sivienn

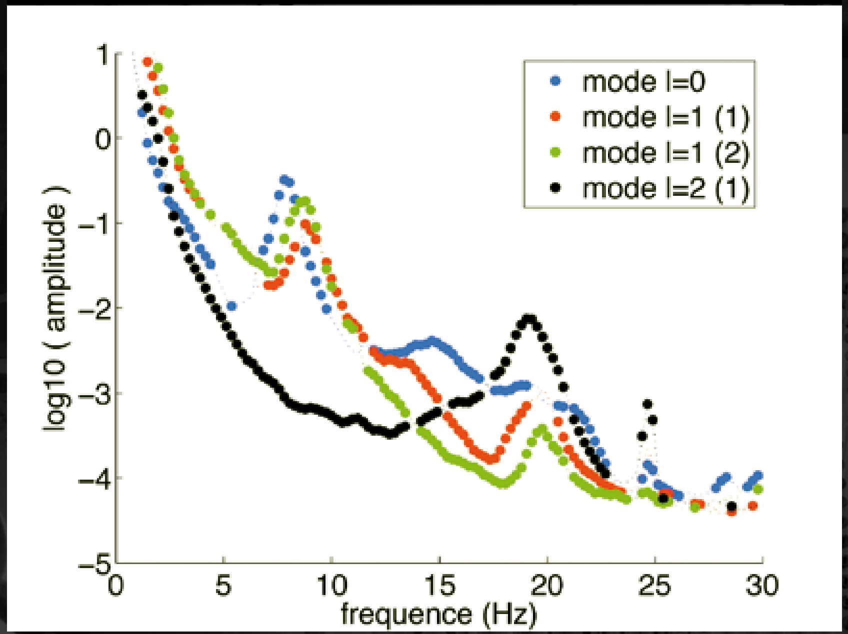
Cross-correlation imaging techniques appeared in the 1990s. Working no longer on the signals themselves, but on correlations between the signals recorded by a network of receivers, cross-correlation specialists are free from controlled sources. They analyse signals from opportunistic origins or uncontrolled ambient noise.

These techniques were first validated in seismology, where they advanced considerably predictions of volcanic eruptions. The detection of seismic velocity changes, caused by magma pressurization, is now possible three weeks before an eruption. The potential of applications is greater when the medium of propagation is heterogeneous or when the use of an active source is difficult.

Sivienn works with researchers at the forefront of science in four main areas, developing its methods at the industrial level, by providing a turnkey solution to the client's imaging problems.

## APPLICATION 1 NUCLEAR REACTOR CORE

SPECTRAL ANALYSIS OF VIBRATION MODES




Control of the assembly of uranium rods in the core of nuclear power plants is crucial. It is very delicate due to the environment, which makes the installation of measurement device inside the reactor almost impossible. Fluctuations of neutron flux are recorded outside the core from their cross-correlations.

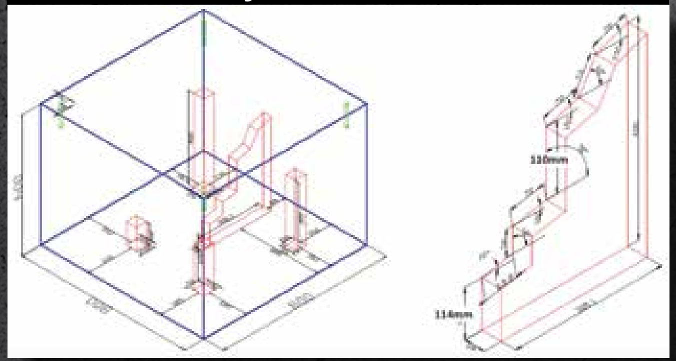
Sivienn identifies the modes, amplitudes and frequencies of vibrations of the structure in order to extract information on what happens within the core.

## APPLICATION 2 CONCRETE

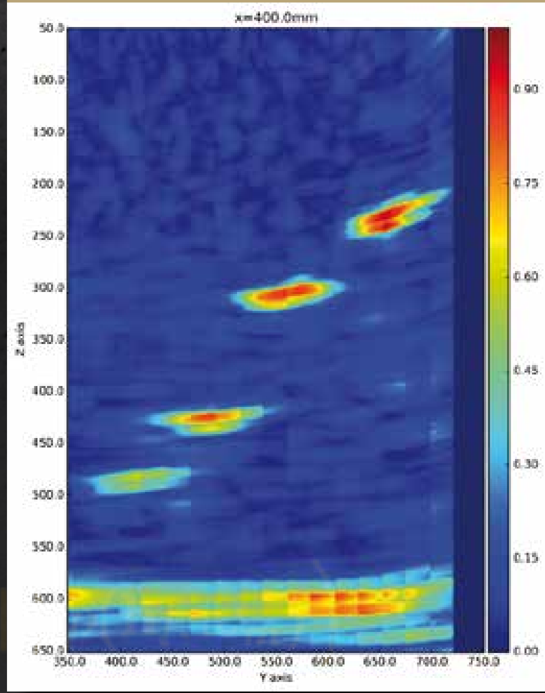
The great heterogeneity of concrete makes ultrasound imaging delicate. The recorded signals are very noisy because of the scattering of the ultrasonic waves in the heterogeneous material. The signal processing in concrete consists of the decomposition of the operator time reversal and coherent interferometric imaging.

