CENTRO ICT
per i Beni Culturali
Università di Salerno

Preserving the Past, Shaping the Future: AI and Technology in Cultural Heritage

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Centro ICT per i Beni Culturali

Università degli Studi di Salerno

https://centroictbc.unisa.it/

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Centro ICT per i Beni Culturali

- Since 2015, in order to better plan, manage and organise research activities and service to the Territory in the field of the use of Digital Technologies for Cultural Heritage, the ICT Centre for Cultural Heritage of the University of Salerno has been established.

- The primary aim of the Centre is to guarantee the University of Salerno an active presence in the introduction of digital and innovative technologies at the service of Cultural Heritage and the Creative Industry.

In this sense, the Centre proposes itself as a reference in the University and in the Territory for the promotion of the use of ICT technologies in the services supporting research activities for the preservation, valorization and sustainable use of Cultural Heritage through a conscious use of technological innovation and the adoption of new forms and modes of communication.

Centro ICT per i Beni Culturali

In order to realize its objectives, the Centre deals with:

- research and development of innovative technologies for the conservation, and enhancement of Cultural Heritage with a view to the socio-economic development of the territory;

- dissemination of innovation in the field of Cultural Heritage;

- scientific initiatives to be carried out within the University or with other universities and public and private research canters;

- national and international research projects and programs.

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Centro ICT per i Beni Culturali

The Centre is responsible for

- the design, realization, ordinary and evolutionary management of innovative solutions and related IT services for the Cultural Heritage with particular reference to territorial planning activities, the valorisation of the archaeological, monumental, museum and archival heritage;the design, implementation, ordinary and evolutionary management of teaching support structures and basic and advanced computer laboratories;

- the organization of courses on systems, networks, technologies and applications for Cultural Heritage;

- the study, experimentation and documentation activities on new computer and telematic systems and technologies and the organisation of seminars for dissemination in the areas of competence;

- the establishment of operational links with other national and international bodies.

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NETCOM GROUP

DATABENC
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per i Beni Culturali

DDT
Digitale Denkmaltechnologien

VIA·APPIA
·REGINA VIARVM·
Una candidatura italiana
per l'UNESCO

MANCHESTER
1824
The University of Manchester

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Bridging Heritage and Innovation:
The Power of Technology in Cultural Preservation and Enhancement

Introduction:

- In an era of rapid technological advancement, the fusion of cutting-edge technologies with cultural heritage has become crucial. By embracing tools like Artificial Intelligence (AI), augmented reality (AR), 3D scanning, and data analytics, we not only ensure the preservation of cultural assets but also unlock new ways to enhance and valorize them:

- Preserve historical treasures for future generations.

- Enhance accessibility to cultural assets, making them available to a global audience.

- Increase the cultural and economic value of heritage sites through innovative experiences.

- Transform the way we engage with our cultural past, offering immersive and interactive experiences.

Bridging Heritage and Innovation:
The Power of Technology in Cultural Preservation and Enhancement

Why It Matters:

- **Conservation**: AI and digital tools help in **restoring and preserving artifacts**, ensuring the longevity of our most valuable cultural assets.

- **Access and Education**: Technology removes physical barriers, allowing people from around the world to experience **museums, ancient sites**, and **cultural archives** remotely.

- **Valuation and Promotion**: Through virtual tours, AR experiences, and AI-driven storytelling, cultural heritage is **enhanced and promoted**, creating new opportunities for **cultural tourism** and increasing its global appeal.

- **Innovation in Storytelling**: New technologies create opportunities for **immersive storytelling**, providing deeper insights and engaging ways to explore history.

By uniting **heritage and innovation**, we not only safeguard the **stories of the past** but also **enhance their value** in the present, ensuring they continue to inspire and drive **economic and cultural growth** in the future.

Bridging Heritage and Innovation:
The Power of Technology in Cultural Preservation and Enhancement

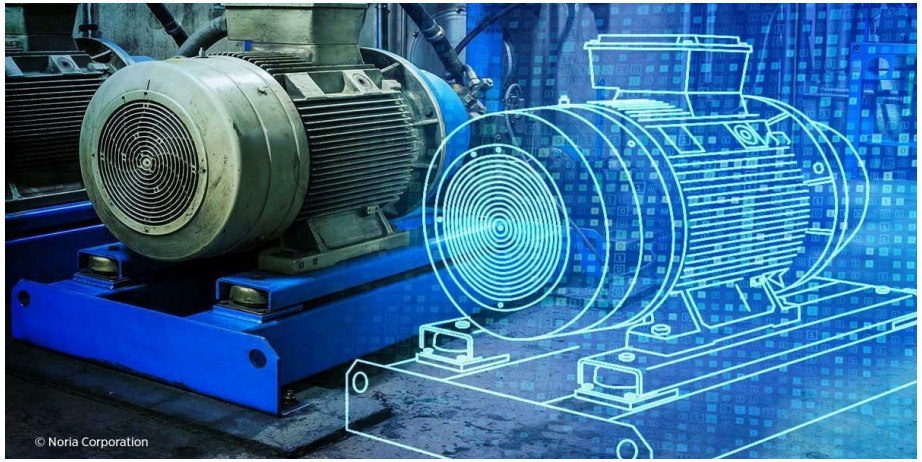
Some Activities:

- Digital Twin for Predictive Maintenance
- Image Analysis for Predictive Maintenance
- Value Added Services for Museum and Archeological Parks
- Context Aware Recommender System

Digital Twin

- A digital twin is a virtual representation of an object or system designed to reflect a physical object accurately.

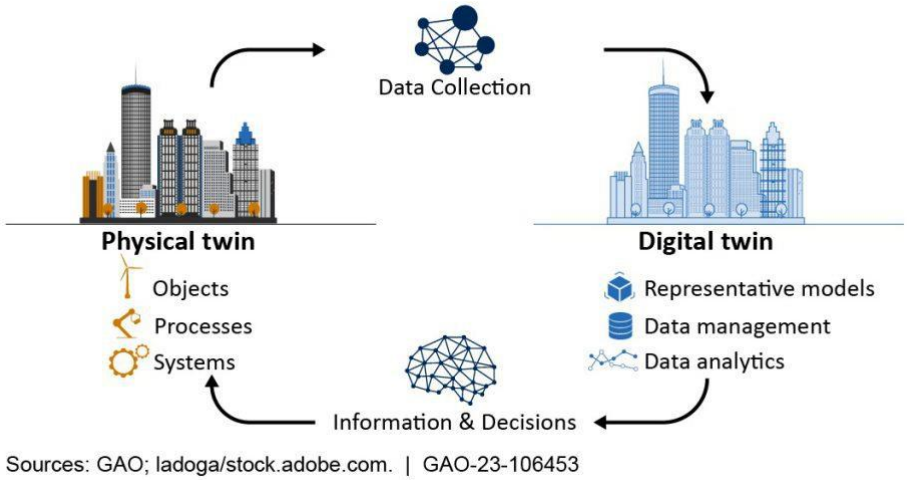
- It spans the object's lifecycle, is updated from real-time data and uses simulation, machine learning and reasoning to help make decisions.



Digital Twin

- The studied object is outfitted with various sensors related to vital areas of functionality. These sensors produce data about different aspects of the physical object's performance, such as energy output, temperature, weather conditions and more. The processing system receives this information and actively applies it to the digital copy.

- After being provided with the relevant data, the digital model can be utilized to conduct various simulations, analyze performance problems and create potential enhancements. The ultimate objective is to obtain valuable knowledge that can be used to improve the original physical entity.



