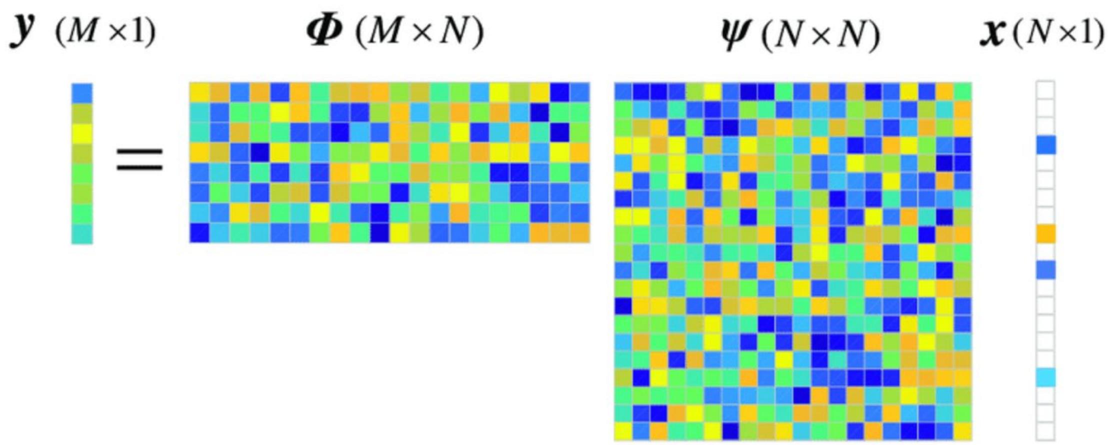
Compressed sensing approaches for EMC

Master thesis project



A depiction of mathematical principle behind compressed sensing: the original measurement vector ***y*** *is reproduced from a sparse vector* ***x****, through a linear transformation including the measurement matrix* ***Φ*** *and the basis matrix* ***Ψ****. The aim is to find such* ***Φ*** *and* ***Ψ*** *which allow recovering* ***y*** *from the sparsest* ***x*** *possible, therefore saving space and time.*

Summary:
The aim of the project is to explore approaches that enable reducing the time or number of samples for time- and/or frequency-domain signals needed for EMC assessment.

Problem definition:
In the field of Electromagnetic Compatibility it is common to use spectrum analyser for performing an EMC assessment. Otherwise time-domain signals may be collected and FFT performed to get similar results. These approaches follow the Nyquist theorem which states that the sampling frequency must be at least 2 times higher than the maximum frequency one wants to capture. This results in either lengthy process or one in which many data points needs to be saved. However, in many EMC scenarios the signals are likely to be of a specific class (e.g. square, triangular, damped oscillations). It might be therefore possible to use this *a priori* knowledge and find a more compact or sparse representation of the signals. The task is to explore and/or develop methods that serve this purpose. In particular, the student will be encouraged to explore approaches steming from the so-called Compressive Sensing suite of methods.

Method:
During this project the student will work in the domain of Digital Signal Processing using circuit simulation software (LTSpice, Simulink etc.) and programming language of choice (Python, Matlab etc.) and will perform EMC assessment using lab-based spectrum analysers. The student will also need to be able to perform a literature survey on the existing approaches.

Research objectives:
The objective is to develop a method/algorithm for a compact or sparse representation of EMI signals, particularly in the frequency domain. Evaluated will be the accuracy of the representation, judged by comparison with real-life data, speed and size of the representation, compared with the size of the data occupied by traditional FFT-based approaches. Additional points will be given for a clear mathematical explanation of the algorithm.

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Courses and supervision:

For a successful start of the project the student should be willing to work independently and be able to grasp simple mathematical concepts related to representation of signals. The student should be therefore familiar with some basic Digital Signal Processing algorithms (such as FFT) and ideas behind it, as well as should be able to program simple DSP programs in a programming language of choice. A guidance on mathematical and EMC aspect can be given by the supervisors. The student is encouraged to follow a free course on Compressed Sensing, accessed through YouTube platform[1] as well as consult appropriate papers [1], [2].

References:

[1] D. L. Donoho, "Compressed sensing," *IEEE Trans Inf Theory*, vol. 52, no. 4, pp. 1289–1306, Apr. 2006, doi: 10.1109/TIT.2006.871582.

[2] E. J. Candes and T. Tao, "Near-optimal signal recovery from random projections: Universal encoding strategies?," *IEEE Trans Inf Theory*, vol. 52, no. 12, pp. 5406–5425, Dec. 2006, doi: 10.1109/TIT.2006.885507.

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1 https://www.youtube.com/watch?v=SbU1pahbbkc