ASSOCIAZIONE INGEGNERIA GEOTECNICA LABORATORI ALIG

I LABORATORI AUTORIZZATI PER LE PROVE SULLE COSTRUZIONI ESISTENTI

La qualità delle indagini e la sicurezza in esercizio.(DPR n. 380/2001, comma 2, lettera c-bis)

L'ALIG si rivolge alla filiera del settore delle prove ed indagini sugli edifici esistenti e propone un incontro tra tutti gli operatori coinvolti per un confronto critico e costruttivo sullo stato della qualificazione dei laboratori e sui requisiti dei soggetti che operano nel settore delle prove e delle indagini in sito.

MERCOLEDÌ 31 **MAGGIO** 2023 ORE 10.00–14.00

Caratterizzazione delle strutture mediante metodologie avanzate
monitoraggio dinamico mediante processamento di immagini

Gianmarco de Felice

Università Roma Tre, Dipartimento di Ingegneria

Motivations

Ageing structures and infrastructures need to be monitored, but the installation of conventional sensors is often costly or unfeasible because of accessibility issues.

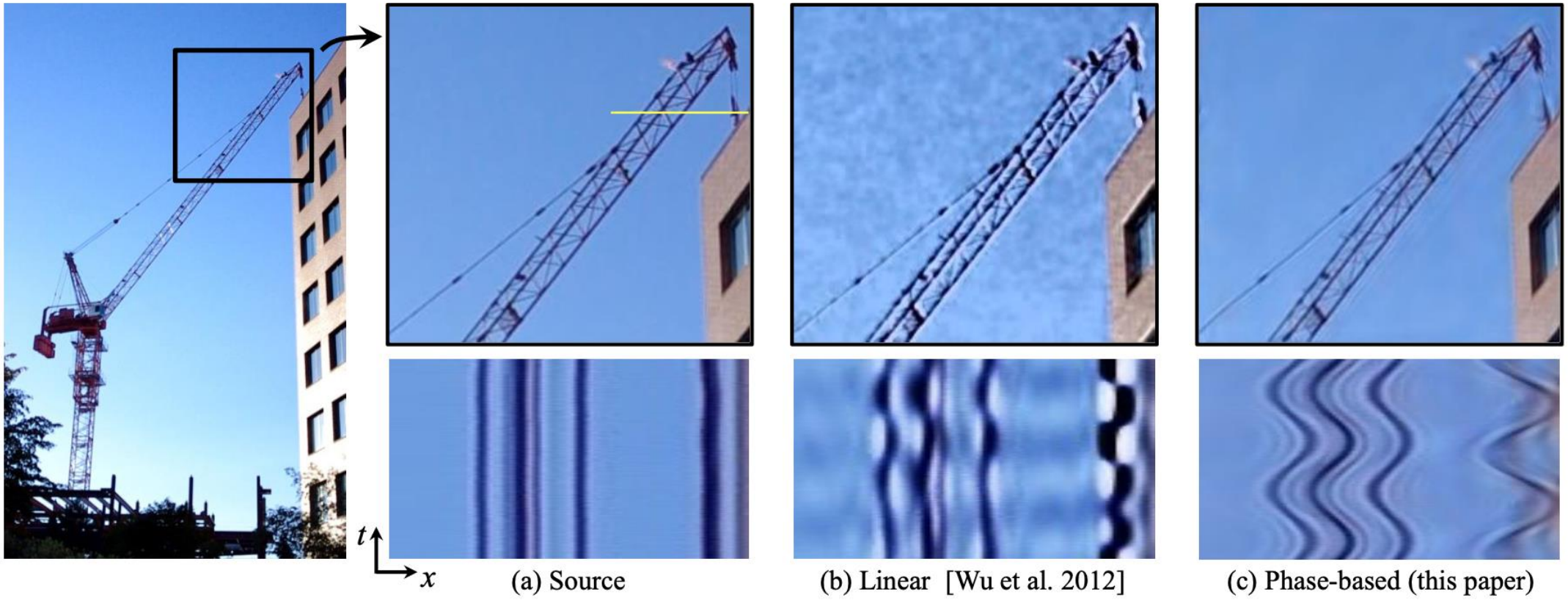
Outline of the presentation

- Validation of through small-scale laboratory tests characterized by known frequencies
- Application to mid-scale laboratory test to retrieve evolving frequencies of a masonry wall subjected to induced seismic damage
- On-site Monitoring of the dynamic response of an elevated water tank in Rome

Phase-Based Video Motion Processing

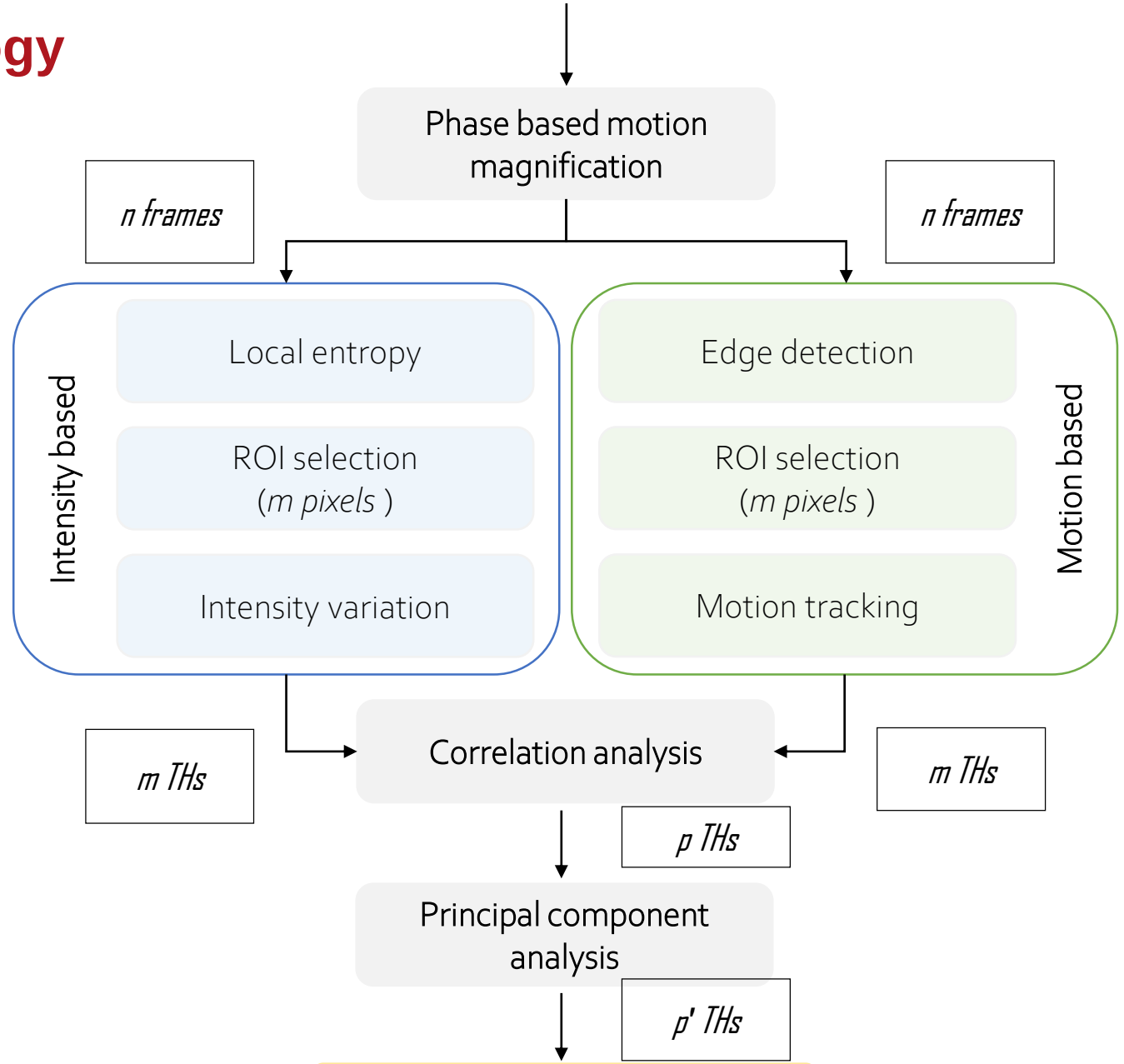
Neal Wadhwa Michael Rubinstein Frédo Durand William T. Freeman

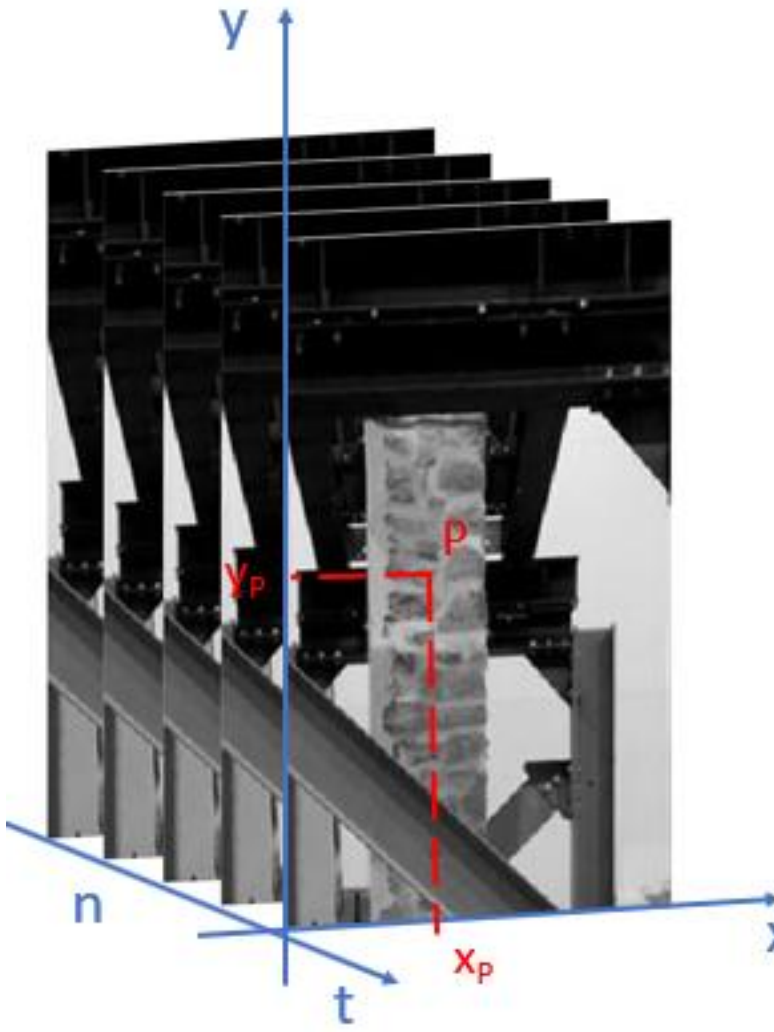
MIT Computer Science and Artificial Intelligence Lab



