School of Engineering and Applied Science (SEAS), Ahmedabad University

CSE 400: Fundamentals of Probability in Computing

Project Milestone 1 Submission

Topic: Multi-cycle Cyclostationary based Spectrum Sensing Algorithm for OFDM Signals with Noise Uncertainty in Cognitive Radio Networks

Group No.: 11

Domain: Wireless Communication

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1 Project System and Objective

1.1 Probabilistic Problem and System Description

This project proposes a simple multi-cycle cyclostationary based signal detection (spectrum sensing) algorithm for Orthogonal Frequency Division Multiplexed (OFDM) signals in cognitive radio networks. We consider a cognitive radio receiver that observes a sequence of discrete-time baseband samples and must decide whether an OFDM primary user signal is present or not. The noise samples are assumed to be independent and identically distributed random variables with unknown variance. This detection task is formulated as a probabilistic binary hypothesis testing problem. Under the first hypothesis, the received samples contain only noise, while under the second hypothesis the received samples contain an OFDM signal corrupted by noise. The receiver uses statistical processing of the observed samples to infer which hypothesis is more likely. The system uses the cyclostationary property of OFDM signals, which is created by the cyclic prefix, to differentiate the OFDM signal from random noise.

1.2 System Objective and Sources of Uncertainty

The primary aim of the system is to reliably identify the occurrence of an OFDM primary user signal and retain a constant and regulated probability of false alarm. One of the requirements is that such a performance should be realized even in cases when the actual noise power is not known with precision. The major sources of uncertainty in the system consist of the randomness of the noise samples, the uncertainty in the noise variance as well as the randomness of the received signal samples by the transmitted OFDM symbols and its inherent structure.

2 Key Random Variables and Uncertainty Modeling

2.1 Key Random Variables

The main random variables in the project are the noise samples $w[n]$, the received signal samples $x[n]$, and the test statistic T_{mc} used for detection.The noise samples $w[n]$ are modeled as zero-mean, independent and identically distributed circularly symmetric complex Gaussian random variables. The received signal samples $x[n]$ are random because they are formed by the superposition of the transmitted OFDM signal and the random noise.The test statistic T_{mc} is a random variable computed from the received samples using multi-cycle cyclic autocorrelation processing and is used for final decision making.

2.2 Uncertainty Modeling and Assumptions

The noise variance σ^2 is treated as an uncertain parameter. It is assumed to lie within a bounded interval and is modeled using a uniform distribution over that interval. The main probabilistic assumptions are that the noise samples are independent and Gaussian, and that there are enough samples to provide statistical approximations on which the analysis can be made.

3 Probabilistic Reasoning and Dependencies

Probabilistic relationships are of central importance in the detection strategy. The statistic properties of the cyclic autocorrelation estimates are simplified using the independence and identical distribution of the noise samples.The random quantities that created the numerator and denominator of the proposed multi-cycle test statistic are supposed to be independent, under the noise-only hypothesis. This autonomy is essential, as it enables the ratio of these two amounts to be analytically formulated.Conditional probability is applied in decision making. Specifically, the detector measures the likelihood of the test statistic exceeding a value in case of the absence of anything other than noise. It is through this conditional distribution that the detection threshold is designed to ensure that the likelihood of false alarm is pre-determined.Since the numerator and denominator are both assumed to be independent chi-square random variables in the noise-only scenario, the test statistic has an F-distribution. This is a probabilistic relationship which enables the system to determine the probability of the false alarm in closed form, and directly aids in selecting the threshold without necessarily having to know the exact value of the noise variance.

4 Model–Implementation Alignment

5 Cross-Milestone Consistency and Change

6 Open Issues and Responsibility Attribution

End of Submission