



Augmented reality and intelligent systems in Industry 4.0

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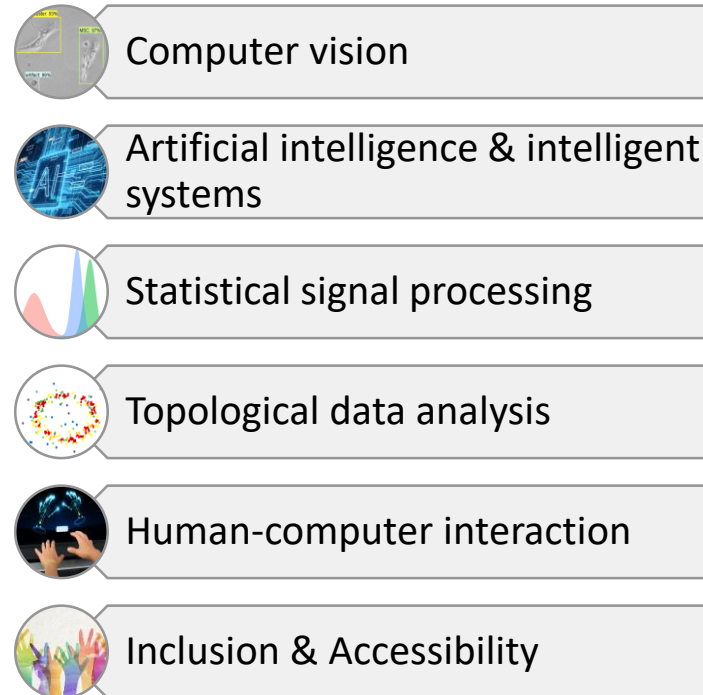
APRIL 28, 2021



The Team



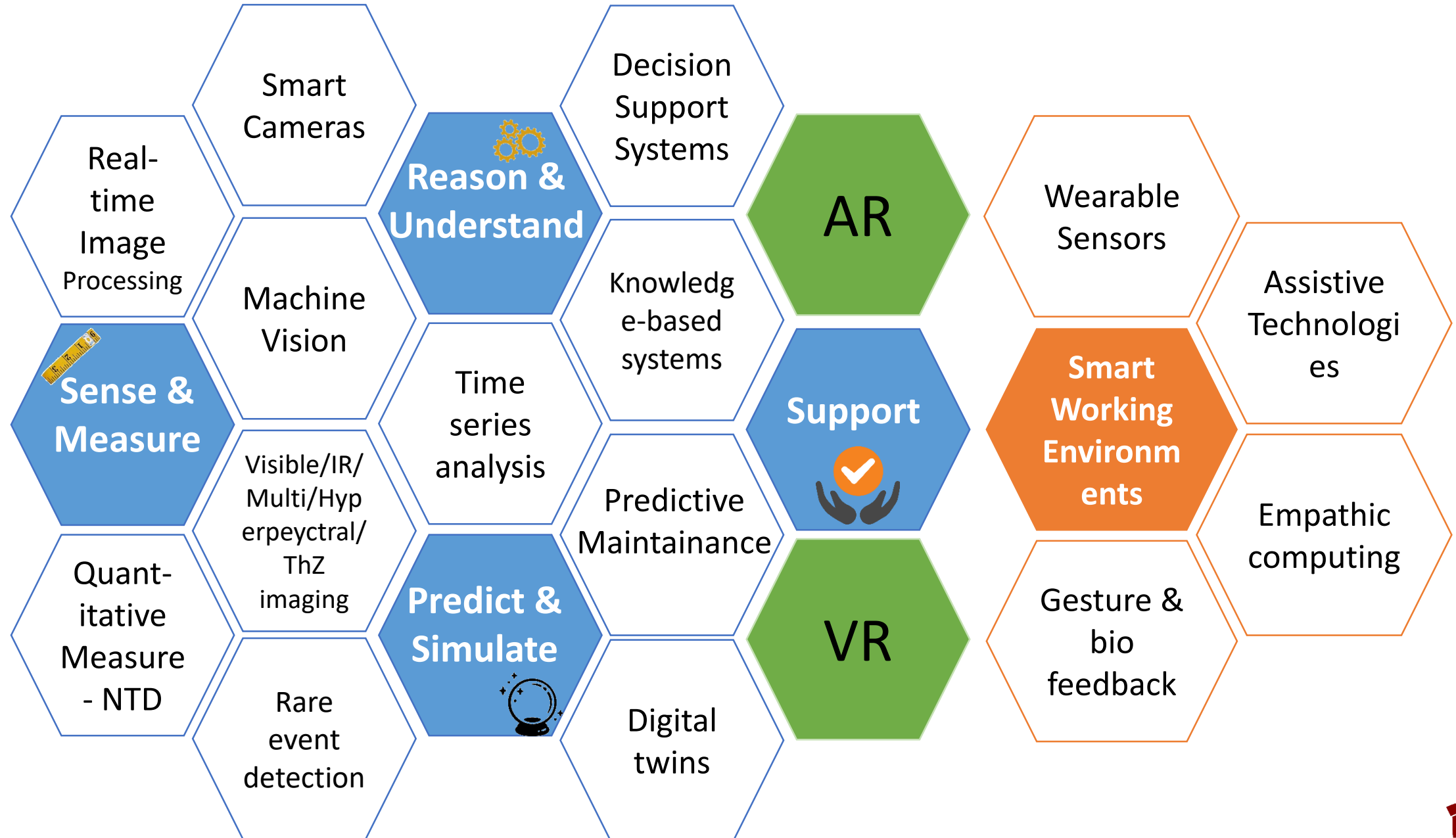
Competences



Application fields



Signals and Images Lab for Industry 4.0





Outline

XR Continuum

XR in Industry 4.0

XR in action:

- Monitoring and maintenance of production facilities
- AUV-based Inspections
 - Structural health monitoring
 - Powerline analysis



XR Continuum & AR in I4.0



Extended Reality Continuum

EXTENDED REALITY (XR)

REAL

VIRTUAL

REAL
ENVIRONMENT

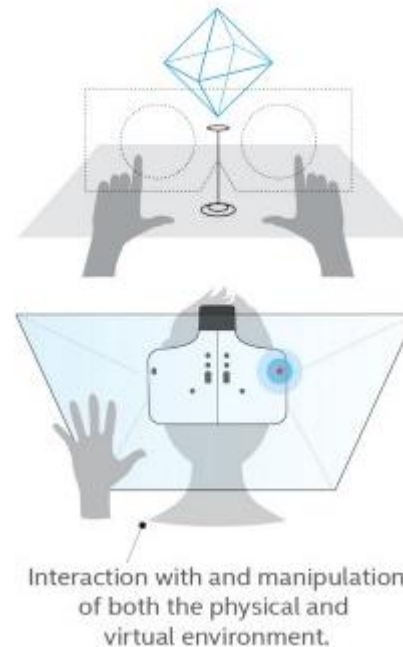
AUGMENTED
REALITY (AR)