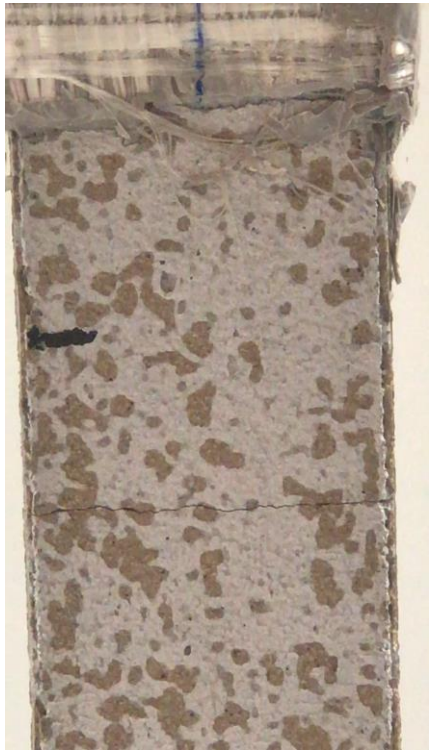
(a) Source (b) Linear [Wu et al. 2012] (c) Phase-based (this paper)

Methodology



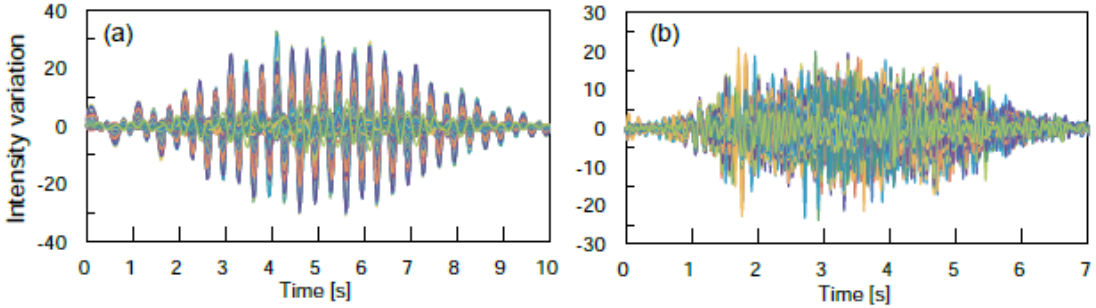


Validation



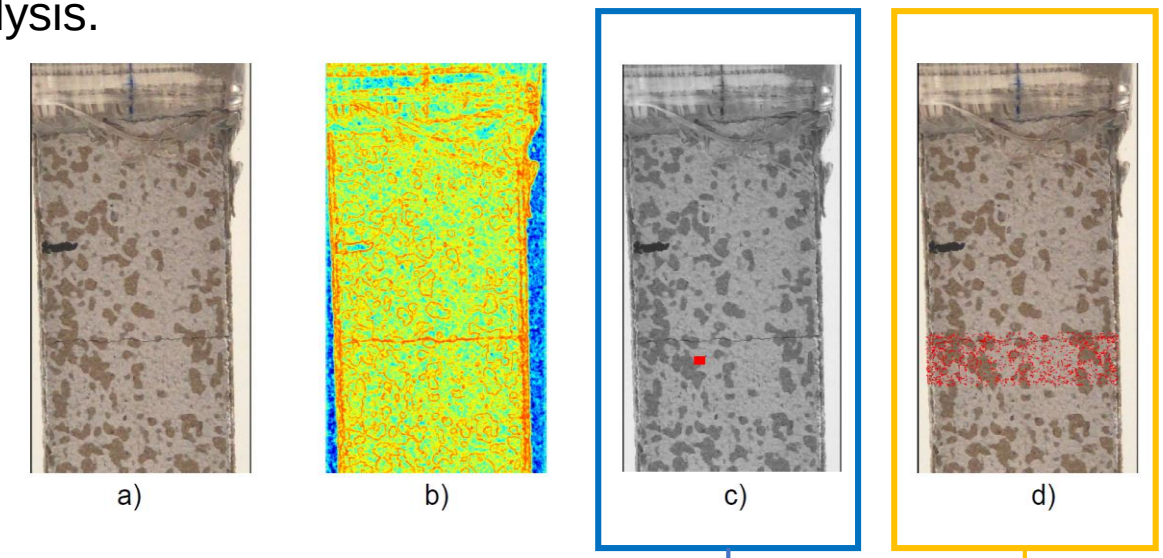
3 Hz

10 Hz



Time histories of the intensity of the selected pixels

a) original frame, b) entropy map, c) grey-scaled frame and ROI, and d) monitored pixels in the motion tracking analysis.