Digital Twin and (Virtual) Archaeology

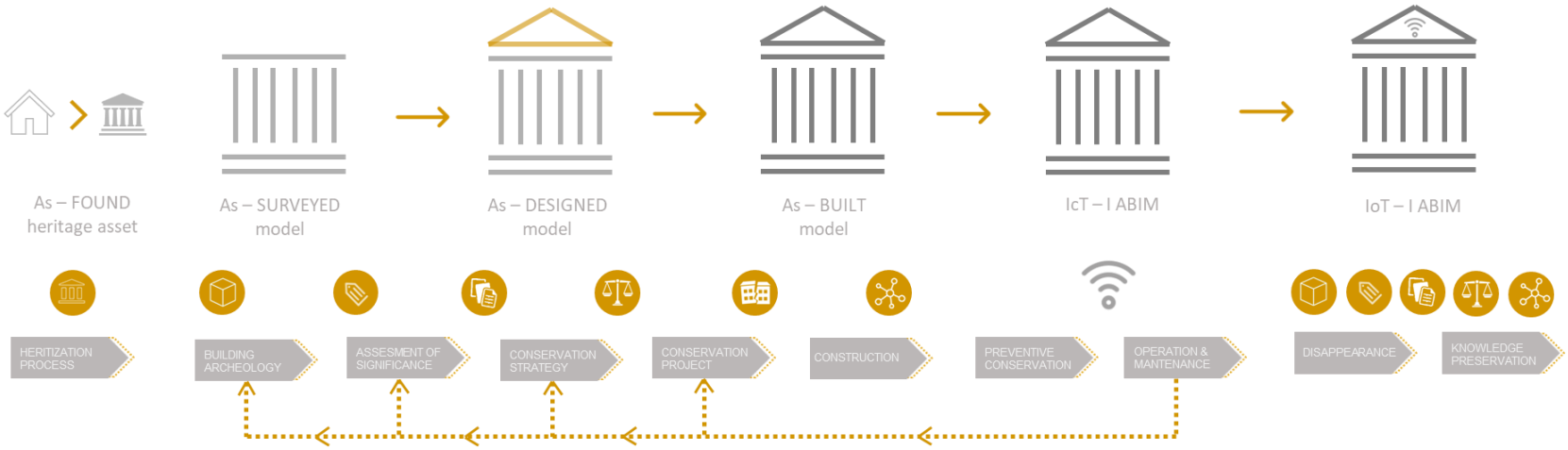
DIGITAL INFORMATION MODEL

The type of information that should be integrated in HBIM data model in comparison with standard BIM data models

Digital Twin and (Virtual) Archaeology

DATA MANAGEMENT PROCESS

The evolution of the data model in HBIM data management processes along the different phases of Heritage places lifecycle



Digital Twin and (Virtual) Archaeology

INTEROPERABLE STRUCTURED DATA

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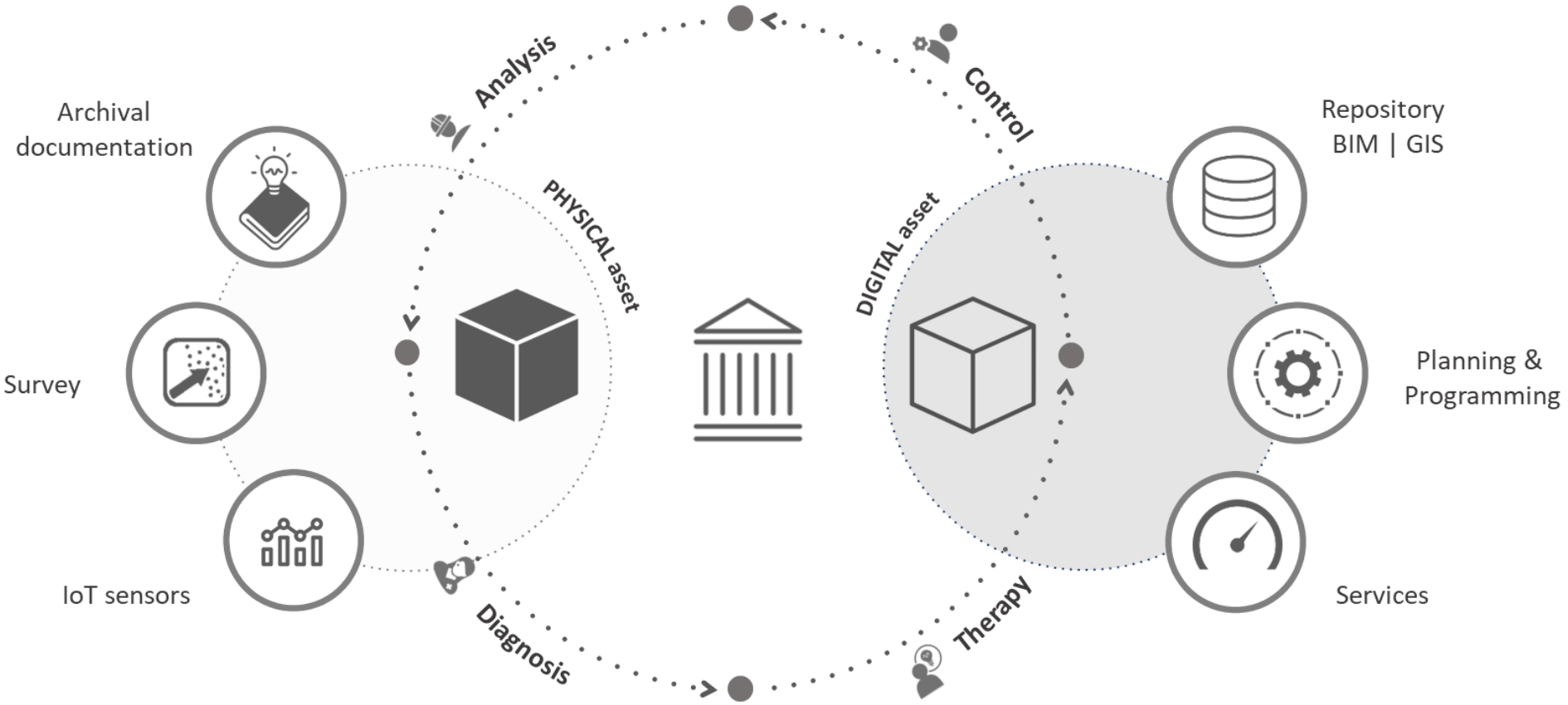
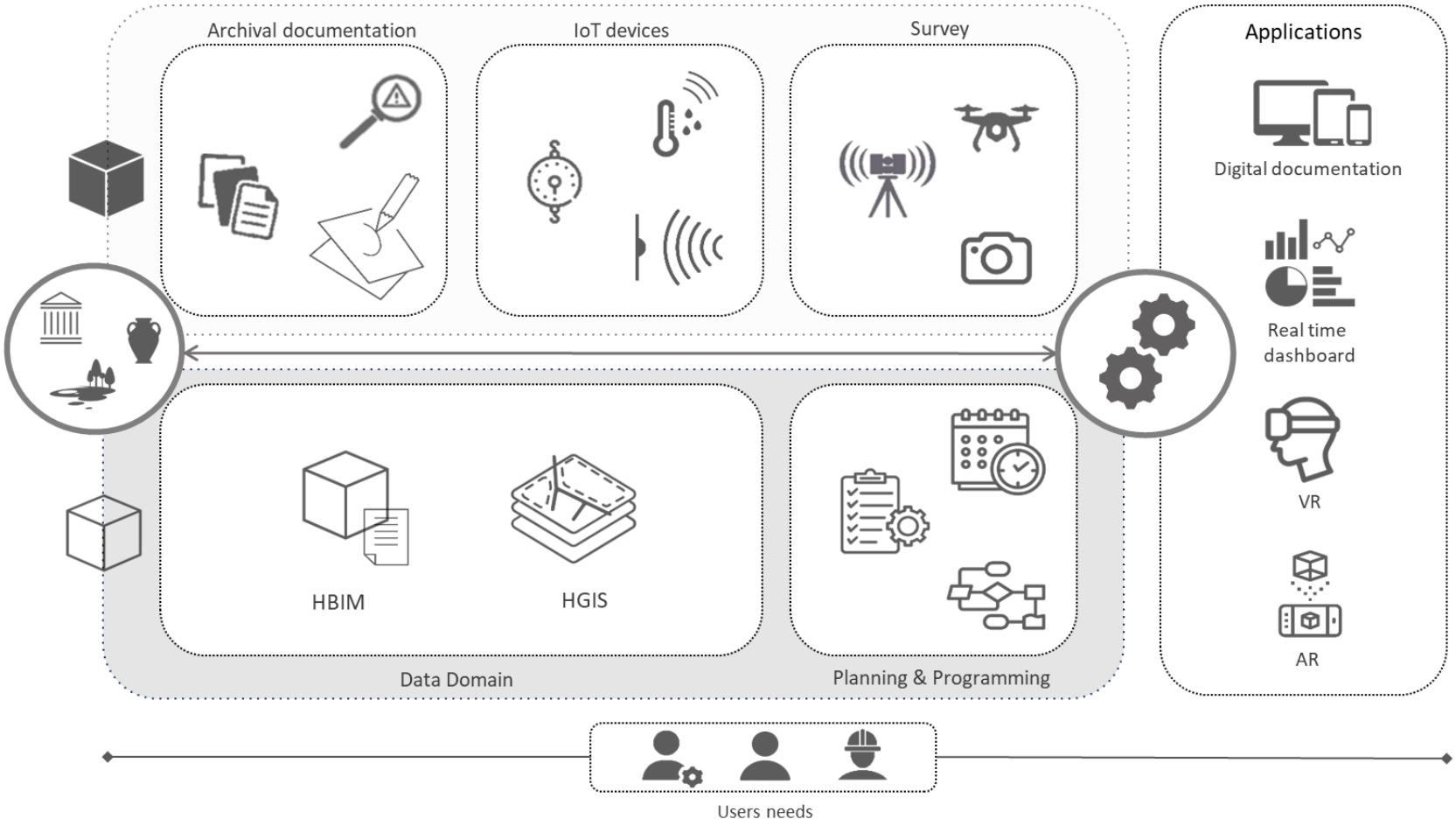


