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Monitoring Masonry Walls Subjected to Earthquake Loading with a ToF Range Camera

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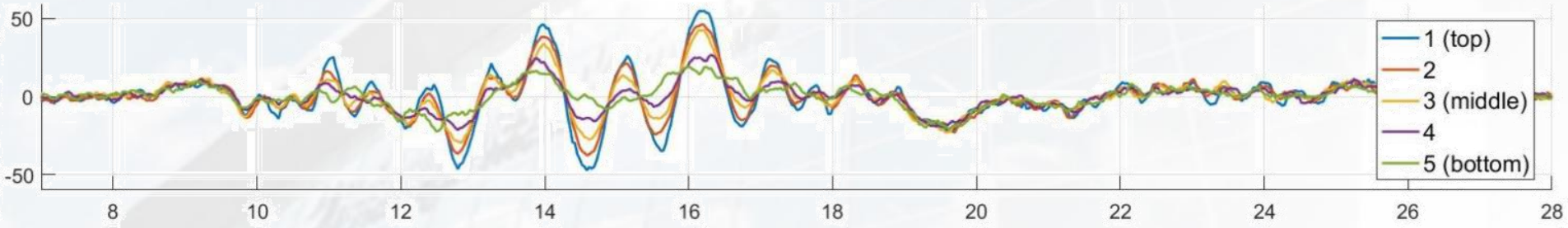


Motivation

- Masonry buildings are at risk of collapsing during earthquakes
- Reducing this risk by applying repair material
- Structural loading tests to assess the effectiveness of the material