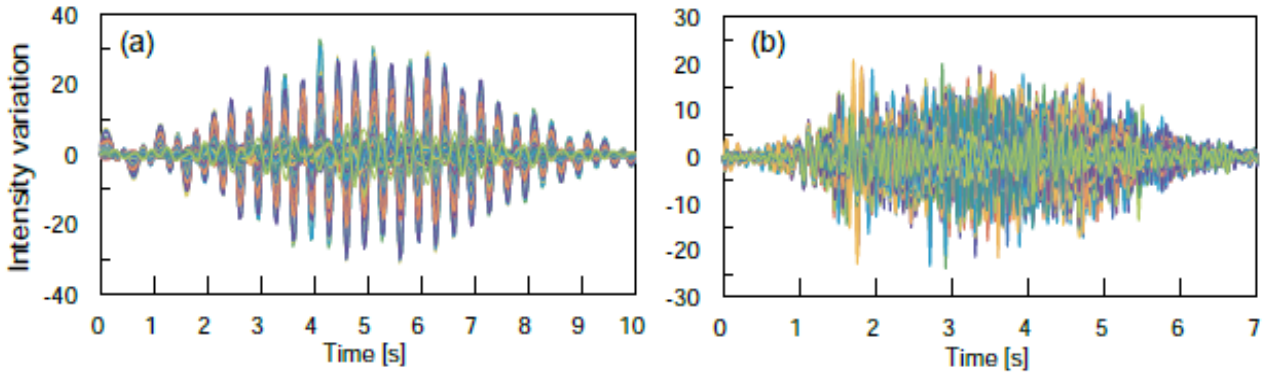
ROI – Intensity variation

ROI – Motion tracking

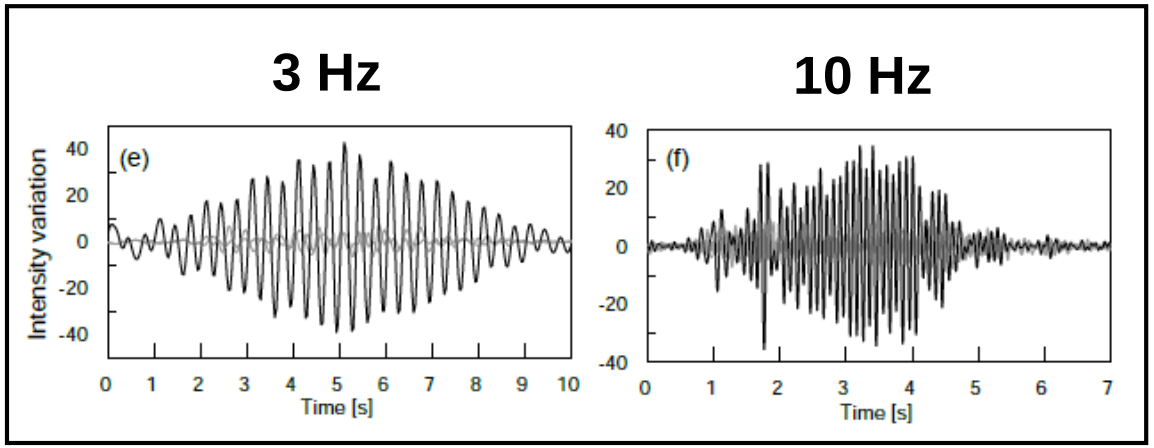
Validation

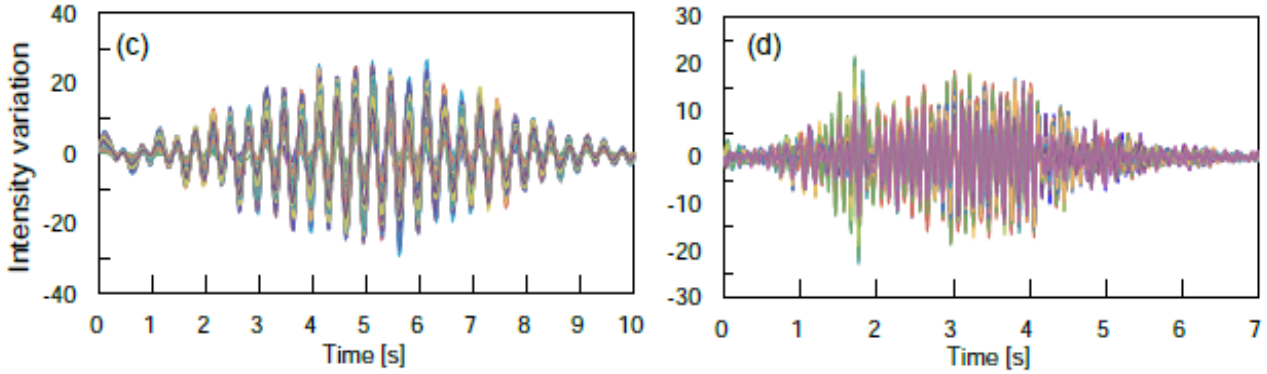
Principal Component Analysis results

3 Hz **10 Hz**



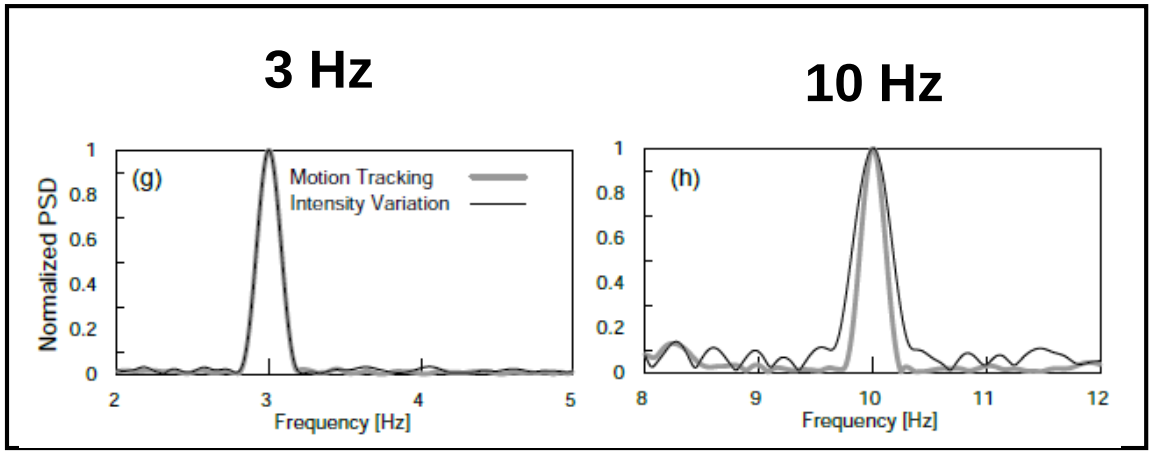
Uncorrelated time-histories





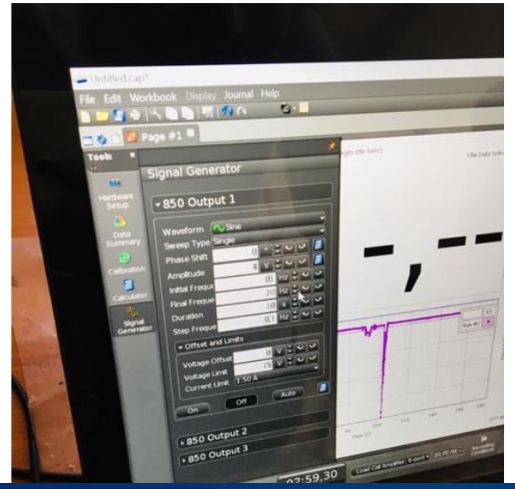
Selected time histories ($C_{min} \geq 0.8$)

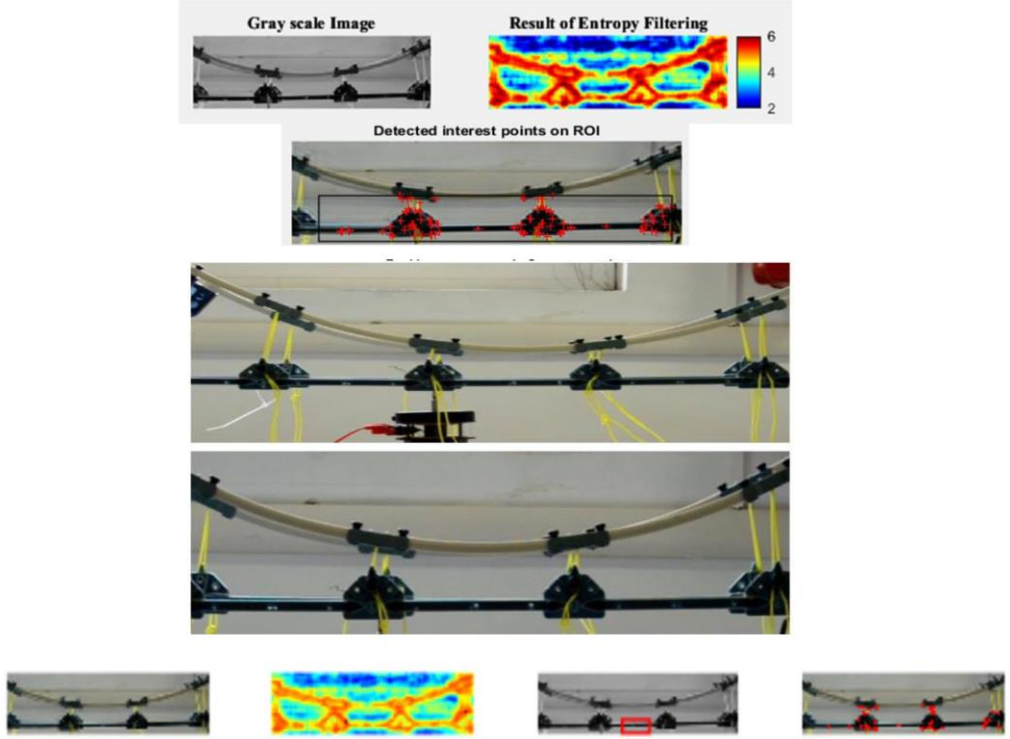
Detected frequencies



Validation

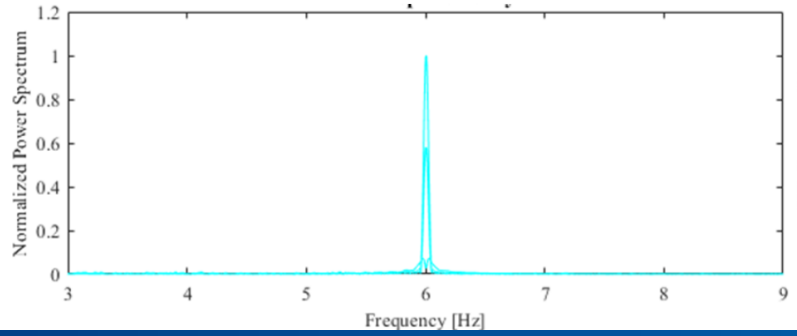
Fig.1 Experiment setup

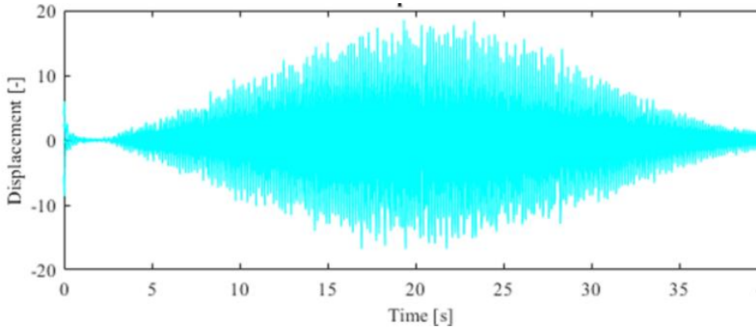




Amplification factor *a*	Frequency Brand f_{min}–f_{max}	ROI (Region of Interest) mm
20	1-10	60 × 200 (Rectangle)

Adopted parameters for motion magnification





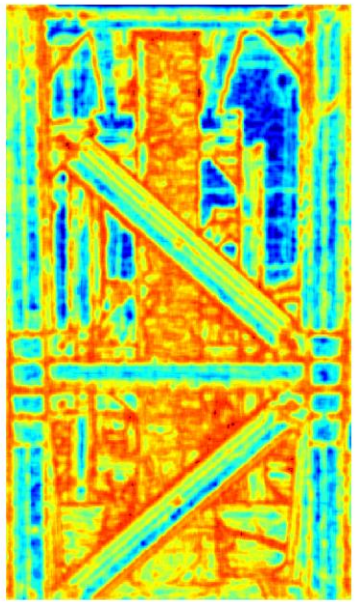
Application to laboratory tests

1) **RANDOM**: Video recorded during the 0.05 g white noise test
2) **NOISE**: Video recorded with the table on but not moving

i-th frame

(a)

Entropy map



(b)

Intensity variation ROI

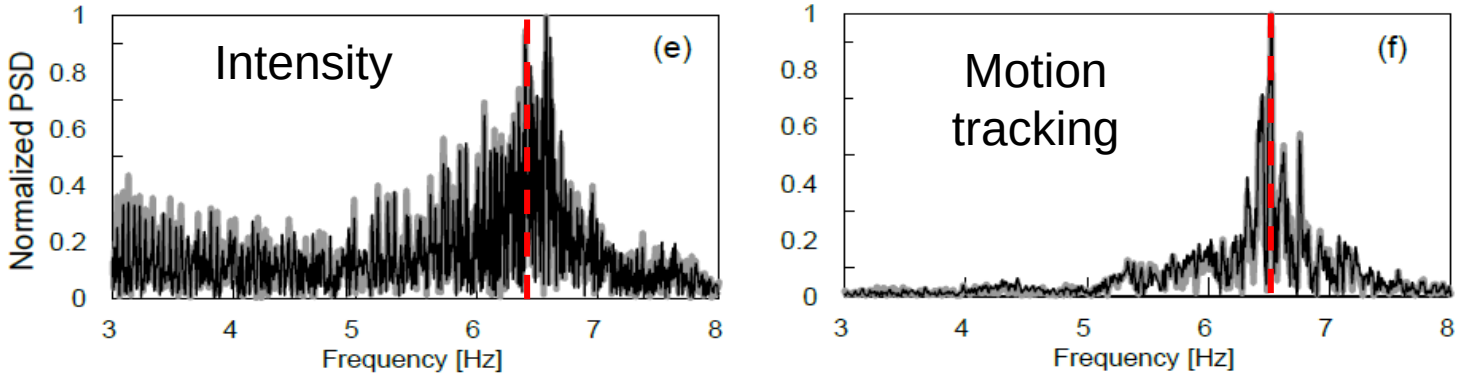
(c)

