

# A Software Tool in MATLAB for Spectrum Sensing in Cognitive Radio

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**Abstract**— The following paper presents a new algorithm for spectrum sensing. The algorithm uses a simple technique to determine each time if there is spectral gap in the given spectrum, as quickly as possible. The algorithm is presented using a software tool with a Graphical User Interface (GUI). The tool was written in MATLAB. The GUI implements the function of the algorithm and exports results about its performance.

**Keywords**—Cognitive Radio; Spectrum Sensing; MATLAB

## I. INTRODUCTION

Spectrum sensing is one of the most important stages in the operation of cognitive radio [1]. Several methods have been proposed for identifying the presence of signal transmissions [2]. Additionally, the problem of dynamic spectrum assignment has drawn much attention [3-5]. In these approaches, characteristics of the identified transmission are detected for deciding the signal transmission as well as identifying the signal type.

The proposed technique is based on the existence of a database which contains information about the spectrum and thereby finding a spectral gap becomes easier and faster.

## II. ALGORITHM DESCRIPTION

The algorithm is implemented in a collaborative, central-based setup as shown in Fig.1.

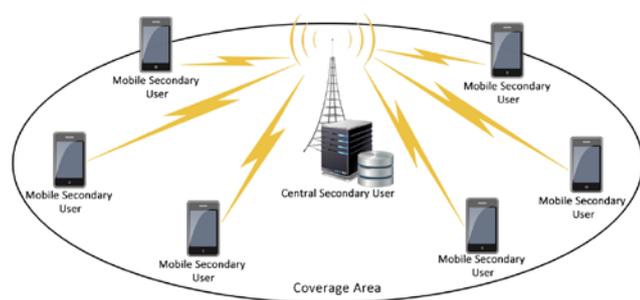


Fig.1 Network setup.

In a cognitive radio network there is a central node who senses the environment at regular intervals and processes the received information in order to renew its database. The algorithm runs only on the central node, which does not transmit. The other users when they want to transmit, they

make a request to the central node in order to inform it at what frequency they can transmit if there is a spectral gap.

The operation of the algorithm is described below. At first, the number of spectrum samples to be evaluated at each interval, is selected. Obviously, larger the number of samples, results to better knowledge about the spectrum. The given spectrum range is divided by the number of samples in order to determine the step. This step is used to find the frequencies that will be evaluated. These samples (frequencies) are the boundaries of each band.

All spectrum frequencies are assigned weight values with initial values at zero. At each interval the algorithm checks whether the value of each frequency is below the threshold that initially was assigned to the central user. If the value is below then this frequency weight value is increase by one. When all the frequency weights have been evaluated they are sorted in descending order and the central user database is updated. The ones with the higher weight values are the most likely to transmit. Using this procedure the system knows at every time interval which frequency has the highest probability of being free for transmission.

When a secondary user wants to transmit he makes a request to the central user. With the request, he sends the needed bandwidth  $B_r$  for transmission. Then the central user finds based on the sorted list frequency list at which frequency the user can transmit if a frequency gap exists. The frequency selection process is presented next.

The algorithm checks sequentially all frequencies in the sorted list until he finds one that is below the threshold value. Then he checks if the transmitted signal fits in this region by searching whether the surrounding samples from the left and from the right are below the threshold as well. The number of the nearby tested samples each time depends on whether the width of the transmitted signal consists of even or odd number of bands. If it is an even number, the algorithm checks the  $B_r/2$  bandwidth from the right of the central frequency and the  $B_r/2$  bandwidth from the left of the central frequency. In case of odd number of bands, first the  $B_r/2+0.5$  bandwidth from the right and the  $B_r/2-0.5$  bandwidth from the left are examined. Then if a gap has not been found, the algorithm checks the  $B_r/2-0.5$  bandwidth from the right and the  $B_r/2+0.5$  from the left. Once a gap is found, the algorithm assigns this gap to the secondary user in order to transmit the signal.

III. RESULTS

To evaluate the performance of the algorithm a software tool in MATLAB with a GUI was created. The tool creates a number of random spectra over which the algorithm operates. The user can select how many spectra from all the simulations will be constant. The reason for the above is to simulate that we have transmission the primary user.

The user must enter in the GUI the following:

- The number of the samples.
- The number of the threshold limit.
- The maximum/minimum power level in the randomly created spectrum.
- The maximum/minimum width of the bands in the randomly created spectrum.
- The maximum/minimum ripple of the bands.
- The bandwidth of the transmitted signal.

