

TACK – Tunnel Automatic Crack Detection

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SAPIENZA
UNIVERSITÀ DI ROMA

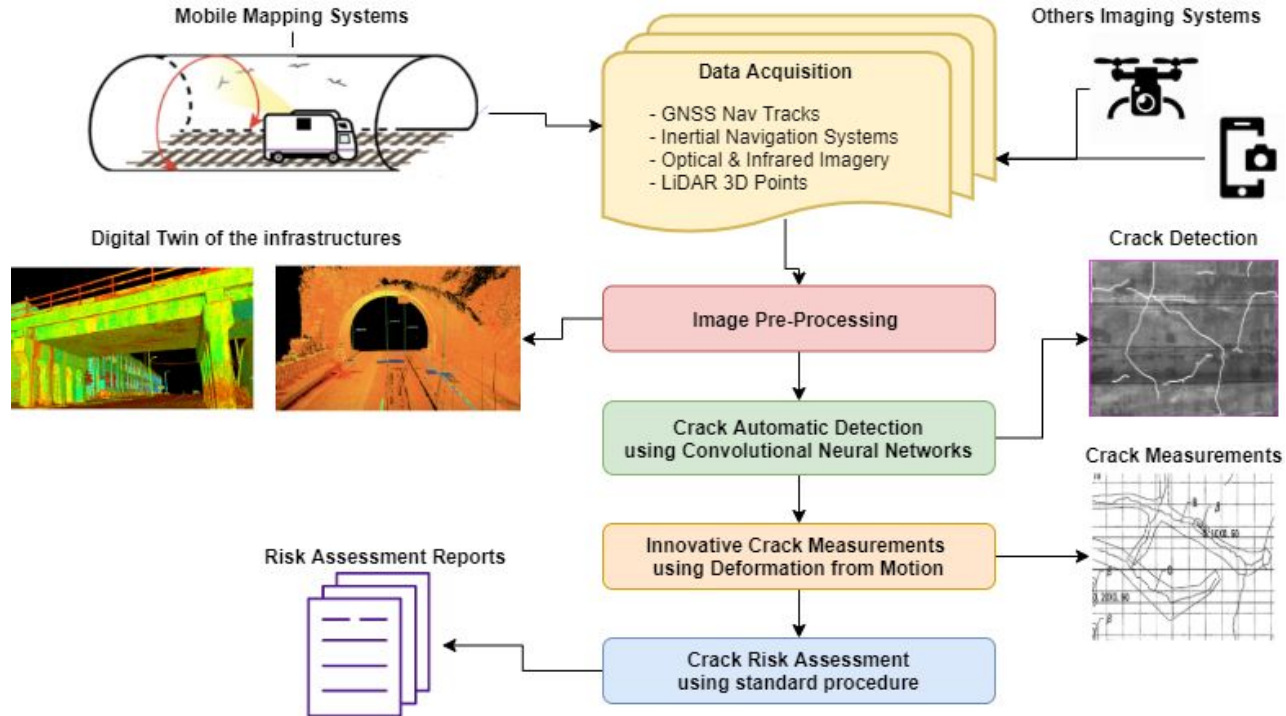


Outline

1. Aim and Goal of the project
2. Important results
 - a. Deep-Learning for crack detection
 - b. Photogrammetry for crack measurement
 - c. Risk Assessment
3. Next step towards implementation
4. Discussion



The TACK project



Goals of the project

- Annotate images from different tunnels and create a **new dataset** of tunnel defects
- Train and test a **deep learning** models for automatic **crack detection**
- Validate the trained deep learning model on the new dataset
- Develop and test a novel photogrammetric model for **crack measurement** using cameras with different positions over time
- Investigate tunnel **risk assessment**

Deep-Learning

- **Convolutional Neural Networks (CNN)** are powerful deep-learning techniques for automatic feature extraction and classification problems
- CNN use annotated datasets to learn how to recognise specific patterns in new unseen images

Crack

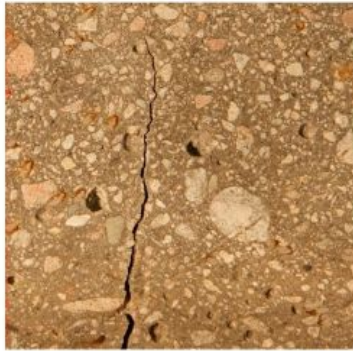
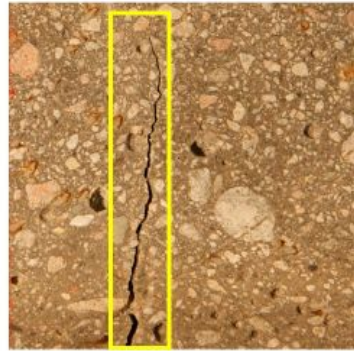
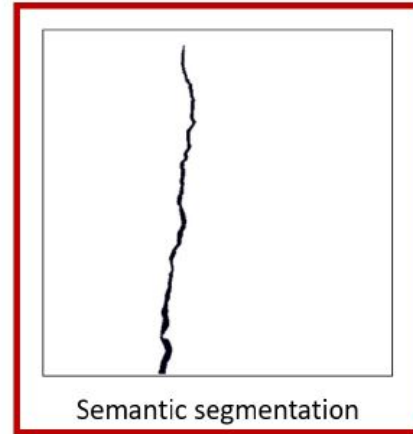


