

AI-assisted inspection of concrete surfaces at dams

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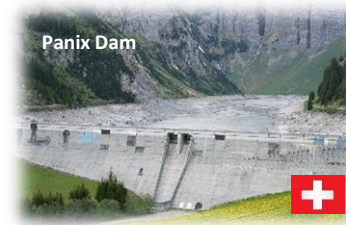
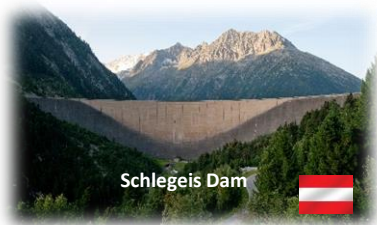


vgbe / Verbund Expert Event
Digitalization in Hydropower - Vienna 17./18. November 2022

Verbund

Motivation

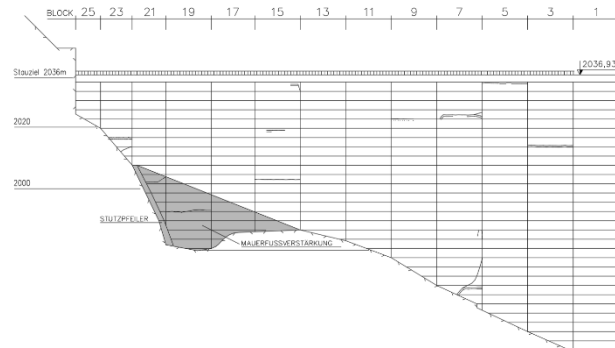
- Axpo and Verbund operate 48 large dams in Austria and Switzerland
 - First impounding: 1925 – 1986
 - Height of dams: 15 – 200 m
 - Reservoirs: 0.1 – 200 Mio. m³
- All dams are intensively monitored
 - ➔ Visual Inspection is part of an extensive monitoring



Review - Expert Event 2021

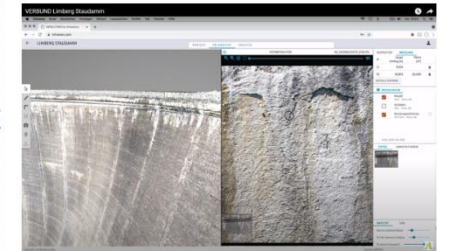
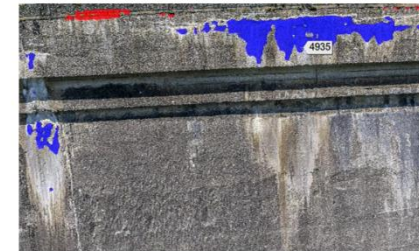


Documentation in Drawings



Upgrade to Surface Monitoring

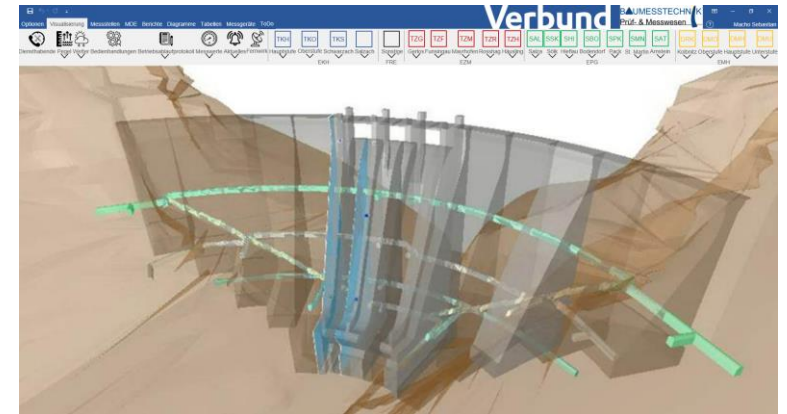
1. Automated aerial survey & Image recording with UAV
2. Photogrammetric 3D reconstruction
3. Automated image analysis using Artificial Intelligence (AI)
4. More detailed visualization, analysis & documentation



Review - Expert Event 2021

First technology and field tests have proven:

- Potential to revolutionize current inspection methods
- Detection potential of >90% ➔ Further AI-improvements necessary
- Multiple use of 3D dam model ➔ BIM applications
- Still manual work necessary ➔ Potential to reduce it

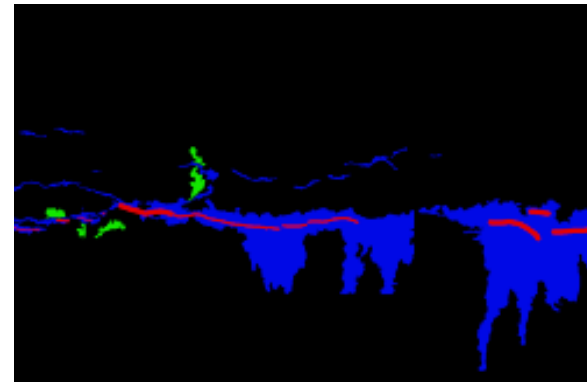


Progress since last year - What's new?