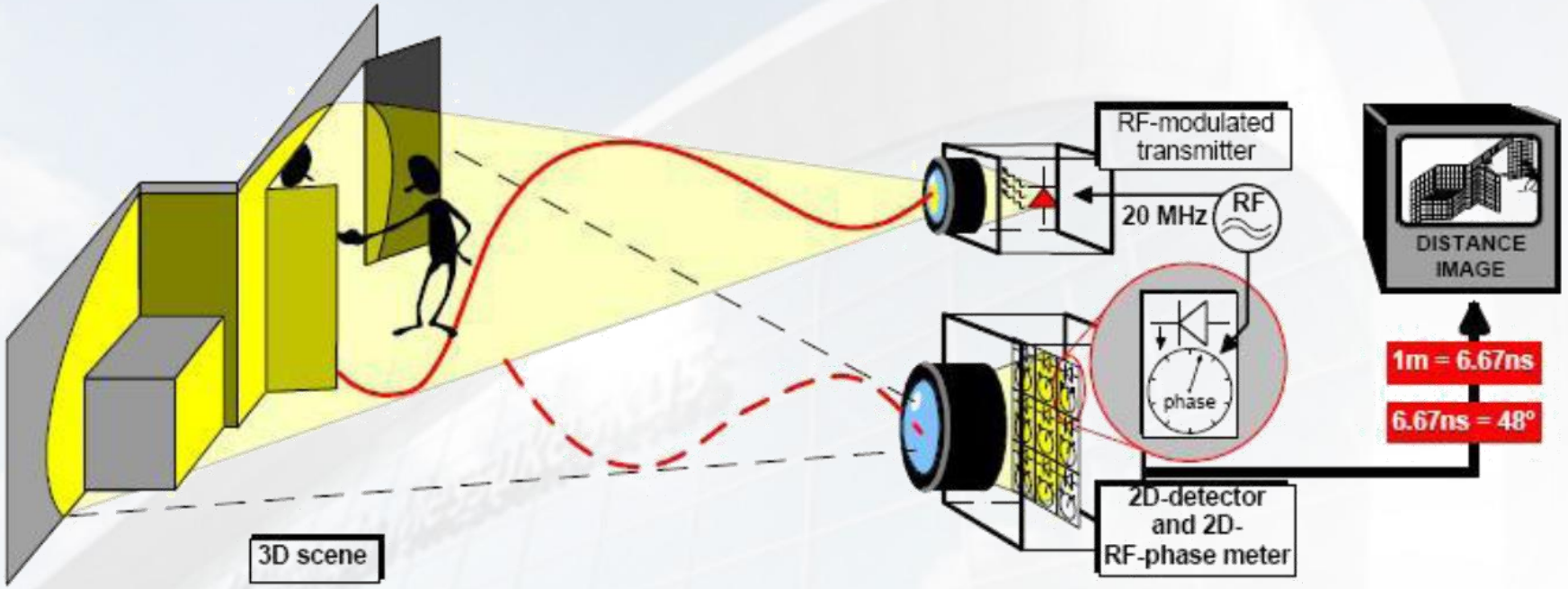
Research Objectives

- Monitoring the experiments using a ToF range camera

→ Delivering additional 3D information

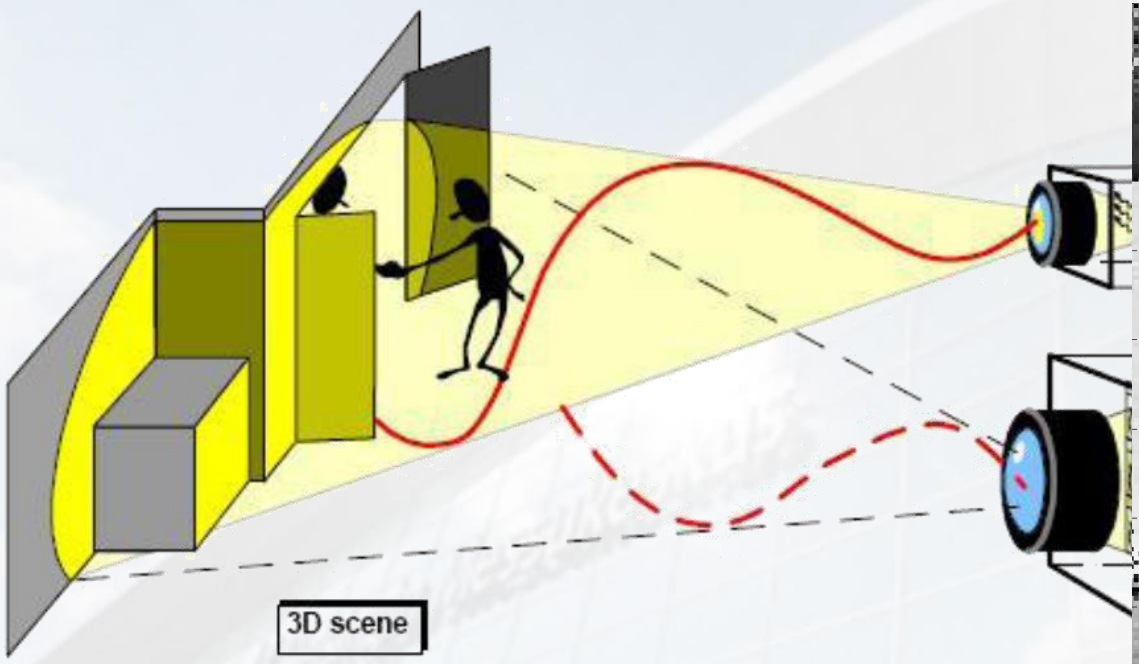
→ Applicability of range sensors for structural loading tests