Digital Twin and (Virtual) Archaeology



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Digital Twin and (Virtual) Archaeology

APPLICATIONS

Digital Documentation

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APPLICATIONS

Real Time Dashboard

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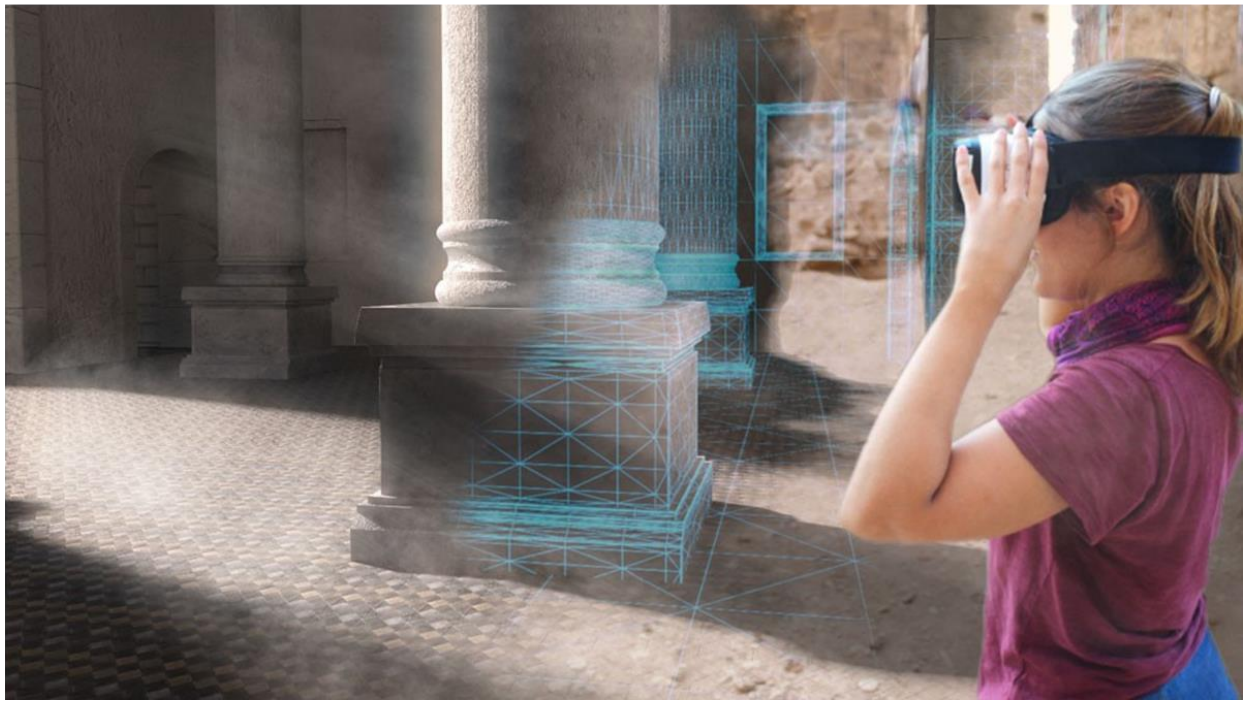
APPLICATIONS

Virtual Reality



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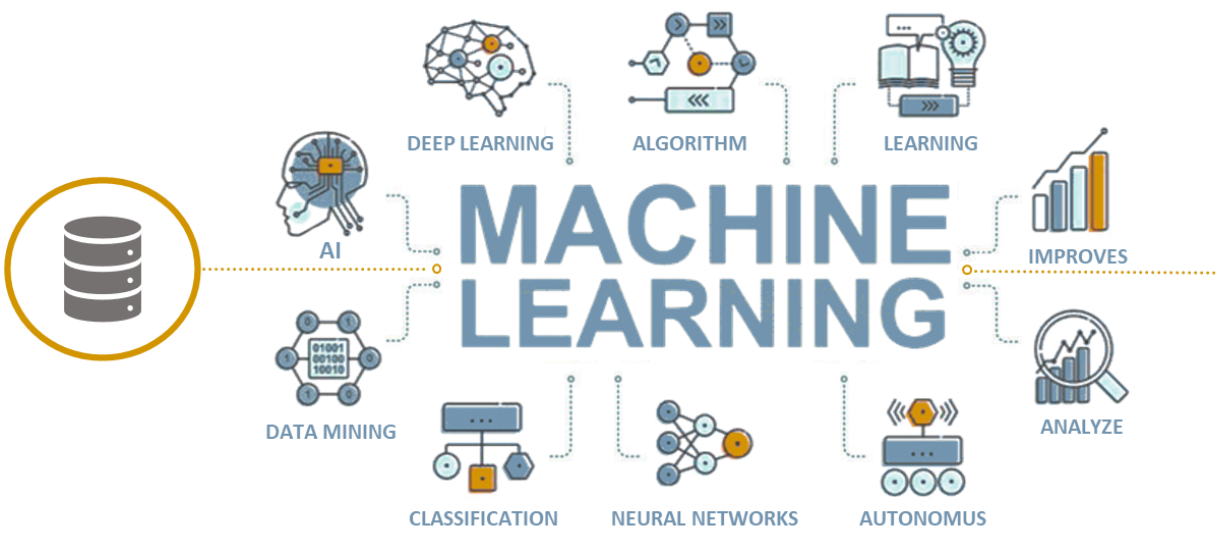
Digital Twin and (Virtual) Archaeology

