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Cooperative Spectrum Sensing in Multiple Antenna Based Cognitive Radio Network using an improved Energy Detector

Malothu Amru[1]Dr.Sake. pothalaiah[2] Dr. R P Singh [3] Dr.Dayadi.Laksmaiah[4] ,
Ph.D scholar[1]
Sri SatyaSai University of Technology &Medcial Science, Bhopal[1],[3]
VignanaBharathi Institute of Technology [2,4]Hyderabad, INDIA

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Abstract:
The exhibition exam of agreeable variety detecting with the help of an advanced power finder is done in this paper. Subjective radios are contains of numerous reception equipment. Each CR acknowledges vital patron sign with progressed energy discovery for instance power 'p' of adequacy of essential examples. Each CR takes its very very personal desire and ahead to combination recognition. The mixture recognition intertwines each one of the choices and take remaining preference of essential patron is available or missing. The articulations for the bogus caution danger and probability of overlooked identity have been inferred and complete mistake fee is determined. Enhancement of entire variety of CR, energy discovery power 'p' and amount of reception apparatuses at every CR is finished with the help of diagram and articulations by means of way of restricting absolute mistake charge. It is indicated that with the help of severa radio wires with low SNR among PU-CR joins, we will accomplish least mistake fee.

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I. INTRODUCTION

Inside the far flung correspondence, stages are the extensive property. In a ways flung help, particular recurrence band is allotted to specific consumer simply with the purpose that different purchaser can't get to others statistics. Because of prominence of far flung correspondence desires extra recurrence band and this presentations into range scarcity problem[3]. The extensive majority of the radio recurrence stages are wastefully used. In many quantities of the world, cellular mobile phone corporations are filled. The special recurrence agencies like television, navy, newbie, radar, and so forth are in element used. Assessment of Federal communication commission (FCC) inferred that range use is based upon time and spot. To decrease range scarcity and strife problem, Cognitive Radio (CR) innovation is furnished. It allows auxiliary patron to get unused variety of critical customer. Subjective radio is a framework, which knows the radio recurrence situation, it units parameters like recurrence, data transmission, stress and faculties the range gap within the crucial consumer band and dole out that range to auxiliary person[1-3].

Agreeable variety detecting with regular power detector[1] in unmarried recieving twine based totally subjective tool for improving device unwavering super in distinguishing variety starting has been tested substantially in past due time[2]-[4].It's far seemed in [5],[6] that the presentation of the mental radio device can superior by way of the usage of the use of strength indicator in highbrow radios, wherein customary strength identifier is altered by using the usage of setting squaring hobby of the had been given signal plentifulness with a discretionary incredible pressure p .In [7],[8],it's far

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proven that the dependability of the variety detecting can be stepped forward in CR thru the use of severa reception equipment. In this paper we don't forget the streamlining of beneficial variety detecting plan with an stepped forward power finder, severa reception apparatuses at each CR, and wrong saying channels by way of limiting the full of the agreeable chances of bogus alert and overlooked reputation alluded to because the entire mistake price within the paper. The number one evaluation among this paper and [6] is as consistent with the following. In [6], a solitary recieving twine based agreeable CR framework with added substance white Gaussian commotion (AWGN) channel over the PU-CR connections and impeccable revealing station is taken into consideration, even though, in this paper, we keep in mind a severa radio wire primarily based useful CR framework with Rayleigh blurring critical client (PU)- CR connections and blemished pronouncing stations.

II. SYSTEM MODEL

We consider a the cognitive radio network containing N CRs, one PU, and a fusion center (FC).It is assumed that each of the FC and PU contain a single antenna and each CR contain M antennas. There are two hypothesis H_0 and H_1 corresponding to the signal received in the i-th antenna at each CR,

$$v_i(t) \sim CN(0,\sigma_h^2) \; v_i(t) \sim CN(0,\sigma_h^2)$$

$$\begin{aligned} H_0 &: y_i(t) = v_i(t) && \text{if PU is absent} \\ H_1 &: y_i(t) = h_i(t)s(t) + v_i(t) && \text{if PU is present} \quad (1) \end{aligned}$$

where i is the antenna index $(i =1,2,\ldots, M)$ at each CR, $s(t)$ denote the signal transmitted by the PU at time instant t with energy E_s , is circularly symmetrical complex AWGN, and all are independent and identically distributed complex normal circularly symmetrical channel gains implying Rayleigh fading. It is assumed that the CRs do not have any information about the channels of the PU-CR links. Further, it is assumed that each CR contains the improved energy detector [5]; the statistics at the i^{th} antenna for deciding the presence or absence of the PU is given by

$$W_i = |\, y_i \,|^p \qquad P>0 \qquad (2)$$

Where, we have dropped the time index t for simplicity. It can be seen from (2) that for $p=2$, W_i reduces to the statistics corresponding to the conventional energy detector [1].For the above discussed set-up, cooperative spectrum sensing is performed as follow i) Each CR calculates decision statistic given in (2) for all ($i = 1,2,\ldots.M$) antennas and uses selection combining for taking a binary decision of a spectrum hole.ii) The a binary decision of each CR is sent to the FC over an imperfect reporting channel. iii) The FC applies the 'OR' rule to the binary decisions received from all CRs and takes a final decision on whether the PU is present or not .