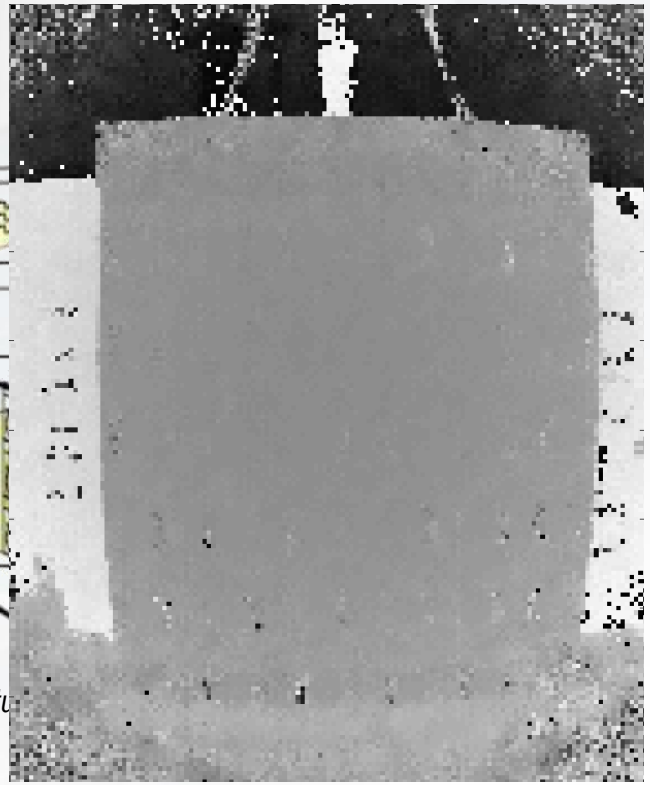
Time-of-Flight Range Camera Principle



Lange, R. and Seitz, P., 2001. Solid-State Time-of-Flight Range Camera. *IEEE Journal of Quantum Electronics*, 37(3), pp.390–397.

