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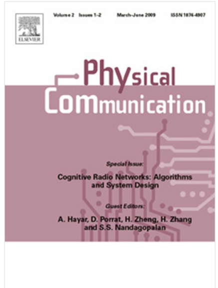

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A Comparative Analysis of Local and Global Adaptive Threshold Estimation Techniques for Energy Detection In Cognitive Radio

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Abstract

In this paper, we compare local and global adaptive threshold estimation techniques for energy detection in Cognitive Radio (CR). By this comparison we provide a sum-up synopsis on the effective performance range and the operating conditions under which both classes best apply in CR. Representative methods from both classes were implemented and trained using synthesized signals to fine tune each algorithm's parameter values. Further tests were conducted using real-life signals acquired via a spectrum survey exercise and results were analysed using the probability of detection and the probability of false alarm computed for each algorithm. It is observed that while local based methods may be adept at maintaining a low constant probability of false alarm, they however suffer a grossly low probability of detection over a wide variety of CR spectra. Consequently, we concluded that global adaptive threshold estimation techniques are more suitable for signal detection in CR than their local adaptive thresholding counterparts.

Keywords

Cognitive Radio, Comparative Analysis, Energy Detector, Global, Local, Threshold

1. Introduction

Cognitive Radios are smart radios designed for dynamic and opportunistic communication in which channels are utilized if detected to be free (signal absent), and vacated if occupied (signal present) [1]. CRs are now widely considered in the wake of the spectrum scarcity/underutilization problem currently beleaguering the wireless communication industry [2]. However, the potency of CR systems greatly depends on how well existing spectrum sensing (SS) methods are improved upon [3]. In this regard, one popular method widely used for spectrum sensing is the Energy Detection (ED) approach known for its quick sensing capability, simple design and its independence of the Primary User (PU) signal waveform [1], [4], [5]. Essentially, the ED approach determines if a band is free (noise only) or not by comparing the energy level in a channel to an estimated threshold value. It is expected that the estimated threshold value should be above the noise level in the channel. However, in situations where the noise estimate is unknown *a priori* and unstable, adaptive threshold estimation techniques become essential to guarantee minimal error rates in the CR decision making process.

Adaptive Thresholding Techniques (ATTs) are defined in CR as methods deployed for estimating the threshold of an ED without prior knowledge of the noise power in the measured spectra [1]. They are particularly important for improving the performance of the ED in vacillating noise floor conditions where the effect of noise uncertainty is known to be significant [6]. It is perhaps obvious that without the use of ATTs, the ED performs poorly in noise uncertainty regimes resulting in increased false alarm (spectra underutilization), and missed detection rates (signal interference) [7], [8]. For these reasons, ATTs have become fundamental components in most modern EDs, thus advancing their use in recent industrial applications such as in cyber physical systems (CPS), low power wide area networks (LPWANs), smart grids [9], industrial wireless sensor networks [10], [11], and in smart metering, and smart city applications [12].

We classify ATTs into two basic types namely the Local and the Global based methods. We define the local thresholding methods in CR as methods that compute a different threshold value for each sample in the measured spectra. These are elsewhere referred to as constant false alarm rate (CFAR) detectors [8], [13]–[15]. On the other hand, we define global thresholding methods as methods that compute a single threshold value over an entire range of samples in a reference window (or measured spectra). We liken this to the global thresholding concept in Image Processing. An overview of both classes is presented in Section 2 including notable examples.

The literature teems with different ATTs belonging to both classes, however, an obvious lack of a systematic comparative analysis of both classes is observed. This lack limits the ability of the CR Engineer to clearly state with certainty which class