Turning a loudspeaker into an indoor event monitoring system

Utilisation d'un haut-parleur comme un système de surveillance intérieur

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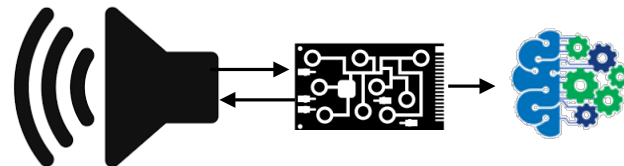Pitch scientifique de l'institut inSTI

L'avenir est à créer

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Context

- Proactive management of indoor building safety
- Need of privacy-friendly monitoring technology

Type of detection	magnetic reed switch	CCTV camera	micro	IR sensor	CO$_2$ & Temp sensor	ultrasonic detector	EARSENS
Occupancy	✗	✓	✓	✓	✓	✓	✓
Perimeter	✓	✓	✗	✗	✗	✗	✓
Thermal anomalies	✗	✗	✗	✓	✓	✗	✓
Privacy-friendly	✓	✗	✗	✓	✓	✓	✓

- The EARSENS* solution:

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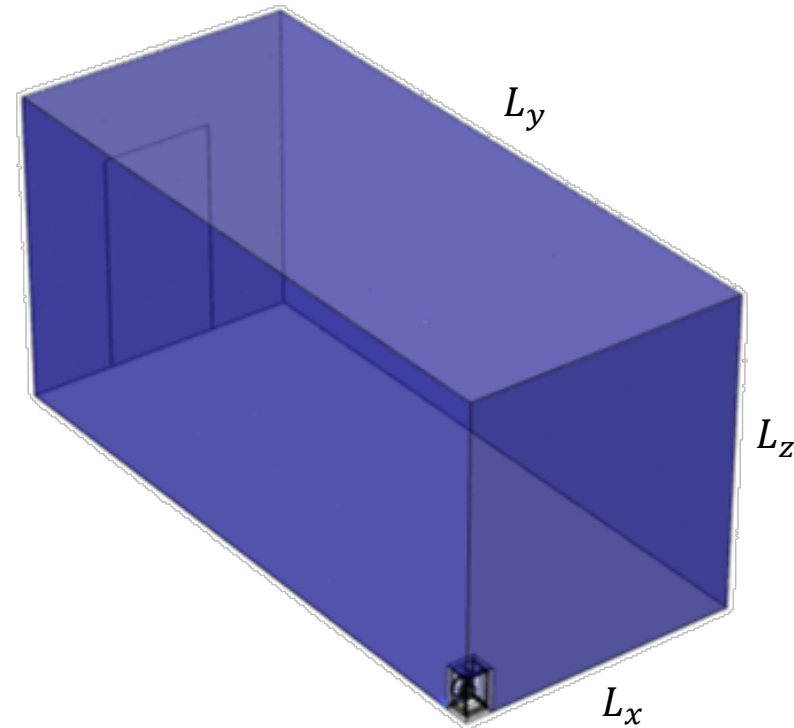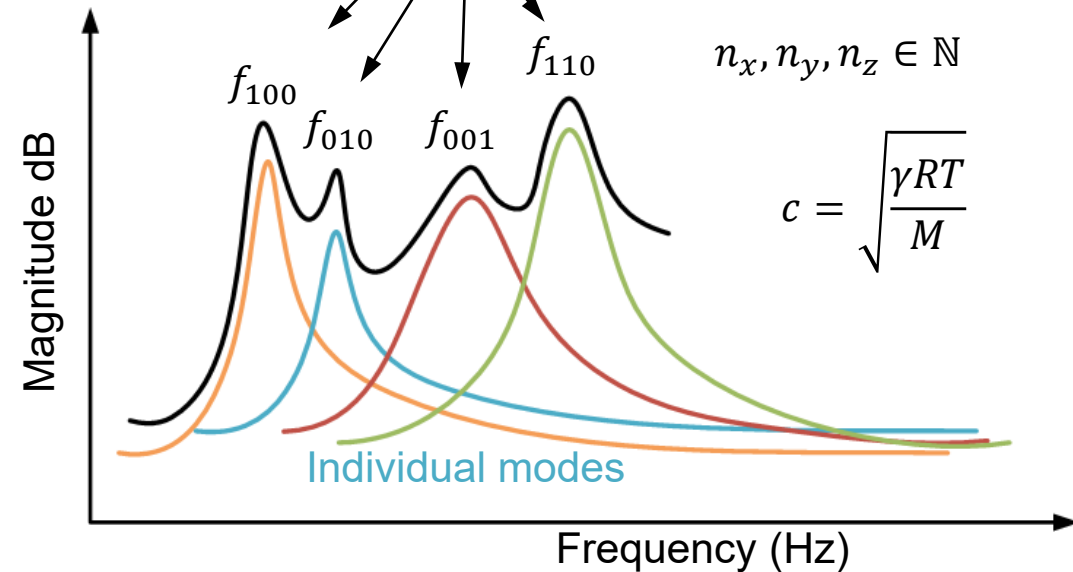Hes·SO GENÈVE
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Basic physical principle