III. PERFORMANCE ANALYSIS OF MULTIPLE ANTENNA BASED COGNITIVE RADIO WITH IMPROVED ENERGY DETECTOR

The cumulative distribution function (c.d.f.) of the improved energy detector can be written as

$$P_{W_i}(x) = P_r(\,|\, y_i \,|^p \leq x\,) \qquad (3)$$

Where, Pr (.) denote the probability. By using the condition probability density function (p.d.f) of $|y_i|^2$ in (3) and after some algebra, we get the conditional p.d.f. of W_i under hypothesis H_0 and H_1, respectively, as

$$f_{W_i|H_0}(y) = \frac{2y^{\frac{2-p}{p}} \exp\left(-\frac{y^{\frac{2}{p}}}{\sigma_n^2}\right)}{p\sigma_n^2} \qquad (4)$$

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$$f_{W_i|H_1}(y)=\frac{2y^{\frac{2-p}{p}}exp\left(-\frac{y^{\frac{2}{p}}}{E_s\sigma_h^2+\sigma_n^2}\right)}{p\left(E_s\sigma_h^2+\sigma_n^2\right)} \qquad (5)$$

From (4), the probability that the decision statistic W_i is less than z, under hypothesis H_0 is given by

$$Pr(W_i \le z|H_0)=\int_0^z f_{W_i|H_0}(y)dy=1-exp\left(-\frac{z^{\frac{2}{p}}}{\sigma_n^2}\right) \qquad (6)$$

Maximal-ratio combining scheme is not considered since it has spectrum sensing overhead due to channel estimation. Moreover, a combining scheme based on the sum of the decision statistics of all antennas in the CR is not analytically tractable. Therefore, we assume that each CR contain a selection combiner (SC) that outputs the maximum value out of *M* decision statistics calculated for different diversity branches as $Z = max(W_1,W_2,W_3,\dots W_M)$. Hence, from (6), the c.d.f. of the SC under hypothesis H_0 is

$$Pz(z|H_0)=P_r\left[max(W_1,W_2,W_3,.......,W_M)\le z\,|\,H_0\right]$$
$$=\left[1-exp\left(-\frac{z^{\frac{2}{p}}}{\sigma_n^2}\right)\right]^M \qquad (7)$$

The condition p.d.f. $f_{z|H_0}(z)$ of the SC can be obtained by differentiating (7) w.r.t. *z*, resulting in,

$$f_{W_i|H_0}(z)=\frac{2Mz^{\frac{2-p}{p}}exp\left(-\frac{z^{\frac{2}{p}}}{\sigma_n^2}\right)}{p\sigma_n^2}\left[1-exp\left(-\frac{z^{\frac{2}{p}}}{\sigma_n^2}\right)\right]^{M-1} \qquad (8)$$

The output of the SC is applied to a one bit hard detector which takes decision of a spectrum hole as

$$z \underset{0}{\overset{1}{\gtrless}} \lambda \qquad (9)$$

Where λ is decision threshold in each CR and binary bits 1 and 0 correspond to the decision about presence and absence, respectively, of the PU. From (8),(9) and after many algebraic manipulations, the probability of false alarm P_f in each CR can be obtained as

$$P_f=\frac{1}{M}-\frac{1}{M}\left[1-exp\left(-\frac{\lambda^{\frac{2}{p}}}{\sigma_n^2}\right)\right]^M \qquad (10)$$

Similarly, the conditional p.d.f. of the output of the SC under H_1 is

$$f_{W_i|H_1}(z)=\frac{2Mz^{\frac{2-p}{p}}exp\left(-\frac{z^{\frac{2}{p}}}{E_s\sigma_h^2+\sigma_n^2}\right)}{p(E_s\sigma_h^2+\sigma_n^2)}\left[1-exp\left(-\frac{z^{\frac{2}{p}}}{E_s\sigma_h^2+\sigma_n^2}\right)\right]^{M-1} \qquad (11)$$

From(9),(11), the probability of miss P_m in each CR is

$$P_m=\frac{1}{M}\left[1-exp\left(-\frac{\lambda^{\frac{2}{p}}}{(1+\gamma)\sigma_n^2}\right)\right]^M \qquad (12)$$

Where $\gamma = E_s\sigma_h^2 / \sigma_n^2$ is the *average signal to noise ratio* (SNR) of the PU-CR link.