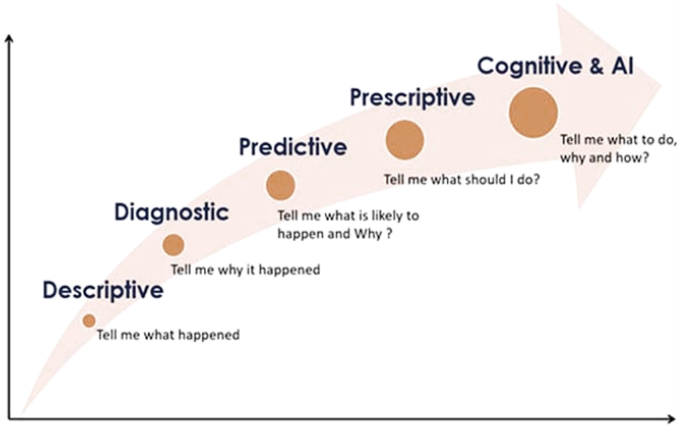
APPLICATIONS

Augmented Reality

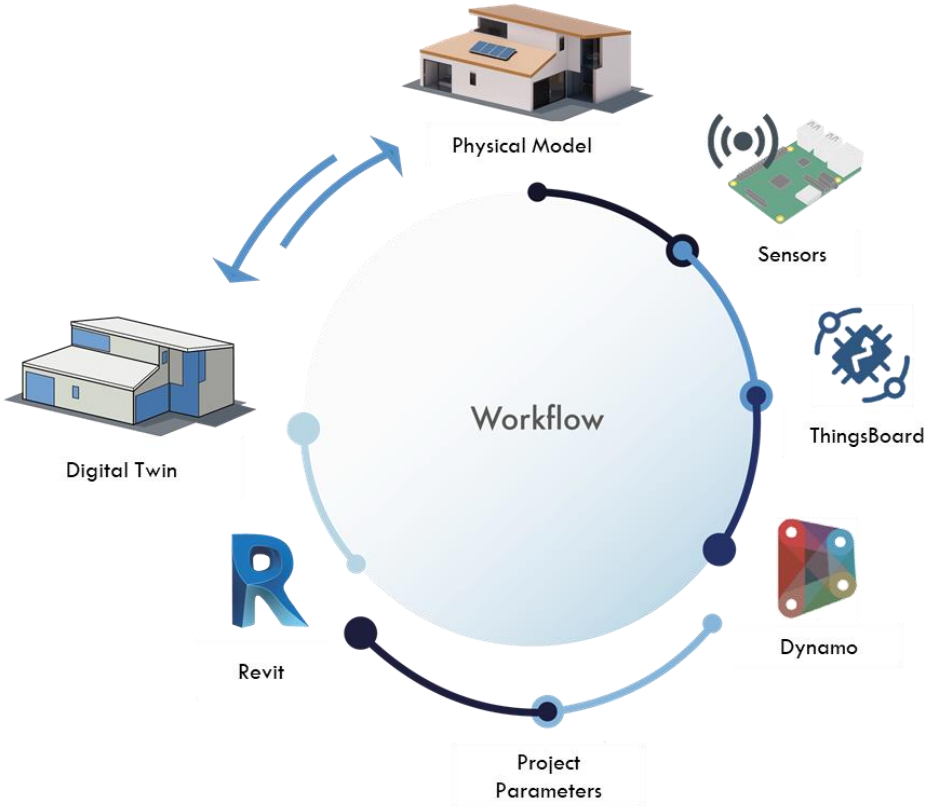
Digital Twin and (Virtual) Archaeology

FUTURE TRENDS



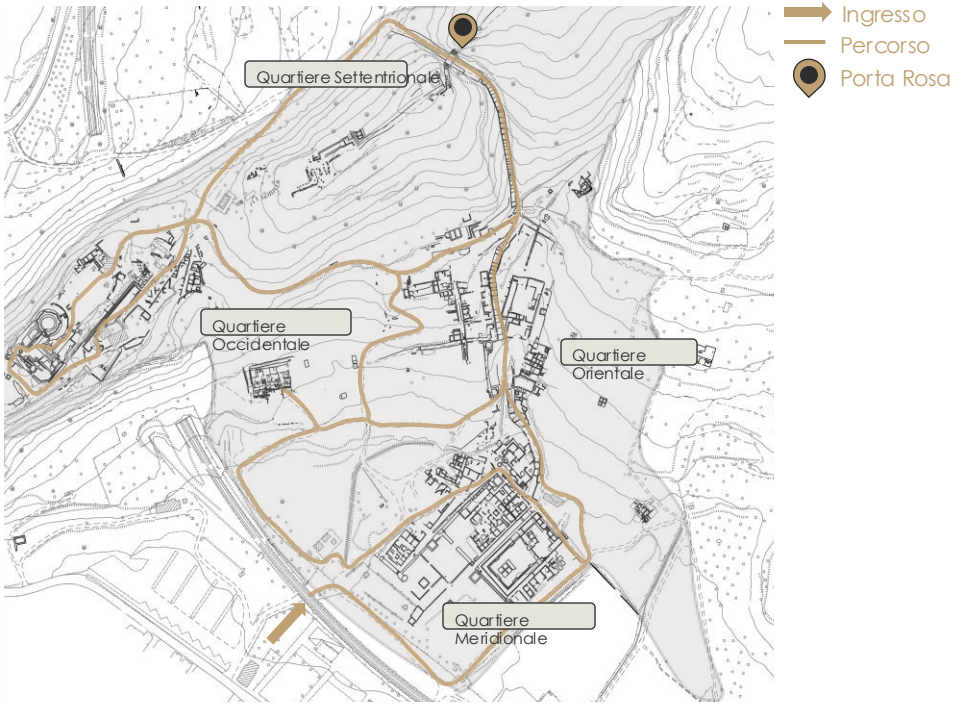


Digital Twin: General Workflow