Real world with digital
information overlay



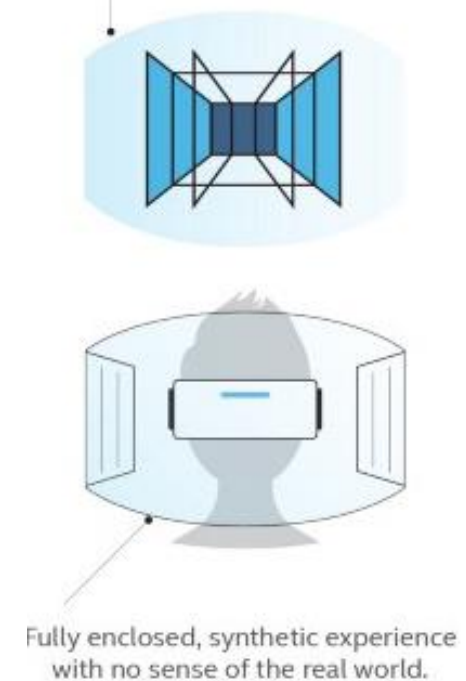
MIXED REALITY
(MR)

Real and the virtual are intertwined

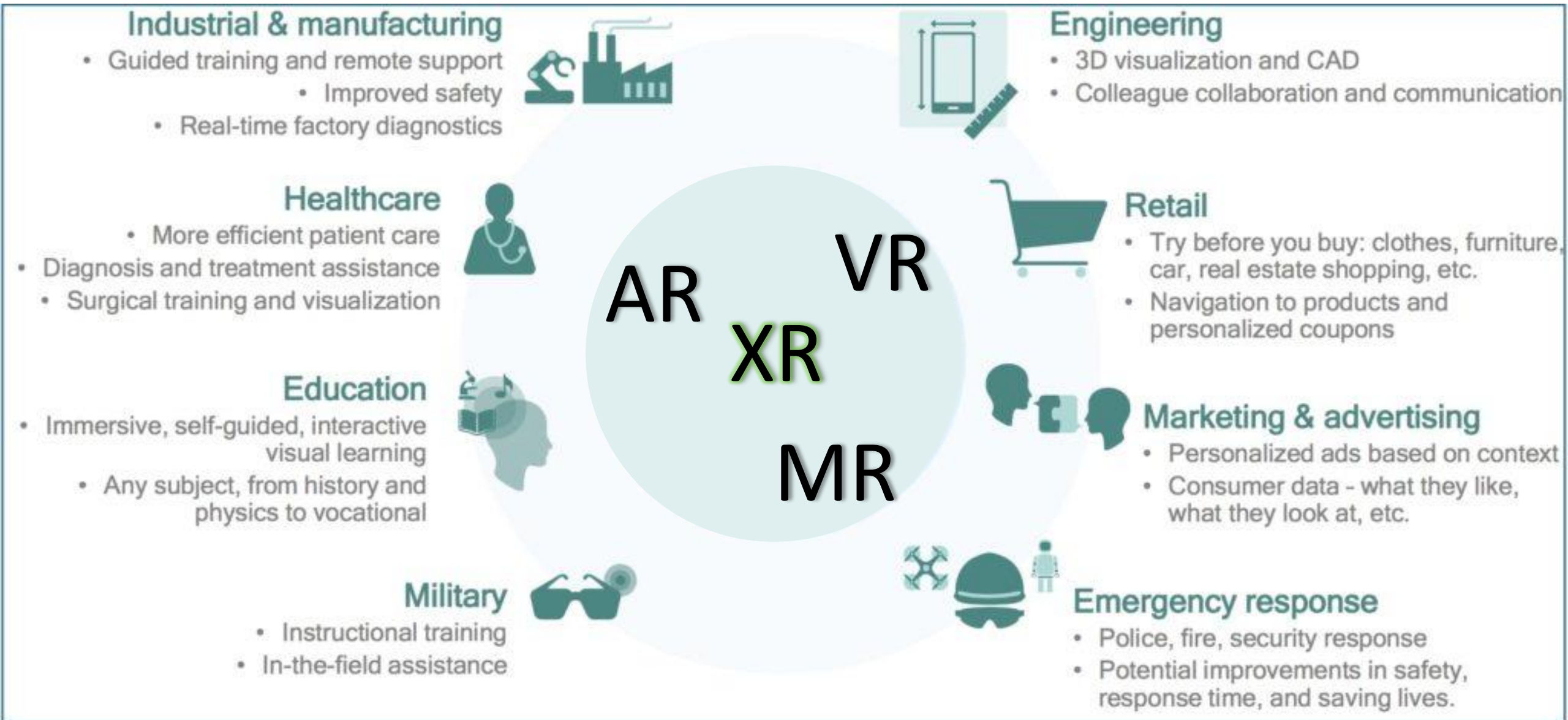


VIRTUAL REALITY
(VR)

