CONTINUOUS SPECTRUM MONITORING

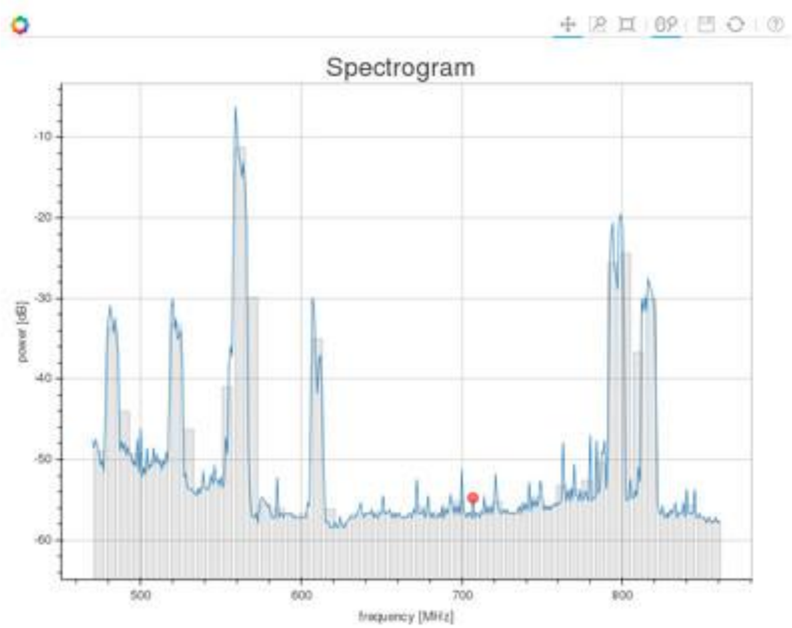
Just before the holidays and with some help from my colleagues at the Institute I managed to finally deploy the first spectrum sensor based on my new UHF receiver design. A handful of similar deployments are planned for the next year. At the end of January I'm traveling to London to mount two similar sensors that will monitor the TV White Spaces pilot in UK as part of a cooperation between King's College London and the CREW project I'm working for.

The sensor is based on the VESNA sensor node and is mounted in a small, weather-proof metal box. The previous generation of spectrum sensors (like those that were deployed in our testbed in Logatec) were designed to work in a wireless sensor network. However the low bit rate and reliability of the sensor network and interference caused by another radio next to a sensitive receiver proved to be very limiting. So for this device I went with wired Ethernet even though that reduces the deployment possibilities somewhat. Ethernet now provides a sufficient bit rate to allow for continuous monitoring of the complete UHF band with increased precision that is possible with the new receiver.

In some modes of operation however, the bandwidth from the sensor is still a limiting factor. The Digi Connect ME Ethernet module used here only allows for streaming data up to around 230 kbit/s, which is around 2-3 times slower than what the VESNA's CPU can handle. This is not a problem if you do signal processing on-board the sensor and only send some test statistics back over the network. In that case other things, like the local oscillator and AGC settle time, are usually the limiting factor. However if you want to stream raw signal samples, the network becomes the bottleneck.

Antenna for the sensor is mounted on top of one of the buildings at the Jožef Stefan Institute campus in Ljubljana. Most of the setup, like power and Ethernet connection, is shared with WLAN Slovenija, who already had some equipment mounted there. On the picture above, my UHF antenna (Super Scan Stick from Moonraker) is second from the left (one with three radials). I'm still using SO-239 connectors and RG-58 coax which I know is not optimal, but they were what I had in stock.

There is direct line of sight to a DVB-T receiver near Ljubljana Castle around 1500 m away and two cellular towers on nearby buildings, so there are plenty of strong transmissions to look at. On the same mast there is also a big omni-directional antenna for 2.4 GHz Wi-Fi. This might cause some interference with sensing in the 800 MHz band (2.4 GHz is the third harmonic of a 800 MHz LO signal), but I don't think that will be a problem. RG-58 cable is bad enough even at sub-1 GHz frequencies and that part of the spectrum seems to be occupied by a strong LTE signal anyway.



If you click on the image above, you should see a live visualization in you browser of the data stream coming from the sensor.

At the time of writing, the receiver is sweeping the band between 470 MHz and 861 MHz in 1 MHz increments. For each 1 MHz channel, it takes 25000 samples of the baseband signal. From these samples, it calculates the baseband signal power and a vector of sample covariances. It then sends these statistics back to a server that logs them to a hard drive and also provides the visualization (using a somewhat convoluted setup).

The signal power is shown on the spectrogram plot in logarithmic scale. Currently on the spectrogram you can see four DVB-T multiplexes at 482, 522, 562 and 610 MHz and some LTE activity around 800 MHz. Note that the power level is in relative units: 0 dB is the maximum ADC level which can correspond to different absolute power levels due to automatic changes in gain. The sensor can provide calibrated absolute power figures as well, but they are not shown at the moment.

Sample covariances are currently used by a maximum auto-correlation detector to detect whether a channel is vacant or not. This is shown on the live graph below the spectrogram. Note though that this detector works best for narrow-band transmissions, like wireless microphones, and often marks a channel vacant when it is in fact occupied by a wide-band transmission like DVB-T

Source :

https://www.tablix.org/~avian/blog/archives/2014/12/continuous_spectrum_monitoring/