AI-Improvements

Further training of the detection-algorithm


- Selection of a high resolution image data set representing the characteristic concrete dam surfaces (129 images: 113 for training, 16 as test set)
- Additional classes: crack with efflorescence, joint
- Precise annotation of the abnormalities (pixel precise)



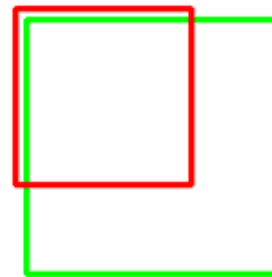
AI-Improvements

Evaluation criteria:

Intersection over Union (IoU) in combination with „ground truth damage“

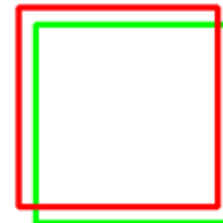
$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$


IoU: 0.4034



Poor

IoU: 0.7330



Good

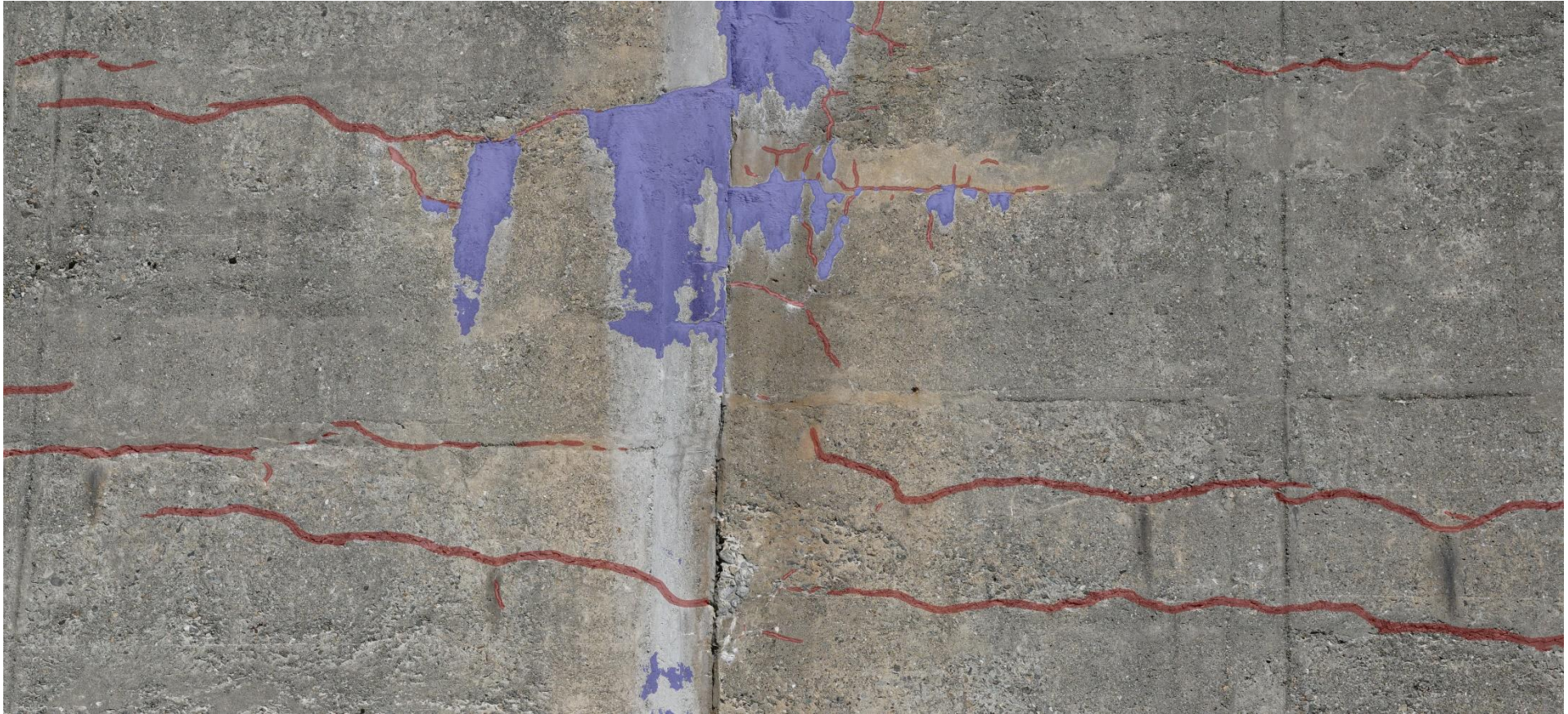
IoU: 0.9264



