Military Technical College
Kobry El-Kobbah,
Cairo, Egypt

10th International Conference
on Electrical Engineering
ICEENG 2016

Cognitive Radio and Spectrum Scanning Optimization

By

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Abstract:

Cognitive radio can intelligently detect whether any portion of the spectrum is in use or not and can temporarily use it without interfering with the transmission of licensed users. In this paper firstly a brief discussion of various option of spectrum analyzing technique has done and secondly an optimized technique of scanning spectrum, that is bilateral scanning method has been analyzed using mat lab and compared with linear scanning on the basis of time taken in scanning and allotting the free gap to cognitive radio.

Keywords:

CR (cognitive radio), PR (primary user), SR (secondary user), PSD(power spectral density).

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1. Introduction:

Although electromagnetic spectrum is infinite as per theory but practically it is always scarce for commercial purposes, the assigned spectrum by license allocation is far from being fully utilized all the time so it remain idle mostly, and so efficient spectrum use is a growing concern; CR offers a solution to this problem. Cellular network frequency bands are overloaded in most part of the world and most of the time, but other frequency bands such as military, amateur radio, paging frequency and TV spectrum are insufficiently utilized. CR is considered as a solution towards this. It is the software based radio platform and should evolve to a fully reconfigurable wireless transceiver which automatically adapt its communication parameter to network and user demand. Qualities of CR include determining its location, sensing spectrum, changing frequency, adjusting output power or even altering transmission parameter and characteristics, all this will provide highly flexible, efficient, and comprehensive use of spectrum in real time.

2. What is cognitive radio?

A cognitive radio is an intelligent wireless communication system that is aware of its environment and uses the experienced in building a methodology to adapt to statistical variations of the input stimuli considering the objectives, first; highly reliable communication wherever and whenever needed. Second; efficient utilization of the radio spectrum. The properties possesses by CR are:

Frequency agility: ability to change its operating frequency to optimize its use in adapting to the environment.

Dynamic Frequency Selection (DFS): the radio senses signal from nearby transmitters to choose an optimal operation environment.

Adaptive Modulation: The transmission characteristics and waveform can be reconfigured.

Transmit Power Control: power of transmission can be controlled for better spectrum sharing.

Location awareness: it should be able to determine its location.

3. Cognitive cycle:

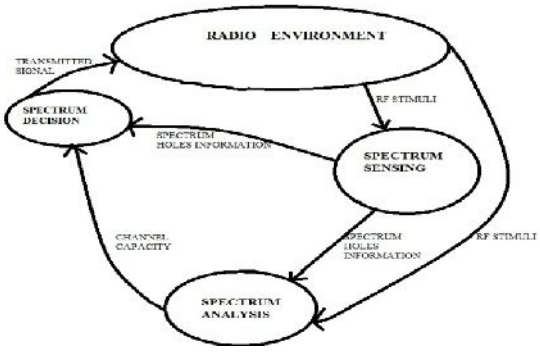


Figure (1): The Cognition Cycle.

Three main steps of cognitive cycle are :
Spectrum sensing: monitoring spectral band, capture information and detect the spectrum holes.
Spectrum analysis: the characteristics of the spectrum holes that are detected is estimated.
Spectrum decision: appropriate spectrum band is chosen according to the spectrum characteristics and user requirements, along with this it has to track changes in the radio environment, it has to check rigorously for the available opportunities therefore holes in the spectrum to avoid any chance of interference with the main user.

4. Spectrum scanning classification:

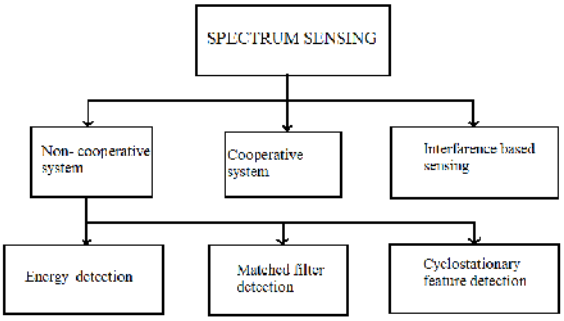


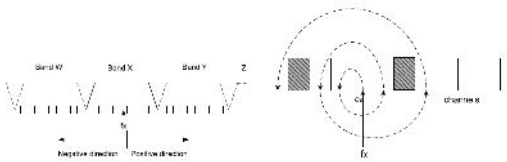
Figure (2): Classification of spectrum scanning technique.

A major challenge in cognitive radio is that the secondary users need to detect the presence of Primary users in a licensed spectrum and quit the frequency band as quickly as possible if the Corresponding primary radio emerges in order to avoid interference to primary users. Spectrum sensing and estimation is the first step to implement Cognitive Radio system. Figure 2. Shows the detailed classification of the spectrum sensing techniques, broadly classified into three main types.
Non cooperative scanning: in this case the detection of primary users is performed based

on the received signal at CR users. This approach includes matched filter based detection.
Cooperative scanning: primary signals for spectrum opportunities are detected by interacting or cooperating with other users, and the method can be implemented as either centralized access to spectrum coordinated by spectrum server.
Interference based sensing: in this secondary user coexist with primary users and are allowed to transmit with low power and are restricted by the interference temperature level so as not to cause interference to primary users.
The non cooperative scanning is further classified into three subtypes; energy detection, matched filter detection and cyclostationary feature detection. Energy scanning is one of the common type of scanning process, here available signals PSD(power spectral density) is sensed, in the analyzation of bilateral scanning algorithm energy scanning is used. Matched filter scanning requires the prior knowledge of the primary user. Cyclostationary process uses the periodicity in the received primary signal to identify the presence of primary users (PU). As noise do not exhibit periodicity so this detection process is immune to noise