- Detect variations of the room modes (resonances)

$$f_{n_x n_y n_z} = \frac{c}{2}\sqrt{\left(\frac{n_x}{L_x}\right)^2 + \left(\frac{n_y}{L_y}\right)^2 + \left(\frac{n_z}{L_z}\right)^2}$$
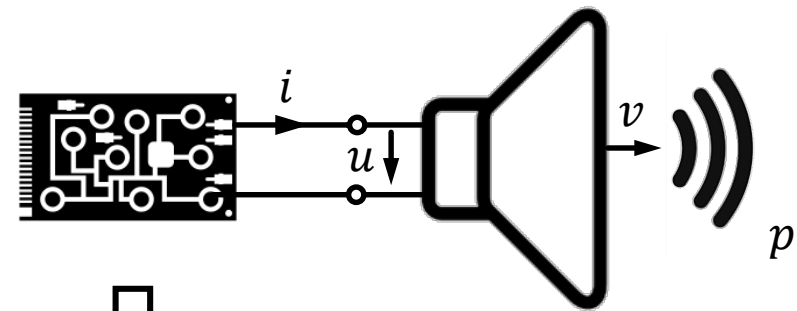
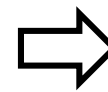$n_x, n_y, n_z \in \mathbb{N}$

$$c = \sqrt{\frac{\gamma RT}{M}}$$

f_{100} f_{010} f_{001} f_{110}

Magnitude dB

Individual modes

Frequency (Hz)

