# Ambient seismic noise suppression in COST action G2Net

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EGU General Assembly 2020 (GI1.2)

# CA17137 : A network for Gravitational Waves, Geophysics and Machine Learning

COST ACTION CA17137
A NETWORK FOR GRAVITATIONAL WAVES, GEOPHYSICS AND MACHINE LEARNING

WG1 Machine Learning for Gravitational Wave astronomy
WG 2 Machine Learning for low-frequency seismic measurement
WG3 Machine Learning for Advanced Control techniques

https://www.cost.eu/actions/CA17137/#tabs|Name:overview
https://www.g2net.eu/

# WG 2: Machine learning for low-frequency seismic measurement

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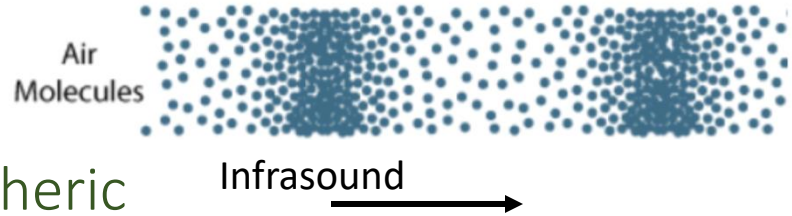
## Abstract

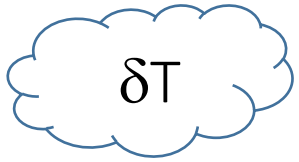
The performance of Earth-based GW detectors is largely influenced by the ability of combating the low-frequency ambient seismic noise and other seismic influences. These tasks require multidisciplinary research in the fields of seismic sensing, signal processing, robotics, machine learning and mathematical modeling.

The working group 2, deals with acquisition, processing and interpretation of seismic data, with the goal of combating the seismic influences at GW detector site, using the multidisciplinary research, with a focus on advanced techniques available from state of the art machine learning algorithms.

# WG 2 focus
# Newtonian noise on GW detectors

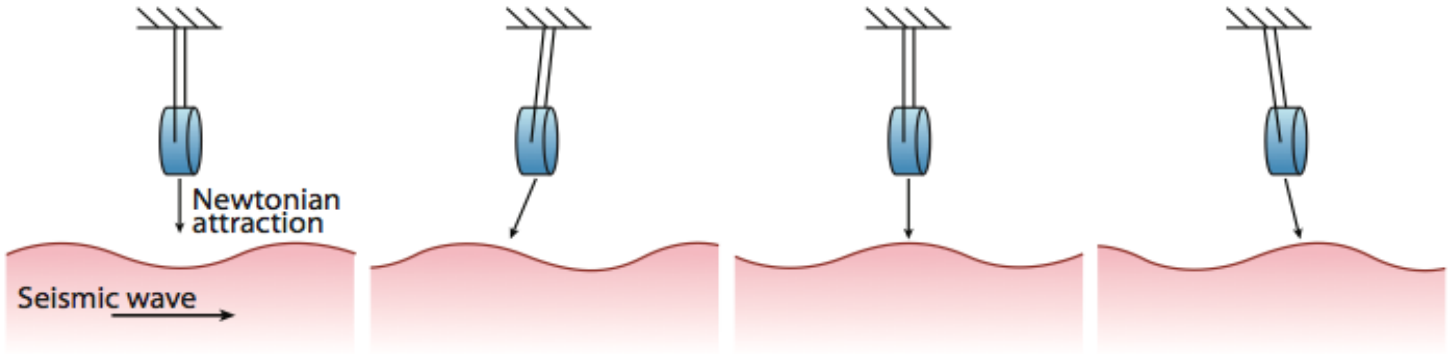
atmospheric




Temperature fluctuations

seismic




Gravitational coupling between the mirrors and surrounding mass density fluctuations

# WG 2 objectives

Bringing the NN challenge to a new level by involving expertise outside GW physics

ML techniques for seismic field modeling
and NN field reconstruction:
-wave propagation characteristics
-noise stationarity and time evolution
-design of optimized sensor arrays

Robotics for adaptive arrays of environmental sensors

Complementary to WG3

# WG 2 objectives

## Interdiscpilinary research topics (check out CA17137 Memorandum of Understanding):

**Seismology**:

- earthquacke waveforms, seismic array intereferometry, Newtoian noise analysis

**Signal processing**:

- match-filtering, Wiener filtering, deconvolution

**Mathematical modeling**:

- Bayesian analysis, Markov chains, Fokker-Planck and Langevine equations

**Machine learning for robotics**:

- deep learning, reinforcment learning, Belief space planning

**Gravitational waves detection:**

- instrumentation, hardware and data processing

# WG 2 Tasks

WG 2 is structured in several tasks

1. Applied mathematics for seismology
2. Optimized sensor arrays
3. Mobile networks of environmental sensors
4. Machine learning for seismology

More info: https://www.g2net.eu/wgs/WG 2-machine-learning-for-low-frequency-seismic-measurement

# Equipment

Quantum by INNOSEIS (a spin-out from the National Institute for Subatomic Physics in the Netherlands) is an ultra-light weight (< 1kg) wireless seismic sensor network that dramatically reduces deployment costs, while scaling up to 1 million nodes for onshore exploration. It has be designed for static Wireless, sensor networks. However, a daisy-chain small network is operating in Cascina already and no major issues prevent to mount them on mobile platforms.

