapter as we have performed the analysis on different values of SNR as it plays a vital role in the spectrum sensing. Next we have performed the analysis for probability of error defined in previous chapter draws some curves under AWGN channel and fading environment.

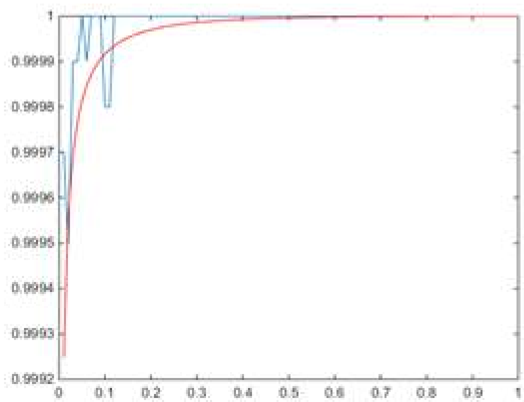

Figure 7: Probability of Detection vs. SNR (dB) at Pfa=0.2 for channel

In above figure the Probability of Detection versus SNR (in dB) at 20dB is shown for the Probability of False Alarm Pfa=0.2 and 0.02, respectively. The result shows that the probability of detection is increased with increase of SNR values and results are quite different with the theoretical values.

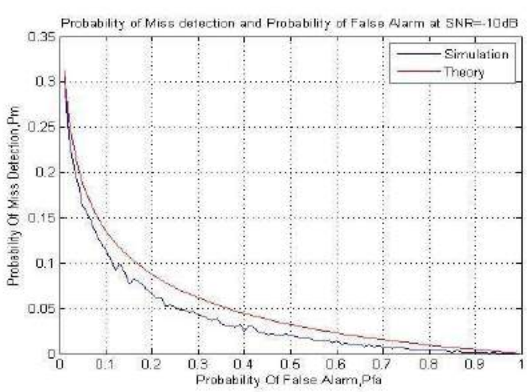

Figure 8: Pm vs. Pfa at SNR=-10dB

In above figure the Probability of Detection versus SNR (in dB) at -10dB is shown for the Probability of False Alarm Pfa=0.4 and 0.01, respectively. The result shows that the probability of detection is increased with increase of SNR values and results are quite different with the theoretical values.

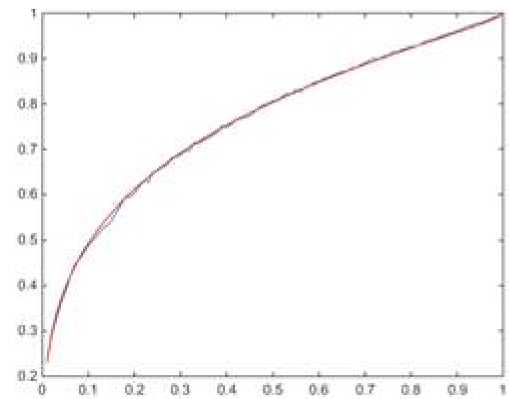

Figure 9: Probability of Detection vs. SNR (dB) at P_{fa}=0.4.

In above figure the Probability of Detection versus SNR (in dB) is shown for the Probability of False Alarm P_{fa}=0.2 and 0.01, respectively. The result shows that the probability of detection is increased with increase of SNR values and results are quite different with the theoretical values.

V. CONCLUSION

A cognitive radio network is a wireless scheme that can configured dynamically and programmed to consume the finest wireless channels in its locality. The radio set frequency spectrum is an insufficient resource with countless and great importance. Cognitive Radio is a distinctive system that can be potentially expand the utilization effectiveness of the radio spectrum. Deploying and building a network of cognitive radios is a complicated task. Cognitive radios have the capability to monitor, detect and, sense the situations of their functioning environment, and enthusiastically reconfigure their specific features to finest match those circumstances. The most essential procedures in cognitive radio is spectrum sensing, which permits the secondary users to perceive the occurrence of a primary user into the spectrum. Cooperative spectrum sensing is improved than conventional spectrum sensing systems as it overcomes reduces false alarm, unseen node problem, and provides added precise signal discovery. We proposed soft decision weighted distributed cooperative spectrum sensing with the help of PSO method in cognitive radio. Experimental results shows that our system is best appropriate for distributed cooperative sensing. In future work we will increase long-term secrecy data transmission speed of CRNs. We will also consider harvested energy improvement in CRNs. As in future investigation we will increase number of secondary user in CRNs and reduce the energy consumption.

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