OPTIMIZATION OF COOPERATIVE SPECTRUM SENSING IN COGNITIVE RADIO NETWORK

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ABSTRACT

One of the great challenges of implementing spectrum sensing is the hidden terminal problem, which occurs when the cognitive radio is shadowed, in severe multipath fading or inside buildings with high penetration loss, while a primary user (PU) is operating in the vicinity. Due to the hidden terminal problem, a cognitive radio may fail to notice the presence of the PU and then will access the licensed channel and cause interference to the licensed system. To deal with the hidden terminal problem in cognitive radio networks, multiple cognitive users can cooperate to conduct spectrum sensing. It has been shown that spectrum sensing performance can be greatly improved with an increase of the number of cooperative groups. Cognitive radio allows unlicensed users to access licensed frequency bands through dynamic spectrum access to reduce spectrum scarcity. This requires intelligent spectrum sensing techniques like co-operative sensing which makes use of information from number of users. This thesis investigates the use of cyclo-stationary detector and its simulation in MATLAB for licensed user detection. Cyclo-stationary detector enables operation under low SNR conditions and thus saves the need for consulting more number of users. Simulation results show that implementing co-operative spectrum sensing help in better performance in terms of detection.

Keywords: - ***Cognitive Radio, Spectrum Sensing, Signaling Overhead, Cooperative Sensing.***

Introduction

Cognitive radio (CR) is now mature enough to be exploited as the solution to spectrum inefficiency. The spread and diversity of investigations have been substantial in both academia and standardization bodies. The consolidation of these efforts has recently appeared in the form of a prominent standard, IEEE 802.22 for WRANs, which aims at diminishing the rural-urban divide by extending the reach of technology as far as possible. At this point, CR seems to be just a tiny step away from commercialization and transformation into something beyond a technological concept [1-3]. For this very reason, researchers in both academia and industry need to designate particular attention to IEEE 802.22 standard by refining its features and capabilities, and introducing compatible, yet more efficient, methods and mechanisms. To incite curious minds, the said needs have been explicitly stated in the form of open issues in this standard. Among these, the distributed sensing fusion mechanism (SFM) is fundamental [4-5].

With the rapid development of various wireless services, the limited spectrum resource is eventually causing the spectrum scarcity problem. How to improve the spectrum utilization is an urgent problem to be solved. Underlay spectrum access model is a useful strategy to improve the spectrum utilization for cognitive radio network (CRN)[6-8]. The ability of a CR to dynamically adapt to the radio environment is critically dependent on spectrum sensing and awareness. These functions involve signal detection, classification, and blind parameter estimation, which are often very challenging. In underlay CRN, the primary user (PU) and the secondary user (SU) share the same band which causes the problem that two or more time-frequency overlapped signals appear simultaneously in a general narrow band receiver[9]. In the rest part of this research work, section II –cooperative sensing, Section-III Proposed work, Section-IV simulation and result analysis and finally discussed the conclusion and future work in section V.

II. Cooperative Sensing

However due to spatial diversity of each user it is very unlikely that each of them will face problems in detection simultaneously. Thus, all the users can co-operate among themselves and share their information so that the chances of incorrect detection are minimized. The sharing of information among users leads to the concept of co-operative spectrum sensing without increasing the cost as little extra hardware is required. Figure 1 shows comparison of power level for non-cooperative and cooperative case [10-12]. It can be easily concluded that due to cooperation the degradation in power level is much lower. The gain achieved due to cooperation defines the decrease in degradation which in turn is controlled by the amount of time spent on sensing the environment. With less sensing time more data can be transmitted during a given time interval and vice-versa. Thus, there is always a trade-off between the sensing time and the cooperative gain achieved[12-15].