Sivienn has developed original imaging techniques allowing it to identify anomalies at depths well beyond that, which classical methods do not achieve.

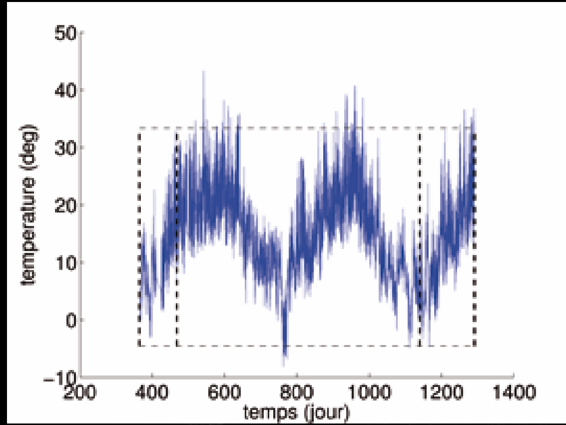
OBJECTS TO IMAGE



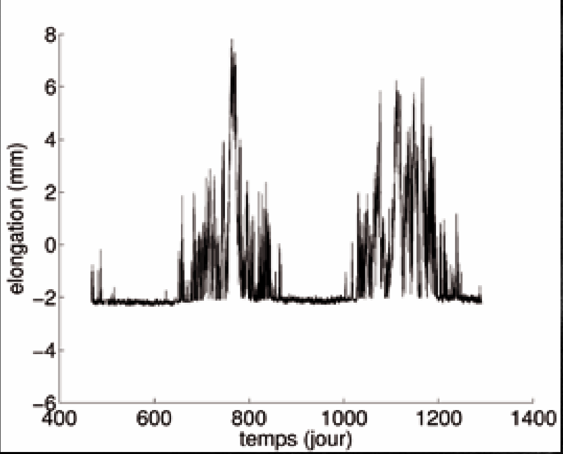

VERTICAL SLICE DOWN TO 60 CM



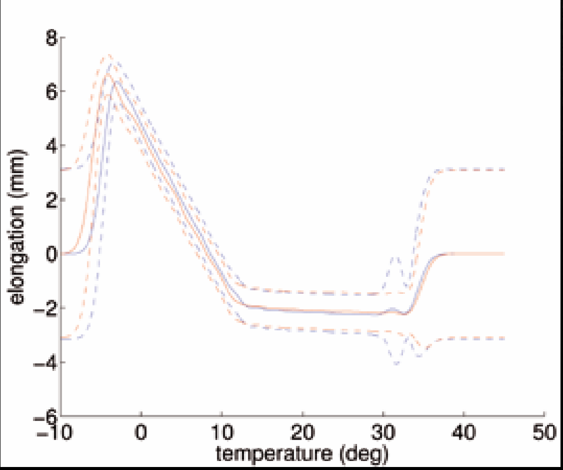

OBSERVED TEMPERATURES




OBSERVED ELONGATIONS




ELONGATION VS. TEMPERATURE LAW




## APPLICATION 3 BUILDINGS

Passive surveillance, over long-term, works by means of sensors installed or integrated into the build. It can detect challenging structural changes. The problem is that these deformations are noisy. They can be caused by factors such as temperature, wind, traffic, and so on.

By combining its imaging methods with statistical learning techniques, Sivienn finds the slow changes to these structures, in a passive way.

APPLICATION 4

# UNDERWATER OBJECTS

In order to remain stealthy or eco-friendly, underwater imaging must be passive. Using underwater noise as a source of illumination, cross-correlation imaging methods create visual representations that could previously only be obtained through active sonars.

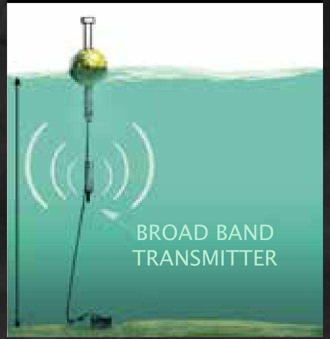
With active sources:

detection and localization by the migration of cross-correlations in complex geometry through wave-guides.

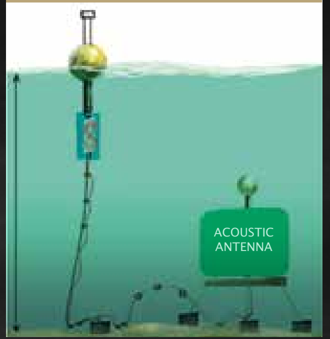
With ambient noise:

access to information on the environment contained in the cross-correlations (bottom depth, impedance, absorption...).

