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

CSE 400: Fundamentals of Probability in Computing

Project Milestone 2 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 The probabilistic problem being addressed in this project.

The project is about the studies of a smart radio receiver which must able to decide that if an OFDM signal is present or not. The receiver on the other side gets many small samples of the signal. These samples can have only noise that is H_0 or can also have OFDM signal mixed with the noise that is H_1. The receiver of this signal can not be 100 percent sure of the received signal because noise is random. So to chose which case is more likely to occur we make use of probability and statistics. This makes the work as a probabilistic binary decision problem. Here, the system will check the patterns in the received data to detect the signal.

1.2 The objective of this system.

The main objective of this system is that it should correctly detect the presence of an OFDM primary user signal. Along with this, it must ensure that the probability of false alarm is small and fixed. Also, when the exact noise power is not known even then it must work properly. Hence, the systems makes the use of a multi-cycle cyclostationary method which will improve the detection performance and will make reliable decisions based on the noisy data.

1.3 The primary sources of uncertainty involved.

The system also faces several uncertainties. Some of them are:

1. Random noise samples - Over the time, the noise changes randomly.
2. Unknown noise variance - We do not know what the exact strength of the noise is.
3. Random transmitted OFDM symbols - Variation in signal data itself.
4. Signal structure and environment effects - Due to change in the channel conditions, there might be the change in the received samples.

2 Key Random Variables and Uncertainty Modeling

2.1 Key random variables.

This system handles the signals that change randomly, so they are considered as the random variables.

1. Received signal $x[n]$

   This is the main observed data at the receiver. This can be only noise or both signal and noise. This is the reason why it is random because both signal and noise will change over time.

2. Transmitted OFDM signal $s[n]$

   These are the real transmitted signal samples which are sent by the primary user. The symbols inside the OFDM are random because digital data changes continuously.

3. Noise samples $w[n]$

   Since noise is completely random and comes from the environment or electronic devices, and it will strongly affect the detection performance.

4. Test statistic T_{mc}

   This is the detector which will calculate a specific value using the received samples. This value will be random because it will depend on the random noise and the random signal data.

2.2 Uncertainty modeling for each random variable.

- Received signal $x[n]$ - This is modeled with 2 cases.
  1. under H_0 which is only noise: $x[n] = w[n]$
  2. under H_1 which is noise + signal: $x[n] = w[n] + s[n]$
- Noise $w[n]$ - This is modeled as:
  1. Zero-mean random values.
  2. Independent and identically distributed
  3. With the help of unknown variance
- OFDM signal $s[n]$ - OFDM signal is random due to following reasons:
  1. The symbols of modulation changes.
  2. There is a repeating structure due to cyclic prefix.
- Test statistic T_{mc} - It is modeled as a random variable but we can not study distribution for this random variable. Under the case of noise-only this will follow a known probability form and this will help to compute false alarm probability.

2.3 Probabilistic assumptions made.

1. Noise samples are independent and they are distributed identically.
2. Mean of noise is assumed to be zero.
3. We have assumed that OFDM signals have the periodic patterns because of the cyclic prefix and this will be helpful for detection.

3 Probabilistic Reasoning and Dependencies

1. Independence of noise samples

   The value of one noise will not affect the another one because all the noise values will behave in the same random manner. Due to the independency the detector will be able to add many samples together safely. This will also help to make mathematical formulas for probability easier. The distribution of the test statistic will become easier to calculate.

2. Conditional Relationships

   The received signal $x[n]$ depends on the fact that which of the two hypothesis, that is H_0 or H_1 is true. This means that the detector makes the use of conditional probability to measure things such as false alarm probability $P(T_{mc} > \lambda | H_0)$. This will tell the system that how likely a wrong decision will be when there is only noise present.

3. Dependence between Variables

   Variables such as test statistics will depend on the received signals. Further, the received signals depend on both signal and noise. The detector will understand these dependencies and will use statistical reasoning to separate the useful signals from random noise.

4 Model–Implementation Alignment

5 Cross-Milestone Consistency and Change

6 Open Issues and Responsibility Attribution

End of Submission