A Review of Enhancement in Frequency Spectrum Prediction Technique in Cognitive Radio

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Abstract: The Federal Communications Commission (FCC), utilization of the assigned spectrum geographical variations in range from 15% to 85% in current spectrum allocation policies. Therefore there is requirement of finding the ways to allow wireless devices to efficiently share the EM waves. The Frequency spectrum sensing mechanism on support vector machine (SVM) method could evaluate the probability density of idle state duration and occupied state duration of authorized users in given channel. Therefore, it can assess and amend the result of frequency spectrum real-time detection, also can decrease the impact of false alarm probability and misjudgment probability on cognition system and authorized system. The result of simulation shows that the mechanism is obviously efficient to decrease the interference of detection error to authorized system, and also able to apparently reduce the cost of frequency spectrum access chances of cognition system caused by detection error.

Keywords: Cognitive Radio; Sensing spectrum, detection error; support Vector Machine

I. INTRODUCTION

The Berkeley Wireless Research Center reports that 70% of the spectrum less than 3 GHz is available at any specific location and time. Under the FCC's "exclusive rights" model of frequency band ownership, if a licensed system is not transmitting, its spectrum remains off-limits to other users. There is a widespread concern over Cognitive Radio. Cognitive Radio can detect frequency spectrum of other authorized systems periodically and access to frequency spectrum that is idle, that can also realize reutilization of authorize frequency spectrum resource. In practical application, Cognitive Radio should not only maximize the utilization ratio of idle frequency spectrum resource but also assure the priority of authorized system in using authorized frequency spectrum resource and avoid severe interference to authorized system. Under this limiting condition, frequency spectrum detection in Cognitive Radio becomes a very challenging research topic.

There are a lot of spectrum sensing algorithms nowadays, such as matched filter detection, energy detection; correlation detection, cyclo-stationary feature detection and cooperative detection [1], most of them improve detection performance by reducing detection efficiency. Even though, there is complexity of wireless electromagnetic environment, hidden terminal, the limitation of detection time and other problems, frequency spectrum detection error is inevitable, such as false alarm probability and misjudgment probability occur and it can disturb the authorized system and reduce chances of cognition system to use idle frequency spectrum. Therefore here is need to obtain the probability density function of idle state duration and occupied state duration of authorized frequency spectrum according to statistics of idle and occupied state of authorized frequency spectrum, to assess and amend the result of frequency.

II. LITERATURE REVIEW

The signal is predicted by comparing the output of energy detector with threshold which depends on noise floor. Generally, if and only if the measured energy is below the threshold, the radio resource is declared as not occupied, i.e., it is available for opportunistic use. The important challenge with the energy detector based prediction is the selection of the threshold for detecting primary users. The other challenges include inability to differentiate interference from primary users and noise and poor performance under low signal-to-noise ratio values. The approximation of signal energy E gets better as N increases. First, to improve detection reliability, increased prediction time is required. Moreover, there is a minimum SNR below which no signal can be detected. Noise uncertainty, caused by various factors (e.g., temperature changes, ambient interference, and filtering), is unavoidable and leads to errors when setting the threshold for signal detection. PD (probability of detection) and PF (probability of false alarm) are the important factors for energy based detection which gives the information of the availability of the spectrum.

The signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor. In addition, it is more generic as compared to other methods, as receivers do not need any knowledge on the primary users signal .While compared to matched filtering energy detection requires a longer prediction time to achieve a desired performance level. However, its low cost and implementation simplicity render it a favorable candidate for spectrum prediction in cognitive radio systems.

The main drawback of the energy detector is its inability to discriminate between sources of received energy (the primary signal and noise), making it susceptible to uncertainties in background noise power, especially at low signal-to-noise ratio (SNR). If some features of primary signal such as its carrier frequency or modulation type are known, more sophisticated feature detectors may be employed to address this issue at the cost of increased complexity.

