

Title	Contributions of Information Theory and Compressed Sampling for spectrum monitoring
Context	<p>Due to the rapid development of digital communications, radio systems have achieved a high degree of sophistication that is a challenge for spectrum monitoring. The spreading of the frequency bands, the modulation rate, the development of opportunistic and multiple antenna systems, to mention only a few examples, impose on monitoring systems: sampling rate constraints, data volume and computing capacity less and less compatible with the technology and generating significant cost. In addition, these constraints are incompatible with the qualities of flexibility, mobility and rapid deployment that is ideally expected of a monitoring system.</p>
Objectives	<p>The aim of the thesis is to study the problem of spectrum monitoring from the standpoint of information theory. Although the amount of data in a wide frequency band is large, the information is much less bulky. It is therefore theoretically possible to optimize the structure of the monitoring system by adapting it to the information that is to be ultimately extracted from the sampling process (this simplification of the sampling process is obtained at the cost of the need to use a more sophisticated decoding / reconstruction algorithm).</p>
Novelty of the project	<p>In the field of image processing, the proposed approaches in the last few years, which is designated as the "Compressed Sampling" [1], have demonstrated effectiveness. Their application to the field of radio frequency signal has been repeatedly proposed, but in real context this field appears more difficult than that of image processing, in particular because of the robustness with respect to noise problem. Very recent results [2] [3] suggest that the study of the spectrum monitoring problem seen from a different angle, namely that of information theory, can lead to innovative results and has the advantage taking into account the noise explicitly.</p> <p>Beyond monitoring the spectrum, which is the application that will be the subject of the thesis, the radar is another technology that could potentially benefit from progress in the field of compressed sampling and open the way to a new radar receiver that can operate at very high frequencies. With this aim, DARPA is funding studies in this direction. The compressed sampling would actually bring the high frequency radar technology in the digital age. Another possible application is monitoring a large area on the ground. The full scan of a large area requires time and generates large amounts of data. The compressed sampling significantly reduces the amount of data and time of digitalization. Finally, other opportunities are open in the area of communications. We can use the same type of ideas for communications at very low power. We may wish to deploy sensors that operate over a very long period of time without the ability to recharge their batteries. The compressed sampling by reducing the sampling frequency and the amount of data to be transmitted, reducing, consequently, the power consumption and thus increasing battery life.</p>

	<p>References (cited in the text):</p> <p>[1] T. Candès, E.J. Tao, "Decoding by linear programming", IEEE Transactions on Information Theory, vol. 51, pp. 4203-4215, 2005</p> <p>[2] S. Rangan et al., Asymptotic Analysis of MAP Estimation via the Replica Method and Applications to Compressed Sensing, IEEE Transactions on Information Theory, vol. 58, no. 3, pp. 1902-1923, March 2012</p> <p>[3] A.K. Fletcher et al., Ranked Sparse Signal Support Detection, IEEE Transactions on Signal Processing, vol. 60, no. 11, pp. 5919-5931, November 2012</p>
<p>3 publications of the project leader(s) in the field over the past 5 years</p>	<p>K. Hassan, R. Gautier, I. Dayoub, M. Berbineau et E. Radoi. "Multiple-Antenna Based Blind Spectrum Sensing in the Presence of Impulsive Noise". Dans : IEEE Transactions on Vehicular Technology (3/2013). Impact Factor (2014) : 2.642, DOI : 10.1109/TVT.2013.2290839.</p> <p>C. Nsiala Nzéza, T. Blondel, G. Moniak, M. Berbineau et R. Gautier. "Dynamic Spectral Monitoring for Flexible and Reconfigurable Railways Communication Systems". Dans : Proceedings of the 9th International Conference on Intelligent Transport Systems Telecommunications, ITST'09. (20-22/10/2009). ISBN : 978-1-4244-5346-7 (eISBN : 978-1-4244-5347-4), DOI : 10.1109/ITST.2009.5399350, Réf HAL : hal-00485849 version 1. Lille, France, pages 228-233.</p> <p>C. Nsiala Nzéza et R. Gautier. "In Advances in Cognitive Radio Systems ; Editors :Dr. Cheng-Xiang Wang and Prof Joseph Mitola III". Dans : ISBN : 978-953-51-0666-1, DOI : 10.5772/30366, Réf HAL : hal-00714618 version 1. Intech, 5/2012. Chapitre 6: Blind Detection, Parameters Estimation and Despreading of DS-CDMA Signals in Multirate Multiuser Cognitive Radio Systems, pages 1-26.</p>
<p>International collaboration</p>	<p>This very promising field of compressed sensing for spectrum monitoring particularly interested our institutional and industrial partners in the Defense field. We are working since October 2015, with the company SYRLINKS on the subject in the REACC-RF project to develop a network of low cost communications surveillance sensors for the localization of transmitters incorporating an compressed sampling analogical RF front-end unit, followed by an FPGA digital computing unit dedicated to the reconstruction on the spectral support embedding algorithms that we developed. Collaborations will be considered with our partners Military Technical Academy (MTA) of Bucharest and the Faculty of Engineering and Applied Science, Memorial University of Newfoundland.</p>
<p>Expectations</p>	<p>Two contracts have already been completed in this area and this thesis allow us to more fully develop the theory underlying this problem and improve the detection algorithms and reconstruction of the wideband spectral support we have started developed. In addition, for reasons of confidentiality and lack of time, we have not been able to publish the results of our developments in the two previous contracts and we expect valuing them through journal publications and conferences during the thesis. Finally, the PhD student who will be hired will benefit from the radio front-end dedicated to compressed sampling which will be developed in parallel within the REACC-RF project and can therefore validate his theoretical work on real signals and evaluate their robustness with respect to disturbances of the channel and the RF chain imperfections.</p>