Completely digital environment



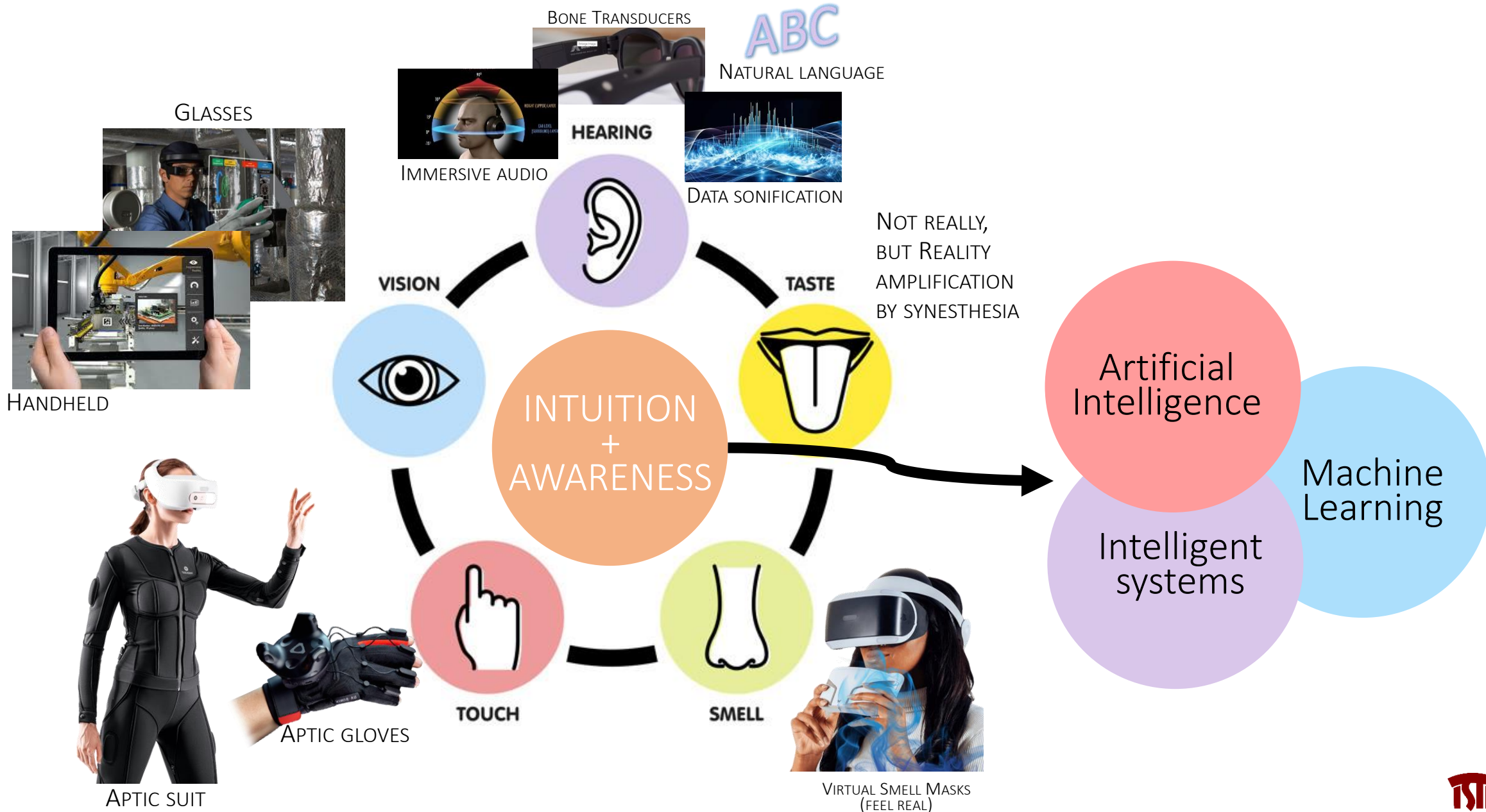
XR Application domains



Extended Reality across Industry 4.0

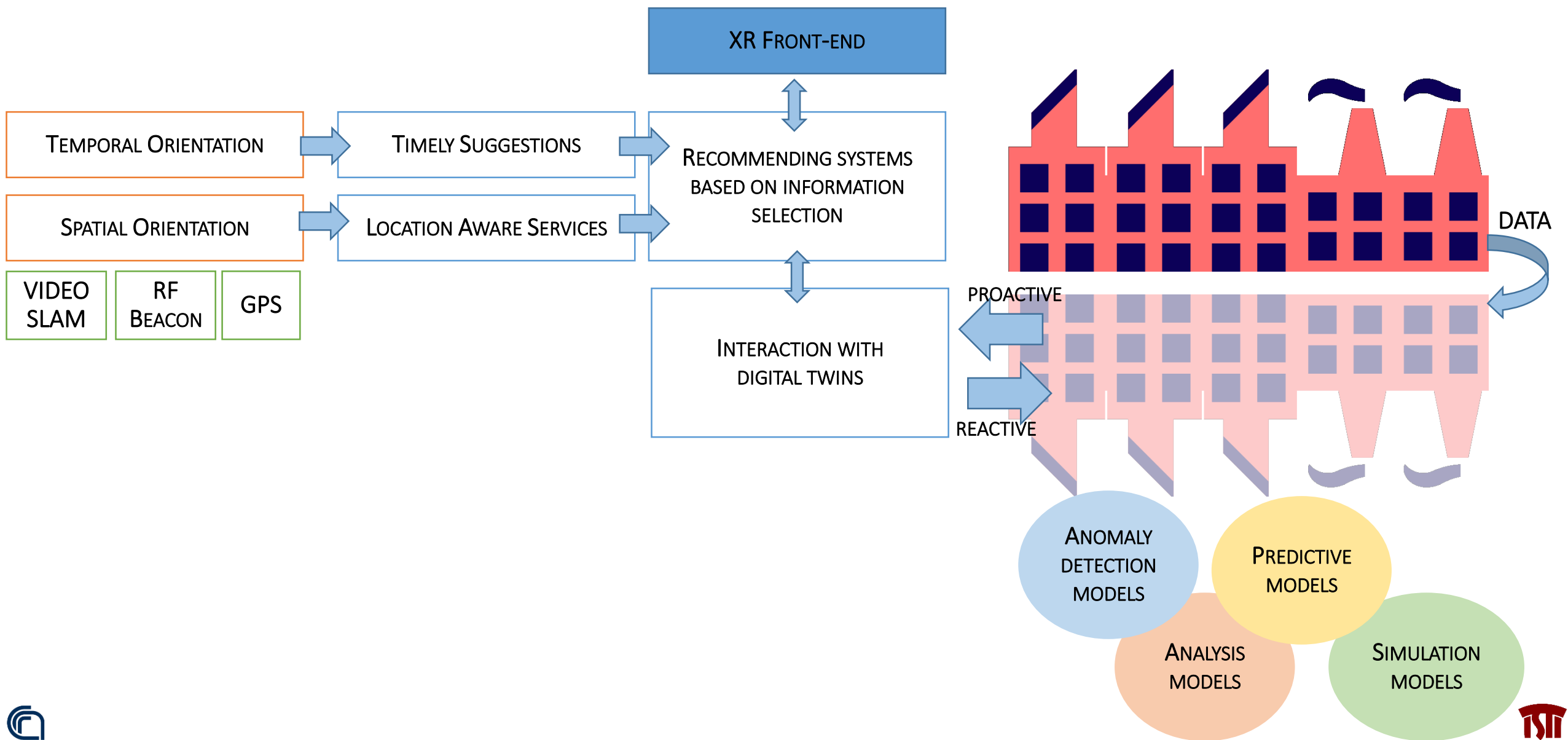
 SERVICE	 MANUFACTURING	 SALES & MARKETING	 DESIGN	 OPERATIONS	 TRAINING
• Manuals & Instruction • Service inspection & verifications • Remote expert guidance • Improved service & Self service	• Quality Assurance • Maintenance work instructions • Performance dashboards • Assembly work Instructions	• Displays & Demos • Logistics • Retails space optimization • Augmented brand experience • Augmented advertising	• Collaborative CAE / CAD / CAM • Inspection of digital prototypes • Error diagnosis	• Head-up displays • Digital product control • Augmented operator manuals	• Job specific training • Safety & Security training • Expert coaching

XR: extending sensing and the 6th sense





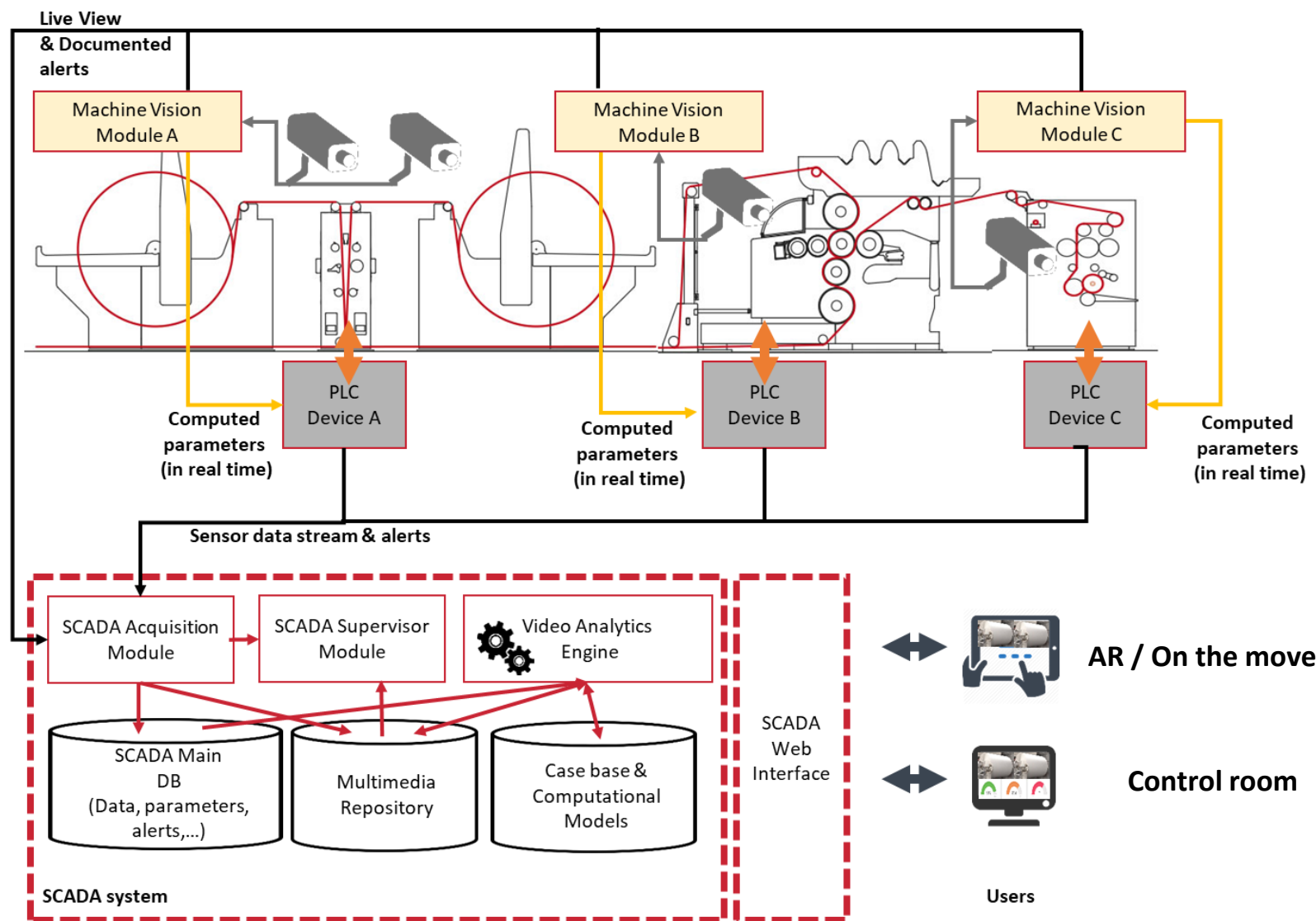
Extending sensing with intelligent services



