Entropic Analysis of Spectrum Sensing for Cognitive Radio

Addendum

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Besides a few interesting obstacles, considerable progress has been made in this study. GNU Radio, the software defined radio (SDR) package used for this project, is fairly undocumented and requires a strong background in both digital signal processing concepts and computer science. Thus, the first month of research was spent meeting these prerequisites, setting up the Linux platform and gaining familiarity with the system. Eventually, after much experimentation and testing, a suitable plot of the spectrum (fig 1) was produced. The code used to generate this plot was tested for accuracy by Dr. Roland Kempter, a post-doctoral research fellow of the ECE department, by comparing the SDR values with a control set. While the sample set shown in the plot was found to be generally accurate, a few discrepancies existed which have consumed much of the past month of work.

As spectral activity changes very rapidly, a realistic model requires a real time representation. Unfortunately the software sampler provided by the GNU Radio project did not meet this requirement and had to be modified. By sampling a smaller range of frequencies and storing more samples into memory before writing to a file a considerable increase in speed was realized. Currently, a complete sample set of the ISM bands (900-928MHz) can be generated in just a few milliseconds enabling a more accurate representation of primary user (PU) activity.

The standard file format used by the GNU Radio project also presented an issue. Ideally, one would like to be able to sample the spectrum a great many times, in various locations and over a large range of frequencies. To do this with the provided script would be messy as the file was binary with no support for location and time in the metadata; thus, one would have to store such information in the name of each file. Initially it was thought a SQL database would provide the most elegant solution but the technical details were enough to slow the progress of the project down. However, a database is planned to be implemented at some point in the future. For now, a simple text file has sufficed; each row being a sample set preceded by a header containing location, frequency and time.

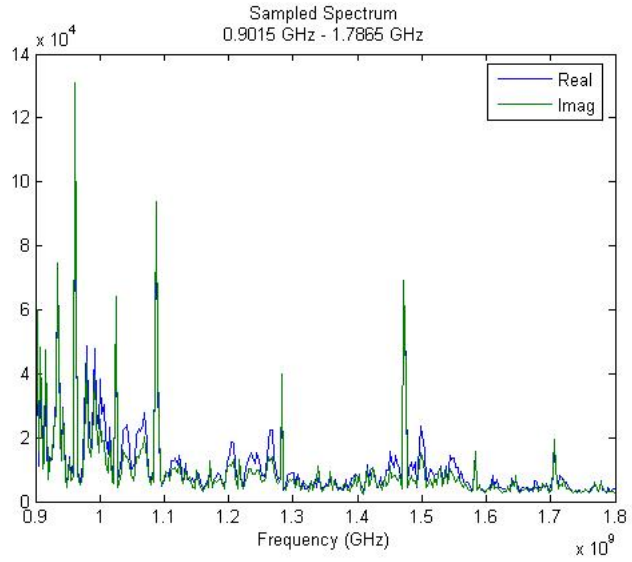

Figure 1: First Spectral Plot

At this point in the project, we've developed a fair understanding of GNU Radio but there still exists one major problem in the data. The GNU Radio software controls a piece of hardware known as the universal software radio peripheral (USRP). Essentially, this device provides an RF front end, several ADC's and a bridge to the computer. The RF front end shifts high frequency signals about DC to provide a more manageable Nyquist rate. Then the signals are convertered from analog to digital and sent across a USB bus to the computer for further processing. The ADC stage is implemented with a series of CIC filters as they're computational efficient low pass filters, providing some measure of anti-aliasing. Unfortunately, the CIC filters also exhibit a strong ripple effect and DC offset, imposing many nulls and spikes in the sample set. At this point, we can now accurately detect the nulls and peaks (fig 2) but must next learn how to minimalize their distortion. While the spikes can be removed by simply deleting the DC content in the spectral domain the nulls present a greater challenge. One thought is to repeatedly perform the experiment, shifting the center frequency each time, and interleaving the results in the frequency domain.

With UROP's continued support, the next semester will involve incorporating this study into a larger model by using the Emulab's collection of SDR's in the MEB. This will provide a testbed to refine our statistical models and instantaneously investigate PU activity over space. Also, if time permits, the development of a simple cognitive radio protocol for colloborative sensing will begin as proof-of-concept of our results.

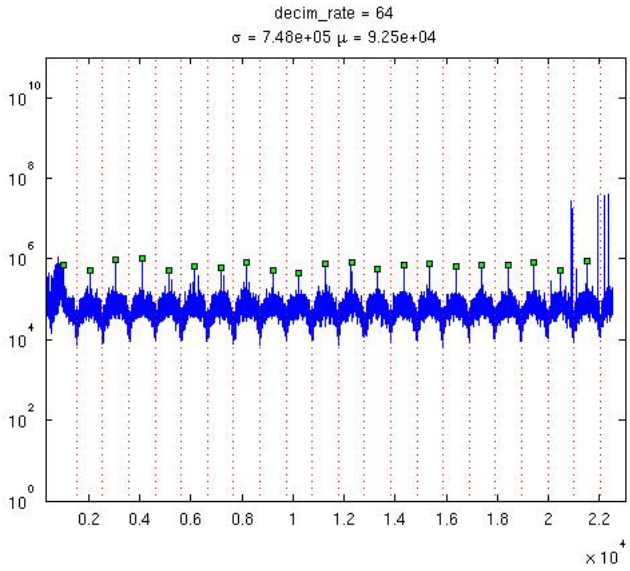

Figure 2: CIC Filter Distortion and Detection

We are also very excited to report that we've recently been asked to present our findings at the upcoming SDR Forum conference in Denver this November. This will be an incredible first time experience for the auther while also an opportunity to further demonstrate the University of Utah's advanced research in cognitive radio and would not be possible without UROP's funding.

Time Table

Once the problems with the CIC filters are worked out, research will continue with the following three goals:

1. Additional analysis with Emulab
2. Refine spatio-temporal statistical models for interference
3. Write and present paper at SDR Forum Conference