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Advanced High-order Hidden Bivariate Markov Model Based Spectrum Prediction

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Abstract

The majority of existing spectrum prediction models in Cognitive Radio Networks (CRNs) don't fully explore the hidden correlation among adjacent observations. In this paper, we first develop a novel prediction approach termed high-order hidden bivariate Markov model (H^2BMM) for a stationary CRN. The proposed H^2BMM leverages the advantages of both HBMM and high-order, which applies two dimensional parameters, i.e., hidden process and underlying process, to more accurately describe the channel behavior. In addition, the current channel state is predicted by observing multiple previous states. Afterwards, the mobility of secondary users is fully considered and we propose an advanced approach based on H^2BMM, termed Advanced H^2BMM, to accommodate a mobile CRN. Extensive simulations are conducted and results verify that the prediction accuracy is significantly improved using the proposed (H^2BMM. The Advanced H^2BMM is also evaluated with comparison to H^2BMM and results show considerable improvements of H^2BMM in a mobile environment.

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1. Introduction

Cognitive Radio Networks (CRNs) are commonly perceived as a promising solution to the issue of spectrum scarcity. In CRNs, Primary Users (PUs) and Secondary Users (SUs) refer to the authorized and unauthorized users of allocated channels, respectively [1]. SUs are allowed to access channels opportunistically without harmful interferences to PUs [2]. To implement CRNs successfully, spectrum sensing is an essential process, in which SUs must obtain awareness about the spectrum usage to avoid destructive interferences to PUs [3].

A traditional CRN requires SUs to continually conduct a spectrum sensing process [4]. Specifically, time is divided into slots which consist of a small portion of sensing period, followed by a relative long period for data transmission. SUs conduct regular sensing and update the sensing result every time slot, which leads to high computational complexity [5]. To speed up the sensing process and save more time for transmission, spectrum prediction is a favorable technology. Spectrum prediction refers to the process of estimating the future channel occupancy status by analyzing sensing history [6]. With prediction, SUs are not required to sense the channel every time slot and hence the time for data transmission is prolonged.

A few spectrum prediction schemes have been proposed in the recent literature. Authors in [7] summarize several state-of-the-art spectrum prediction techniques and illustrate their applications. In [8] [9] [10], Markov related prediction algorithm has been improved from Hidden Markov Model (HMM) to high-order HMM and Hidden Bivariate Markov Model (HBMM). The standard HMM [8], also named the first-order HMM, solely depends on one immediately prior state and the correlation with other previous states is not fully explored. To improve the accuracy, a high-order HMM is proposed and evaluated in [9] where the current channel state depends on more than one prior states. In addition, studies discover that the geometric distribution characteristic of HMM is not suitable for describing channel behaviors, especially when bursty transmissions occur [11]. To better model the cognitive radio channel, hidden bivariate Markov model (HBMM)

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