The tissue converting scenario

- 10k+ components
 - Ordinary and extraordinary maintenance
 - High-level skills required
- AR technologies to support the operator and the remote assistance center.

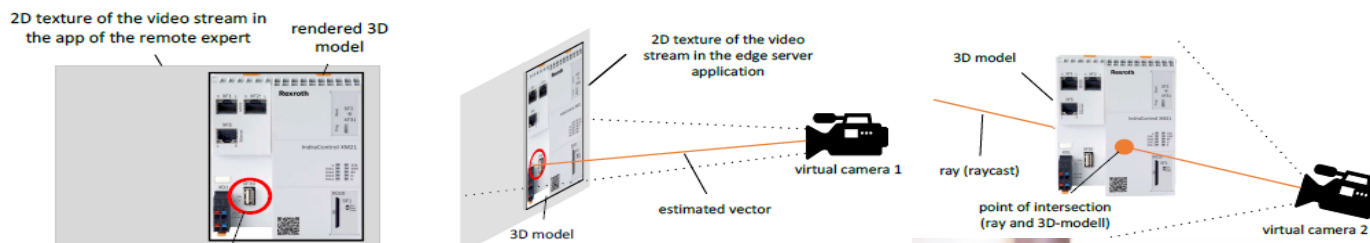
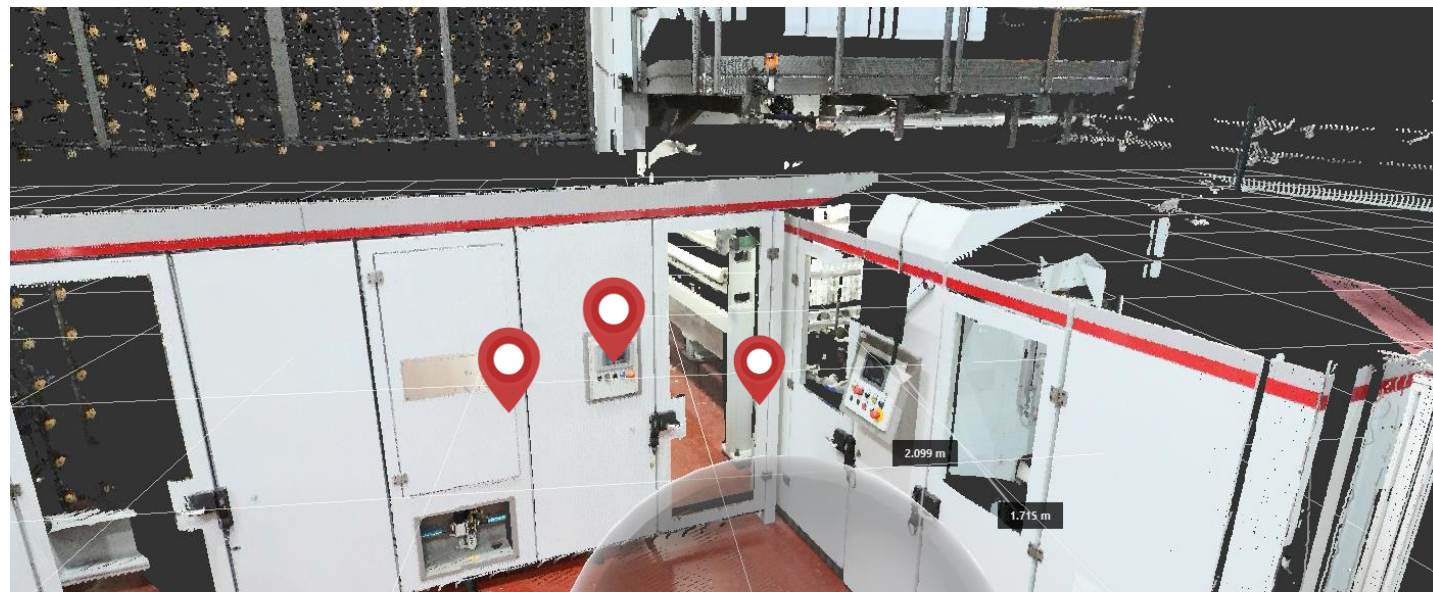




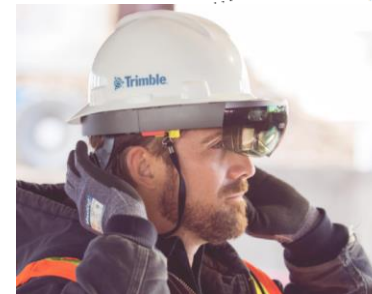
- Real-time local image processing for control
 - Adaptation at single machine level
- Real-time global video analytics for
 - Adaptation at line level
 - Failure prediction
 - Maximize uptime
- Long term monitoring and machine learning for **predictive maintenance**
- Live view and real time operational monitoring through AR

6 Adding Content to Reality in the Factory

- **Markerless** system based on **Natural Feature Tracking**
- Dust and dirt: Activating elements cannot be based only on appearance
- 2D/3D Mapping combined with location based services (RF)
- Interfaces based on smart glasses for factory environment
- Troubleshooting and **proactive functionalities**