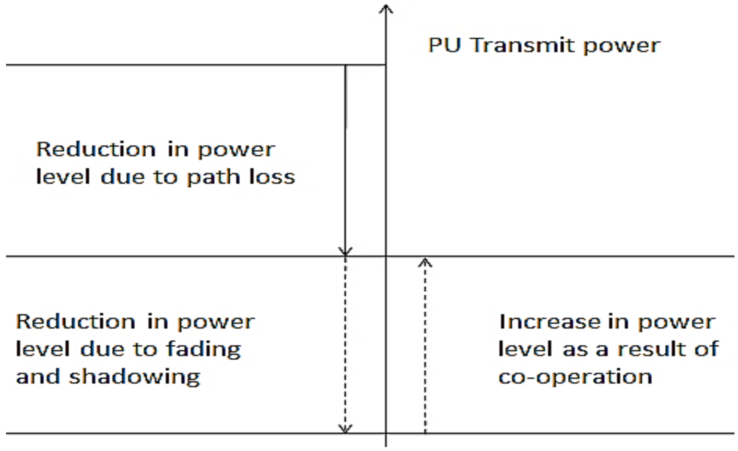

Figure 1: Power level comparison for co-operative and non-cooperative case.

III. Proposed Work

In a cognitive radio network with many CRs, cooperative spectrum sensing may become impractical because in a time slot only one CR should send its local decision to the common receiver to separate decisions easily at the receiver end. Hence, it may make the whole sensing time intolerably long. This issue can be addressed by allowing the CRs to send the decisions concurrently. But it may complicate the receiver design when separating the decisions from different CRs. Another potential solution is to send the decisions on orthogonal frequency bands, but this requires a large portion of available bandwidth. To address these issues, we propose next an efficient sensing algorithm which relies on the transmission of decision in one time slot for one CR but guarantees a target error bound by requiring a few CRs in cooperative spectrum sensing instead of all of them.

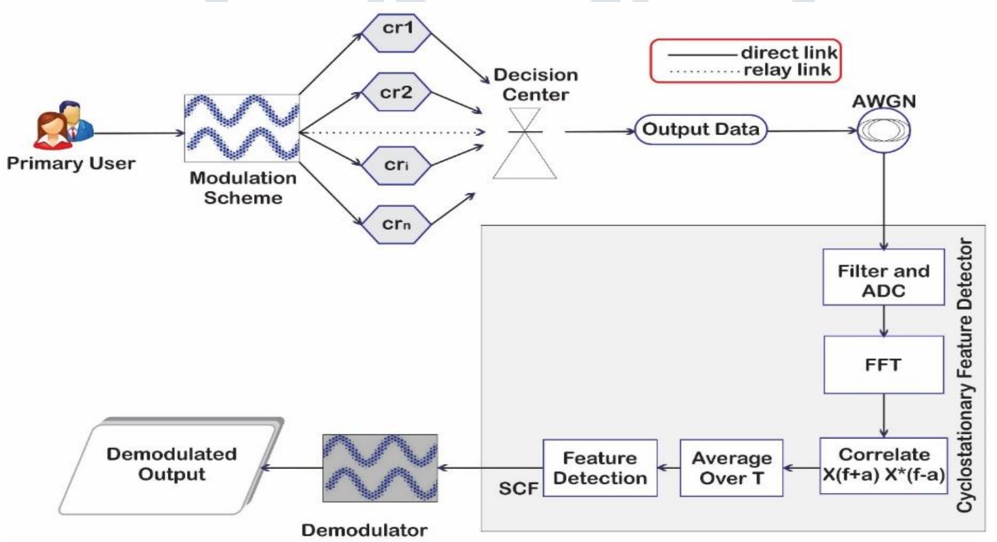

Figure 2: Block diagram of Cyclo-stationary feature detection based on decision center.

First, we assume that $k*\ (1 \leq k* \leq K)$ is the least required number of CRs required in cooperative spectrum sensing so as to satisfy $(Q_f + Q_m) \leq \epsilon$. Then, from Proposition 1, we can see that the optimal voting rule for cooperative spectrum sensing with $k*$ cognitive radios is $n_{k^*}^{opt} = \min\left(k^*, \left\lfloor \frac{k^*}{1+\alpha} \right\rfloor\right)$, where α is related to P_f *and* P_m and can be evaluated from the known λ and the SNR.

