# Detection of informative events in signals

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## Subject

The object is to propose an automatic method for detecting the presence of singular event in a signal on a very general basis without any a priori model or structural knowledge of the event [1][2]. By means of an analogy, a method is to be designed which enjoys similar capabilities as the human ear to recognize information (in the form of abnormal or novel structures) in an arbitrary sound signal.

Current attempts to approach this issue are mainly based on first decomposing the signals in a transformation space where a possible singularity can be single out. Typical examples are the Fourier Transform, its Short-Time version, the Wavelet Transform, the Gabor Transform, the Chirplet Transform, the Hilbert-Huang Transform or Empirical Modal Decomposition, the Karhunen-Loeve Transform, but not only [3][4]. In a second step, the detection of the presence of a singularity is achieved by thresholding, matched pursuit, or best basis algorithms. An important breakthrough has recently been achieved in the theory of compress sensing (or sparse coding), where singular events can be detected with few sensors (or signal samples) if they happen to be sparse in the transformation space [5][6].

The fundamental idea is that an "informative event" has a highly organized structure, which is specifically what makes it different to ambient noise and easily recognizable to human beings. The issue of measuring the "degree of organization" in a signal is a difficult but exciting one. One idea is inspired from Feynman's famous principle of least action, which is at the root of modern physics [7][8]. It is based on the computation of a path integral in the transformation space that would take extreme values when it follows a trajectory with constructive (non-zero) accumulation of phase, as expected for a singular event. Alternatively, for all other (arbitrary) trajectories that do not comply with a singular pattern, the path integral would converge to zero [9].

The proposed research program is very challenging. It involves advanced signal processing methods and theory. It is also closely connected to the most profound ideas of 20th century physics. It involves important applications, in particular in Non Destructive Testing and Condition Monitoring. Validation of the proposed method will be systematically carried out on experimental signals.

## Keywords

signal processing, event detection, time-frequency, sparse coding, compress sensing, least action principle, Feynman's path integral, dictionary learning, vibration signals

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