Epson Moverio BT 2200



Hololens & Hard Hat

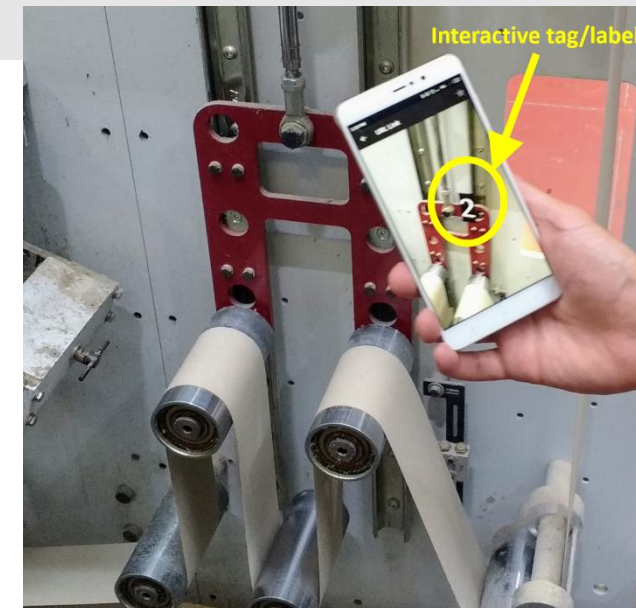
- Many devices useful for Augmented Reality activities:
 - Smartphones, tablets, smart glasses.
- Today, a typical configuration of a mid-range smartphone is suitable for AR applications.
 - Quad/octa-core CPU
 - 4GB+ RAM
 - Rear camera with 12+ Megapixel resolution.
 - Still some battery capacity limitations
- Tablets are not so widespread. Mid-range models and end models are expensive.
- See-through smart glasses: Microsoft HoloLens (1-2), Meta 2, Epson Moverio





Use Cases

- Three main macro-categories of intervention:
 - Monitoring line parameters and live view of the cameras.
 - Ordinary maintenance with documentation and video access.
 - Troubleshooting.
- Real-time access to the machine parameters;
- Monitoring performances;
- Data can only be obtained through the PLC.





Video available at: <https://tinyurl.com/68u2nn2v>

- Test have been carried out with a smartphone (Xiaomi Mi5s Plus) and a tablet (Samsung Galaxy Tab 5Se)
- Application performance depending on the number of images acquired – with a clear scene and in presence of an occluder.

Number of images	Point cloud dim. (kB)	Eff. (%)		Eff. w/ occl. (%)	
		S	T	S	T
20	339	50	20	70	30
30	825	55	25	75	30
40	1548	75	50	80	50
50	2207	85	60	85	60
60	2280	90	80	95	80
70	2795	100	90	100	90

- Application stability – after the scene recognition, the user moves along a predefined path through the scene. The stability refers to how many times the targets are not lost .

Number of images	Stability (%)	
	S	T
20	0	20
30	20	35
40	75	80
50	85	90
60	90	95
70	90	95

Lesson learnt and on-going activities

- A software prototype to perform scene recognition in an Augmented Reality system, to support the maintenance and control of a tissue converting factory line.
- A first prototype to perform laboratory tests.
- Then, an extended implementation in the real factory environment.
- The performance and robustness of the prototype has been analyzed.

On going:

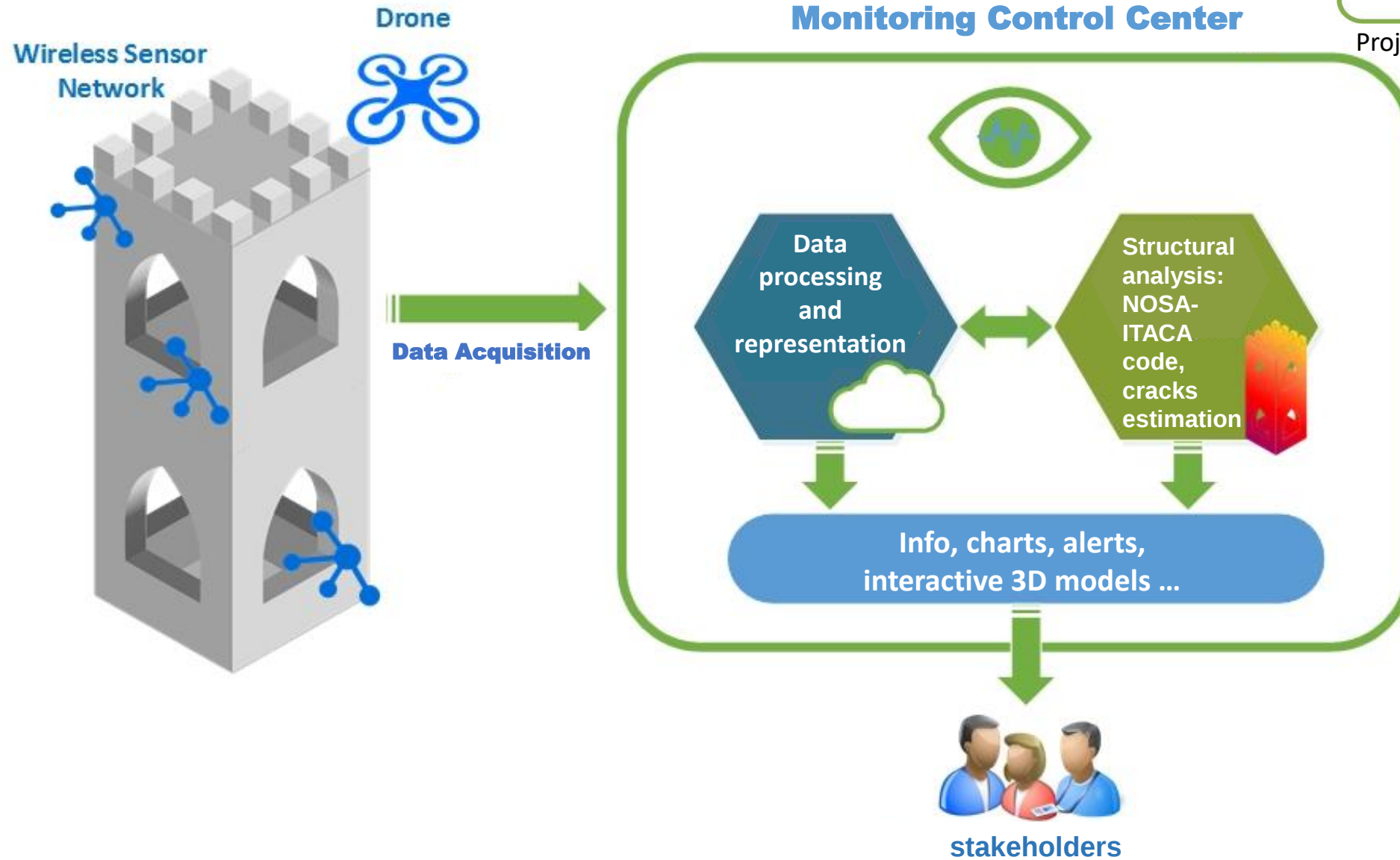
- Big Data analysis integration for predictive maintenance.
- Machine vision for live monitoring of the production process and predictive maintenance.
- Proactive system for troubleshooting.