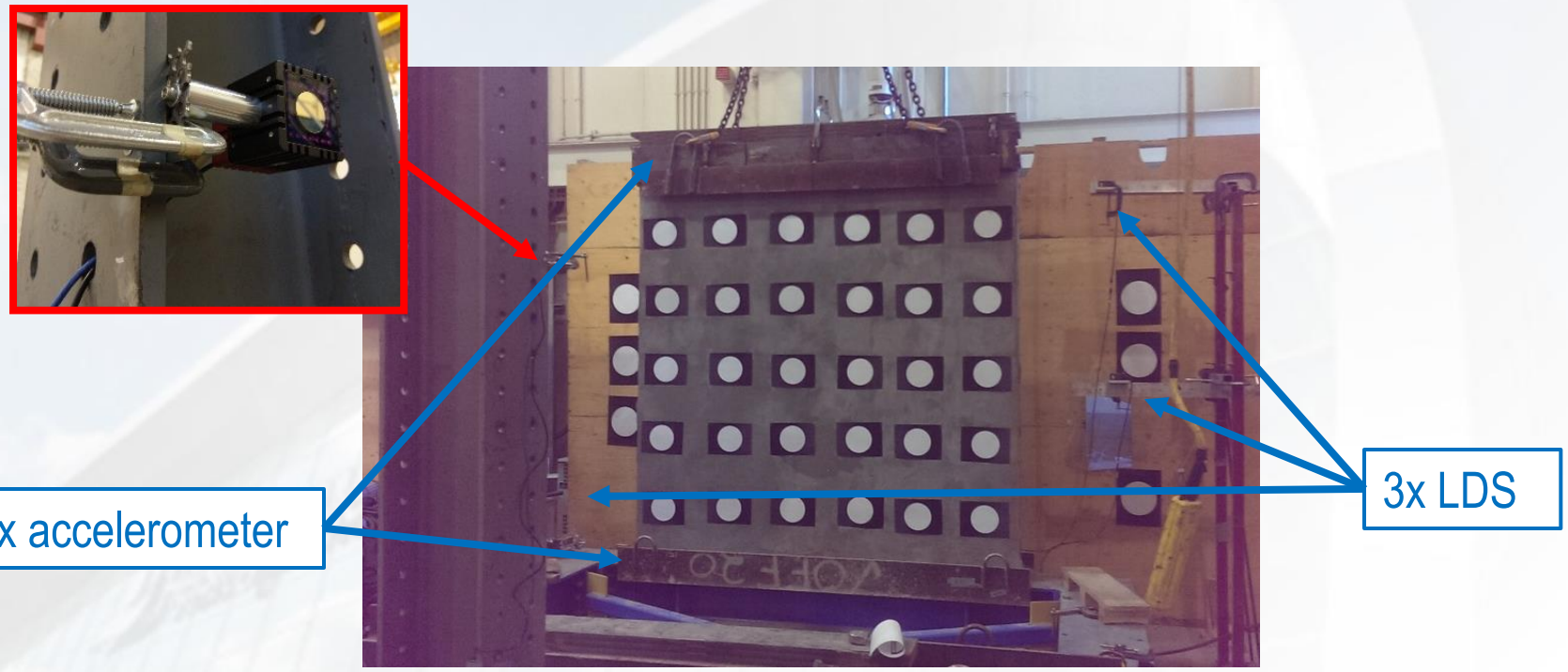
Time-of-Flight Range Camera Principle





Lange, R. and Seitz, P., 2001. Solid-State Time-of-Flight Range Camera. *IEEE Journal of Quantu*

Experiment Setup



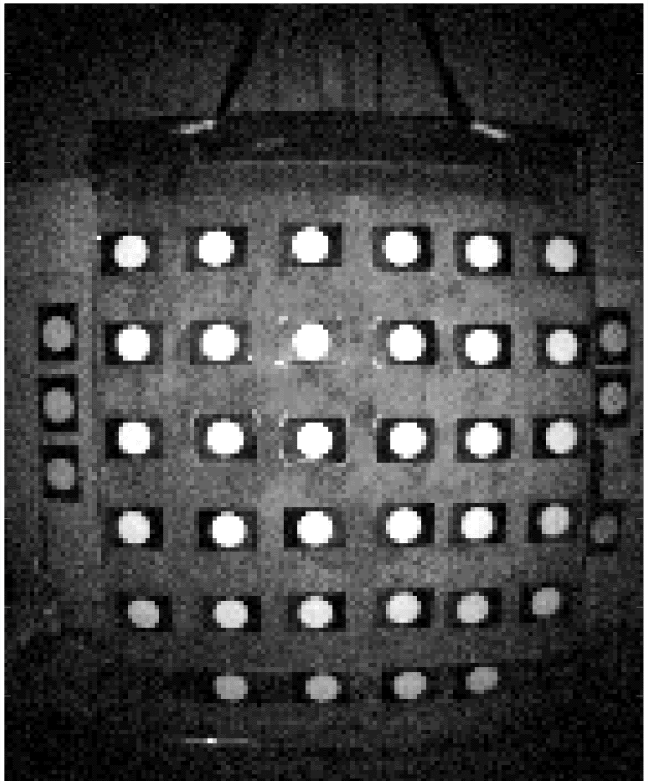
SwissRanger SR4000 Data Sheet

- Absolute accuracy: ± 10 mm
- Repeatability: (for central pixels) 4 - 7 mm
- Non ambiguity range: 5.0 m
- Resolution: 176 x 144 pixel
- Field of view: 69° x 56°
- Max. frame rate 50 Hz

(MESA Imaging, 2011. *SR4000 Data Sheet*.)

Processing

- Tracking targets in 2D amplitude image
- Compute 3D coordinates
- Moving average
- Averaging multiple targets (f.e. per row)
  → under assumption of a rigid body