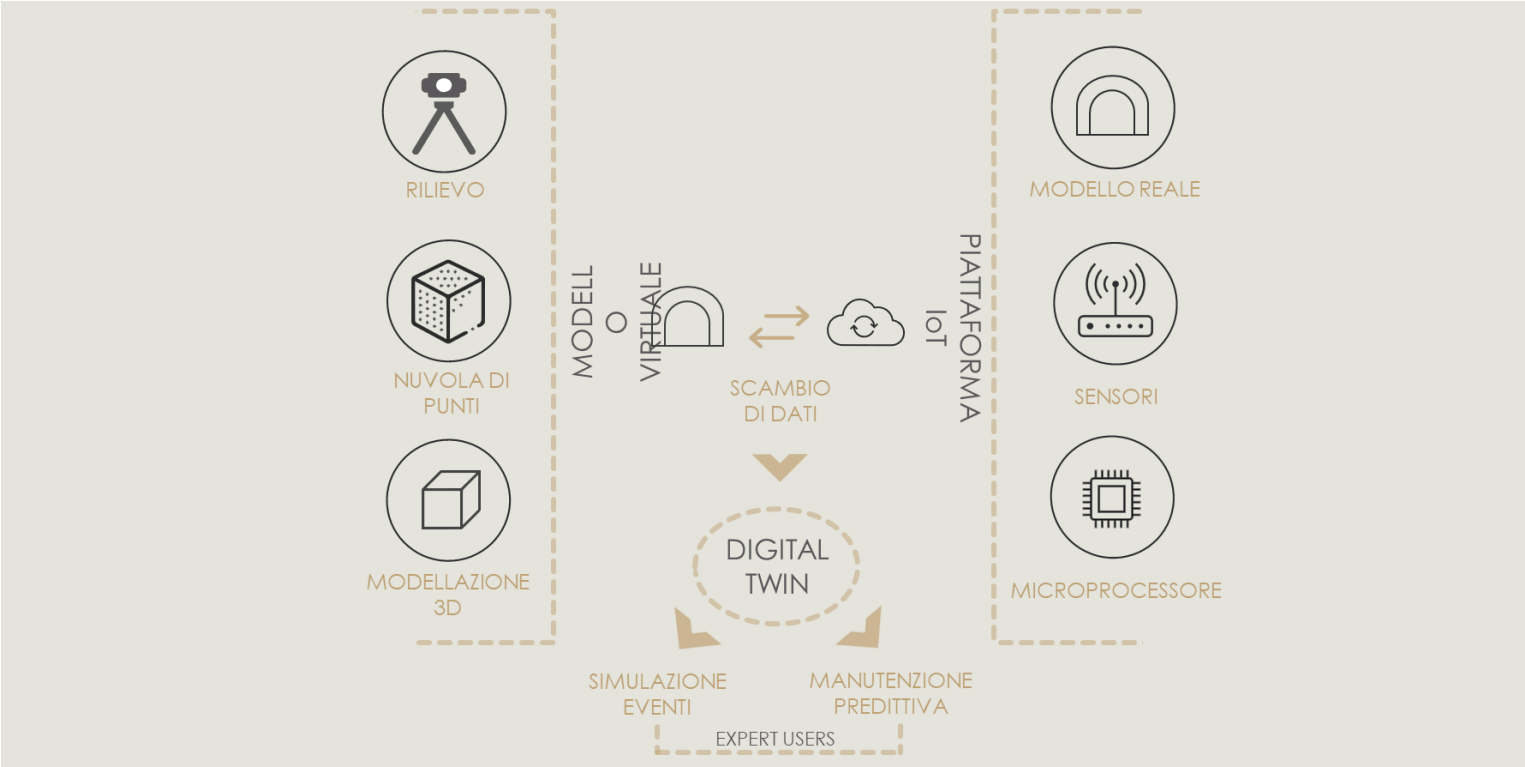


Case Studies

PoC: Porta Rosa - Velia



PoC: Porta Rosa - Velia



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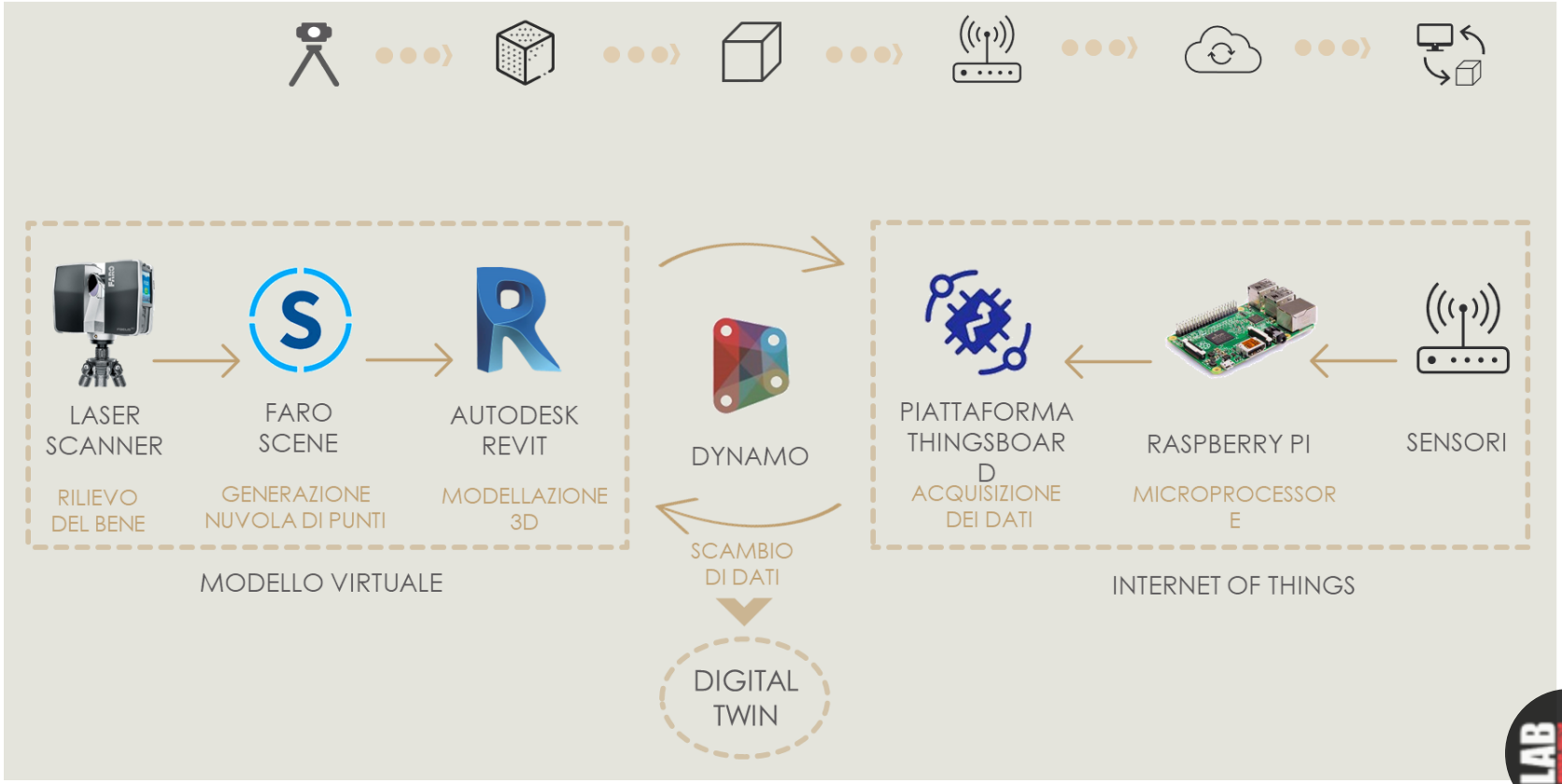
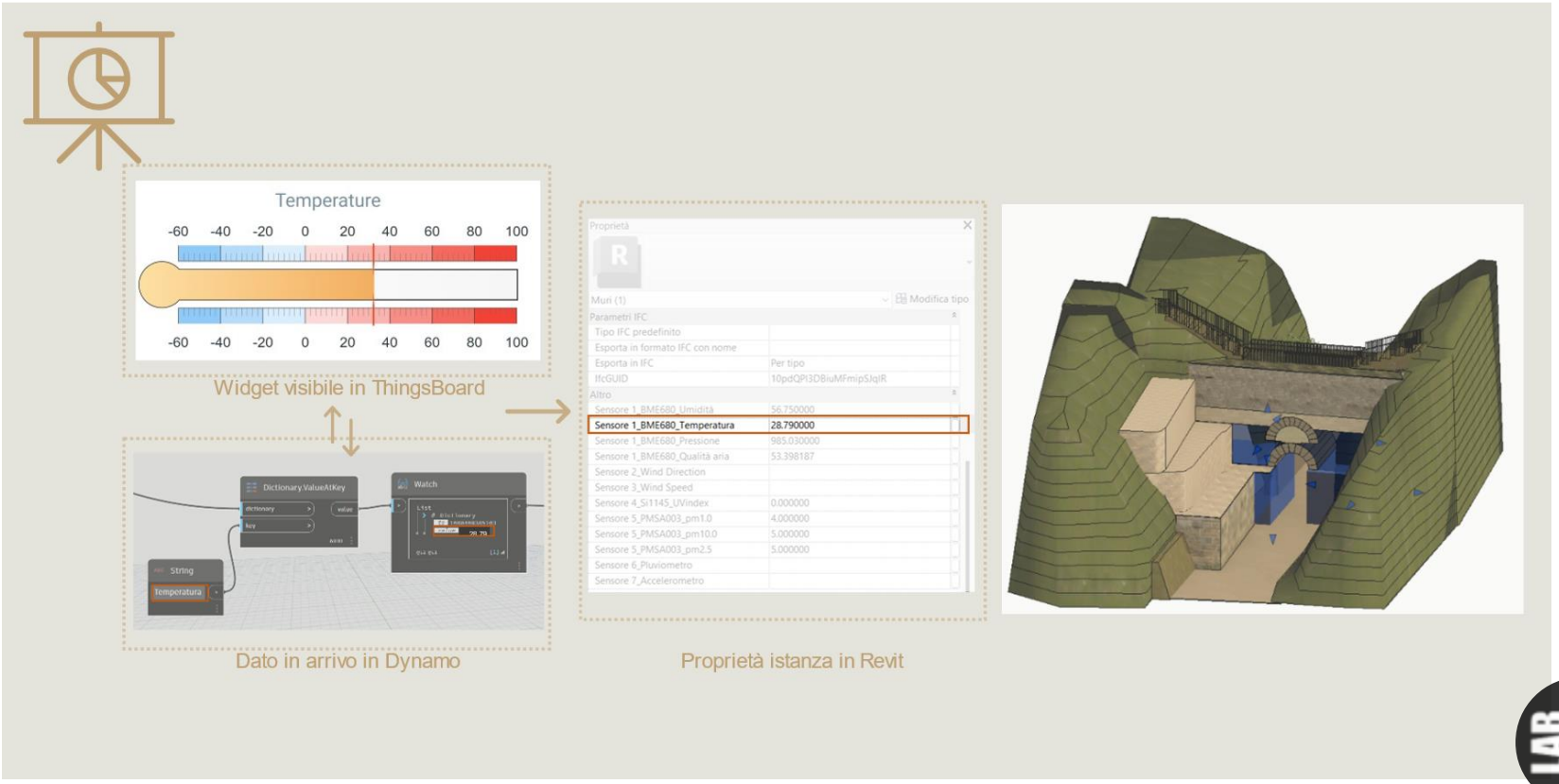