Image classification

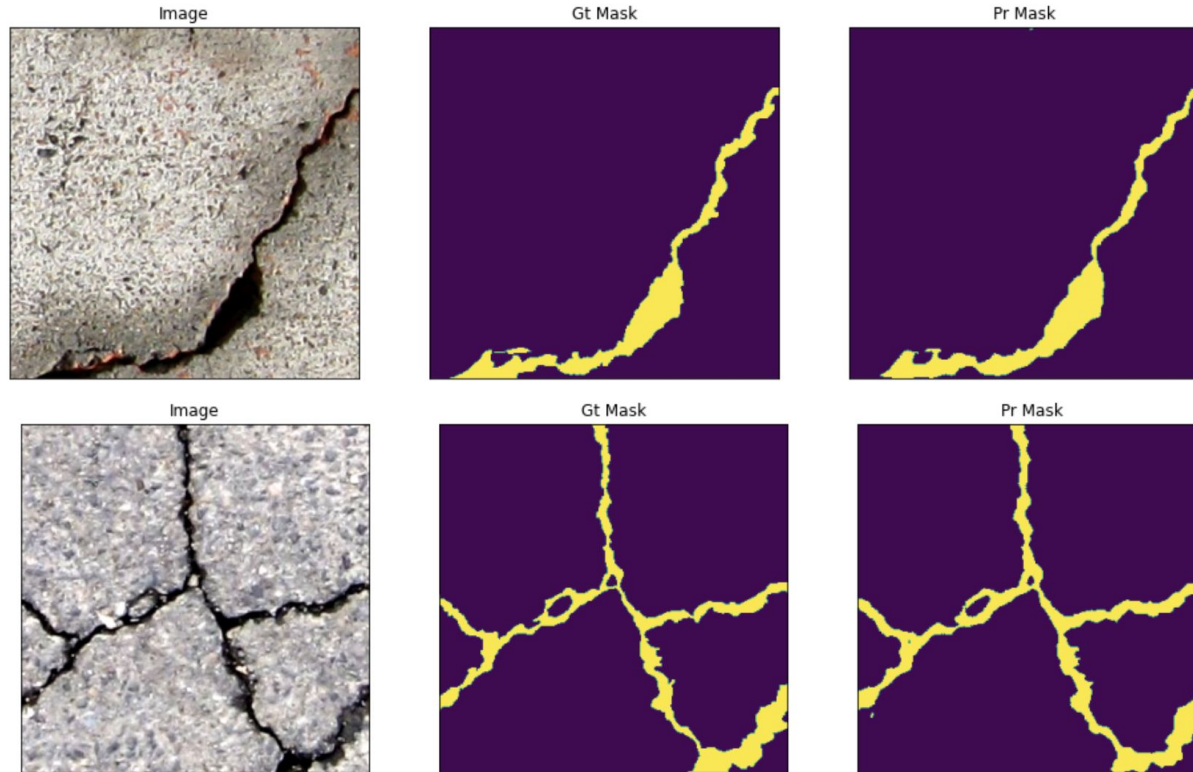


Object detection

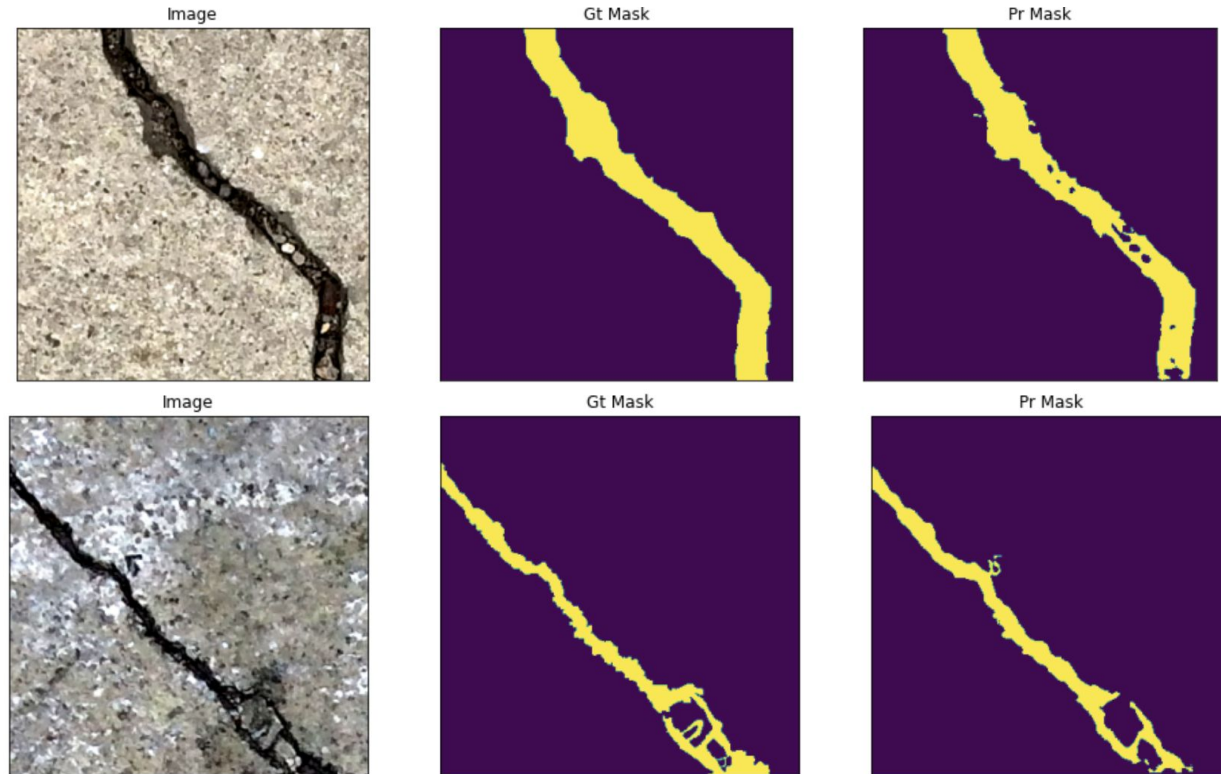


Semantic segmentation

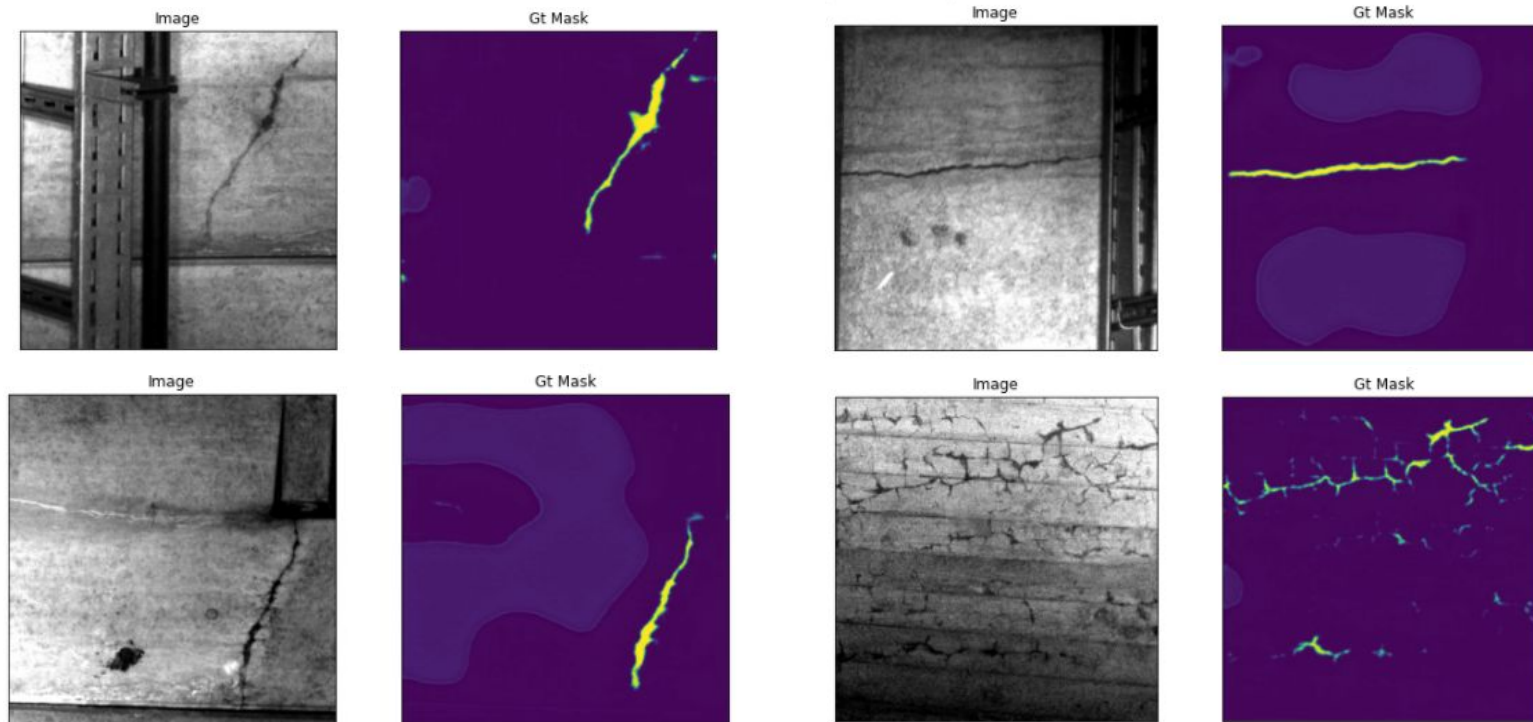