Excellent

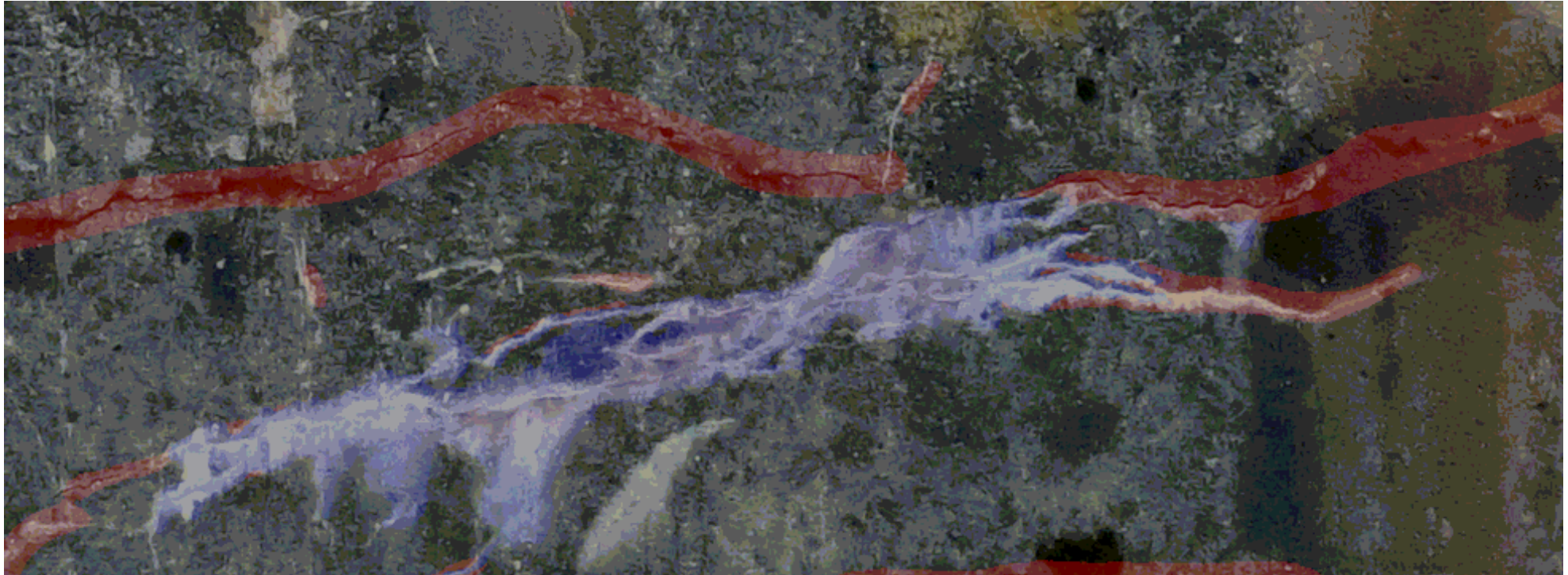
AI-Improvements

Results of the improved AI



AI-Improvements

Results of the improved AI



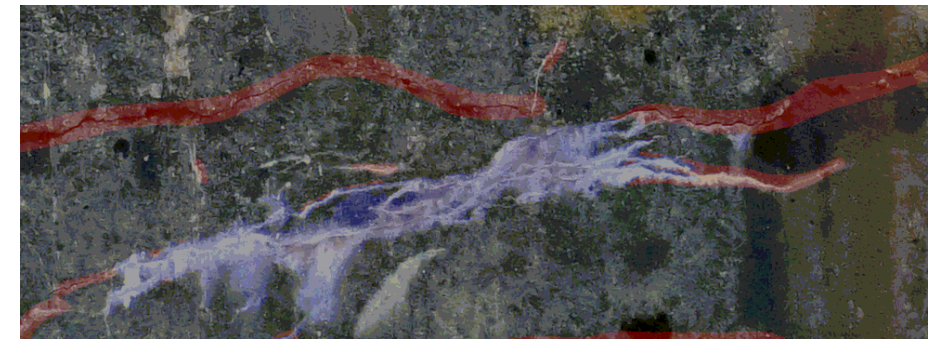
AI-Improvements

Results of the improved AI

Class	IoU	True Positive	False Positive	False Negative	Recall
Crack	0.42	254	75	21	0.92
Efflorescence	0.66	48	5	7	0.87
Spalling	0.42	2	0	1	0.67
Total	0.50	304	80	29	0.91

Main sources of error / challenges:

- Insufficient resolution of images
- Sharpness, brightness of images



Evaluation of alternative imaging sensors

Sony Alpha 7R II



DJI Zenmuse P1



PhaseOne iXM-100



Sensor size [mm]

36 x 24

Megapixel

42,4

Image resolution [pixel]