Define the function $F\,(\cdot,\cdot)$ in terms of the variable k as

$$F\left(k, n_{k^*}^{opt}\right) = Q_f + Q_m - \varepsilon,$$

Where k denotes the number of co-operative CRs in cooperative spectrum sensing and $n_{k^*}^{opt} = \min\left(k, \left\lfloor \frac{k^*}{1+\alpha} \right\rfloor\right)$. The probabilities Q_f *and* Q_m are functions of k and $n_{k^*}^{opt}$. Then, we have

$$F(k^*, n_{k^*}^{opt}) \leq 0$$

$$F(k^* - 1, n_{k^*-1}^{opt}) \leq 0$$

because $k*$ is the least number of CRs satisfying $Q_f + Q_m \leq \epsilon$. Using $k* = \lceil k_0 \rceil$, where k_0 is the first zero-crossing point of the curve $F(k, n_{k^*}^{opt})$ in term of k. Therefor a fast spectrum sensing algorithm can be formulated by considering only $k*$ CRs in cooperative spectrum sensing instead of K. Consequently, the sensing duration (in which the decisions are sent to the common center for decision fusion) can be reduced from K time slots to $k*$ time slots, while the given error bound ϵ is guaranteed.

IV. Simulation and Result Analysis

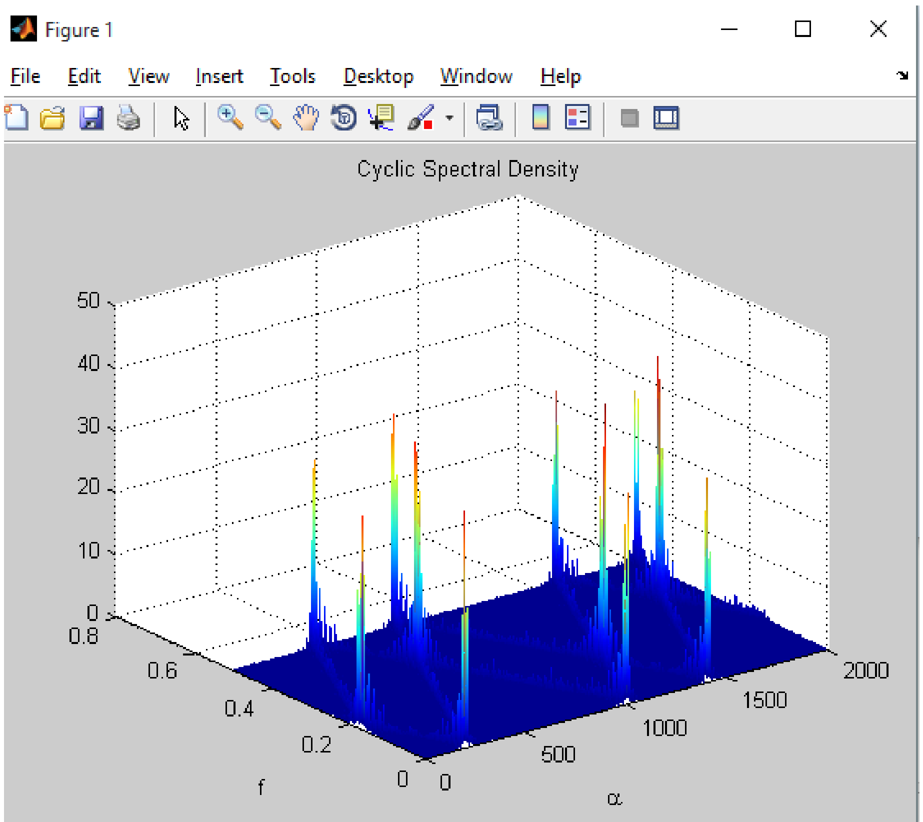

Figure 3: window show that the output figure1 when click on CSD method button of our cyclostationarity detection-based spectrum sensing in cognitive radio networks.