Selected pixels for motion tracking

(d)

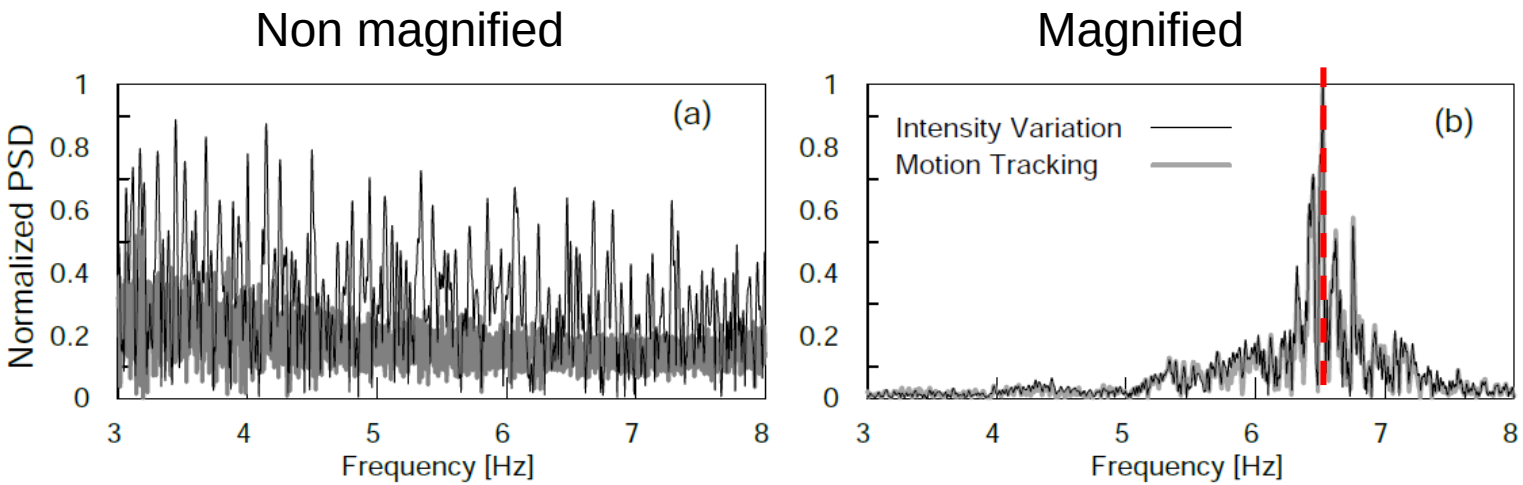
Application to laboratory tests

WN RANDOM VIDEO

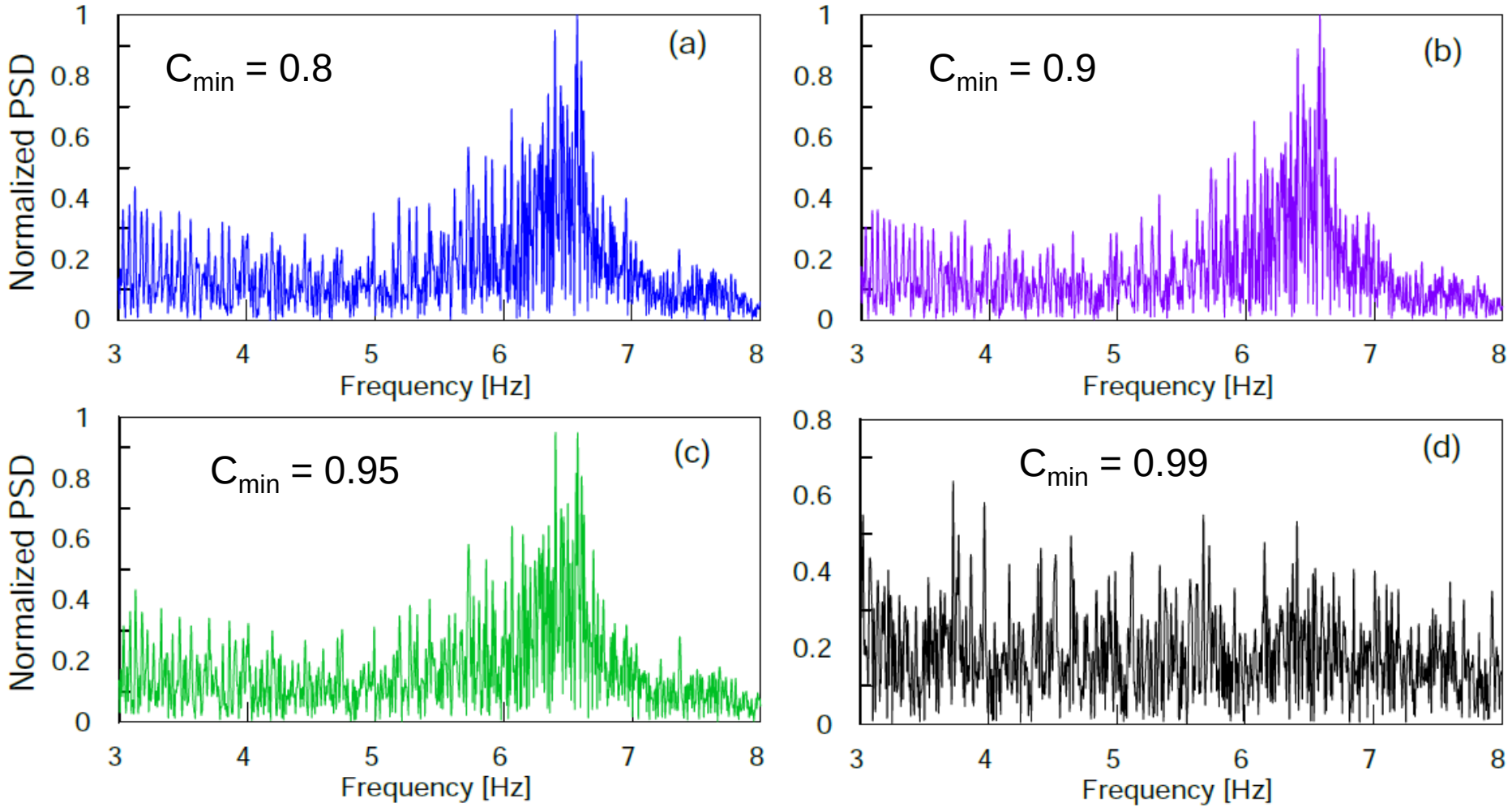


Measured	RANDOM				NOISE			
	Intensity		Motion		Intensity		Motion	
6,64 Hz	6,58 Hz	0,84%	6,58 Hz	0,84%	6,52 Hz	1,75%	6,52 Hz	1,75%