PoC: Porta Rosa - Velia



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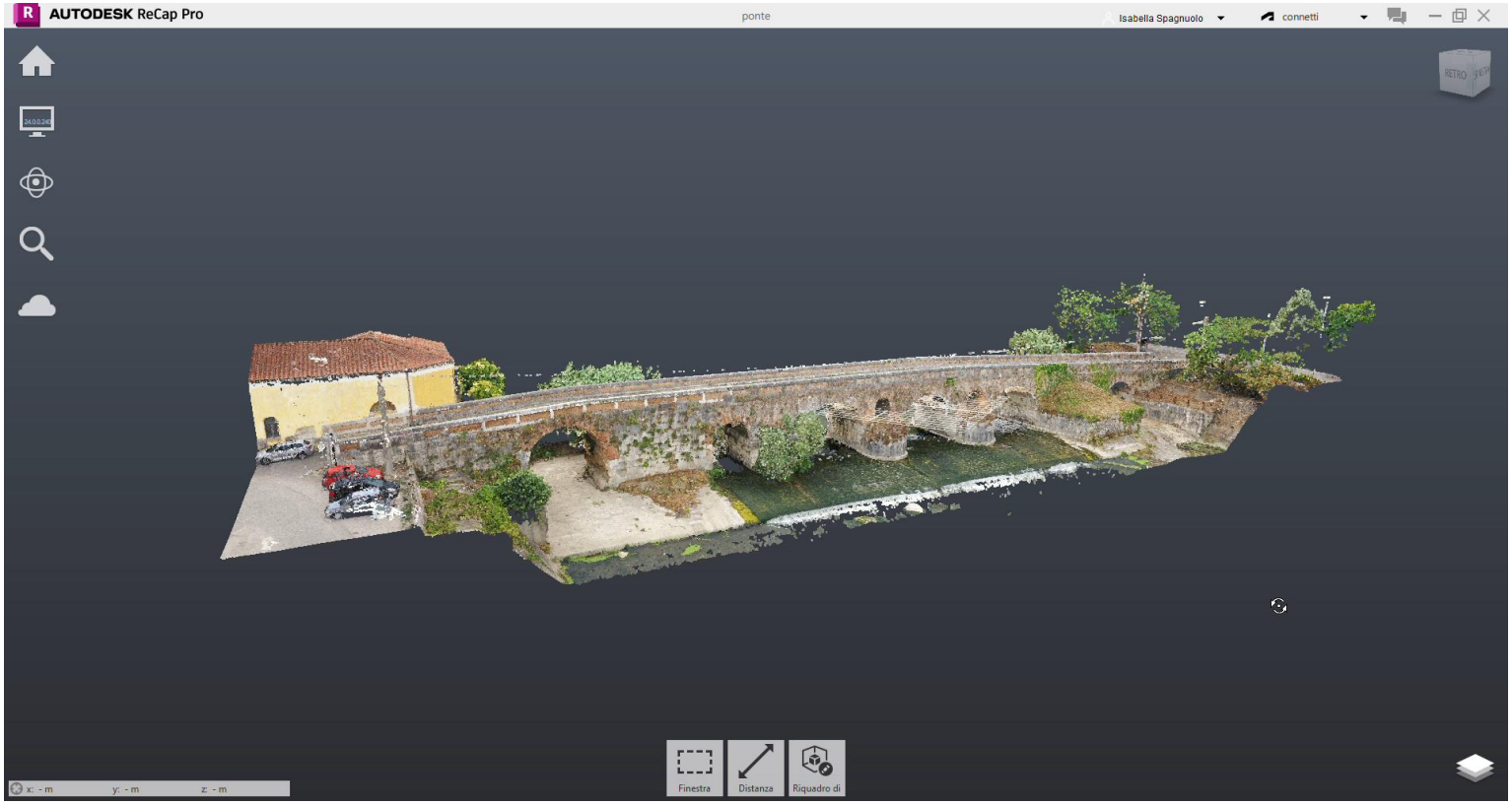
PoC: Ponte Leproso - Benevento



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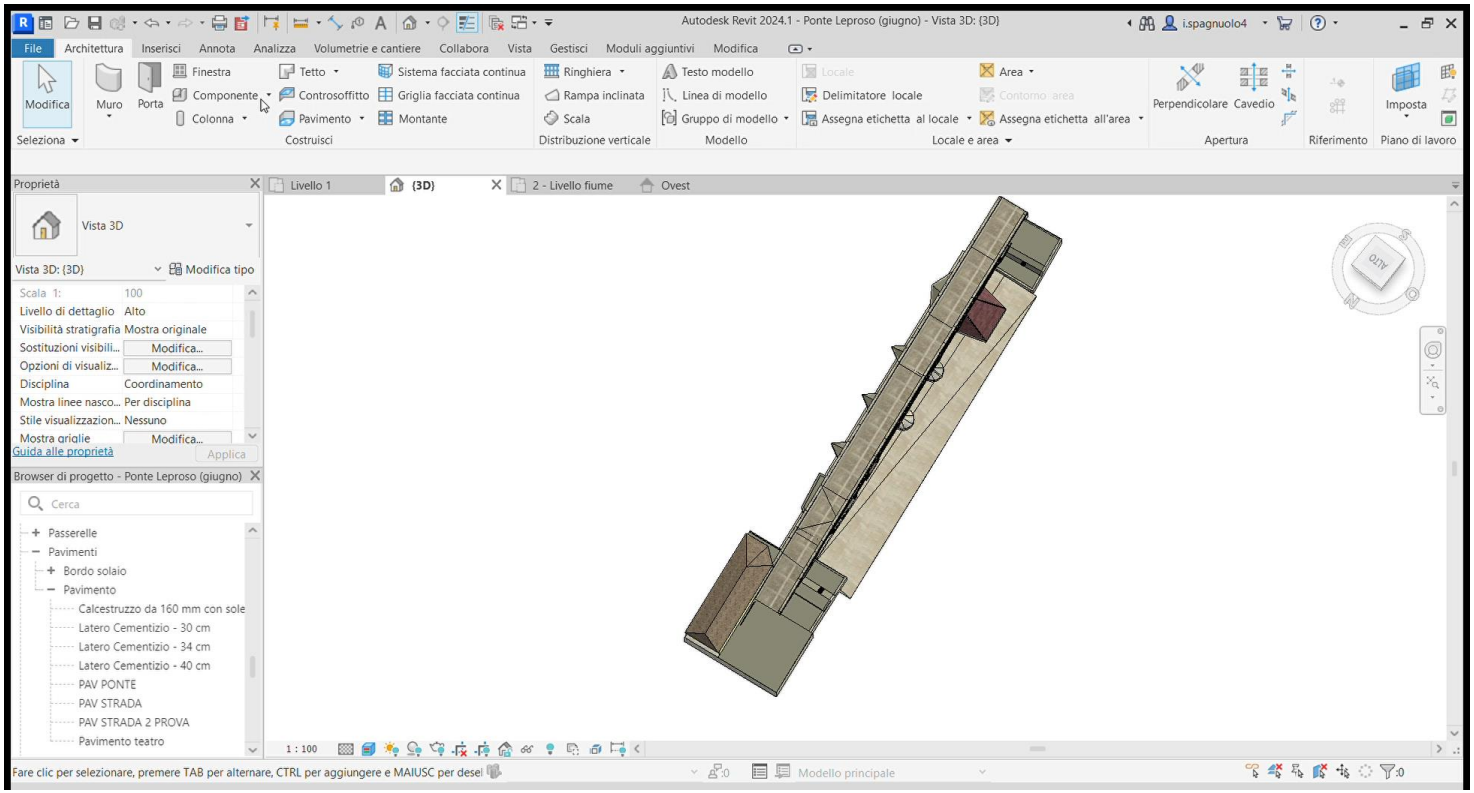

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FAUNO: A Machine Learning-Based Methodology for Monitoring and Predictive Maintenance of Structures in Archaeological Parks Through Image Analysis

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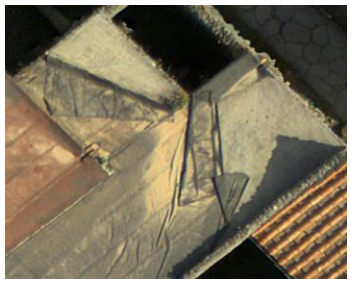
Damaged Elements

Weed Vegetation

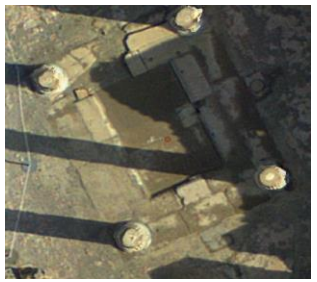
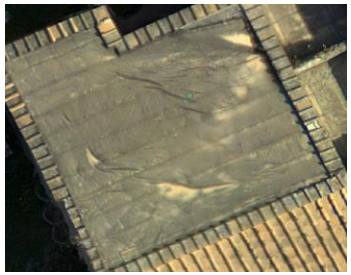
Falling Elements