CNN performance on the test set



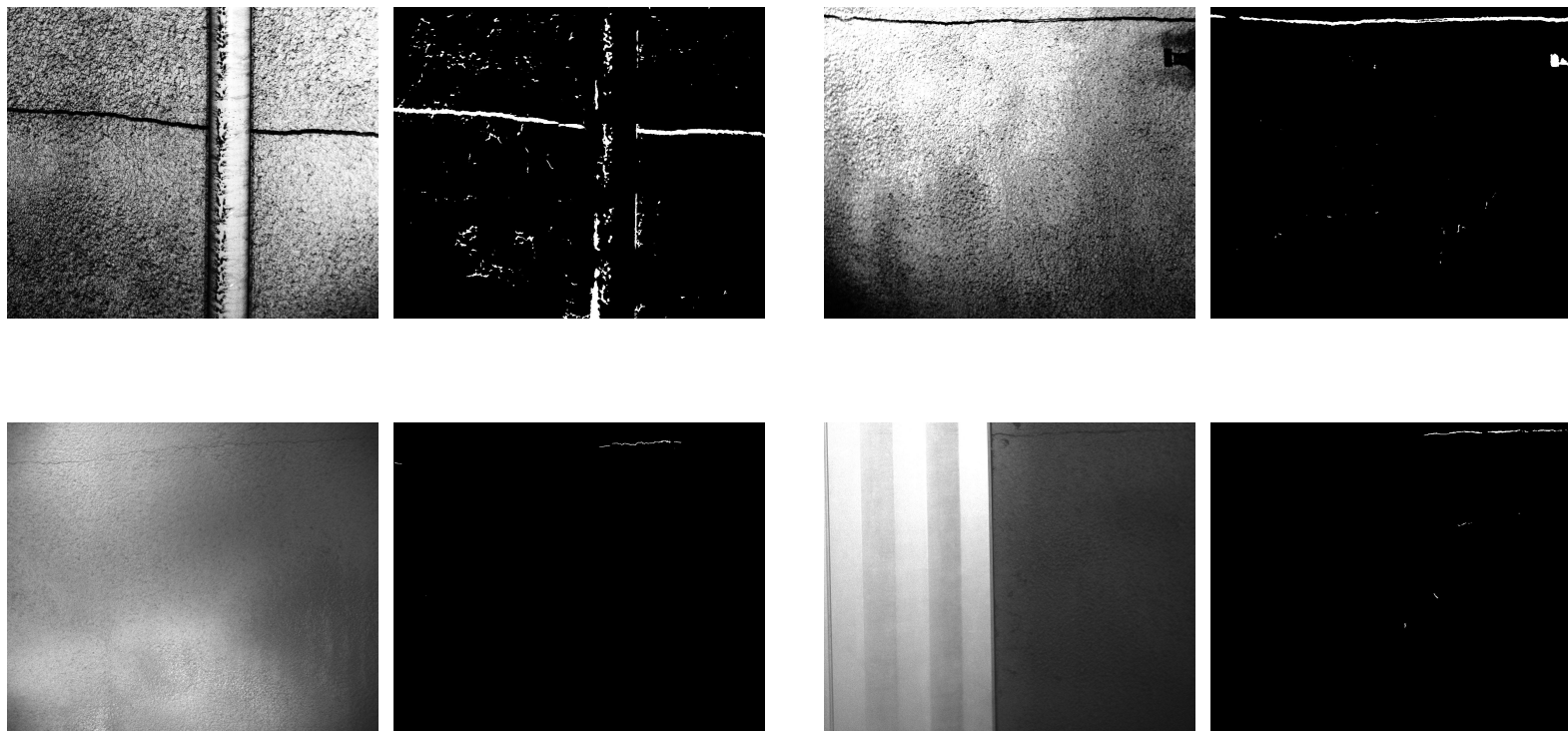
CNN performance on the test set



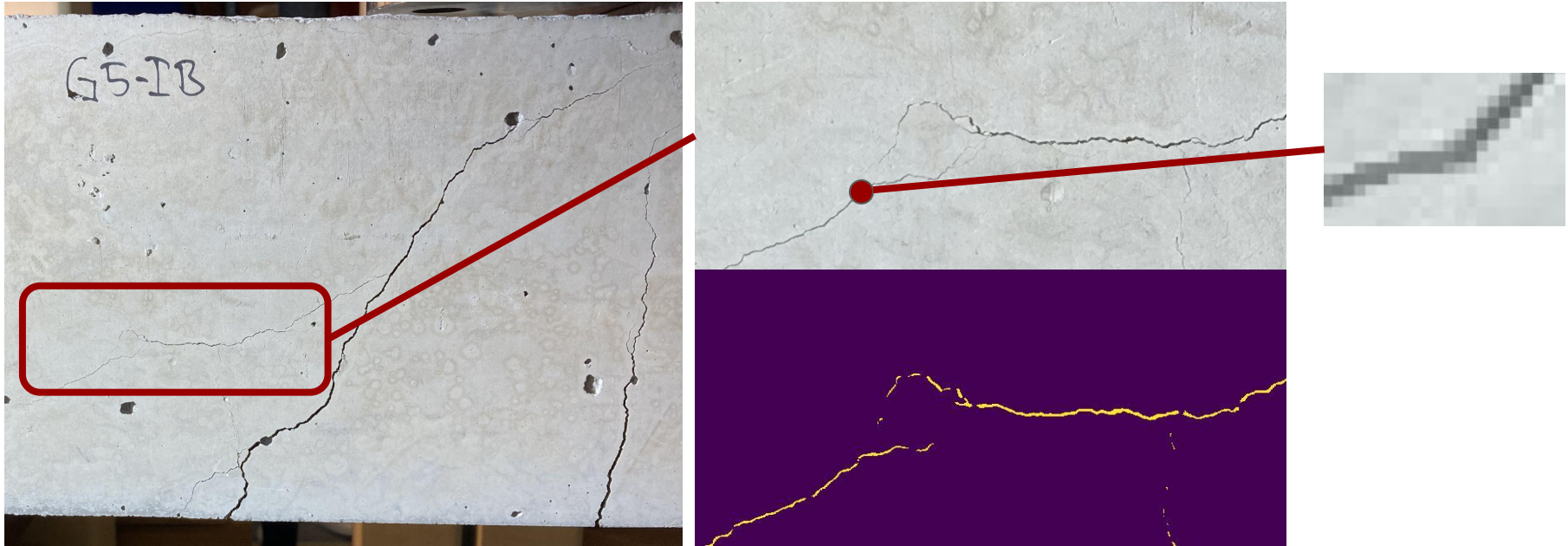
CNN transferability on the City Tunnel dataset