Processing

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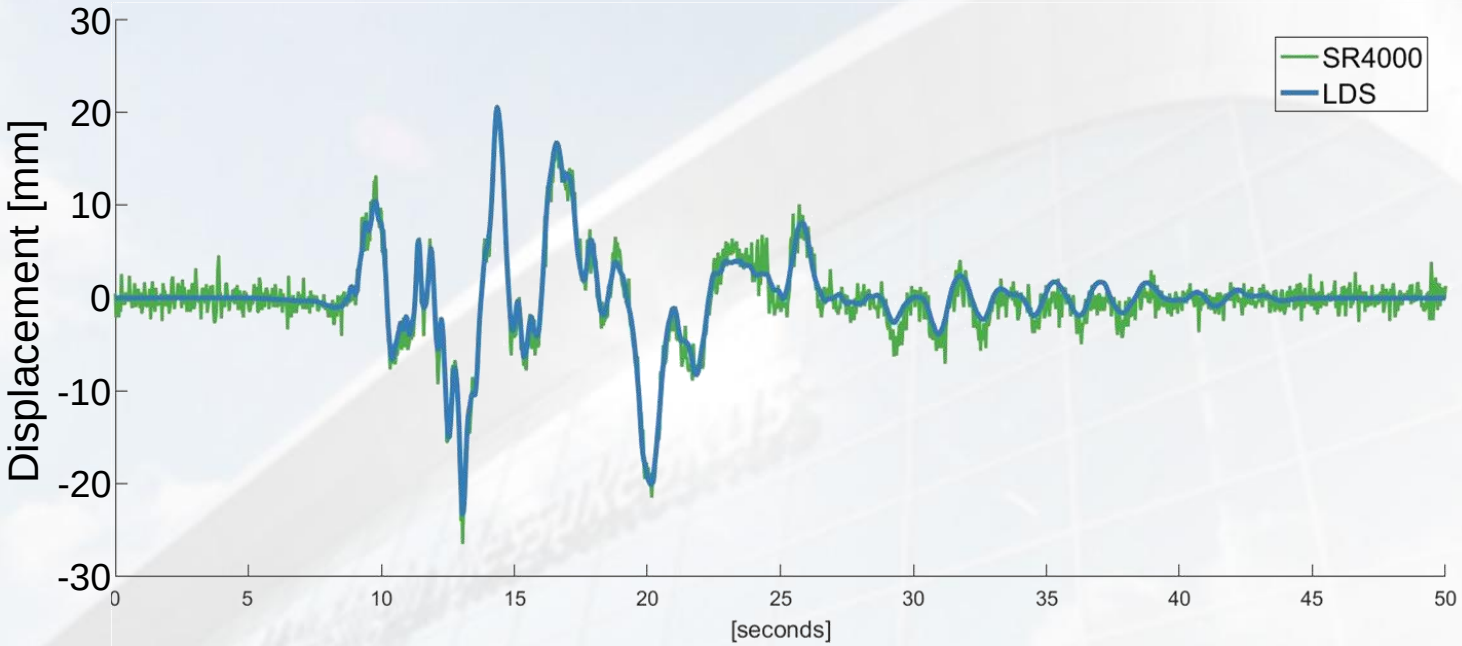
Mean RMS from static tests:

