Recovering Signals and Information From Radio Frequencies Using R (A high school student's experience)

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Radio frequency (RF) is part of the electromagnetic spectrum (10 kHz-300 GHz) and is essential to communications and information transfer. For this study, RF measurements were carried out with antennas connected to a PC software oscilloscope, and a digital receiver combined with a software-defined radio tool kit (GNU radio). The *R* language and environment for statistical computing was used to analyze RF signal strengths as well as the information carried on amplitude modulated (AM) radio signals. The oscilloscope was programmed to take ten RF time histories (with 40,000 points over 2 milliseconds) approximately 2 seconds apart. The RF power spectra (up to 10 MHz in frequency) corresponding to the time histories were computed using the `fft` function, and averaged. Variations in RF signal strengths were then studied by taking the ten time history sets every 6 hours for several weeks, and every half hour over a couple of days. The signal strengths of the four AM stations chosen for detailed analysis were found to vary by as much as two orders of magnitude, with strongest signals typically occurring at noon. The information content of multiple AM signals was successfully analyzed using mixing, filtering, decimation, and interpolation routines written in *R* to demodulate a digital signal. The multiple carrier waves were contained in a single RF signal, which was received and stored using the GNU radio and a digital receiver. Where feasible, the results obtained using these routines were compared with the results from standard or specialized *R* packages such as **signal** and **tuneR**. The reduction of undesirable RF signals inside RF-free environments of homemade Faraday cages was also investigated, with data analysis performed in *R*. Faraday cages were effective in reducing RF signal strengths to 1/1000 of the unshielded signals outside the cages. The plotting capabilities of *R* were used for graphical analysis of the RF data in the form of conventional frequency and time history plots, box plots, and contour plots (sometimes referred to as waterfall plots in RF analysis).

References

Adler, Joseph (2010). *R in a Nutshell, A Desktop Quick Reference,* California, O'Reilly.

Greensted, Andrew (2010). FIR Filters by Windowing The Lab Book Pages, `http://www.labbookpages.co.uk/audio/firWindowing.html#code/`.

Hamming, R. W. (1998). *Digital Filters,* New York, Dover Publications Inc.

Lyons, Richard G. (2004). *Understanding Digital Signal Processing,* New Jersey, Prentice Hall.

Rouphael, Tony J. (2009). *RF and Digital Signal Processing for Software-Defined Radio, A Multi-Standard Multi-Mode Approach,* New York, Elsevier.

Schmitt, Ron (2002). *Electromagnetics Explained, A Handbook for Wireless/RF, EMC, and High-Speed Electronics,* New York, Elsevier.

Spector, Phil (2008). *Data Manipulation with R,* New York, Springer.

Straw, Dean R., Ed. (2007). *The ARRL Antenna Book,* Connecticut, The AARL Inc.