Disconnected Elements

Water Accumulation







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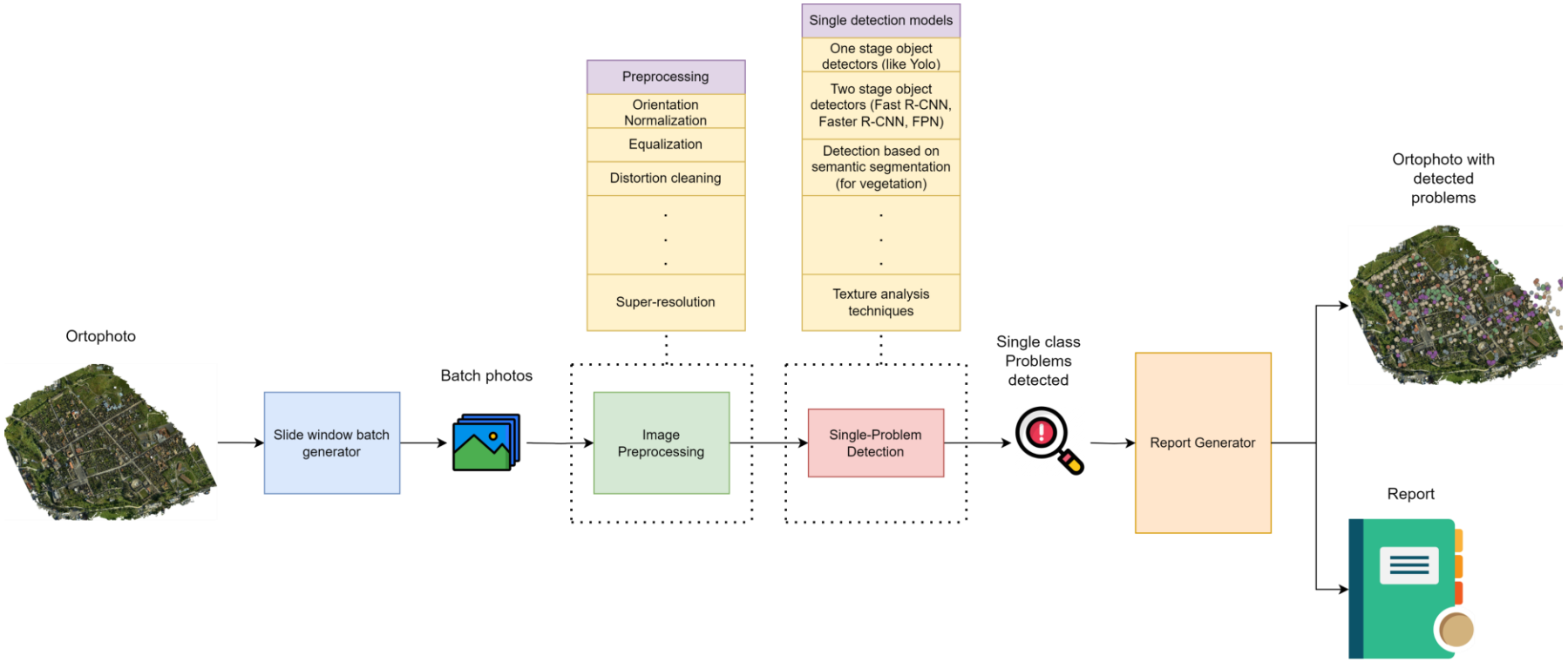

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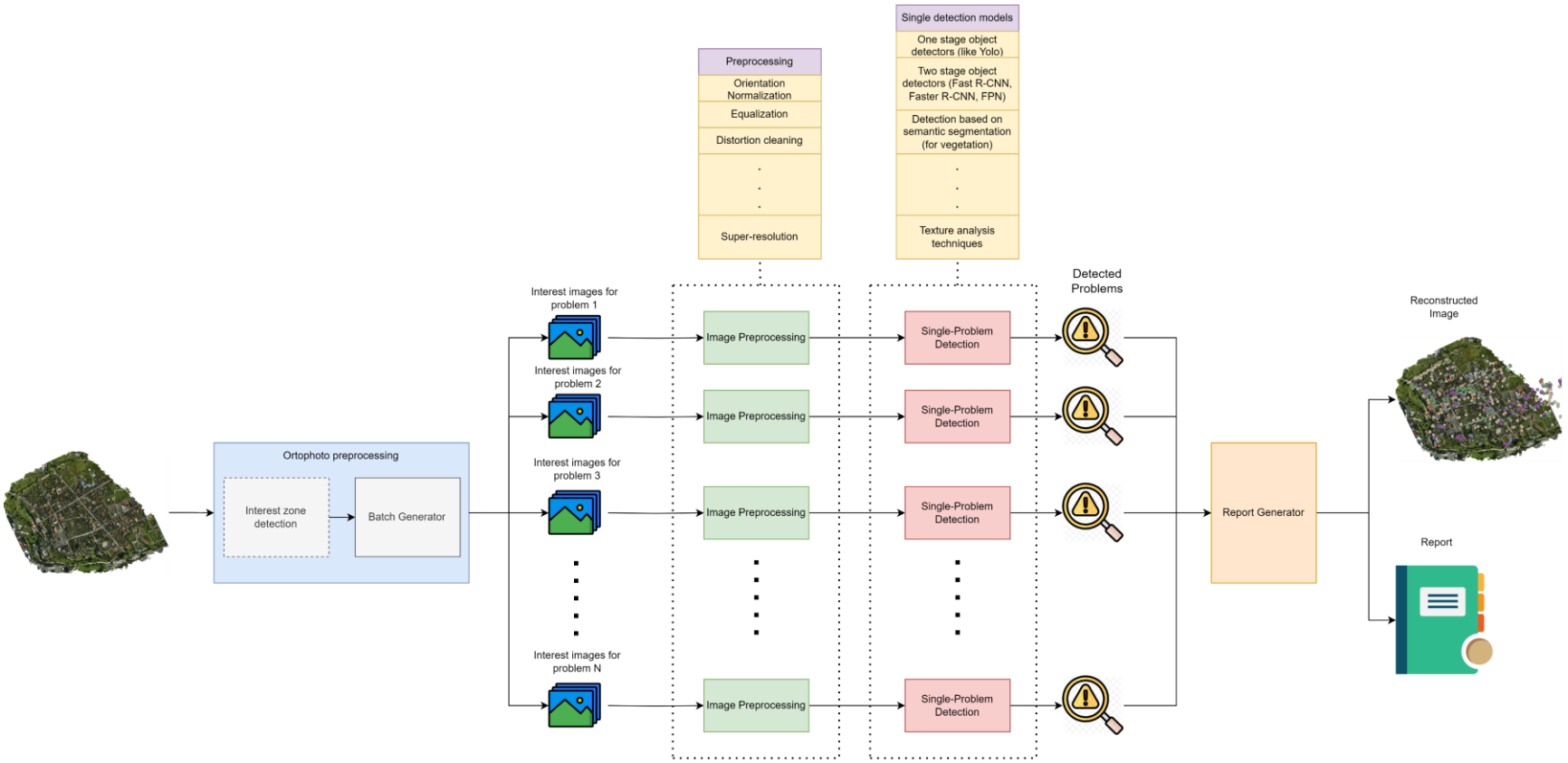