5. Bilateral Scanning Technique:

In sequential unidirectional scanning, the radio scanner scans the channel in steps either in incrementing or decrementing order. Since the search space is limited to one direction, a unidirectional scan could miss a free channel available in the other direction and therefore does not ensure the detection of the nearest available free channel. By adopting bidirectional scanning, the scanning is performed in both directions, expanding through the spectrum space in both directions finding the nearest available channel. Figure 6.1 shows the current band (band X) and the scanning methodology. With the starting frequency f x, the center frequency of channel cx, the bidirectional scanner scans channels on either direction. The scanning steps in either direction are selected alternatively and expand in either side as cx+1, cx−1, cx+2, cx−2,. . . and so on, as shown in 2nd figure. This alternate bidirectional scanning steps appears to be scanning in spiral fashion and hence may be referred to as spiral-bidirectional



Bidirectional Scanning Mechanism

figure (3): bidirectional scanning

6. Matlab Simulation:

Developing an algorithm for bilateral scanning and then comparing it with default linear scanning following steps are followed as shown algorithm with windows shots.
15 normal separate carrier frequency has been taken namely fc1, fc2, fc3, fc4…… fc15 and along with this a sampling frequency more than the nyquist frequency of the maximum frequency out of 15 has also been taken.
After this a modulating signal has taken of cosine function.
Using ammod function each of the 15 transmittable signals was being created shown in window shot figure (4).

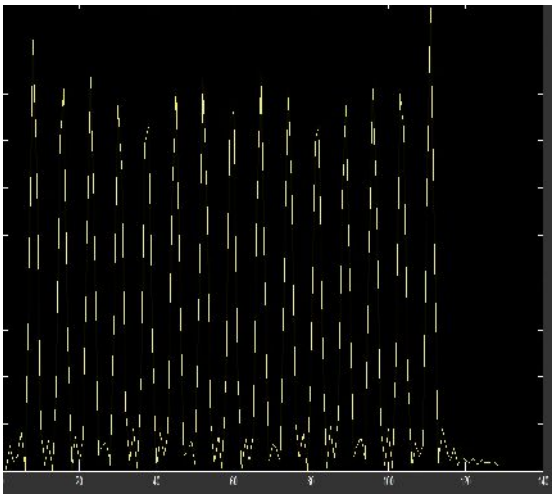


Figure (4): 15 users in the spectrum

Then, another modulating signal of different nature is taken.
Then running loop for eliminating the desired sloth of signal out of 15 is done for example we have fired 5th and 10th slot shown in figure 5.

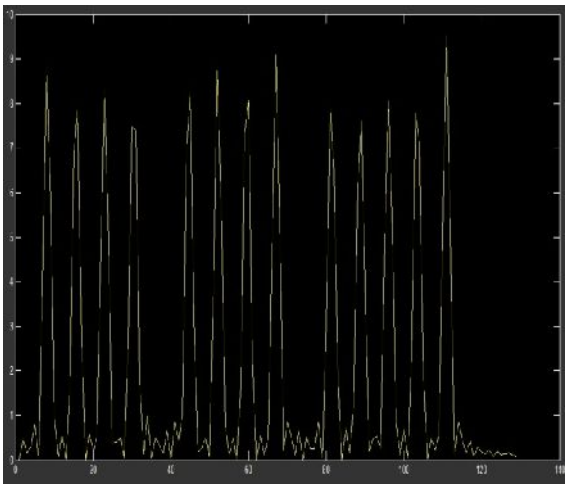


Figure (5): slot 5 and 10 are fired.

Then if no. further sloth is to be eliminate then secondary user ask for the permission to be introduced.
Then if permission is given, it is being asked for type of scanning to be employed either bilateral or linear.
Then according to the choice bilateral scanning technique or linear scanning technique is use to assign suitable vacant band to secondary signal, shown in figure 6. Slot 15 is occupied by secondary user.
If bilateral scanning is chosen than it takes comparatively less time in most of the cases of selected choice of fired slots like in the above example it takes 0.16us in bilateral where as 0.40us in linear scanning.

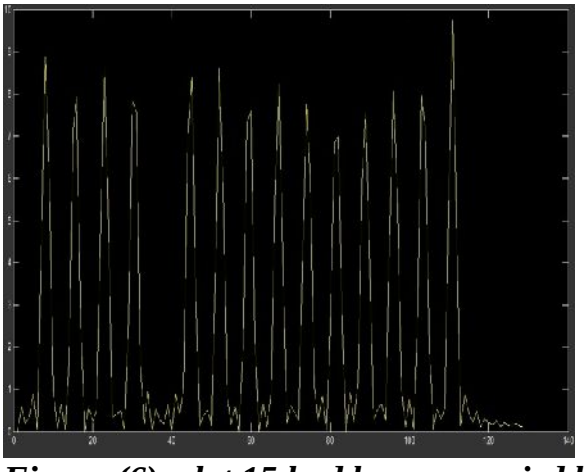


Figure (6): slot 15 had been occupied by secondary user.

Representation of the signals are in the form of PSD (power spectral density) using periodogram function.

7. Conclusions:

Cognitive radios have emerged to solve the current wireless communication system problems resulting from the limited available spectrum and the inefficiencies in the spectrum usage by exploiting the existing electromagnetic spectrum opportunistically. To evolve the cognitive radio technology it has to evolve at each aspect of its functioning and scanning is one of the basic initial process to be realized for its implementation. Bilateral technique promises a simple and efficient method of scanning and can be realized by a software.

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