NOISE VIDEO

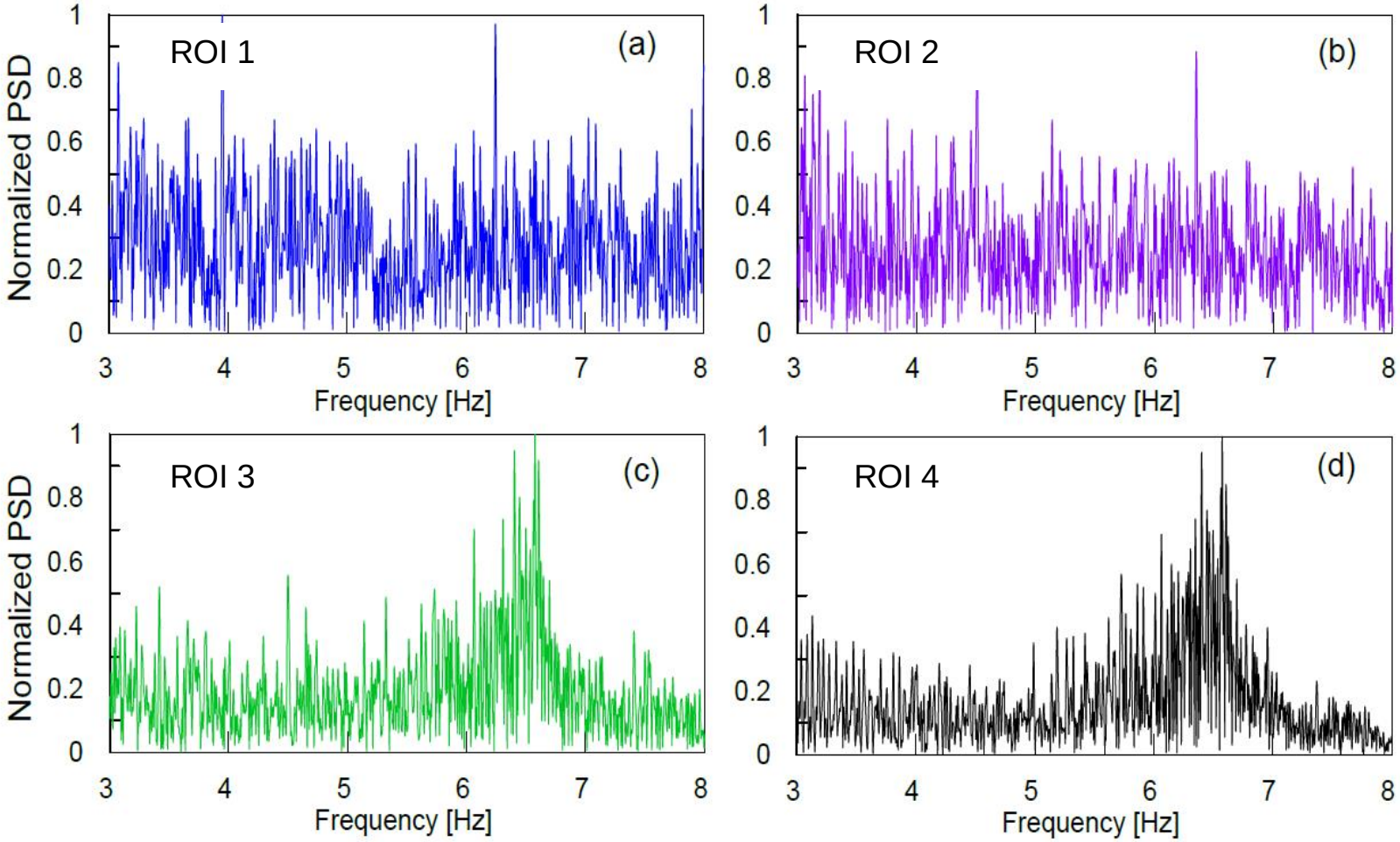


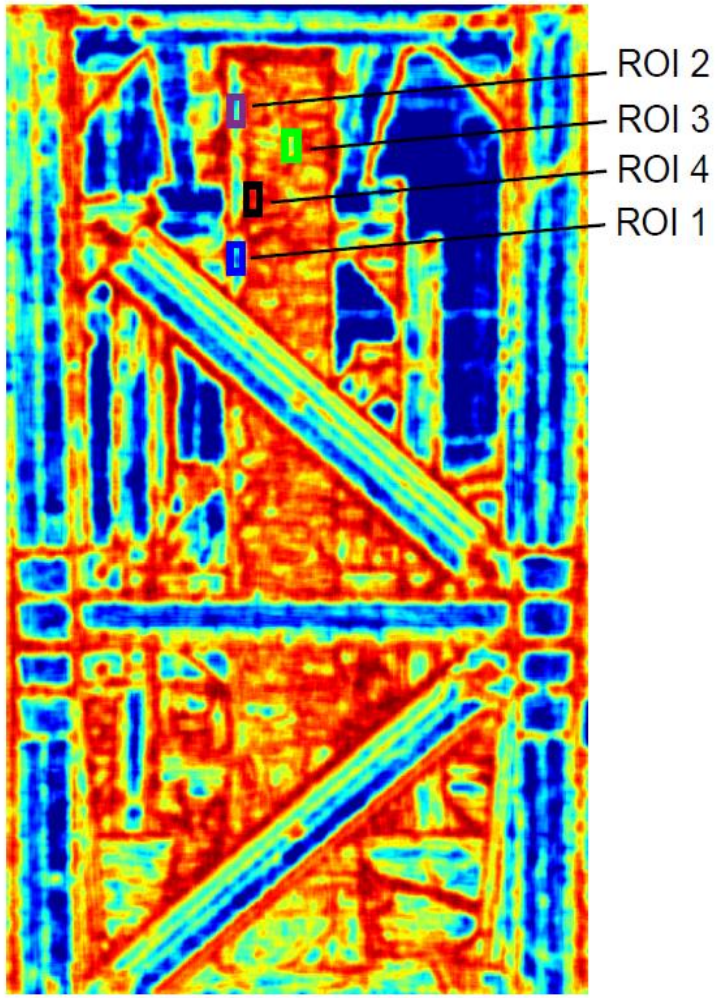
Application to laboratory tests



Normalized power spectrum obtained adopting a correlation coefficient equal to a) 0.8, b) 0.9, c) 0.95 and d) 0.99.

Application to laboratory tests

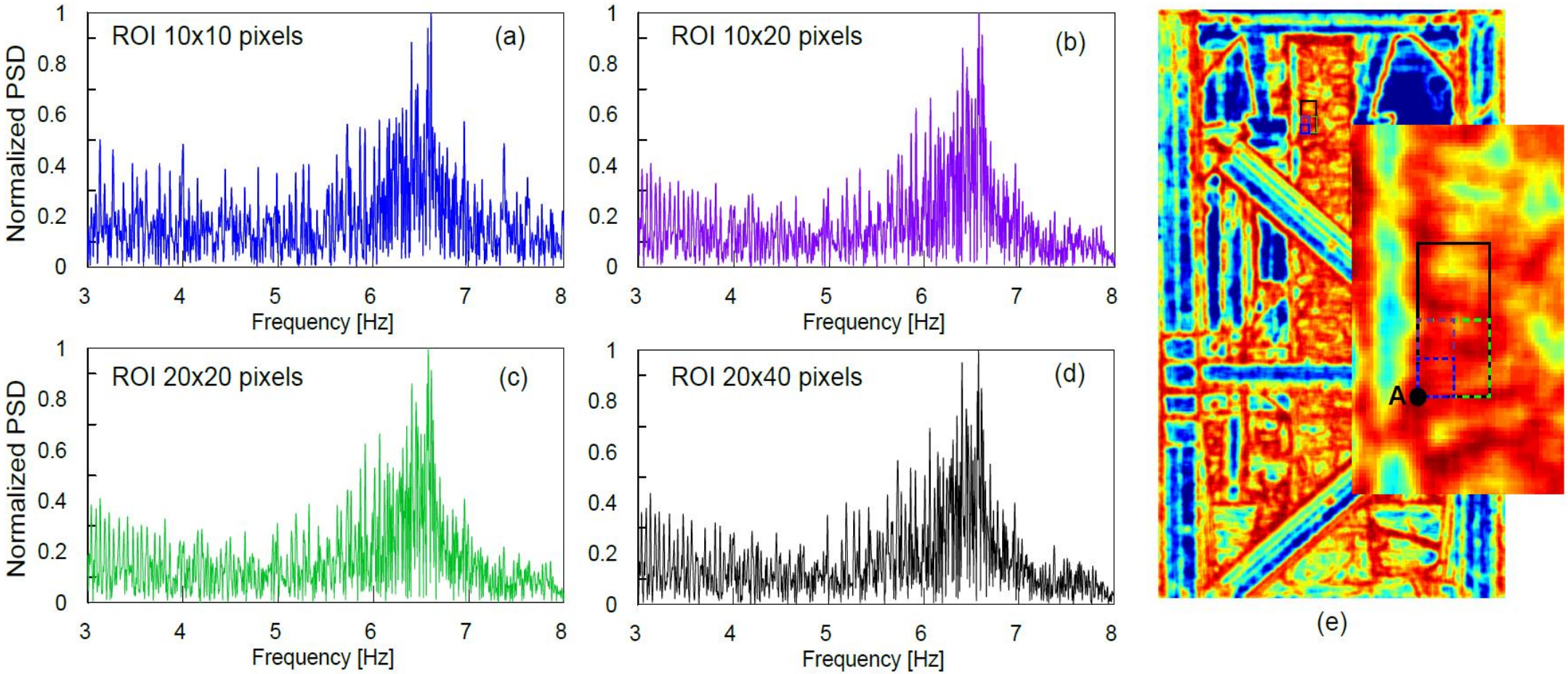




(e)

Normalized power spectrum varying the position of the ROI (a,b,c,d)

Application to laboratory tests



Normalized power spectrum varying the dimension of the ROI (a,b,c,d)

On field application

- 4 peripheral beams having 2.2 m x 0.65 m cross section
- Brick covering 5 cm thick
- Columns are 16.0 m high
- The tank is 9.3 m high and has 8.3 m diameter
- Tank thickness 0.3 m

Photogrammetric survey

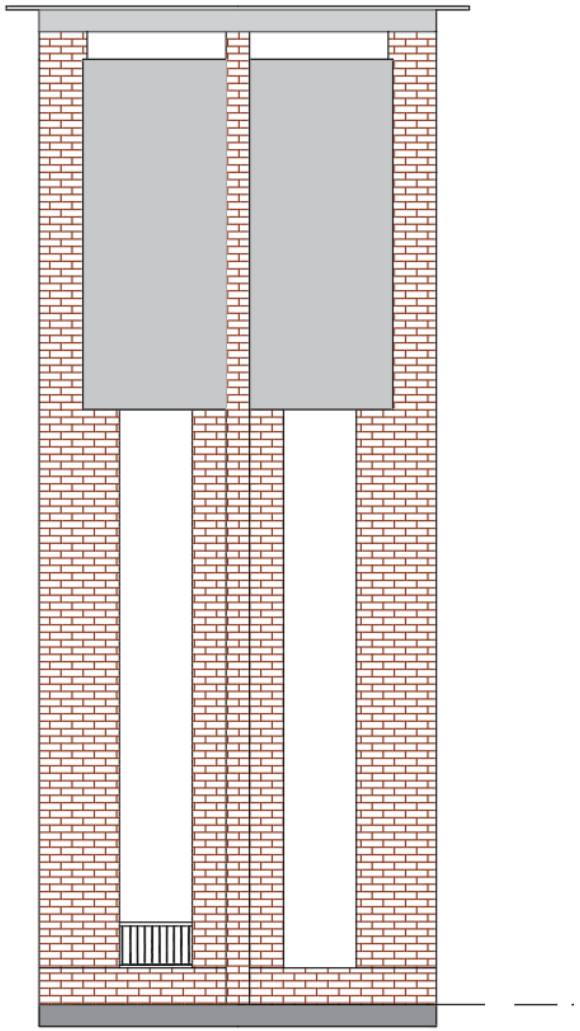
On field application

Definition of the SDOF system

- Mass properties
- Stiffness
- Incomplete information on geometry
- Incomplete information on the mechanical properties
- Incomplete information on boundary conditions

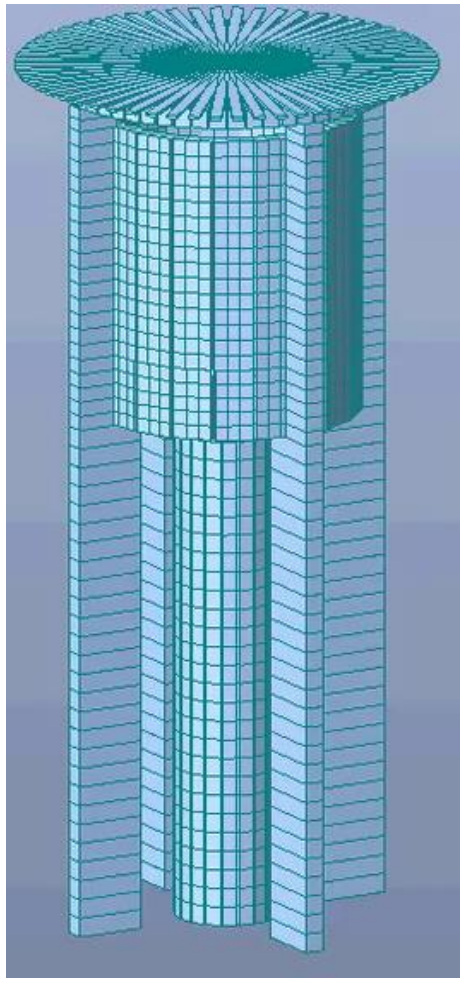
Numerical model

- Columns BEAM
- Tank walls WALL
- Bottom PLATE
- Central support WALL
- Tank-to-columns constraint. RIGID LINK