7952 x 5304

Special features

-

35,9 x 24

45

8192 x 5460

-

44 x 33

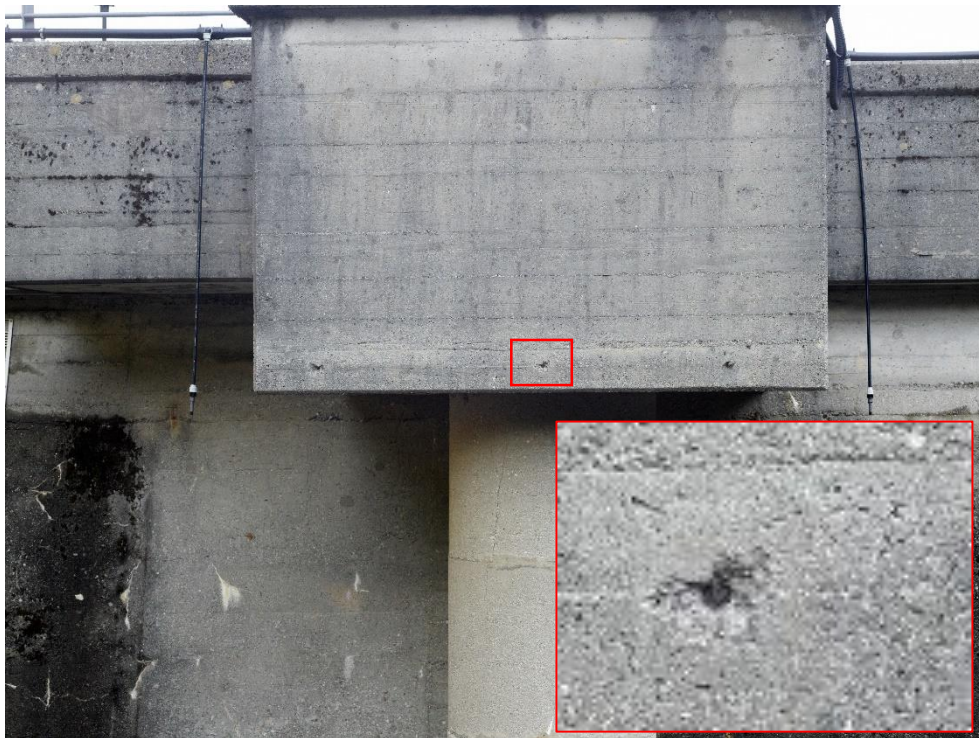
100

11664 x 8750

Laser range finder

Evaluation of alternative imaging sensors

PhaseOne iXM-100

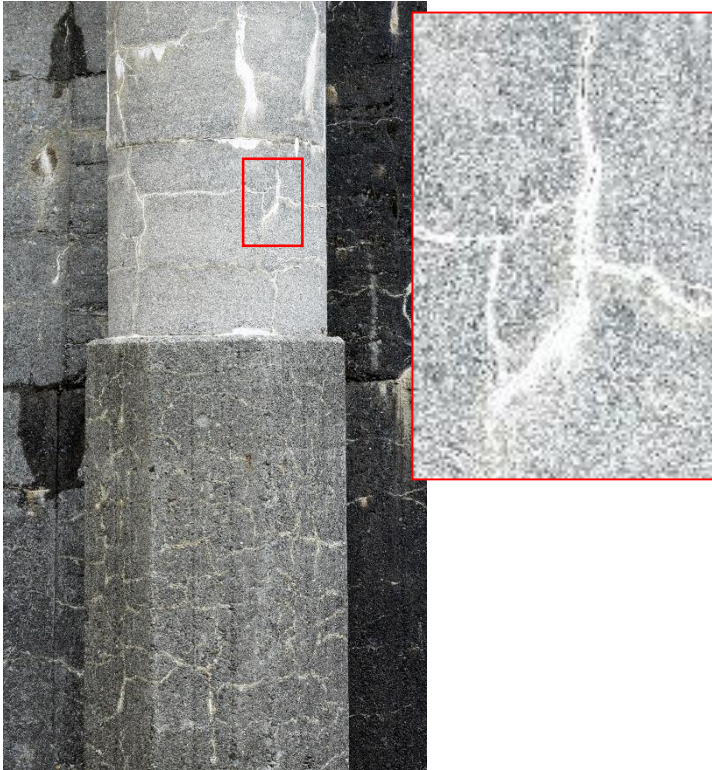


Sony Alpha 7R II

