A SPECTRUM SENSING AND ALLOCATION MODEL FOR PRIMARY USER DETECTION AND INTERFERENCE MITIGATION IN TELEVISION WHITESPACE

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A SPECTRUM SENSING AND ALLOCATION MODEL FOR PRIMARY USER DETECTION AND INTERFERENCE MITIGATION IN TELEVISION WHITESPACE

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF ENGINEERING (M.Eng.) DEGREE IN INFORMATION AND COMMUNICATION ENGINEERING IN THE DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE

FEBRUARY, 2023

ACCEPTANCE

This is to attest that this dissertation has been accepted in partial fulfillment of the requirements for the award of the degree of Master of Engineering in Information and Communication Engineering in the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Nigeria.

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(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I, **NOTCKER, JOACHIM (20PCK02094),** declare that this dissertation is a representation of my work, and is written and implemented by me under the supervision of Prof. Emmanuel ADETIBA of the Department of Electrical and Information Engineering, Covenant University, Ota, Nigeria. I attest that this dissertation has in no way been submitted either wholly or partially to any other university or institution of higher learning for the award of a master's degree. All information cited from published and unpublished literature has been duly referenced.

NOTCKER, JOACHIM

Signature and Date

CERTIFICATION

This is to certify that the research work titled "**A SPECTRUM SENSING AND ALLOCATION MODEL FOR PRIMARY USER DETECTION AND INTERFERENCE MITIGATION IN TELEVISION WHITESPACE**" is an original research work carried out by **NOTCKER, JOACHIM (20PCK02094)** meets the requirements and regulations governing the award of Master of Engineering (M.Eng.) degree in Information and Communication Engineering from the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this work to my lovely mom.

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I'd like to use this opportunity to thank God, who has given me everything I need to succeed in life. All praise and honor are due to him.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CR - Cognitive Radio

TVWS - Television Whitespace

IP – Internet Protocol

ITU – International Telecommunication Union

CISCO – Computer Information System Company

TV – Television

OC – Optimum Combining

MIMO – Multiple Input Multiple Output

PU – Primary User

SU – Secondary User

CRN – Cognitive Radio Network

DNN – Deep Neural Network

CNN – Convolution Neural Network

GNN – Graph Neural Network

ISM – Industrial, Scientific, and Medical

VHF – Very High Frequency

UHF – Ultra High Frequency

IEEE – Institute of Electrical and Electronics Engineers

SNR – Signal to Noise Ratio

MHz – Megahertz

SSDF – Spectrum Sensing Data Falsification

ML – Machine Learning

PUE – Primary User Emulation

IDS – Intrusion Detection System

IoT – Internet of Things

NLOS – Non-Line of Sight

SS – Spectrum Sensing

WRAN – Wireless Region Area Network

PCI – Principal Component Analysis

DLN – Deep Learning Network

ANN – Artificial Neural Network

QoS – Quality of Service

MLP – Multiple layer Perception

CCI – Co-channel Interference

ACI – Adjacent-channel Interference

NFSC – Neural Fuzzy Signal Classifier

RFI – Radio Frequency Interference

ArPLS – Asymmetrically Reweighted Penalized Least Squares

2D – Two Dimension

SED – Spectral Energy Distribution

PDF – Probability Density Function

AP – Access Point

TAS – Transmit Antenna Selection

PPP – Poison Point Process

BER – Bit Error Rate

SINR – Signal to Interference plus Noise Ratio

AWGN – Additive White Gaussian Noise

PHY – Physical layer

WMMSE – Weighted Least Mean Square Error

CSI – Channel State Information

DQN – Deep Q-Network

CU – Cognitive User

DPPO – Distributed Proximal Policy Optimization

WII – Wireless Interference Identification

ABSTRACT

TV White Space (TVWS) is a potentially useful method for overcoming the problem of limited wireless communication spectrum. It refers to the spectrum between 54 MHz and 790 MHz, and its propagation properties have been the focus of an increasing number of investigations in recent years. However, interference is one of the significant issues that limit the utilization of available spectrum in television (TV) bands, lower the quality of services among cognitive(secondary) users, and cause harmful destruction to licensed (primary) users. Extensive works have been devoted to the issue of interference in TVWS networks, with many studies focusing on either preventing interference between primary and secondary users by detecting the presence of primary users, or mitigating interference among cognitive users but did not combine the two. As a result, this work developed an architectural model that integrates spectrum sensing and allocation components to identify the presence of primary user and reducing interference among cognitive users. For spectrum sensing component, an energy detection model was adopted to recognize a primary user so as to avoid interference with secondary users whereas for spectrum allocation component, the particle swarm optimization algorithm was employed to find the optimal allocation of channels among secondary users which result on reducing interference among them. The architectural model was implemented in simulated Cognitive TVWS network using MATLAB R2020a, and its performance was analyzed by taking into account false alarm probability, detection probability, signal to noise ratio (SNR), misdetection probability, and sum throughput. The simulation results showed that when SNR was set to -10 dB, the detection probability for the energy detection was 98.23%, while the matched filter was 92.55%. At false alarm probability of 0.51, the misdetection probability for the energy detection was 0.13%, while the matched filter had a misdetection probability of 2.61%. When 10 channels and 100 secondary users were considered, particle swarm optimization achieved maximum throughput of 279.9 Mbps while artificial bee colony achieved 278.7 Mbps. For 30 channels and 200 secondary users, 1.575Gbps and 1.571Gpps were achieved by particle swarm optimization and artificial bee colony algorithm respectively. Finally, when the number of channels were set to 50 and users to 300, particle swarm optimization achieved 3.879Gbps while artificial bee colony achieves 3.864Gbps. Therefore, the developed energy detection and particle swarm algorithms outperform matched filter and artificial bee colony algorithms respectively.

Keywords: ***Spectrum Sensing, Spectrum Allocation, Television Whitespace, Primary User, Interference Mitigation and Secondary User***