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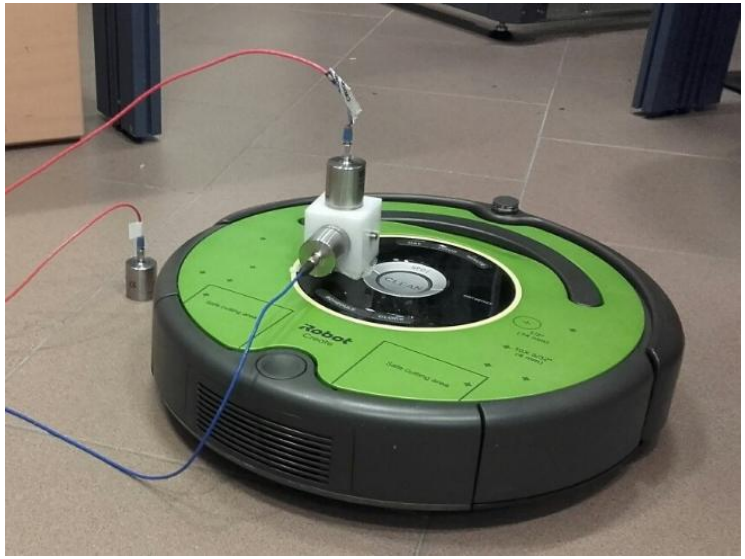
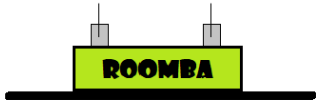
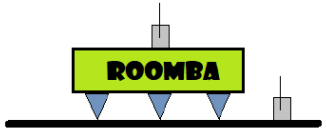
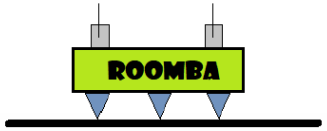
# Equipment

Testing Platform:
A Multisensory Multiagent platform
for GW detection and Geophysics applications



| Configuration number | Description | Sketch drawing |
|---|---|---|
| 1 | One Vertical accelerometer on Roomba, one Vertical accelerometer on ground |  |
| 2 | One Horizontal accelerometer on Roomba, one Vertical accelerometer on ground |  |
| 3 | As n.1 but added extra weight (1kg) on the Roomba |  |
| 4 | As n.2 but added extra weight (1kg) on the Roomba |  |
| 5 | One Vertical accelerometer on Roomba left side, one Vertical accelerometer on Roomba right side. |  |
| 6 | As n.1 but placing the Roomba onto 3 rigid tips |  |
| 7 | As n.5 but placing the Roomba onto 3 rigid tips |  |

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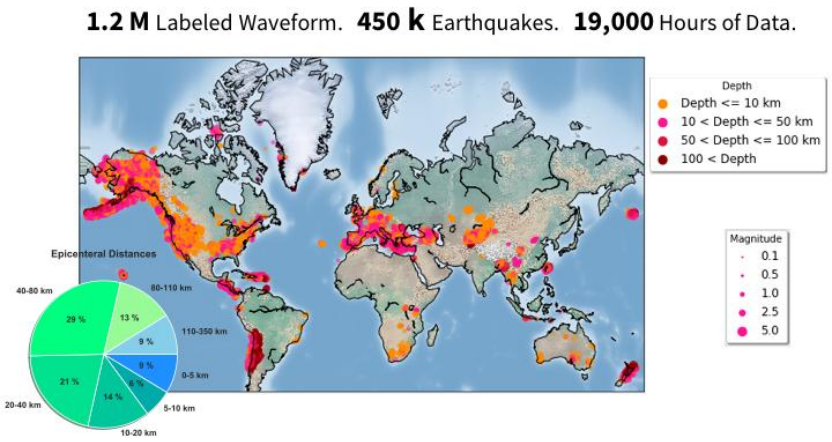
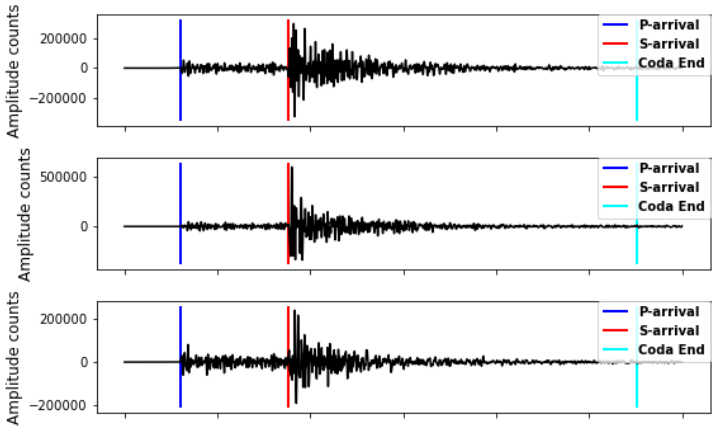
# STSM outcomes