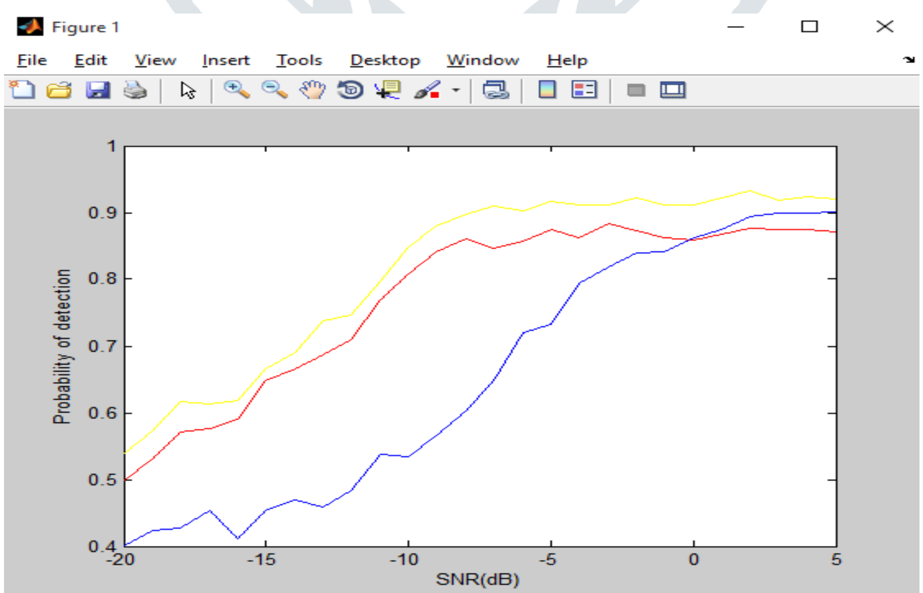

Figure 4: window show that the output figure1 when click on FCD method button of our cyclostationarity detection-based spectrum sensing in cognitive radio networks.