Thus, challenges with energy detector based prediction include selection of the threshold for detecting primary users, inability to differentiate interference from primary users and noise and poor performance under low signal-to-noise ratio (SNR) values.

III. SPECTRUM PREDICTION METHODS FOR COGNITIVE RADIO

Spectrum sensing is still in its early stages of development. A number of different methods are proposed for identifying the presence of signal transmissions. Most common spectrum sensing techniques in the cognitive radio are energy detection based spectrum prediction and Cyclic prefix Based Spectrum Prediction.[2]

To enhance the detection probability, many signal detection techniques such as matched filter, wavelet detection, cyclostationary detection and energy detection are there. Matched filter is the optimal detection technique which requires a prior knowledge of the primary user and has low computational cost. Wavelet detection is effective for wideband signal, does not work for spread spectrum signals demanding high computational cost.

Energy detector is also known as radiometry and it is most common method of spectrum prediction because of its low computational and implementation complexities. The signal is detected by comparing the output of energy detector with threshold which depends on noise floor. Generally, if and only if the measured energy is below the threshold, the radio resource is declared as not occupied, i.e., it is available for opportunistic use. The important challenge with the energy detector based prediction is the selection of the threshold for detecting primary users.[3]

Cyclic Prefix is another method of spectrum prediction detection. Modulated signals are in general coupled with sine wave carriers, pulse trains, repeating spreading, hopping sequences, or cyclic prefixes, which result in built-in periodicity. These modulated signals are characterized as cyclostationary since their mean and autocorrelation exhibit periodicity. These features are detected by analyzing a spectral correlation function. The main advantage of the spectral correlation function is that it differentiates the noise energy from modulated signal energy, which is a result of the fact that the noise is a wide-sense stationary signal with no correlation, while modulated signals are cyclostationary with spectral correlation due to the embedded redundancy of signal periodicity. Therefore, a cyclostationary feature detector can perform better than the energy detector in discriminating against noise due to its robustness to the uncertainty in noise power.[4]

In the work two spectrum prediction techniques (Energy detection based spectrum prediction and Cyclic prefix Based Spectrum Prediction) will be discussed. Mathematical description of both these techniques is illustrated and the closed form expressions of probability of detection for AWGN and Rayleigh Channels are described. Experimental results for Energy detection based spectrum prediction over different fading channels namely; AWGN, Rayleigh. For Cyclic-Prefix based Spectrum Prediction over AWGN channel will be presented using ROC curves.

The performance of licensed spectrum prediction is characterized by two probabilities. The probability of detection $\boldsymbol{P_d}$ represents the probability of detecting the presence of primary user's presence under hypothesis $\boldsymbol{H_t}$. It is observed that for energy detection, much higher SNR is required to obtain a performance comparable to cyclostationary feature detection. For energy detection, about 16 dBs higher SNR is needed to achieve 100% probability of detection. The false alarm probability is the probability of detecting the primary user's presence under the hypothesis. The "probability of false detection" for energy detection technique is inversely proportional to the SNR. At low SNR we have higher probability of false detection and at high SNR we have lower probability of false detection, because energy detection cannot isolate between signal and noise.[5]

IV. CONCLUSIONS

We have discussed the energy detection spectrum sensing technique of cognitive radio networks. Energy detection has the advantage of low implementation and less computational complexities. The sensitivity of spectrum sensing in cognitive radio networks can be improved by using asynchronous cooperative spectrum sensing method. The expected probability of false alarm or detection for spectrum sensing using energy detection method is evaluated. The frequency spectrum access mechanism put forward, which is based on frequency spectrum prediction, when authorized system and cognition system share the same frequency spectrum resource can assess and amend spectrum detection result. That is obviously responsible for decreasing the severe interference of detection error for authorized system, and evidently decrease the lost of chances of cognition system to access to idle spectrum, which is brought by detection error. Thus, that would insure the performance of authorized system and cognition system.

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