IV. ADVANCEMENT OF COOPERATIVE SPECTRUM SENSING SCHEME OVER IMPERFECT REPORTING CHANNELS

It is accepted that the blemished detailing channel between every CR and the FC is a parallel symmetric channel with a blunder likelihood of q. The likelihood of the bogus caution Qf and the likelihood of the miss recognition Qm in the FC is given by [Eq.(3)]

$$Q_f=1-\left[\left(1-P_f\right)\left(1-q\right)+qP_f\right]^N$$
$$Q_m=\left[P_m\left(1-q\right)+q\left(1-P_m\right)\right]^N \qquad (13)$$

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Define a function $Z(p, \lambda, N)$ obtained by adding Q_f and Q_m with equal weight (assuming equiprobable hypotheses),which denote the total error rate of this scheme and is twice the probability of error from an on-off keying of view, thus, the total error rate is given by

$$Z(p,\lambda,N) \triangleq Q_f + Q_m \qquad (14)$$

The optimized value of p for given λ and N can be obtained by taking the first order partial derivative of (14) with respective to p, setting the result to zero, and then using a fixed-point iteration method. Similarly, for given p and N, the optimized value of λ can be found. The optimized value of N_{opt}
Of CRs for a given value of λ and p is obtained from

$$\Delta Z(p,\lambda,N) = Z(p,\lambda,N+1) - Z(p,\lambda,N) = 0 \qquad (15)$$

From (10),(12),(13),(14),and (15), we have

$$N_{opt} \approx \left\lceil \frac{\ln f_2(q,P_f,P_m)}{\ln f_1(q,P_f,P_m)} \right\rceil \qquad (16)$$

and[.] denote the ceiling function, The optimized values of p, N and λ can be obtained jointly by using first order partial derivatives of (14) w.r.t. p and λ (15),by the numerical method given in [11].

V. NUMERICAL RESULT

It is assumed that the average SNR of all PU-CR links is the same and is labeled as 'SNR' in the figure 1 shows that total error rate vs. p for $M=2$, normalized threshold $\lambda_n = \lambda / \sigma_n^2 = 30$,SNR = 10dB, q = 0.001 and varying cooperative CRs , $N=1,2,\ldots,8$. It can be seen from fig.1 that there exists a unique value of $p \neq 2$ and number of cooperative CRs for which the total error rate is minimum. The optimized value of p is numerically found to be 3.049 and optimized number of cooperative CRs is as 4.

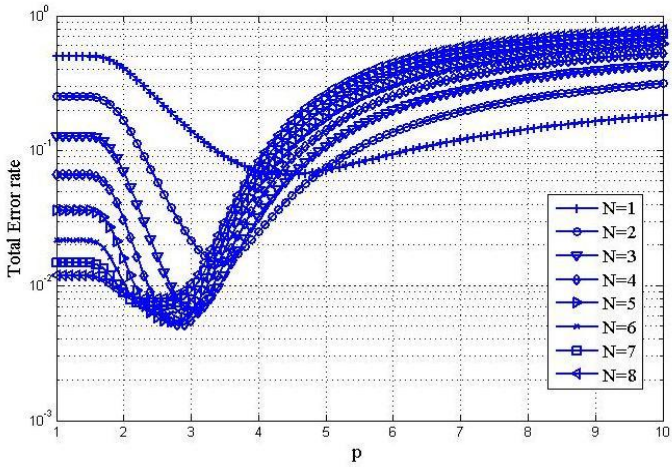

Fig.1. Total Error Rate versus p for varying number of cooperative spectrum sensing

$N=1,2,\ldots,8$, $M=2$, $q=0.001$, $SNR=10dB$ *and* $\lambda_n=30$

The fig.2 is the total error rate vs. SNR plots of the proposed scheme with jointly optimized and sub-optimal values of p, λ *and* N . The plot shows that the cognitive system with multiple antenna based CR (-20dB to 0 dB) as compared to the single antenna based CR system. By using optimized values of N, λ and p, the total error rate of the CR system can be further reduced to very low values at all SNRs. For M =1 , optimized values are $p = 3.28$ and $N=8$. For M = 3, optimized values are $p = 2.92$ and $N = 3$.

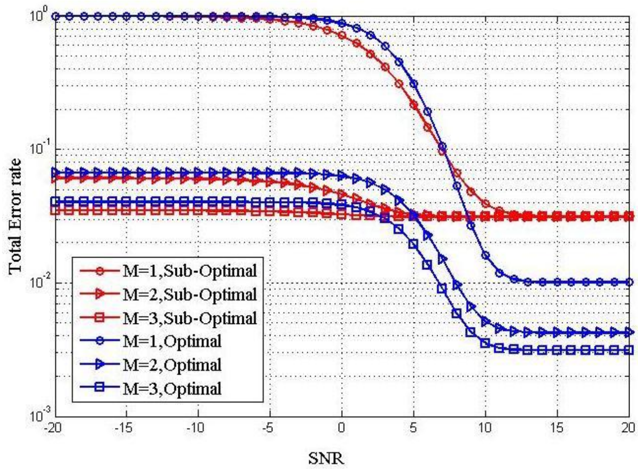

Fig.2.Total error rate versus SNR plots of the proposed with joint optimization and without optimization. For sub-optimal case, $\lambda_n=30$, $N=5$,$p=2$ *and* $q=0.001$

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VI.CONCLUSION

Enhancement of a useful variety detecting plan with an advanced power locator and severa reception apparatuses primarily based CRs over faulty revealing channels is talked about. It is indicated that by utilising the all out blunder rate least paradigm it's far workable to perform massive development in use of the variety starting and decrease in impedance degree for the PU at extraordinarily low SNR pass.

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