ANALYTICAL PREDICTIONS

f_{min} [Hz]	5.8
f_{max}[Hz]	7



NUMERICAL PREDICTIONS

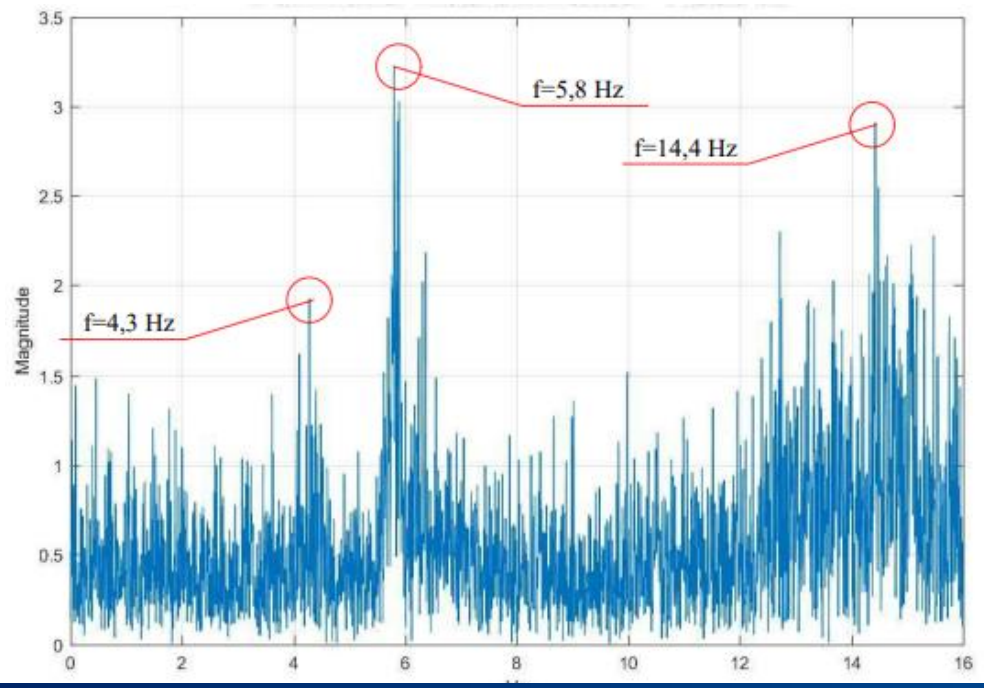
f_{tors} [Hz]	4.6
$f_{x,y}$[Hz]	5.2

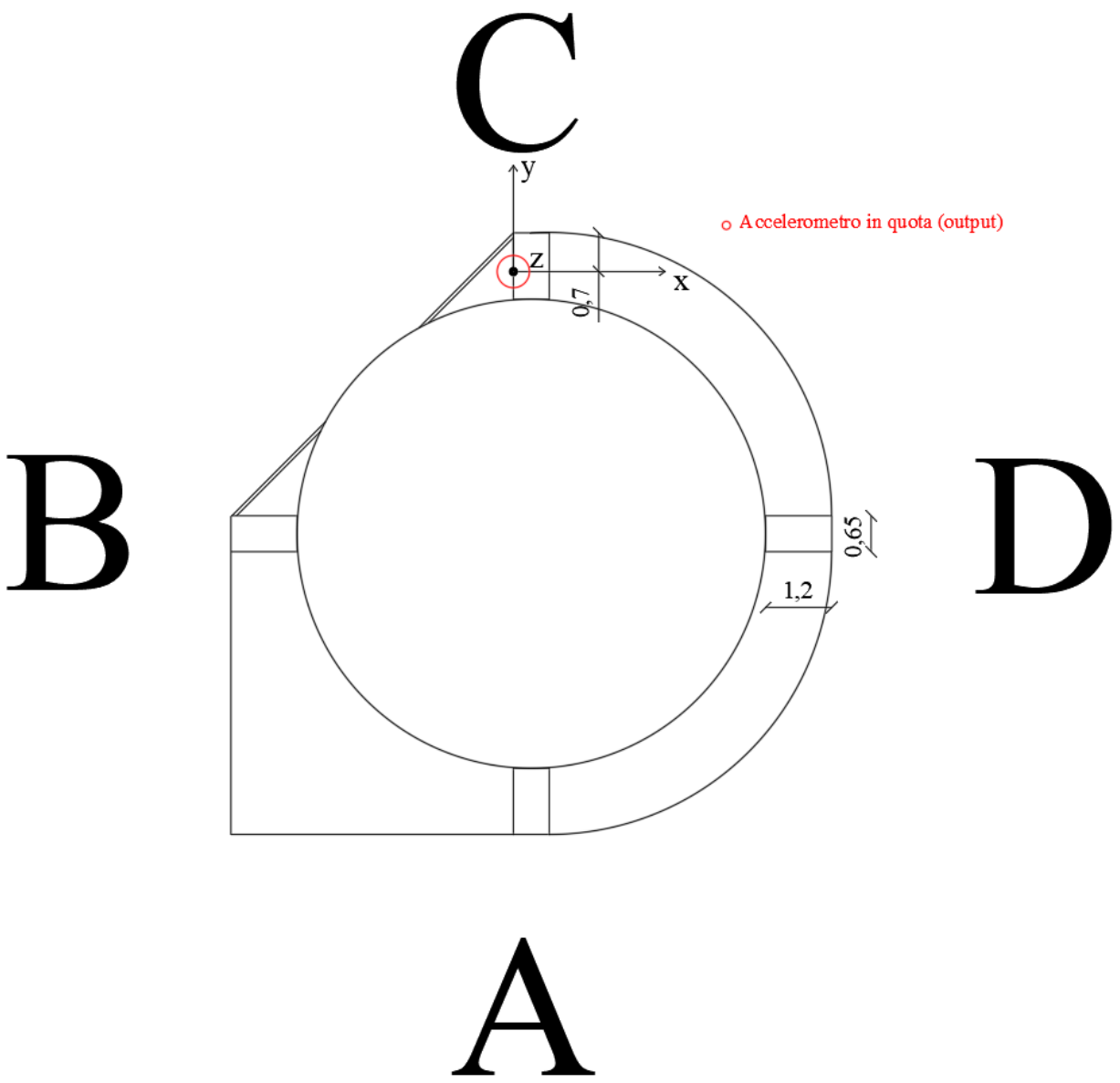
On-field application

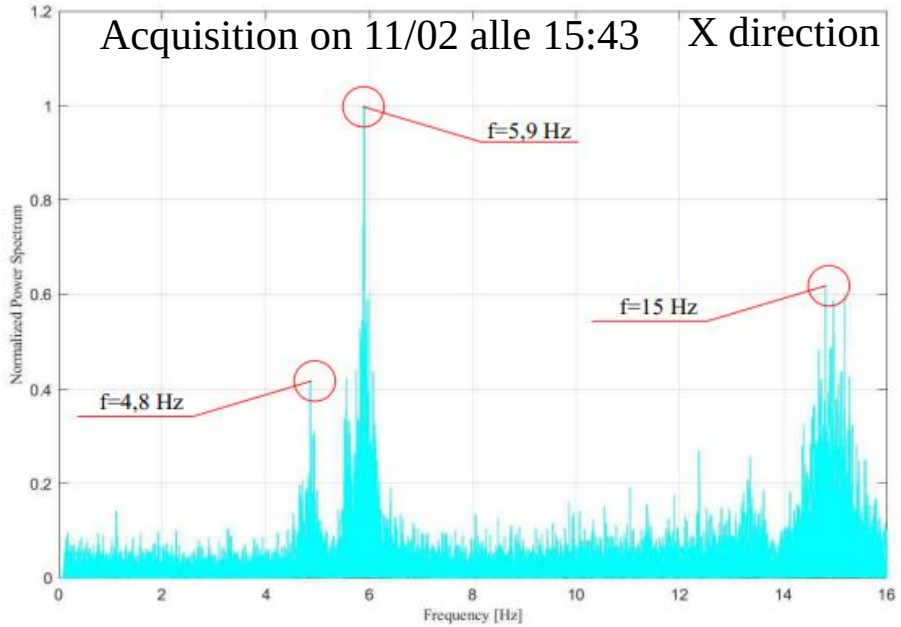
Dynamic identification through OMA

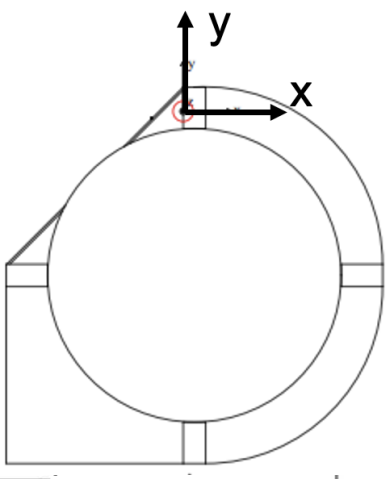
(Operational Modal Analysis)