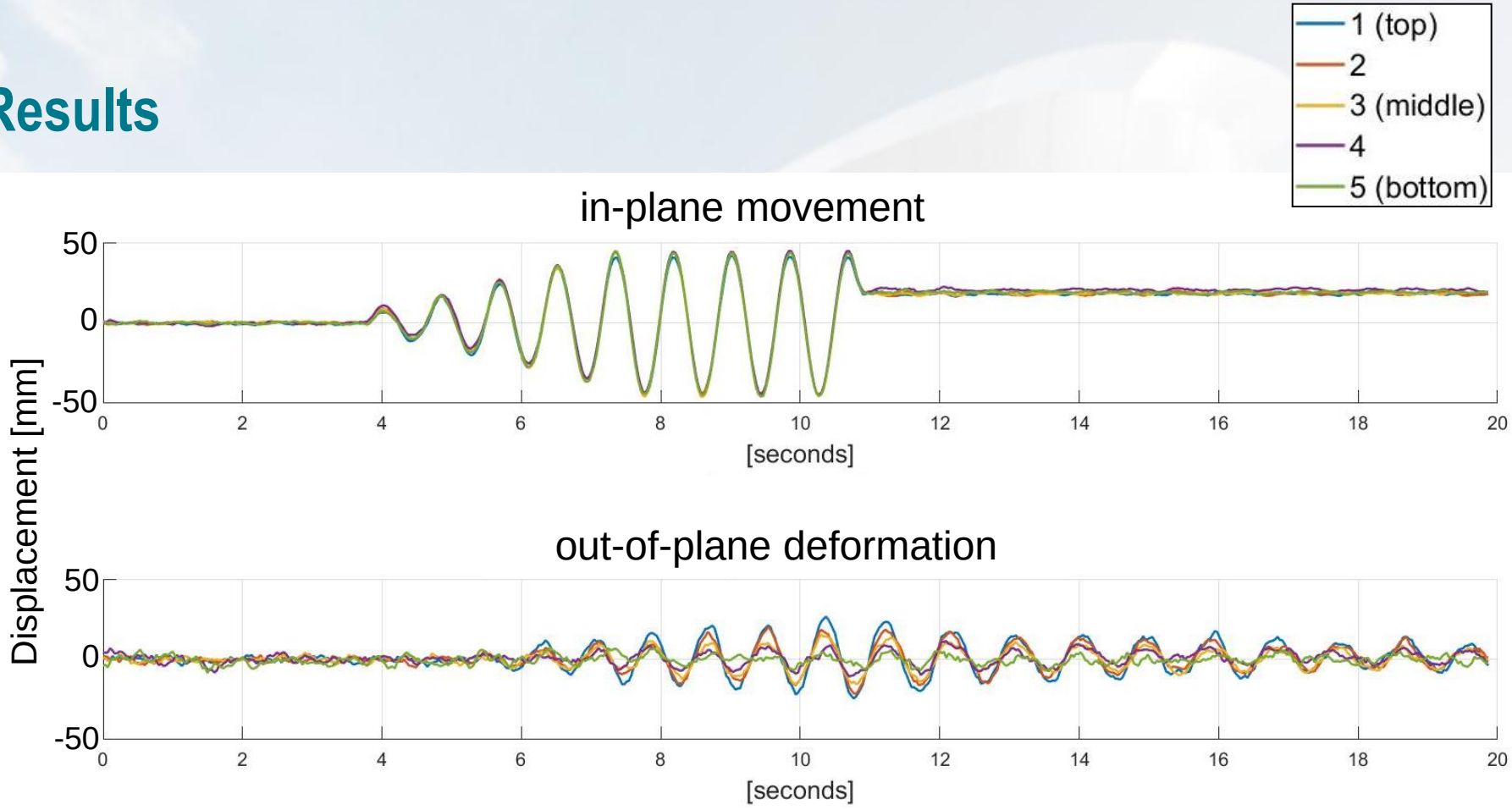
	In-plane	Distance
Single point	2.5	9.7
Moving average	1.1	4.3
Average row	1.2	4.3
Both averages	0.5	1.9