AUV-Based Inspections

Structural Health Monitoring: MOSCARDO system



Project website <http://www.moscardo.it/>



Infomobility SRL
Partner & Capofila



CNR ISTI
Partner

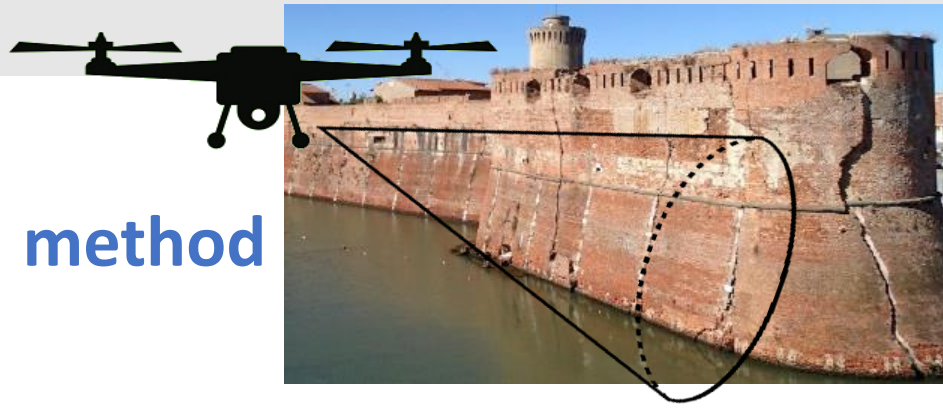


UniFI DICEA
Partner

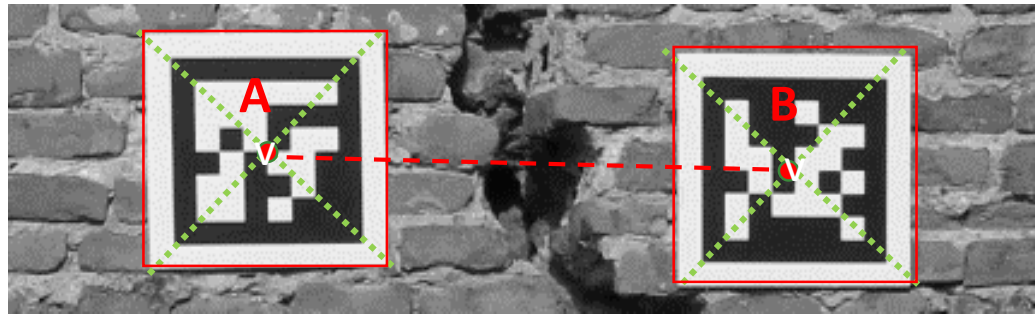


EIS Srl
Partner





ArUco
Marker



UAV + MARKER-BASED SLAM method

Evaluation of cracks features using:

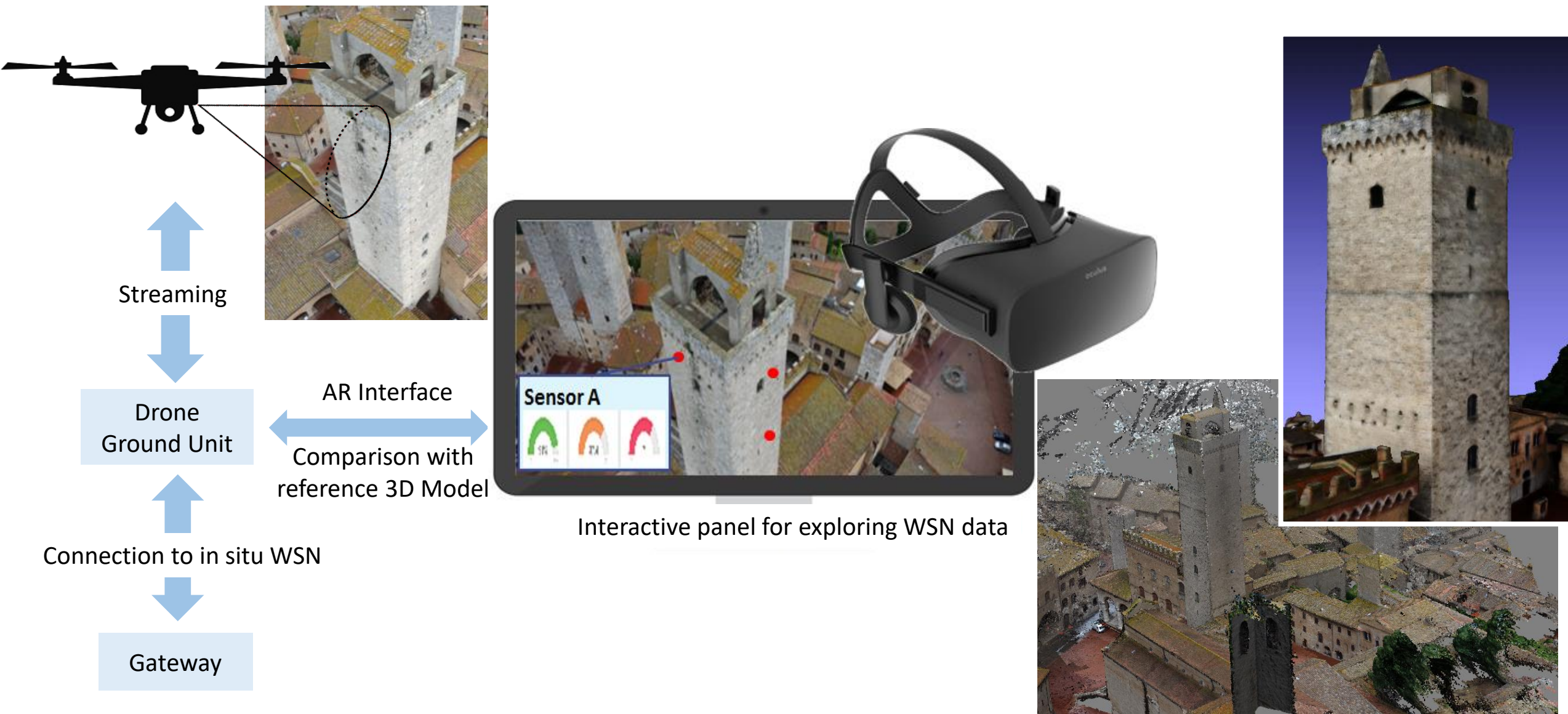
- Image processing
- Suitable ArUco marker configurations for achieving sub-millimetric accuracy

Images acquired by UAV allows for:

- Accessing cracks also in difficult areas
- Capturing cracks from optimal locations
- Fast data acquisition of the whole structure, to get a 3D model

Bacco, M., Barsocchi, P., Cassarà, P., Germanese, D., Gotta, A., Leone, G. R., Pascali M.A., Moroni, D. & Tampucci, M. (2020). Monitoring Ancient Buildings: Real Deployment of an IoT System Enhanced by UAVs and Virtual Reality. IEEE Access, 8, 50131-50148 (<https://doi.org/10.1109/ACCESS.2020.2980359>).