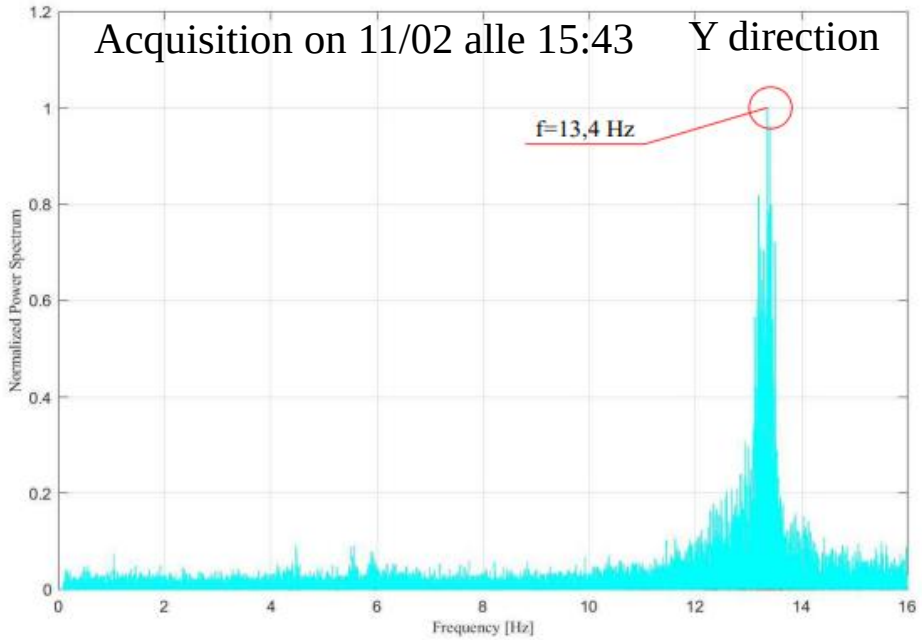
Computation of the FFT (Fast Fourier Transform) and the PSD (Power Spectral Density)

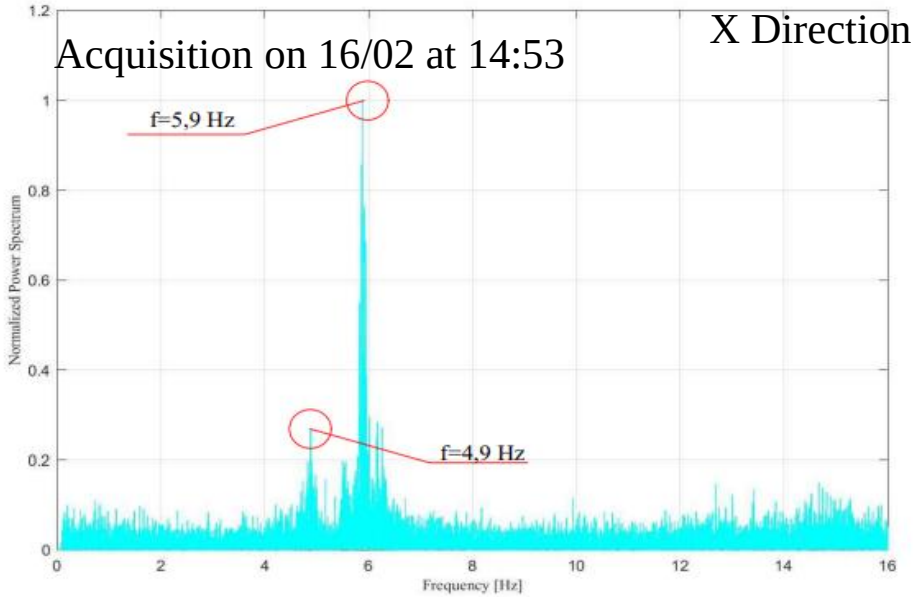


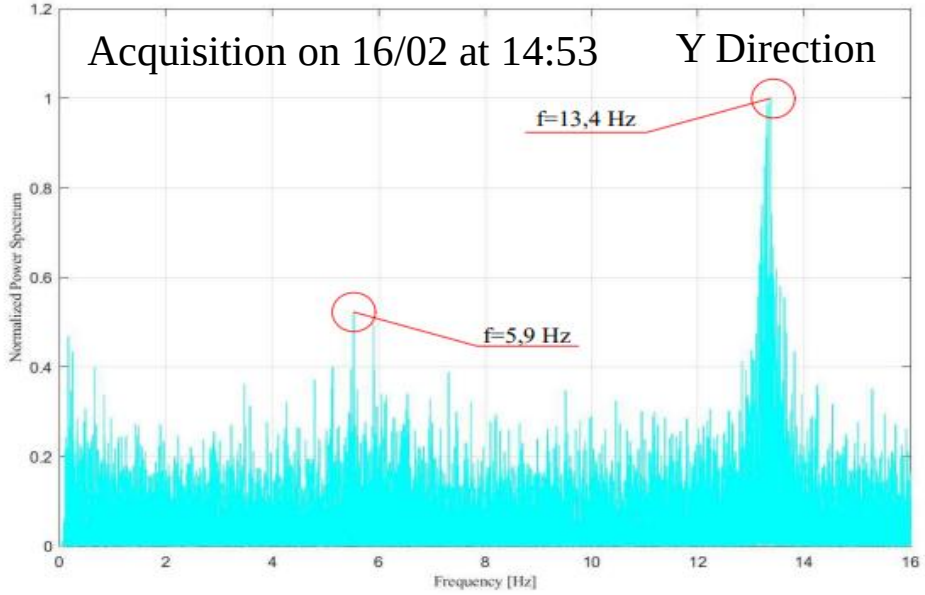



Acquisition on 11/02 alle 15:43
X direction
f=5,9 Hz
f=15 Hz
f=4,8 Hz
Normalized Power Spectrum
Frequency [Hz]

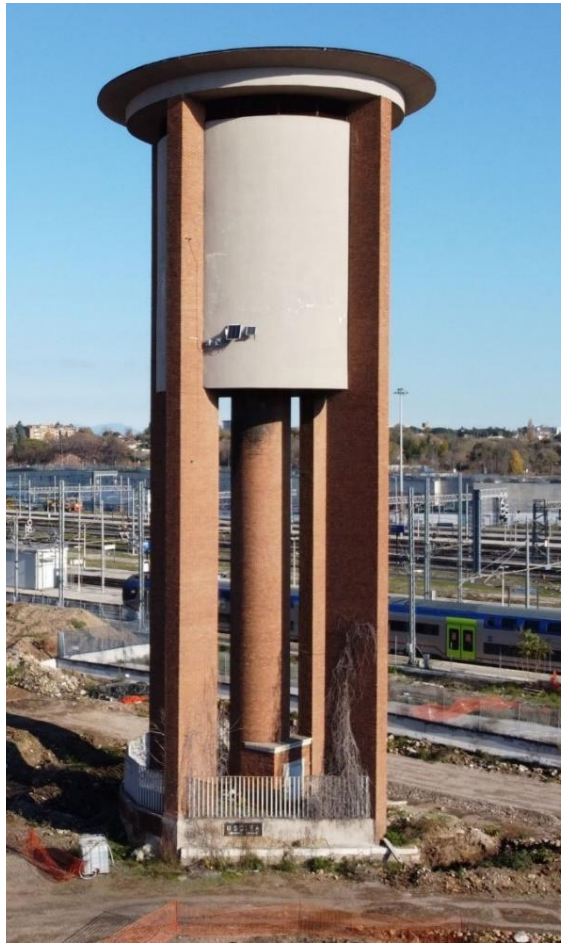

y
x

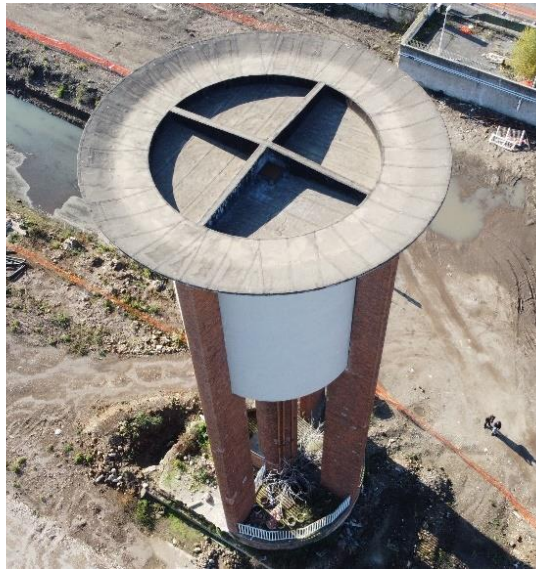

Acquisition on 11/02 alle 15:43
Y direction
f=13,4 Hz
Normalized Power Spectrum
Frequency [Hz]


Acquisition on 16/02 at 14:53
X Direction
f=5,9 Hz
f=4,9 Hz
Normalized Power Spectrum
Frequency [Hz]


Acquisition on 16/02 at 14:53
Y Direction
f=13,4 Hz
f=5,9 Hz
Normalized Power Spectrum
Frequency [Hz]