Comparison with Laser Displacement Sensor

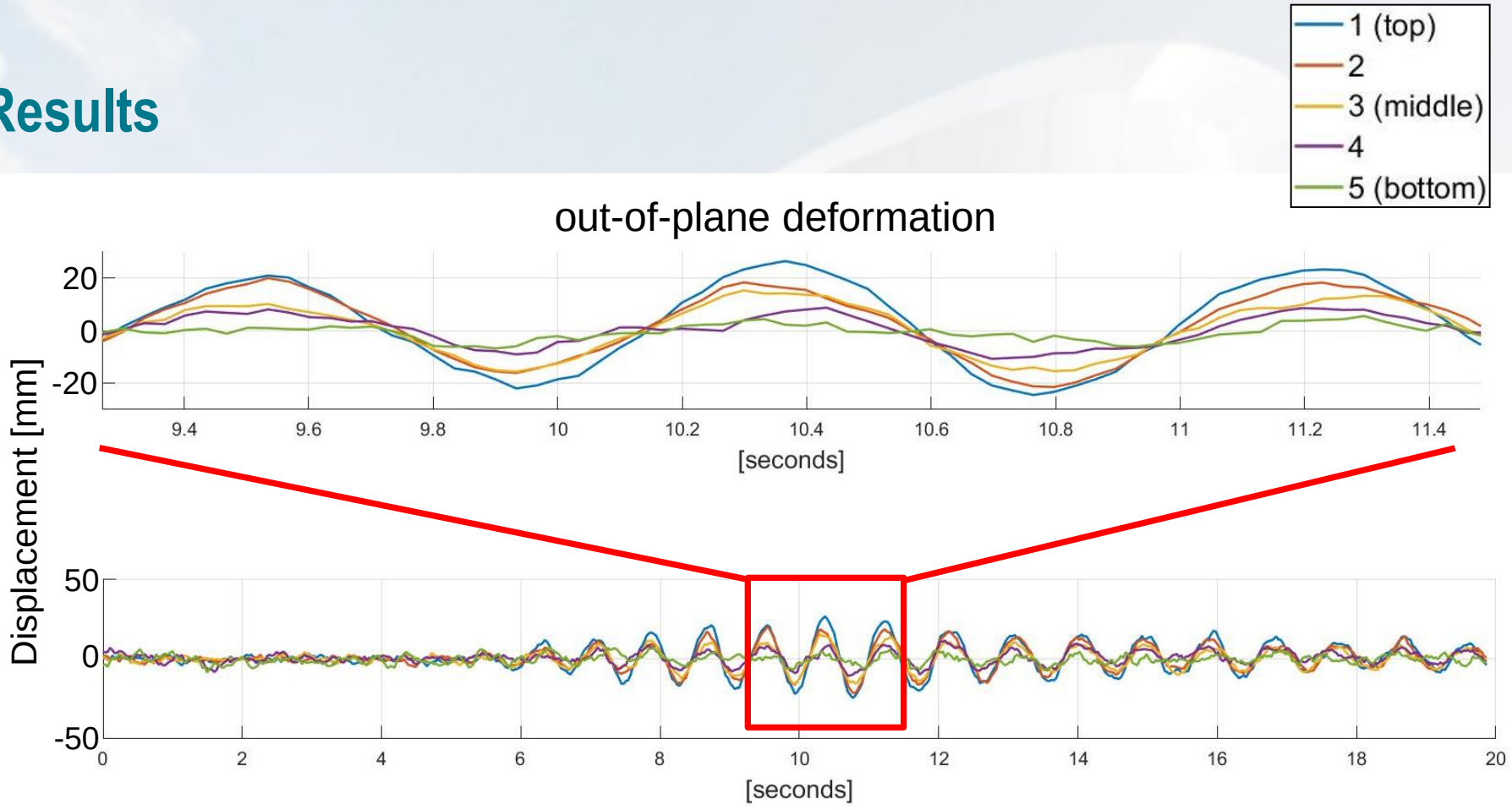


→ Standard deviation of differences 1.3 - 2.7 mm (In-plane)

Results


1 (top)
2
3 (middle)
4
5 (bottom)
in-plane movement
Displacement [mm]
50
0
-50
0
2
4
6
8
10
12
14
16
18
20
[seconds]
out-of-plane deformation
50
0
-50
0
2
4
6
8
10
12
14
16
18
20
[seconds]

Results


1 (top)
2
3 (middle)
4
5 (bottom)
out-of-plane deformation
Displacement [mm]
20
0
-20
9.4
9.6
9.8
10
10.2
10.4
10.6
10.8
11
11.2
11.4
[seconds]
50
0
-50
0
2
4
6
8
10
12
14
16
18
20
[seconds]

Conclusions

- Range camera brings **additional information** to conventional sensors
  - Cover whole wall in **3D** with one sensor
  - **Safe distance** to the specimen
- Advantages compared to photogrammetry or laser scanning
  - Only **one sensor** necessary
  - **Active** Sensor
  - **Dynamic** measurements at video frame rate
- Limitation in accuracy and measurement frequency
- Challenge to extract additional information to compare walls and detect failure

Thank you!