VR: the inspection





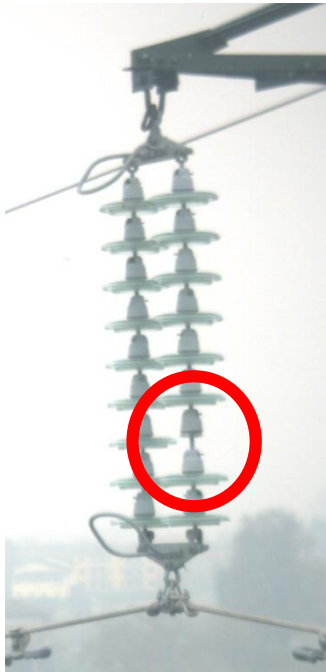
VR: 3D Front-end



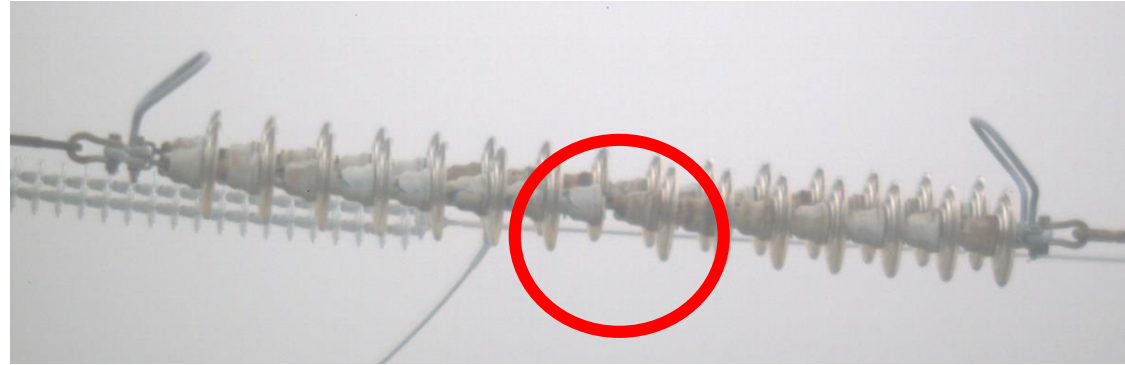
LIVE VR DEMO: <http://moscardo.isti.cnr.it/>

Video available at: <https://youtu.be/WHATS9Voyt4>
(with English subtitles)