CNN transferability on the Northern Link dataset



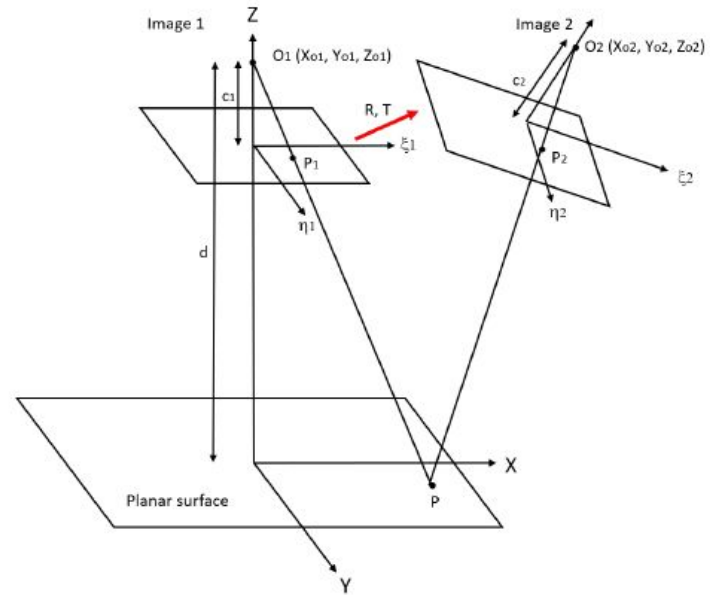
Level of crack detection using CNN



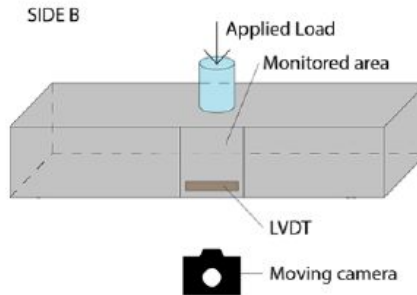
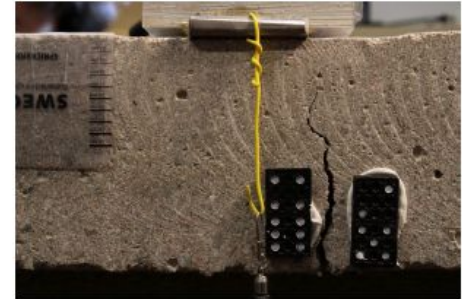
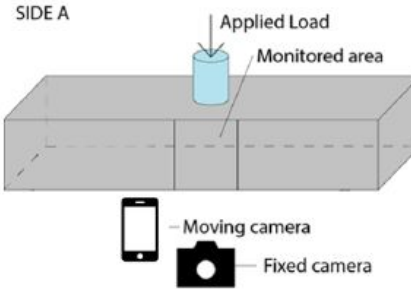
- Crack width of 2-3 pixels
- Pixel dimension of 0.096 mm (Iphone SE at a distance of about 35 cm from the beam)