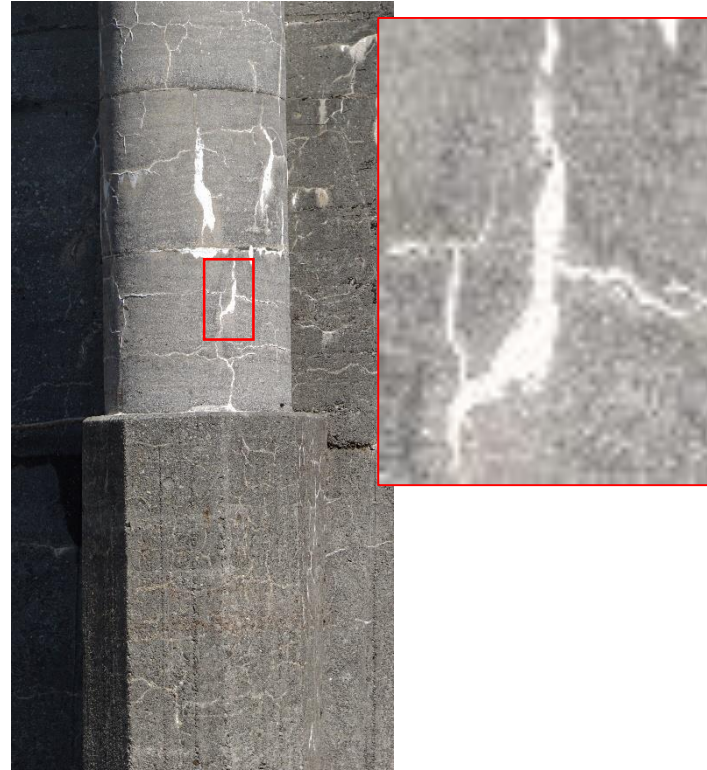


Evaluation of alternative imaging sensors

PhaseOne iXM-100



Sony Alpha 7R II



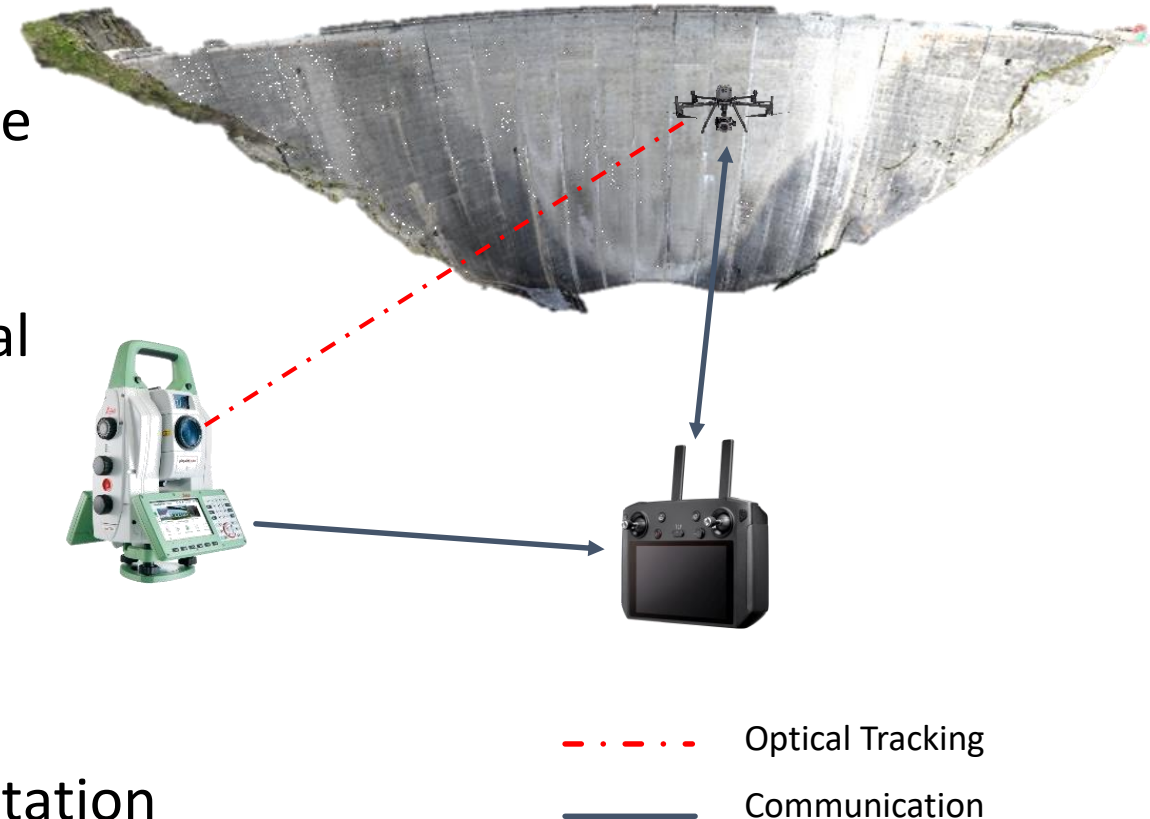
Alternative UAV-Positioning

First field tests have shown:

- Autonomous flights close to the dam (<20 m) are challenging ➡ reduced visibility of satellites
