PERFORMANCE ANALYSIS OF COOPERATIVE SPECTRUM SENSING OVER TWDP FADING IN CRN WITH HARD DATA FUSION

A Thesis
Submitted to the
Atmiya University,
For the Degree of

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in
ENGINEERING & TECHNOLOGY

by

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May, 2023

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Originality of Research Work

I declare that thesis entitled "***Performance analysis of Cooperative Spectrum Sensing over TWDP fading in CRN with Hard Data Fusion***" is my own work conducted under the supervision of **Dr. Vishal S. Vora** at Department of **Electronics and Communication Engineering**, Faculty of **Engineering and Technology**, Atmiya University, Rajkot, Gujarat, India and approved by the Director of Research.

I further declare that to the best of my knowledge the thesis does not contain any part of any work which has been submitted for award of any degree either in this University or any other University without proper citation.

Date: 27-05-2023

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Name of Research Supervisor : Dr. Vishal S. Vora

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I declare that the submitted thesis entitled "***Performance analysis of Cooperative Spectrum Sensing over TWDP fading in CRN with Hard Data Fusion***" incorporates

1. All the suggestions / directions / modifications / additions / deletions received from the supervisor and the external examiners through their thesis evaluation reports.

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[Dobaria Ankit Devjibhai]

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List of Acronyms

RF	Radio Frequency
CR	Cognitive Radio
PU	Primary User (Licensed User)
SU	Secondary User (Unlicensed User)
UWB	Ultra Wide Band
FCC	Federal Communications Commission
ROC	Receiver Operating Characteristics
Tx	Transmitter
Rx	Receiver
PFA	Probability of False Alarm
PD	Probability of Detection
PMD	Probability of Miss Detection
CRN	Cognitive Radio Network
WRAN	Wireless Regional Area Network
M2M	Machine to Machine
AWGN	Additive White Gaussian Noise
SNR	Signal to Noise Ratio
ADC	Analog to Digital Convertor
MFD	Matched Filter Detection
BPF	Band Pass Filter
CFD	Cyclic Frequency Domain
CAF	Cyclic Auto-correlation Function
CFD	Cyclo-stationary Feature base Detection
CRU	Cognitive Radio User
TWDP	Two Waves with Diffuse Power
SS	Spectrum Sensing
CSS	Cooperative Spectrum Sensing
FC	Fusion Center
DGF	Dynamic Group Fusion
LAN	Local Area Network
C_CSS	Centralized Cooperative Spectrum Sensing

DCSS	Decentralized Cooperative Spectrum Sensing
SLC	Square Law Combining
MRC	Maximum Ratio Combining
CH	Cluster Head
ED	Energy Detection
FTR	Fluctuating Two Ray
PDF	Probability Density Function
LoS	Line of Sight

List of Symbols

P_d	Probability of detection
P_{fa}	Probability of false alarm
P_{md}	Probability of miss detection
H_0	Null hypothesis
H_1	Alternative hypothesis
$n(k)$	Additive white Gaussian noise
h	Channel gain
δ_w	Variance
T_{ED}	Testing matrix of energy
γ	Predetermined threshold
$Q(\cdot)$	Marcum Q-function
D	Distance between PU and SU
$\Gamma(\cdot)$	Complete gamma function
ρ	Signal to noise ratio
T	Specular to diffuse power ratio
Δ	Specular to peak average power
q	Approximation coefficient
$X(n)$	Sample of primary user signal
n	Number of samples for observation
L	Total number of Secondary users (Cognitive users)
l	Number of Group (Cluster)
$\Gamma\ (.,.)$	Incomplete gamma function
$y(n)$	Received signal at secondary user
TB	Time bandwidth product
u_1 , u_2	Two Specular components
E	Energy of primary user signal
σ	Standard deviation

Abstract

The constant improvement of wireless devices and technology is a direct result of the ever-increasing popularity of wireless channels of communication. With the expanded variety of products and services that may be offered thanks to the modern integration and compatibility of wireless technologies, there is a great need for effective access to the radio frequency spectrum. In order to combat the obvious spectrum underutilization brought on by the rigid spectrum allotment, cognitive radio (CR), a novel notion of reusing licensed spectrum in an opportunistic way, holds great promise. Cognitive radio (CR) is defined by the Federal Communications Commission (FCC) as "a radio or system that detects its command and control electromagnetic environment and can adaptively and independently modify its radio operating condition to reconfigure network operation, such as to maximize throughput, reduce environmental interference, enable interconnectivity, and connect secondary markets."

CR entails a radio channel setup where the transmitting and receiving devices are able to logically perceive a band of spectrum to determine if it is currently in use. Without disrupting the currently used band, it's able to be switched instantly to the next accessible one. This reduces interruption to primary users while allowing secondary users to make better utilization of the spectrum of radio frequencies. Avoiding interference requires first sensing the specific band of the electromagnetic spectrum. Consequently, cognitive radio's spectrum sensing plays one of the primary roles, as it keeps an eye on the frequencies that aren't being used at any given moment.

Spectrum sensing wherein CR operates independently is referred to as single user sensing or non-co-operative spectrum sensing. Non-co-operative spectrum sensing has some limitations, such as noise inconsistency, fading, and effect of shadow. The answer to these issues can be found in co-operative spectrum sensing (CSS). CSS takes the results from multiple SUs and averages them to make a better judgment. CSS allows the user to detect the spectrum by using a common receiver. It has also been divided into De-centralized CSS (D_CSS) and centralized CSS (C_CSS).

This dissertation compares both ideas by using a set of rules to determine whether a licensed user is present. There is thousands of equipment in certain networks which

are linked to each other in order to share the spectrum. It means that the congestion is a real issue. The very worst scenario of fading in radio connectivity, as anticipated by such Rayleigh scenario, is observed in real-world deployments of sensing devices in metallic protective measure. Hyper-Rayleigh faded channels constitute the most common method of fading in this situation because of their small scale propagations. The two-waves-with-diffuse-power model best describes this phenomenon. In this dissertation clustering based algorithm has be used to the improve the detection performance in many ways such as, minimizes the chances of missed-detection, reducing wrong detection, high detection-probability, fewer power consumption, increased adaptability, Better collision avoidance etc.

This dissertation focuses on D-CSS using clustering approach over TWDP fading channels using two-stage hard decision algorithms using AND & OR decision scheme. We derived the modified hard decision schemes such as OR__OR, OR__AND, AND__OR, and AND__AND for the proposed D—CSS approach from the conventional centralized CSS model. The chances of missed detection at a different SNR values is evaluated for the proposed D_CSS approach with clustering strategy and compared it with conventional centralized-CSS model without employing clustering strategy. To accomplish this scenario, we simulated the result and get different ROC graphs for the different number of SUs. The results of these simulations reveal that the OR_AND decision logic achieves the lowest P_{md} values when compared with the various decision logics presented in the ROC graph. Attaining the least missed-detection probability will result in improved detector performance.

In this dissertation previous standard result of ED based spectrum sensing over AWGN, Rayleigh; wei-bull fading channels are compared with TWDP fading scenario. Out of these all results, the OR_AND decision gives better performance at various SNR levels. The suggested method with AND_AND logic over TWDP fading enhances detection efficiency by up to 30% for SNR values between -20dB and -17dB as compared to the wei-bull fading scenario. According to our findings for different values of T and Δ for TWDP fading scenario, secondary users can save the energy needed to meet the minimum SNR required for detection-probability.