

Wavelet Packet-Based Spectrum Sensing For Cognitive Radio Networks: A Matlab-Based Comparative Analysis

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ABSTRACT

This paper provides a complete MATLAB numerical and graphical study of the WPT-based spectrum sensing for cognitive radio networks. The Daubechies-4 was selected for sub-band decomposition and the signal was decomposed at 4 levels resulting in 16 sub-bands. The analysis of sub-band energy showed that the highest energy present is found in Sub-band 0 (120), and the other values were much lower (<20), therefore Sub-band 0 is most likely referring to the Primary User (PU). This result demonstrates that the detection performance of WPT ($P_d = 0.85$, $P_f = 0.15$) is better than that of energy detection ($P_d = 0.75$, $P_f = 0.20$), while it approaches the performance of cyclo-stationary detection ($P_d = 0.92$, $P_f = 0.10$) with a cutoff 60. The time-frequency heatmap and binary decision output indicate WPT becomes a reliable method to localizing both time and frequency spectrum of PU. These findings indicate that both dynamic spectrum allocation and real-time sensing frameworks can greatly improve quality-of-service while minimizing disruption to primary users. It is also worth mentioning that WPT managed to obtain a reasonable execution time of 0.45 seconds, which proves to be a good compromise between detection accuracy and computational efficiency. In general, the results confirm the suitability of WPT for dynamic spectrum access in cognitive radio settings.

Keywords: WPT, Cognitive Radio Networks, Spectrum Sensing, MATLAB

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I. INTRODUCTION

Advancements in communication technology have increasingly demanded efficient and reliable spectrum sensing techniques to optimize the use of available frequency bands. Cognitive Radio Networks (CRNs) have emerged as a promising solution by dynamically accessing underutilized spectrum, thereby enhancing communication efficiency [1]. A critical challenge within CRNs lies in accurately detecting spectrum availability under diverse and often uncertain noise conditions commonly encountered in real-world environments. Wavelet packet-based spectrum analysis offers a refined approach to signal decomposition and feature extraction, enabling improved detection performance compared to traditional methods. By leveraging adaptive algorithms and advanced signal processing techniques, such as those integrating differential entropy and machine learning classifiers, researchers have significantly enhanced spectrum sensing accuracy and robustness [2]. The integration of CRNs with emerging 5G technologies underscores the urgency of robust spectrum frameworks capable of supporting diverse applications and high data rates. Such advancements highlight the importance of adaptive spectrum management to sustain efficient, reliable wireless communication networks [3]. The advancement of cognitive radio networks necessitates robust tools for evaluating and comparing spectrum sensing techniques to optimize performance. Effective spectrum management in CRNs is crucial to address challenges such as spectrum scarcity, interference mitigation, and quality-of-service (QoS) maintenance. Advanced frameworks incorporating real-time sensing and dynamic spectrum allocation have proven essential for optimizing spectrum use while protecting licensed incumbents [4]. MATLAB serves as an ideal platform for this purpose due to its extensive signal processing libraries and simulation capabilities, allowing researchers to implement complex algorithms such as wavelet packet-based spectrum analysis with precision and flexibility [5]. This study explores how well

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