L_y

L_z

L_x

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The EARSENS solution

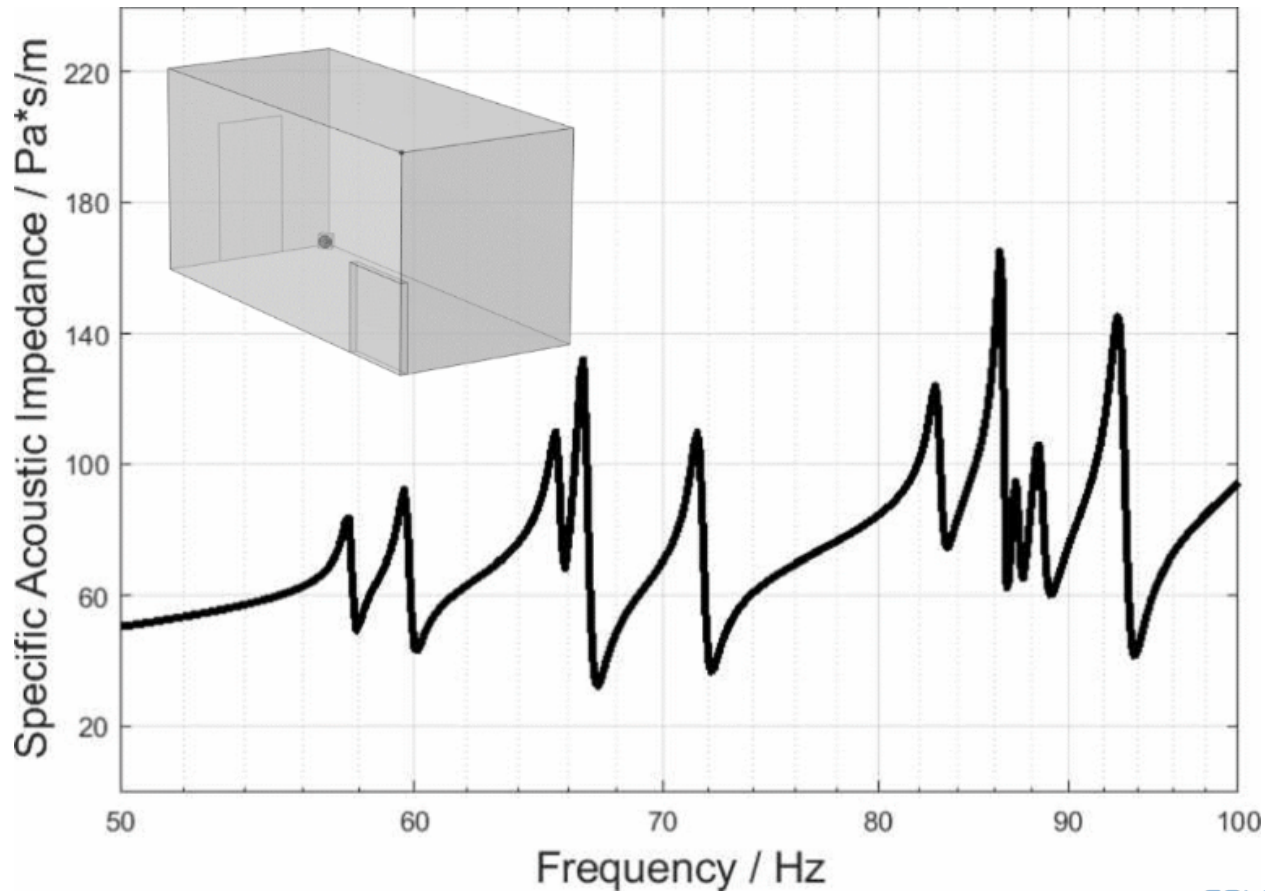- Sensorless monitoring 👤

$$Z_{in} = \frac{u}{i} \implies Z_L = \frac{p}{v} = f(Z_{in})$$

Mesured
input impedance

Estimated
load acoustic
impedance

R. Boulandet, Sensorless measurement of the acoustic impedance of a loudspeaker,
Proc. of the 23rd International Congress on Acoustics (ICA), Aachen, Germany, 2019

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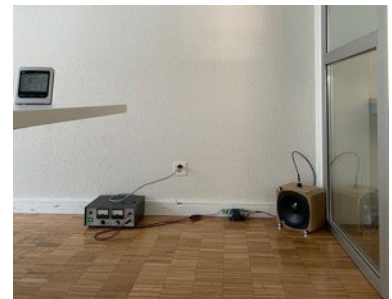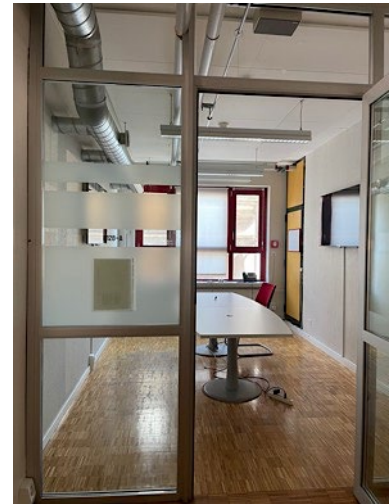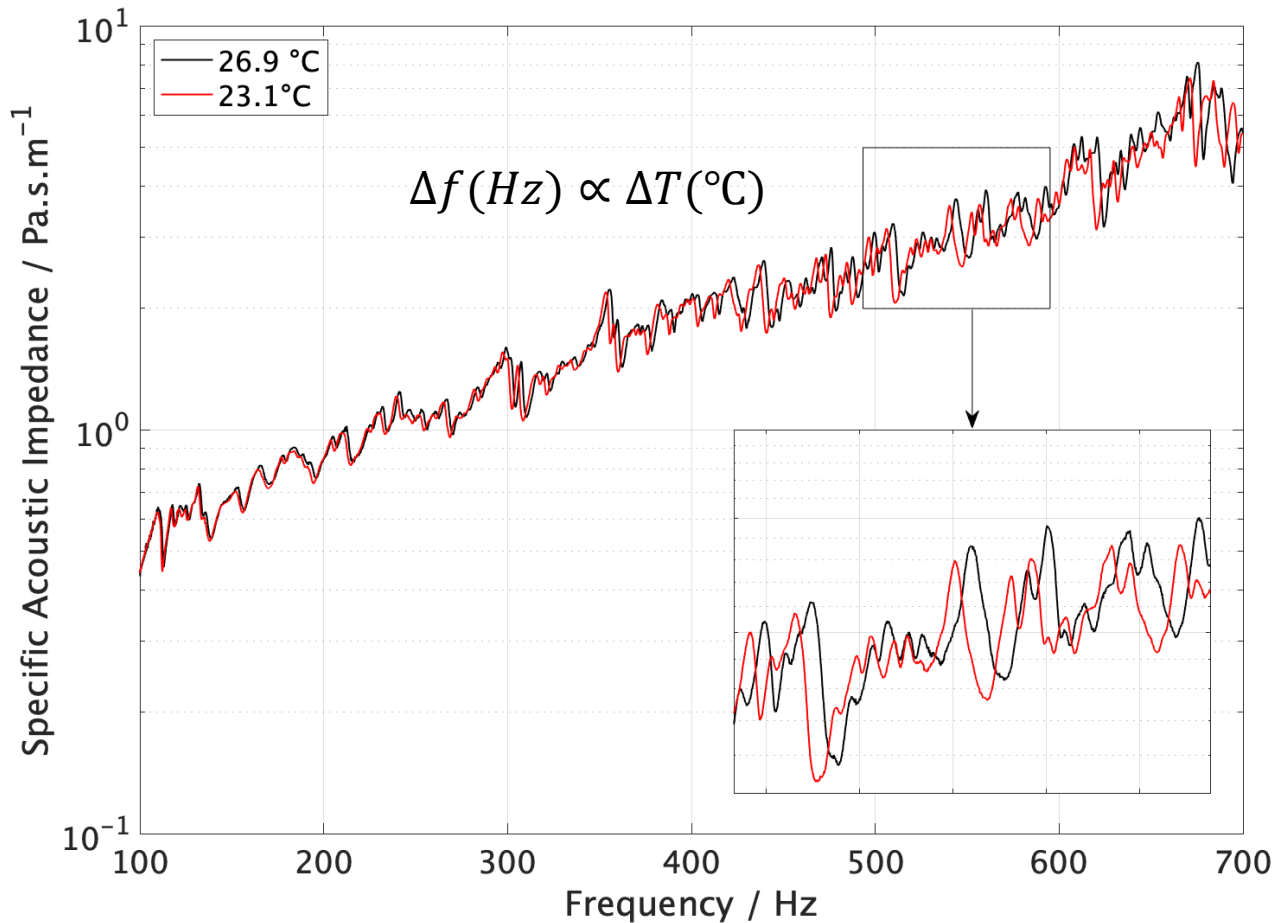de Suisse occidentale