- Often a combination of autonomous and manual flights ➡ repeatability not ensured
➡ **Alternative approaches are required**

Potential solution:

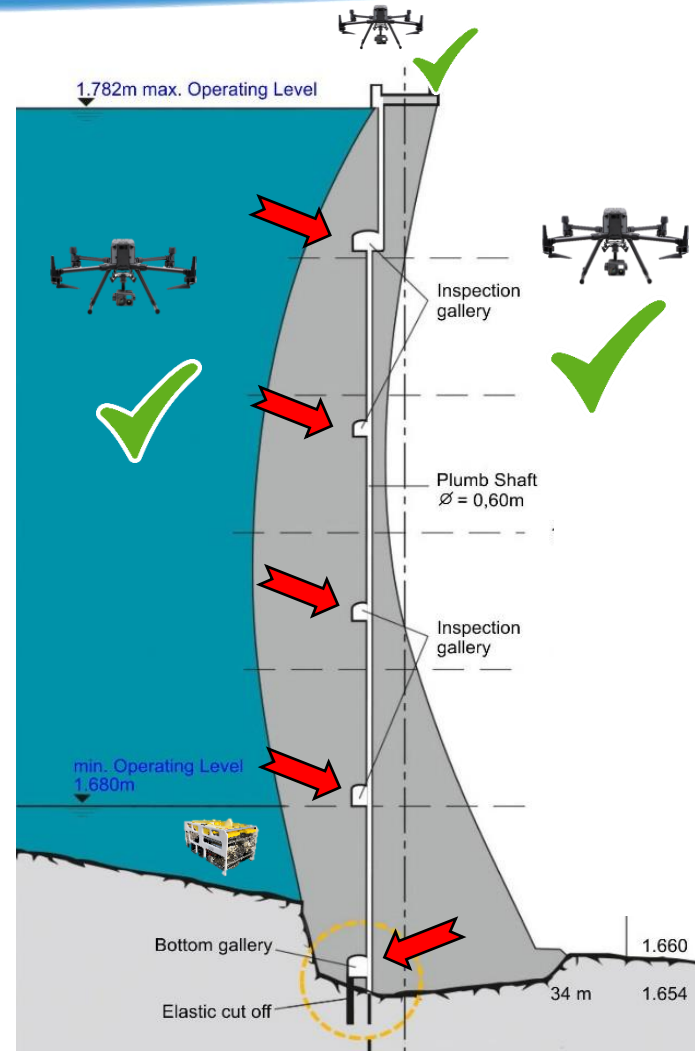
- Tracking and guidance of the UAV with a total station