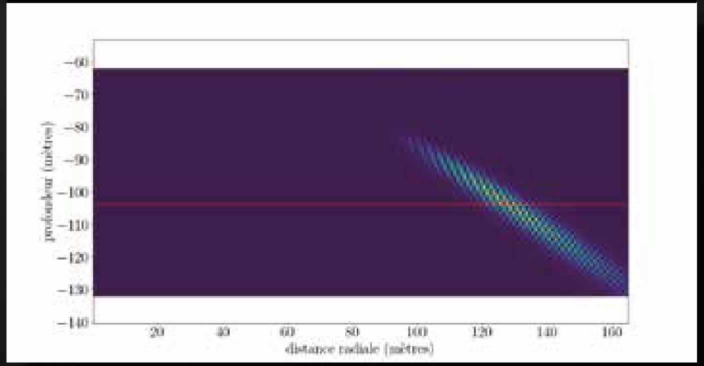
ACTIVE SYSTEM



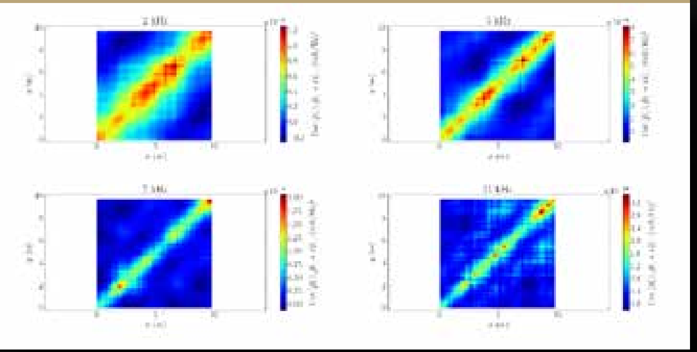

PASSIVE SYSTEM




LOCALISATION OF A BIOLOGICAL SOURCE



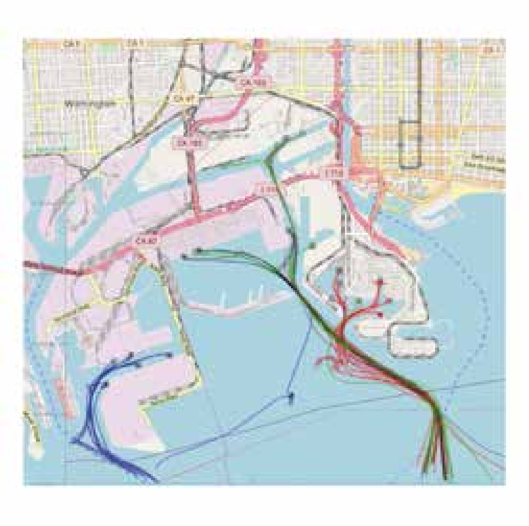

CROSS POWER SPECTRAL DENSITY MATRIX



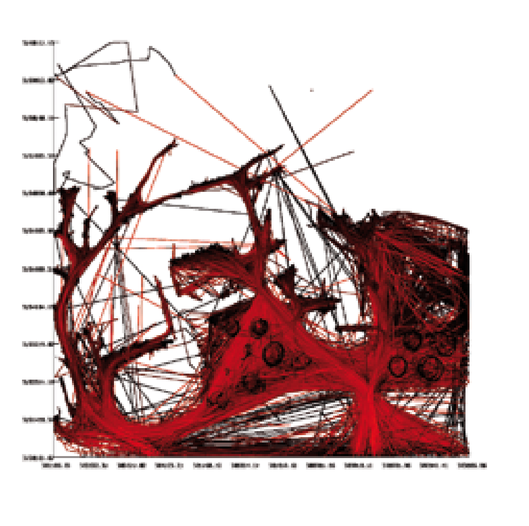
APPLICATION 5

# OUTLIERS

EXTRACTION OF TRAJECTORY CLUSTERS



ANALYSED TRAJECTORIES



Detection of abnormal behaviour of ships in a busy traffic zone assumes the ability to distinguish aberrant trajectories by an unsupervised classification method.

Sivienn has developed an approach allowing the classification of trajectories by groups of typical behaviours and a modelling of the distribution of trajectories in each group. It is possible to characterize and group normal behaviours, to analyse data flows in real time, and to label ships with abnormal trajectories.

Initially developed for seismic imaging, Sivienn's cross-correlation techniques apply today to all kinds of signals.

Sivienn creates and develops robust imaging methods that consider the heterogeneity of the environment in which they operate.

Sivienn has developed its techniques for structural health monitoring, nuclear safety and submarine detection. They have proven effective in areas where imaging is made difficult by signals passing through scattering media or arising from ambient noise sources.

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