## STanford EArthquake Dataset (**STEAD**):

## A Global Data Set of Seismic Signals for AI

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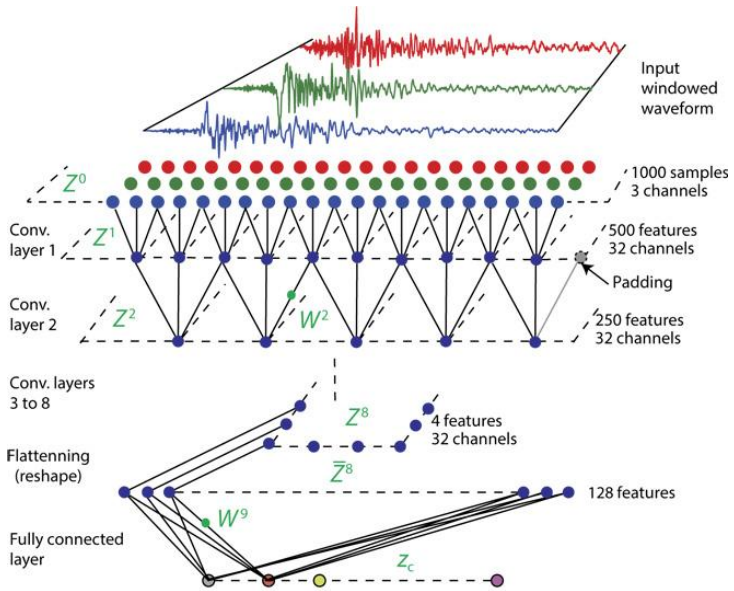
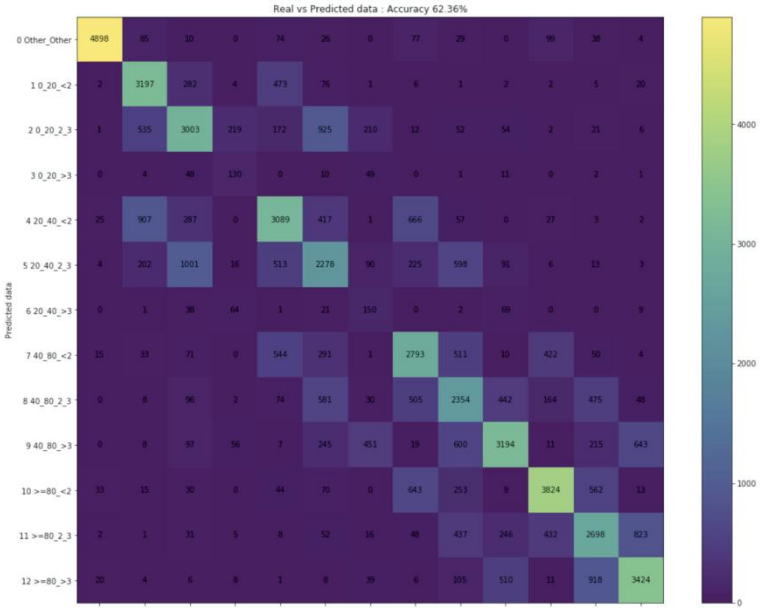
13 classes:

Noise,Distance and Magnitude combination

# STSM outcomes

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- Initial results
- Sample of data
- 62% accuracy
- Noise nearly 100% correct
- Large magnitude (>3) more inaccurracies due to low occurancies

# STSM outcomes

- Investigating the utility of different time-frequency representations for characterization of earthquakes.
- Detection and characterization of seismic waveforms using machine learning
- Exploration of different machine learning techniques and data transformations which help in achieving the goal above
- Rapid ground motion prediction at a site from multi-station waveforms using machine learning

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# Thank you for your attention! Contact us!

WG 2 is still growing!

Feel free to contact us via the links and addresses below.

Website:
https://www.g2net.eu/wgs/WG 2-machine-learning-for-low-frequency-seismic-measurement

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