The GUI is shown in Fig.2.

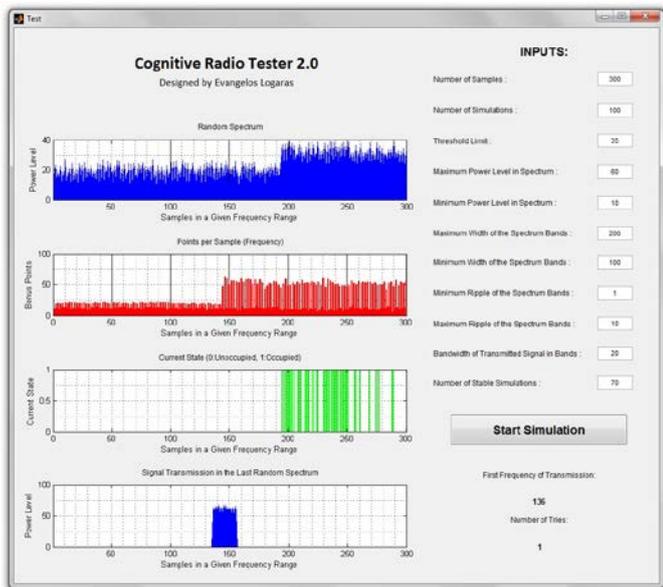


Fig.2 GUI Interface.

It is important to notice, that the program operates in a completely customizable way. For this reason, the input gaps are filled with pure numbers without units. The GUI displays the random graph of the spectrum in which the signal is transmitted (Fig.3), the points for every frequency (Fig.4), the graph with the current state (Fig.5) and finally the graph with the transmitted signal (Fig.6). The latter is shown only if it exists a spectrum gap.

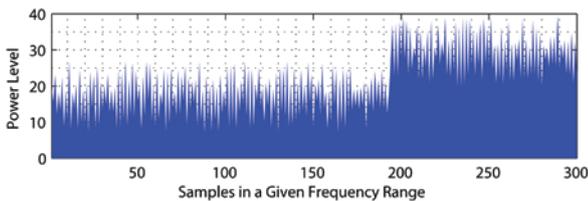


Fig.3 Random spectrum example.

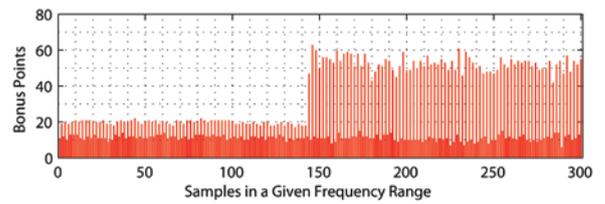


Fig.4 Points per frequency.

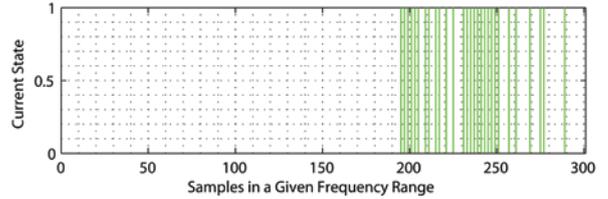


Fig.5 Current state (occupied or unoccupied).

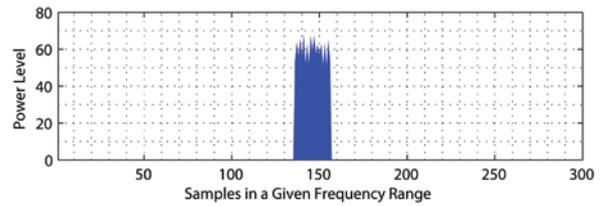


Fig.6 Signal transmission.

The GUI also displays the first frequency of the transmitted signal and also the number of attempts made by the algorithm in order to find the gap for transmission. If no spectrum gap is found, the signal cannot be transmitted. In that case the GUI displays the message: "The Spectrum is Fully Occupied".

IV. CONCLUSIONS

In this paper a new algorithm for spectrum sensing was presented. The main advantage of the algorithm is that it finds in a quick manner, in most cases, free spectrum for transmission using the database information. An additional advantage that can be considered is the algorithm simplicity. A software tool with a GUI written in MATLAB was presented that demonstrates this algorithm.

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