Photogrammetry - Deformation from Motion

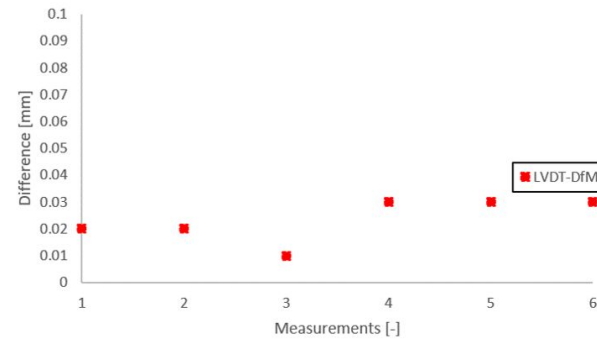
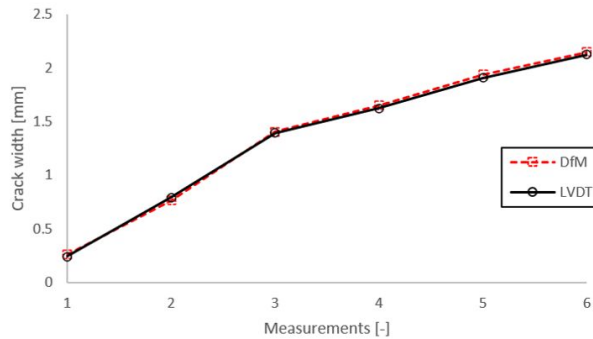
- How to measure the damage using images acquired from **different positions**?



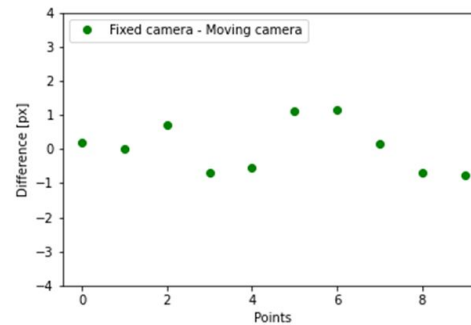
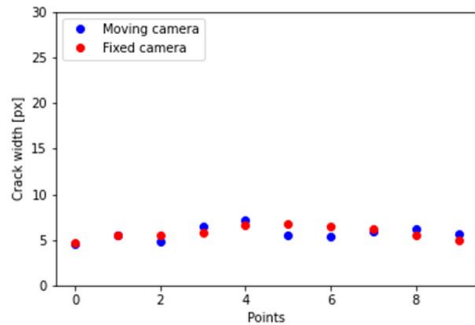
Laboratory test



Results assessment



Test 2 (same step of deformation, different camera poses)



Pixel dimension of
0.096 mm (Iphone SE
at a distance of about
35 cm from the beam)

Risk Associated with Cracks

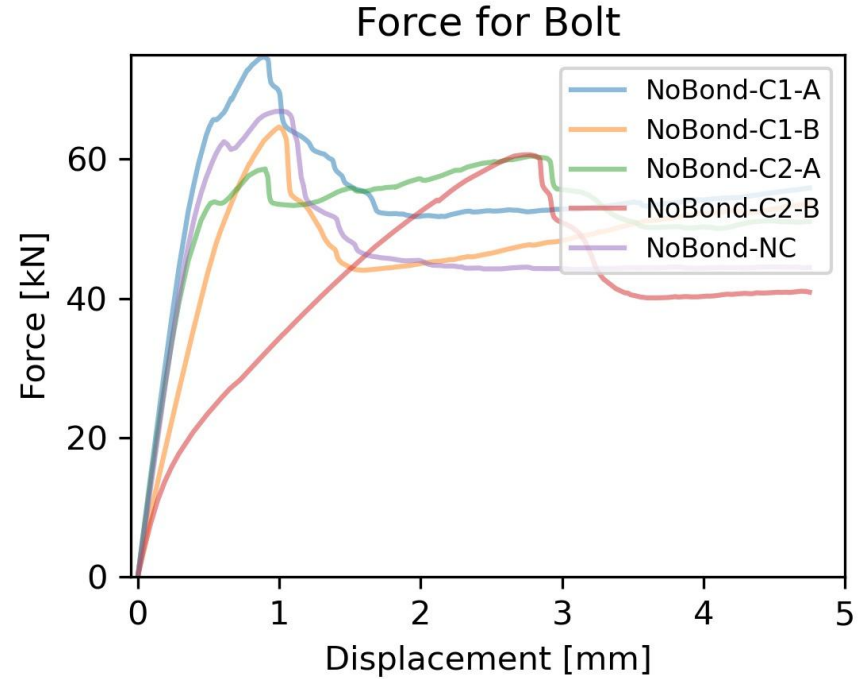
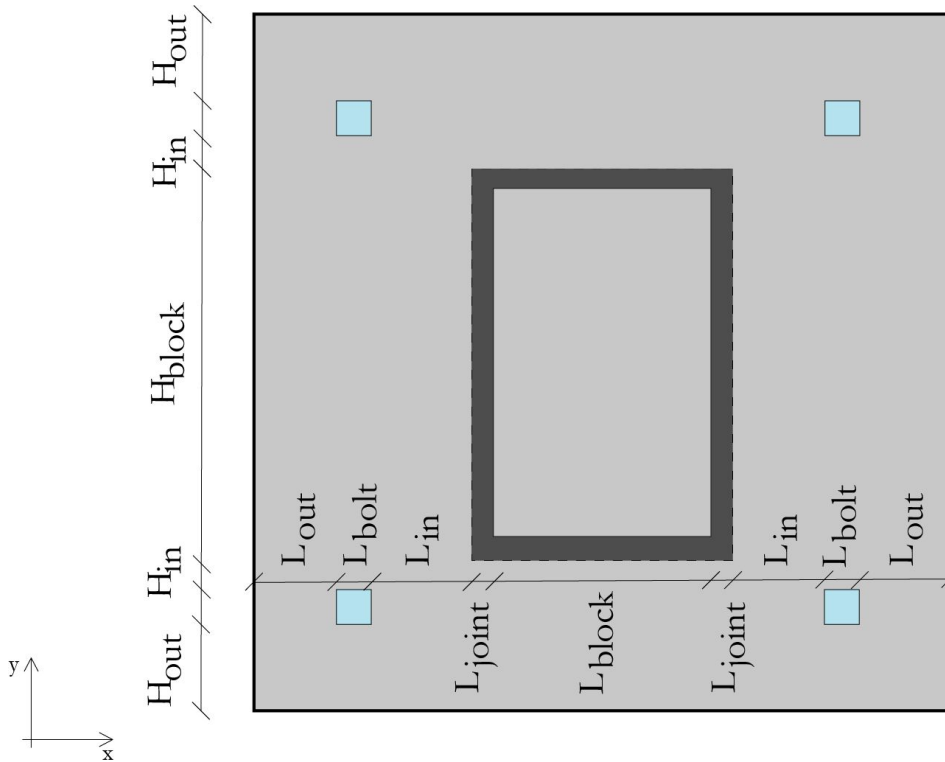
Table 1. Summary of important descriptions for the assessment of damage levels for cracks in shotcrete and concrete in interaction with rock. From guidelines by the Swedish Road Administration⁵⁸.