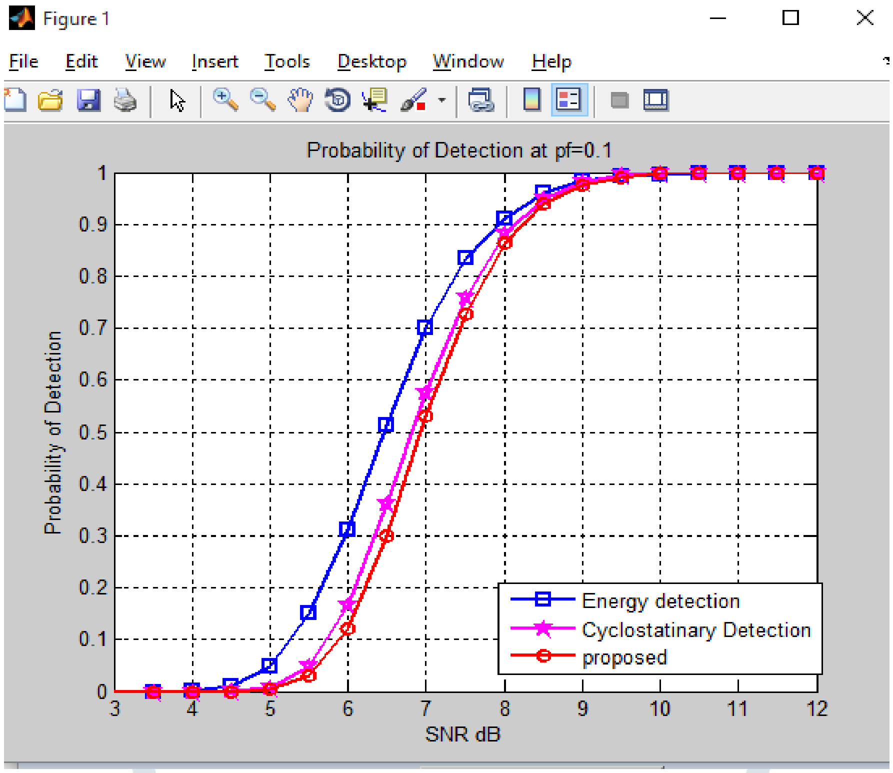

Figure 5: window show that the output figure1 when click on FCR method button of our cyclostationarity detection-based spectrum sensing in cognitive radio networks.

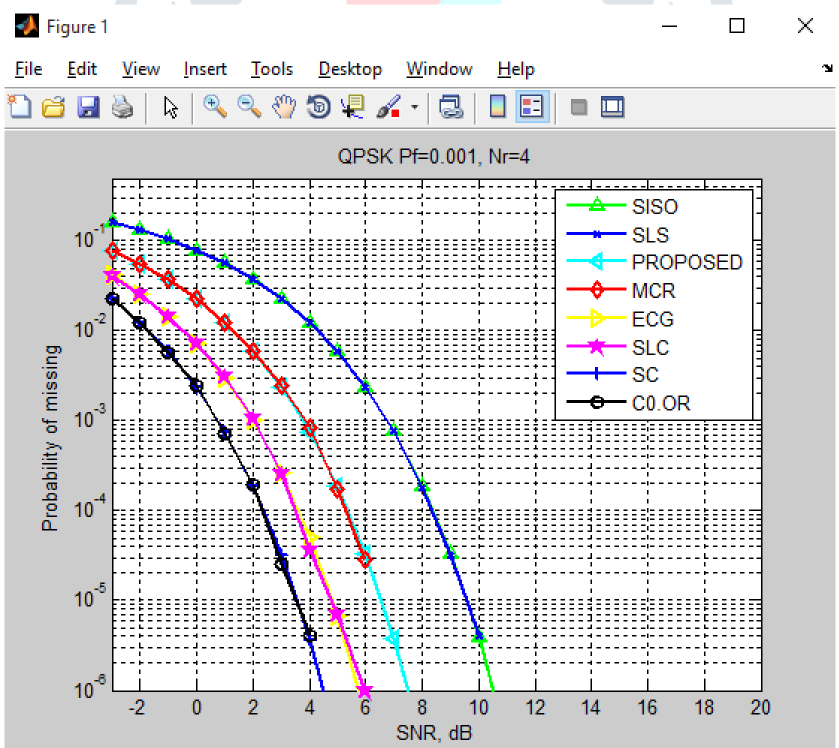

Figure 6: window show that the output figure1 when click on MCR method button of our cyclostationarity detection-based spectrum sensing in cognitive radio networks.

Table 1: CFD computation complexity and energy consumption.

No. Of users	2	4	6	8
Energy consumed for CFD computation	25	45	65	80
Computation complexity of CFD	2	5	22	82

Table 2: ED computation complexity and energy consumption.

No. of users	2	4	6	8
Energy consumed for CFD computation	8	18	38	90
Computation complexity of CFD	21	30	36	52