Proof of concept

- Change in room modal response due to door opening

Proof of concept

- Change in room modal response due to increased temperature

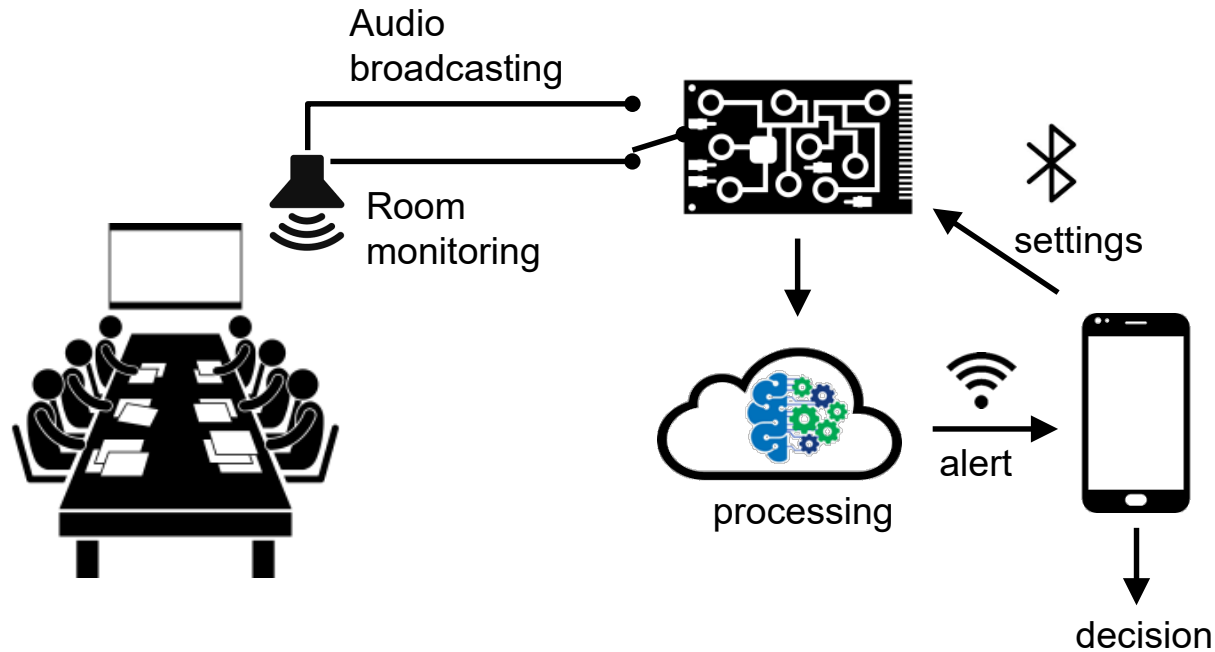$$\Delta f(Hz) \propto \Delta T(°C)$$

Conclusion

- Proof of concept : the idea works!
  - Changes in perimeter, temperature and occupancy can be detected from room modes
  - A loudspeaker can be used as impedance sensor
  - The probability of each event can be estimated by a trained A.I algorithm (Classification)

- Next step :
  - Demonstrator in progress
  - Find a use case and a financial partner!

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Room
monitoring

settings

processing

alert

decision

Thank you for your attention!

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