Level	Description
1	Web-pattern of cracks with diameter less than 50 cm.
2	Crack with a length smaller than the block size.
3	Cracks larger than the block size or web-pattern cracks with a diameter larger than 50 cm.
4	Cracks larger longer than 1 m and/or follows the join patterns in the rock mass.
5	Cracks with a width and length larger than 1 mm and 1 m, respectively.

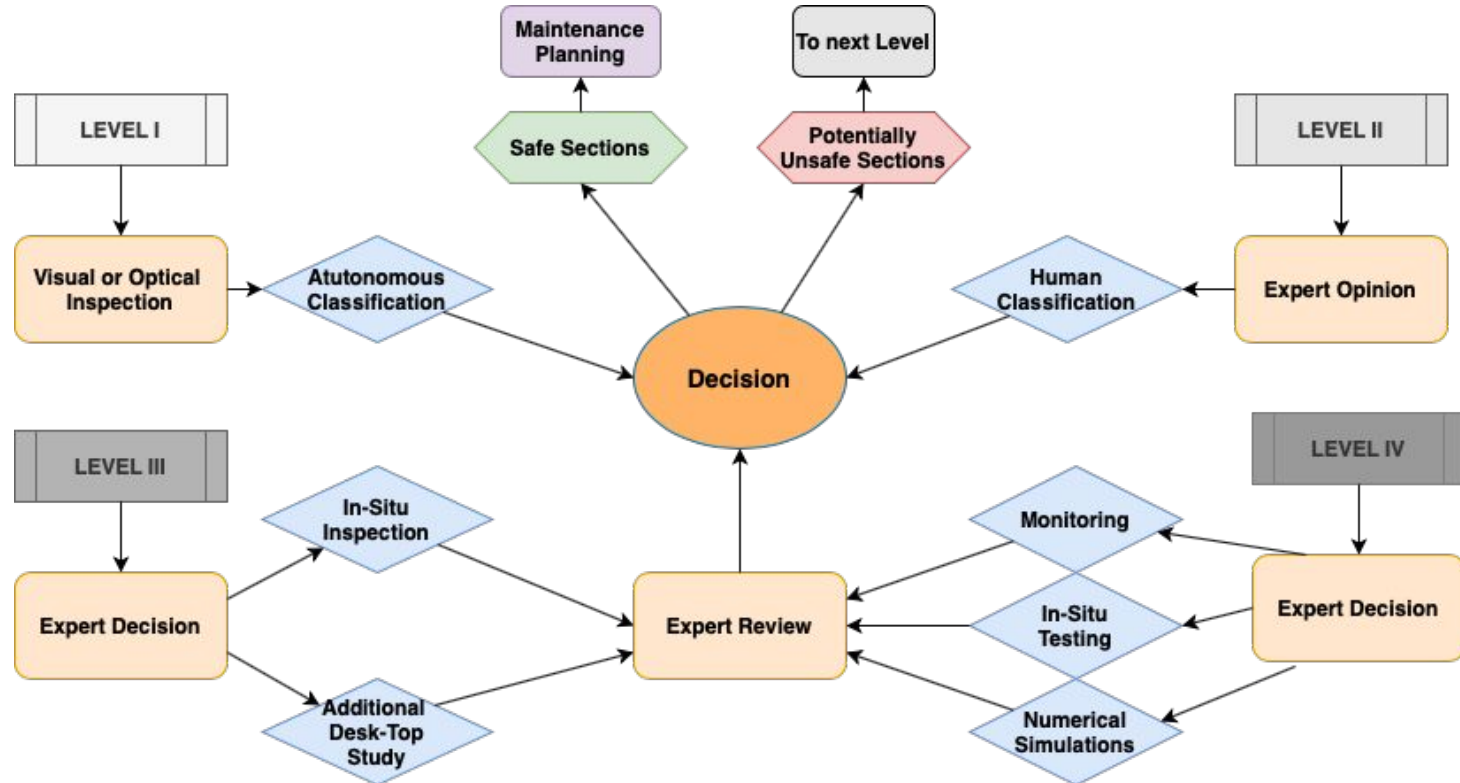
Table 2. Summary of Civil Engineering ratings based on the IQOA-system from the French guidelines⁴⁸