Extension of dam surface inspection

- Air side ✓
- Crown ✓
- Water side ✓

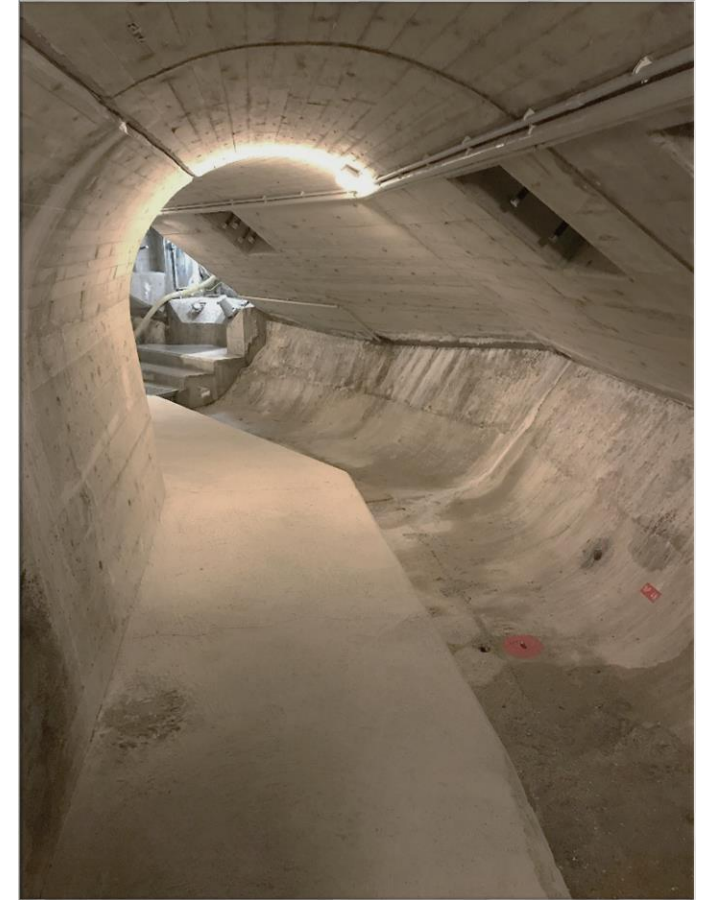
- What about the inside?



Galleries

Surface documentation and inspection – goals:

- Identification of suited sensor / technology
- Identification of suited platform
- Automated data acquisition
- Automated detection of anomalies
- 3D-visualization and documentation



Galleries

Investigated technologies

Terrestrial Laser Scanning

- LiDAR
- IMU
- Range: 0.5 – 130m
- Range accuracy: 1mm + 10ppm



Leica RTC360

- + 3D
- + Accuracy
- + Active System
- Price
- Static measurements

Mobile Laser Scanning

- LiDAR and visual SLAM
- IMU
- RGB Cameras
- Range: 0.5 -25 m



Leica BLK2Go

- + 3D
- + Registered Scan & Trajectory
- + Active System
- Price
- Irregular point cloud

Time of Flight Cameras

- Intensity Images
- Accuracy: 0.3 – 6.0m: ± 10 mm
- Precision: <2mm at 1 m



Lucid Helios

- + 3D
- + Price
- + Active System
- Field of view (59° x 45°)
- No battery

DSLR Cameras

- RGB Video
- RGB Photos



Lumix DMC-FZ2000

- + Resolution
- + Price
- Passive System
- 2D
- Field of view

Galleries

Investigated Platforms

Wheel based vehicles



- + heavy payload
- only for horizontal areas

Drones



- + vertical shafts accessible
- limited payload

Legged Robots



- + Payload
- vertical shafts not accessible

Galleries

First results

Mobile scanning



- + quick
- resolution not sufficient

DSLR



- + high resolution
- no scale and geo location

TOF Camera



- low resolution
- no geo location

Outlook – next steps

- **Visualization of the detected anomalies in 3D model**
- **Implementation of the anomalies and 3D model in web platform**
- **Further investigations on the best platform for indoor applications**
- **Adaption of the AI-algorithm for indoor applications**

Thank you for your attention!



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