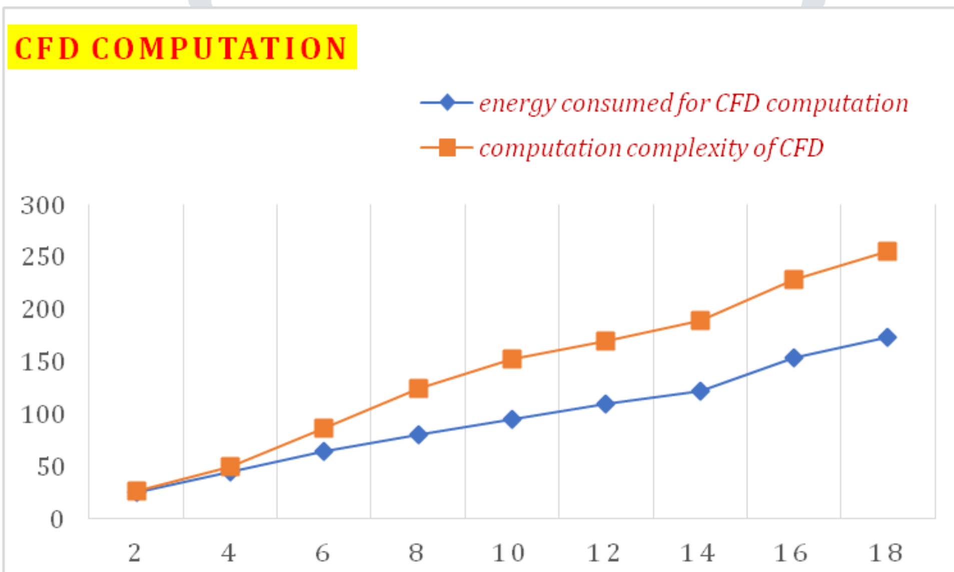

Figure 7: CFD computation complexity and energy consumption.

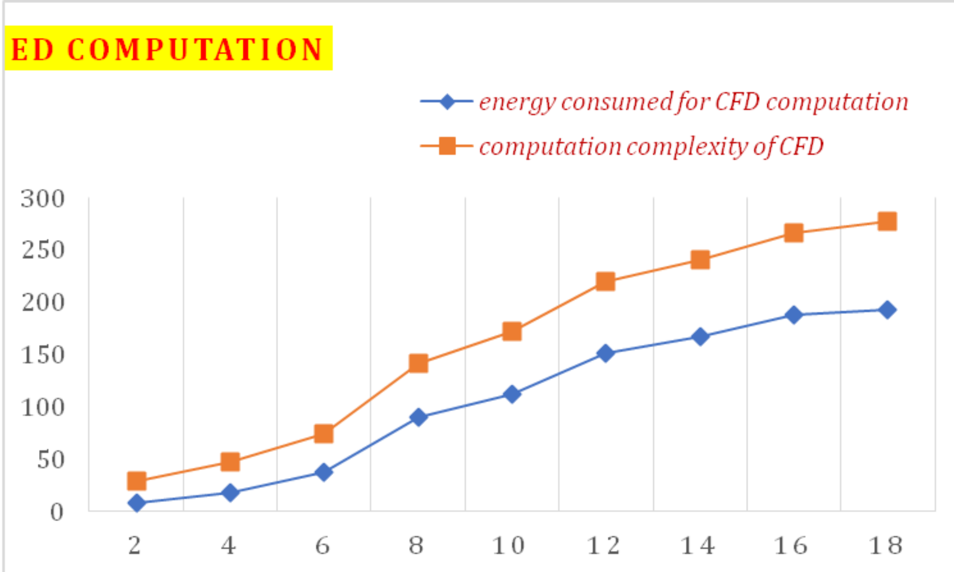

Figure 8: ED computation complexity and energy consumption.

V. Conclusions

Simulation results indicate that the optimal scheme varies the number of users so that error is kept as minimum as possible without compromising the detection probability. With the increase in false alarm probability the minimum number of users required for satisfactory performance decrease. Thus, instead of keeping a fixed number of users for decision schemes in co-operative spectrum sensing, the number can be varied in accordance with the false alarm probability.
Multi-objective optimization technique highlights a very good method which results in increased detection probability without putting many constraints on the objective function. It is applicable to functions even though they are not differentiable as it is different from classic methods in terms of operation. It also proves to be flexible as different weightage can be given to parameters and performance can be evaluated for different scenarios.

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