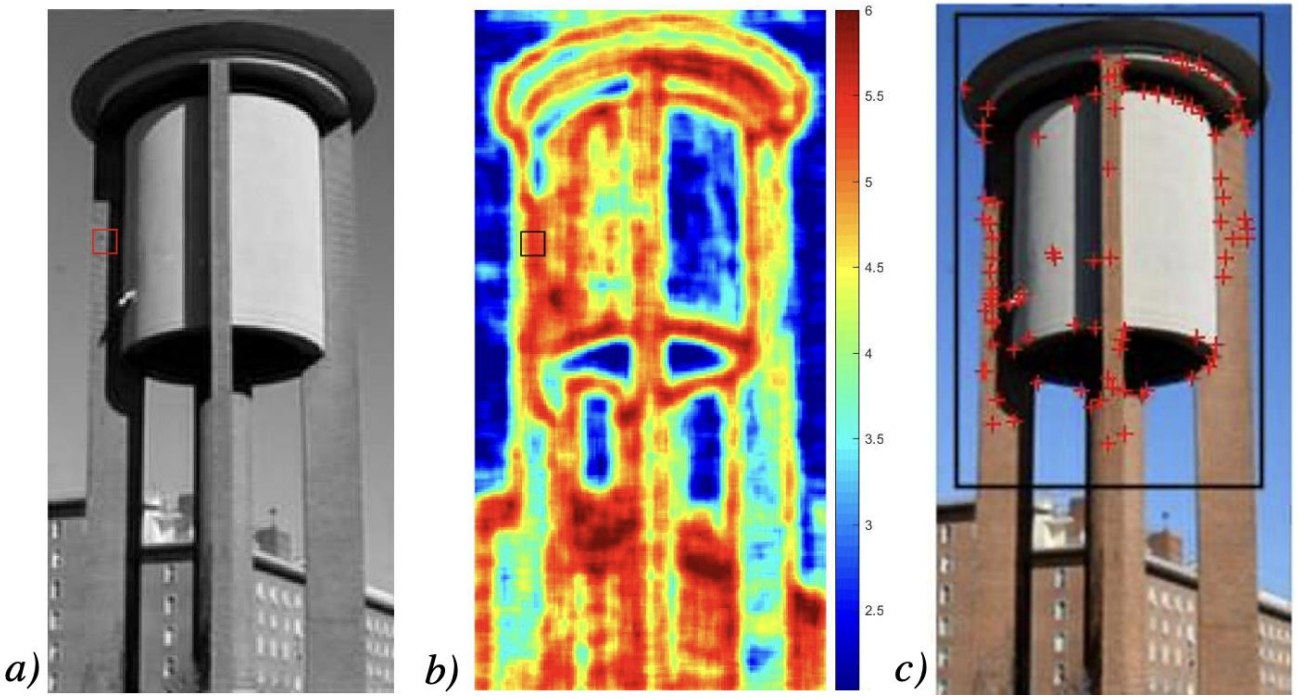
On field application





On-site application

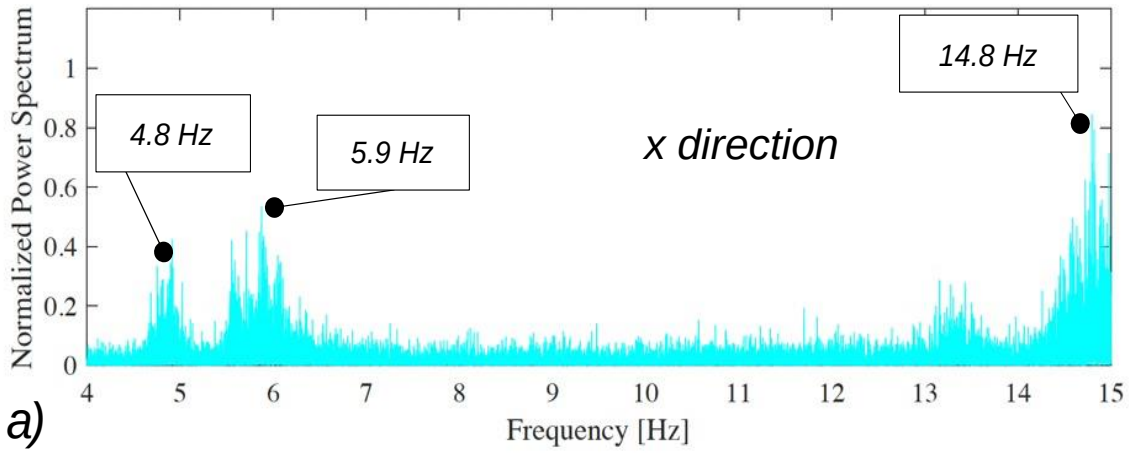
- Photogrammetric survey
- Materials
- Analytical determination of dynamic properties
- FEM model and modal analysis
- Accelerometric measurements processing
- Video processing



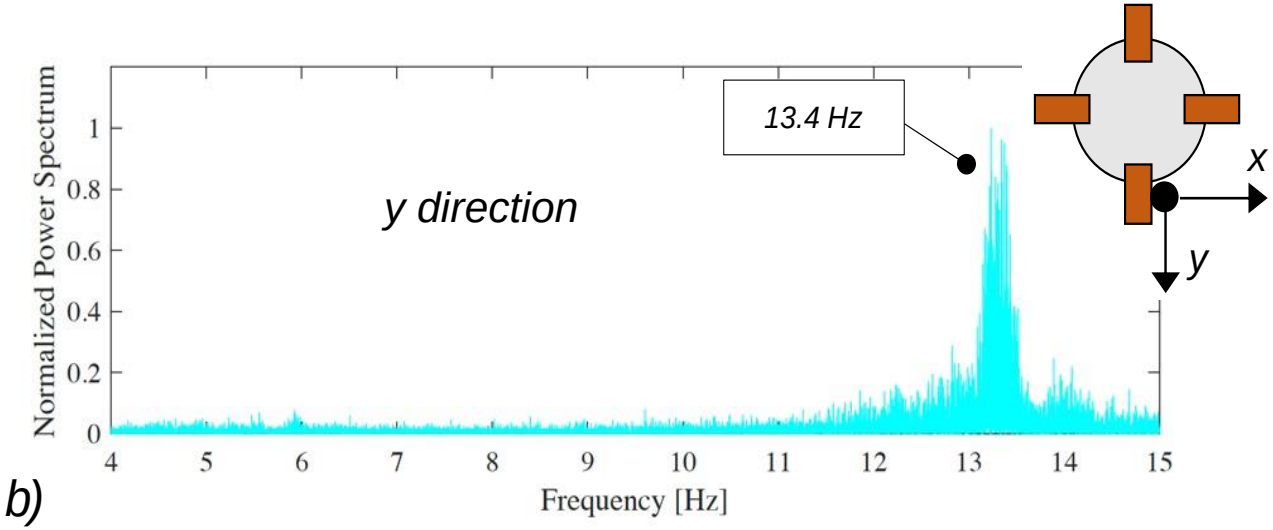
Video processing stages: sample frame (a), entropy map (b) and selected pixels for motion tracking

On field application

Accelerometer

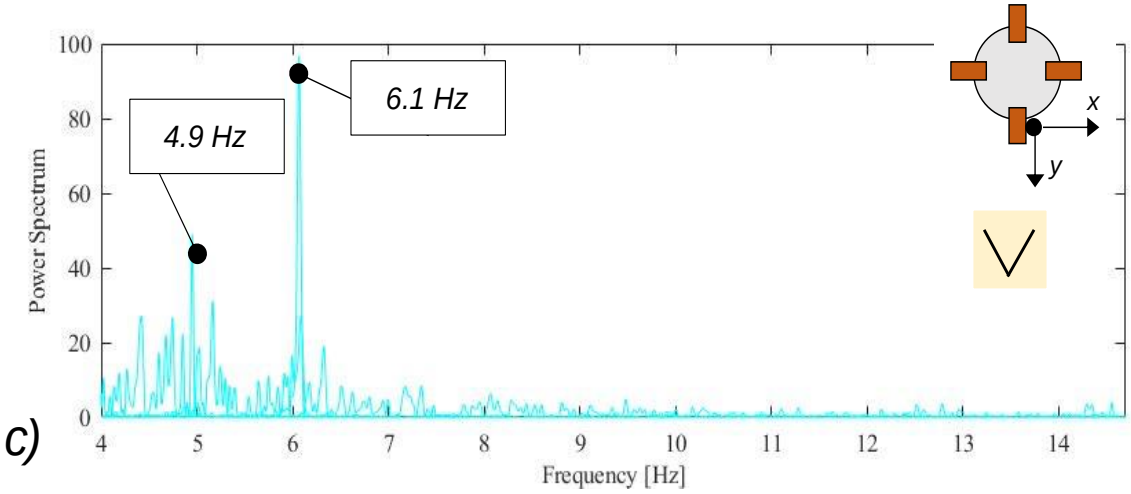


a)

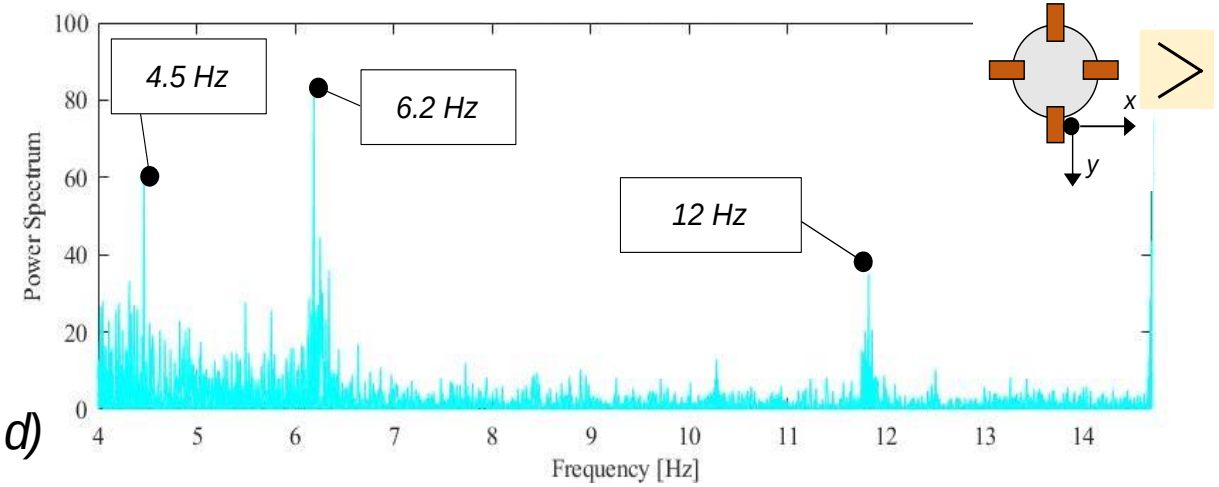


b)

Computer Vision



c)



d)

Current applications

Conclusions

- A **computer-vision-based method** is used to **detect the natural frequencies** of existing structures
- The approach makes use of a **motion magnification alghoritm** for improving accuracy, given the small amplitude of the oscillations caused by environmental noise.
- The approach is under validation by means of laboratory tests under controlled conditions and comparison with OMA for real scale structures under environmental vibrations.

& Ongoing developments

- The identification of the **Mode Shapes** through the application of the proposed methodology combined with Motion Magnification algorithm and video processing techniques.
- The application and calibration of the proposed methodology for the structural **Identification of bridges.**
- The **structural identification** through videos recorded by **drones**

Stefano De Santis

Arnaud Montabert

Pietro Meriggi

Marialuigia Sangirardi

Vittorio Altomare

- STAND Stima e analisi del danneggiamento indotto da scavi in area urbana (2021-2022)
- RIPARA Integrated systems for the seismic retrofitting of architectural heritage (2022 – 2023)

GRAZIE PER L'ATTENZIONE