5 Inspection of aerial power lines



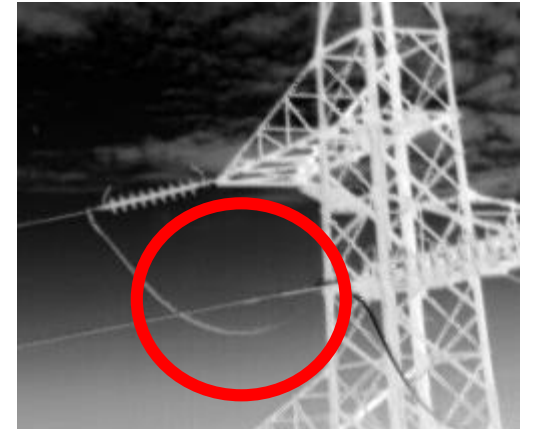
Missing insulator #1



Rust and missing insulator

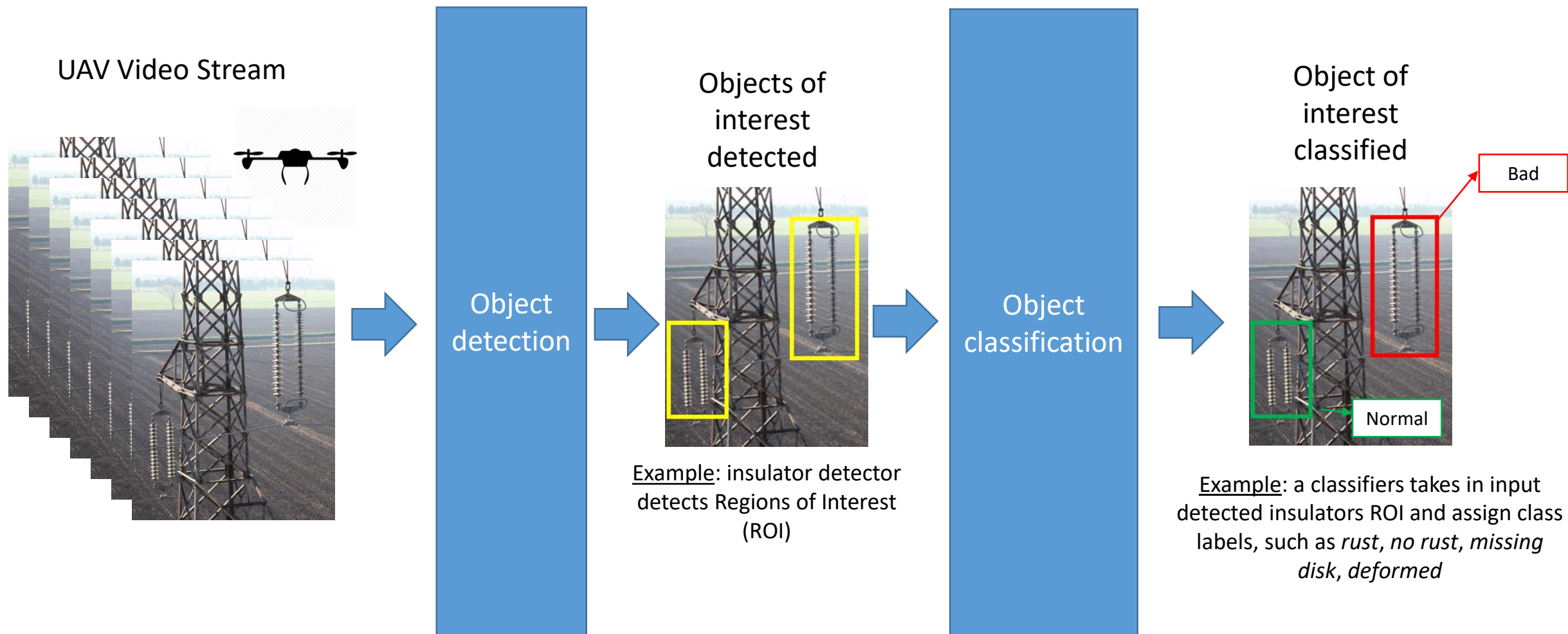


Strefolatura – Broken strands



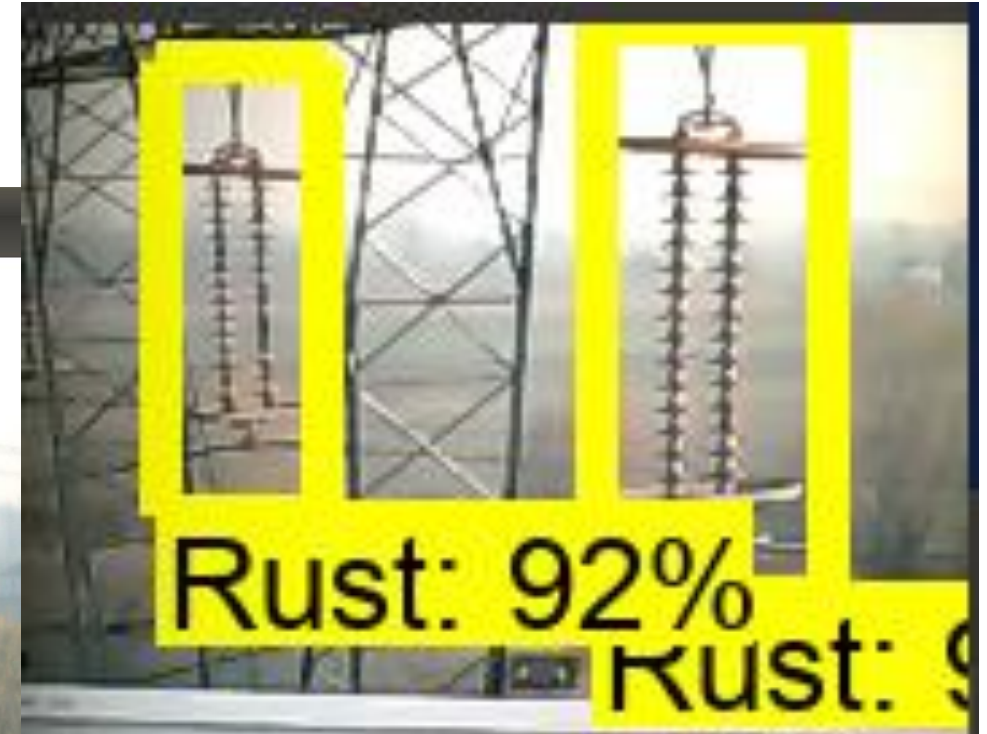
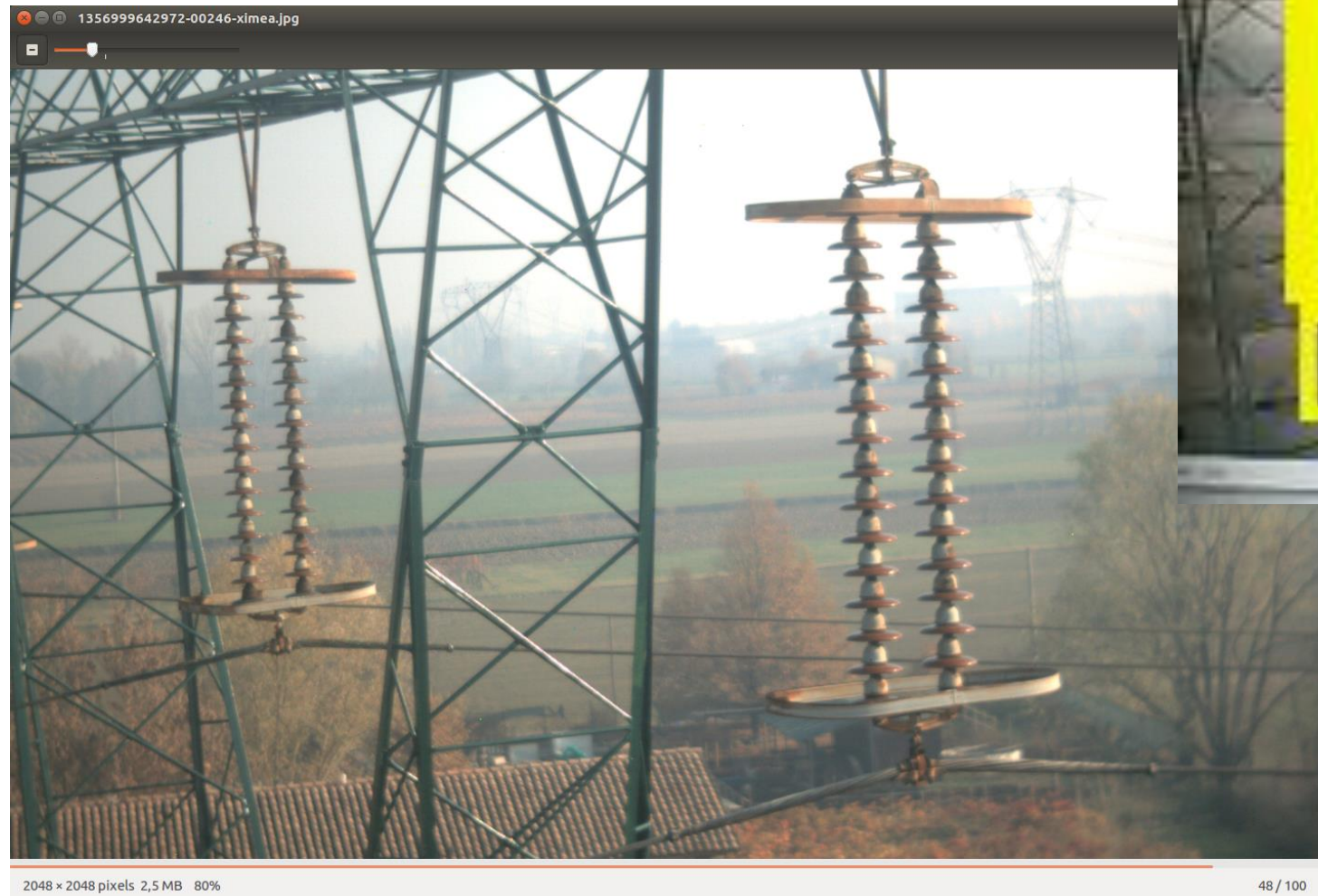
Infiascatura





- Used 2 **Convolutional Neural Network** (CNN - Deep Learning)
 1. Detection: State of the art R-CNN trained for insulator detection
 2. Classification
 - New CNN trained on only 2 classes (Rust / No Rust)
 - Train accuracy = 100.0%
 - Validation accuracy = 90% (N=110)
 - Final test accuracy = 97% (N=110)
- Encouraging results
 - Good performance, suitable for **on board processing**
- But:
 - Limited dataset
 - Need more data and examples from several sites to perform proper validation
 - Interest in incrementing the number of classes to detect also missing parts and other faults

Inspection of aerial power lines: Deep Learning



Visible Images:

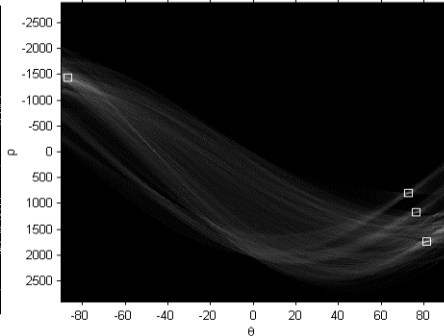
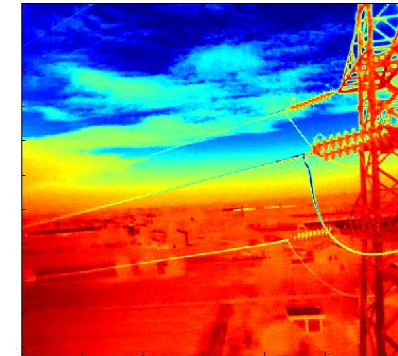
- Image Enhancement
- Edge detection (canny edge detection with threshold adjustment)
- Hough Transform
- Mask generation
 - Identification of clusters of peaks corresponding to nearly parallel lines

Infrared Image:

- Cables inspection and fault detection

On Larger perspective:

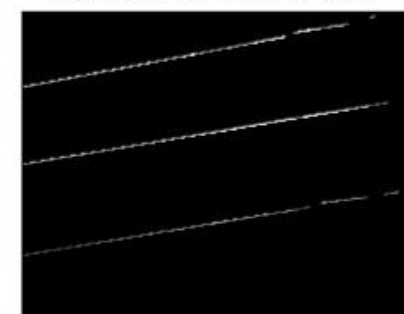
- Image registration both visible and Infrared images
- Fully automatic algorithm
- Fast algorithm



Hough transform detection in Images



Detected power lines in Images





Conclusions

- XR has a great potential in **Industry 4.0** that has not been fully unveiled
- **Artificial Intelligence** and Intelligent Systems represent a **sixth-sense** enabling even more applications
- Their combination has already been proven to be effective in disparate scenarios:
 - From production plants to aerial inspections
- Still, there exist a number of non-technological barriers that should be tore down:
 - **Regulation issues**
 - Data accessibility and **shareability**



THANK YOU

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<http://si.isti.cnr.it>





References

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