Class	Description of deterioration in area
1	In good visual condition
2	Minor deterioration which do not effect the stability of the structure.
2E	Same as class 2 but larger possibility of continuous degradation and/or increase in extent.
3	Deterioration indicates that the structure has been altered or that the stability might be affected.
3U	Indicates of deep/severe damage that effects the overall stability.
S	The indivcator "S" can be included to any of the classes and indicates possible danger to user.

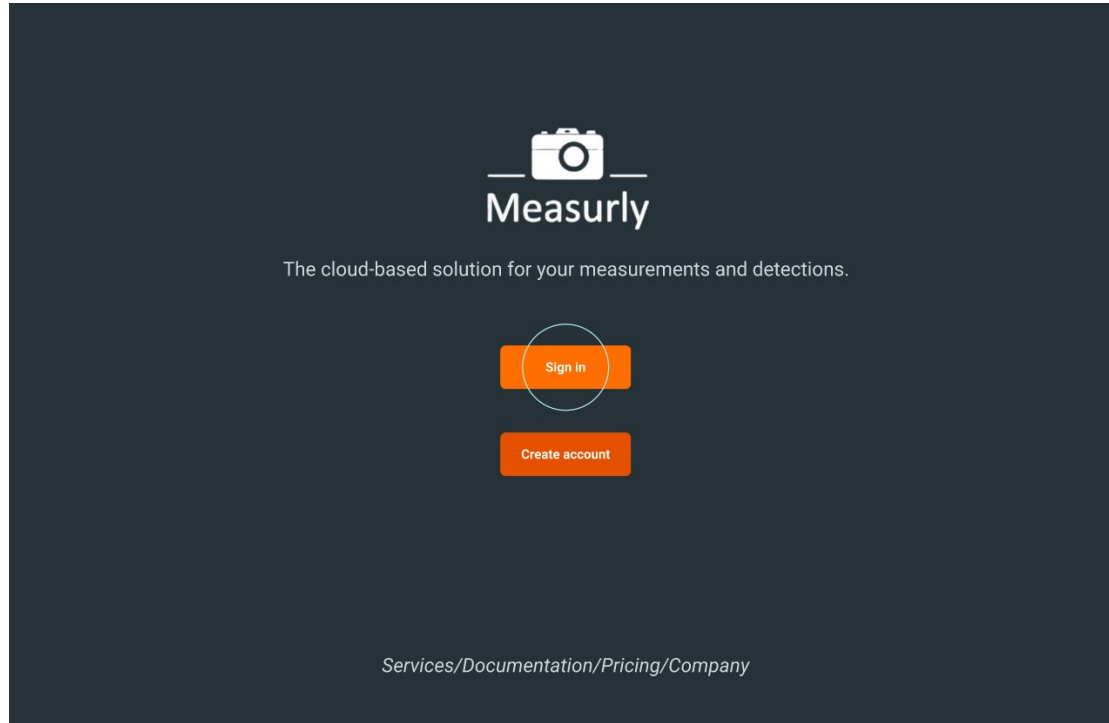
Risk Associated with Cracks



Risk Assessment



Technology transfer



Collaboration with

- KTH Innovation
- Nevermind Media

for the development of **Measurly**, a **prototype** for **cloud-based** damage measurements and detections

Discussion



Discussion

Status of Technology

- We have shown that it is possible to use deep-learning and photogrammetry to automatically detect and measure cracks.

Next Step towards Implementation

- Proof of concept: Use more field data, compare results from autonomous inspections to in-situ inspections.



Discussion

Status of Technology

- We have shown that it is possible to use deep-learning and photogrammetry to automatically detect and measure cracks.

Next Step toward Implementation

- Requirements: We have some preliminary results that can be used to specify equipment needed, i.e. the width of a crack in terms of pixels. This can be used to specify camera requirements.



Discussion

Status of Technology

- We have shown that it is possible to use deep-learning and photogrammetry to automatically detect and measure cracks.

Others Steps toward Implementation:

- Common standard for data
- Rules and regulations
- Rules for procurement