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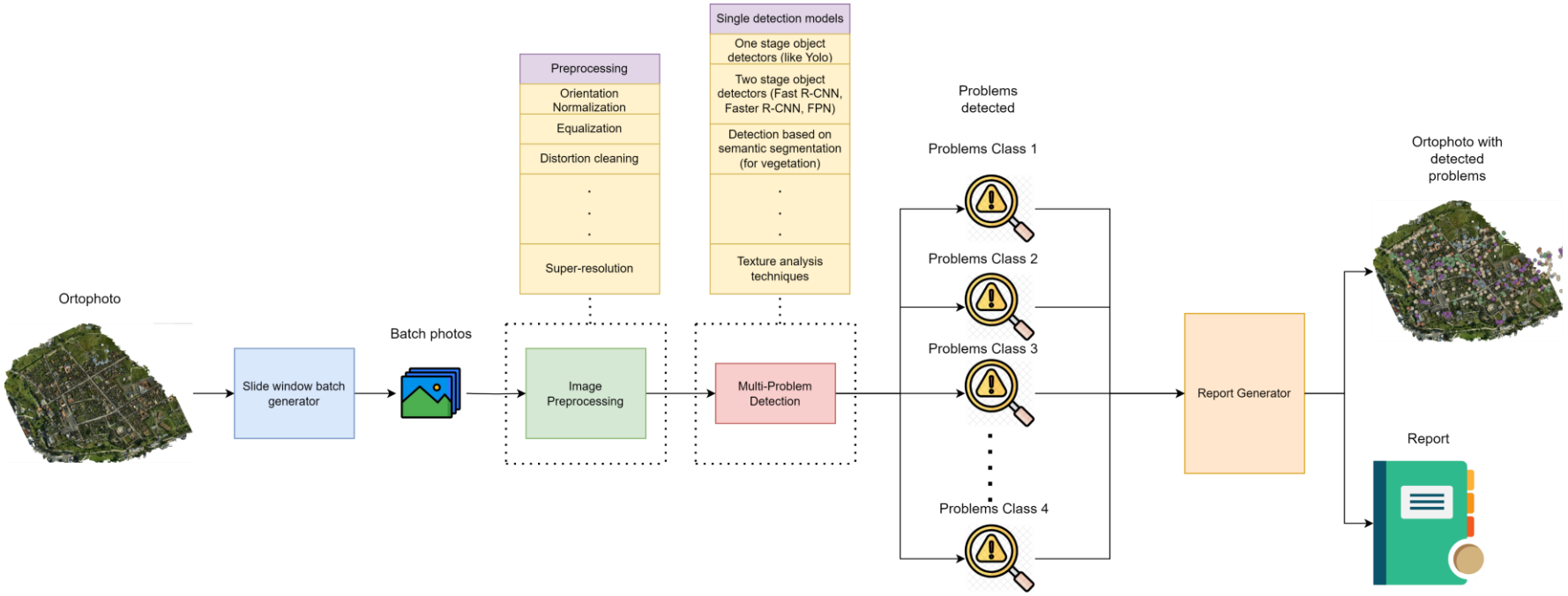

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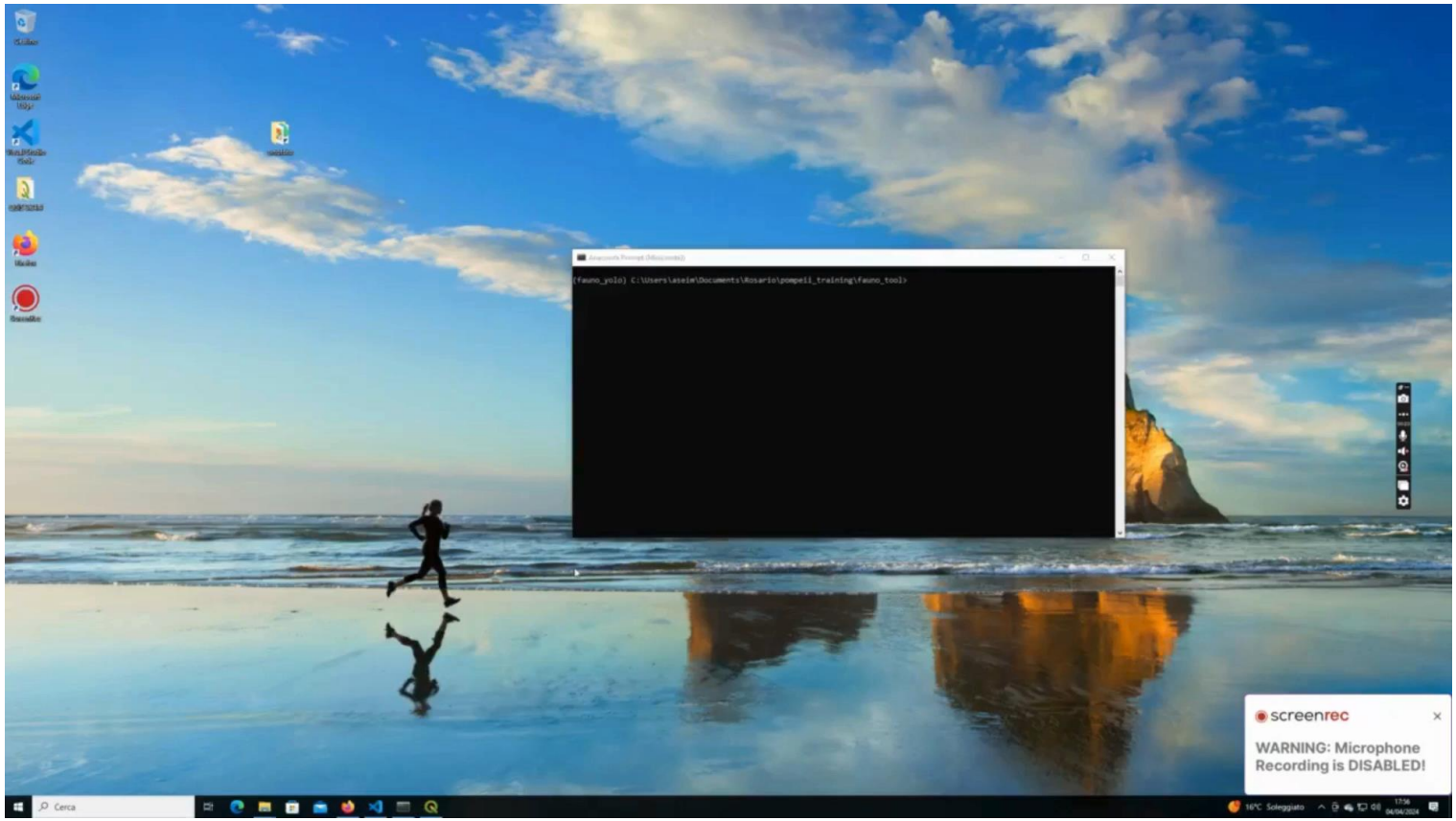
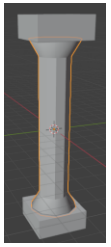
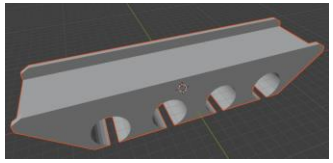


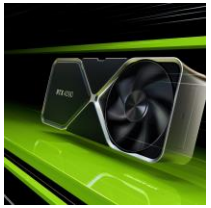
Physics-Informed Neural Networks

- Interaction with 3D Models related to cultural assets

- Identification of appropriate models
  - Temperature monitoring
  - Corrosion analysis
  - Environmental effects


- Reliable and fast resolutions methods
  - Exploiting Deep Learning



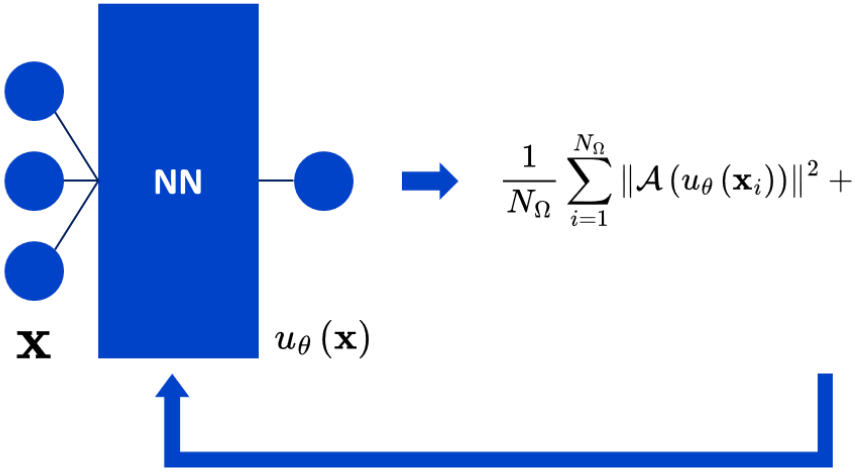

Physics-Informed Neural Networks

Physics-Informed Neural Networks (PINNs) exploit Neural Networks to approximate the solution of Partial Differential Equations

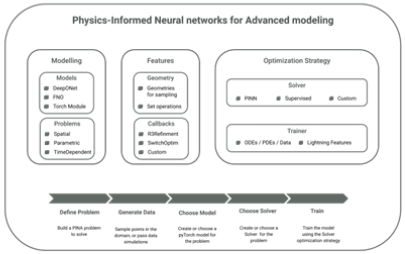
- Unsupervised Learning

$$\begin{cases} \mathcal{A}(u(\mathbf{x})) = 0 & \mathbf{x} \in \Omega \\ \mathcal{B}(u(\mathbf{x})) = 0 & \mathbf{x} \in \Gamma = \partial\Omega \end{cases}$$

$$u_\theta(\mathbf{x}) \approx u(\mathbf{x})$$



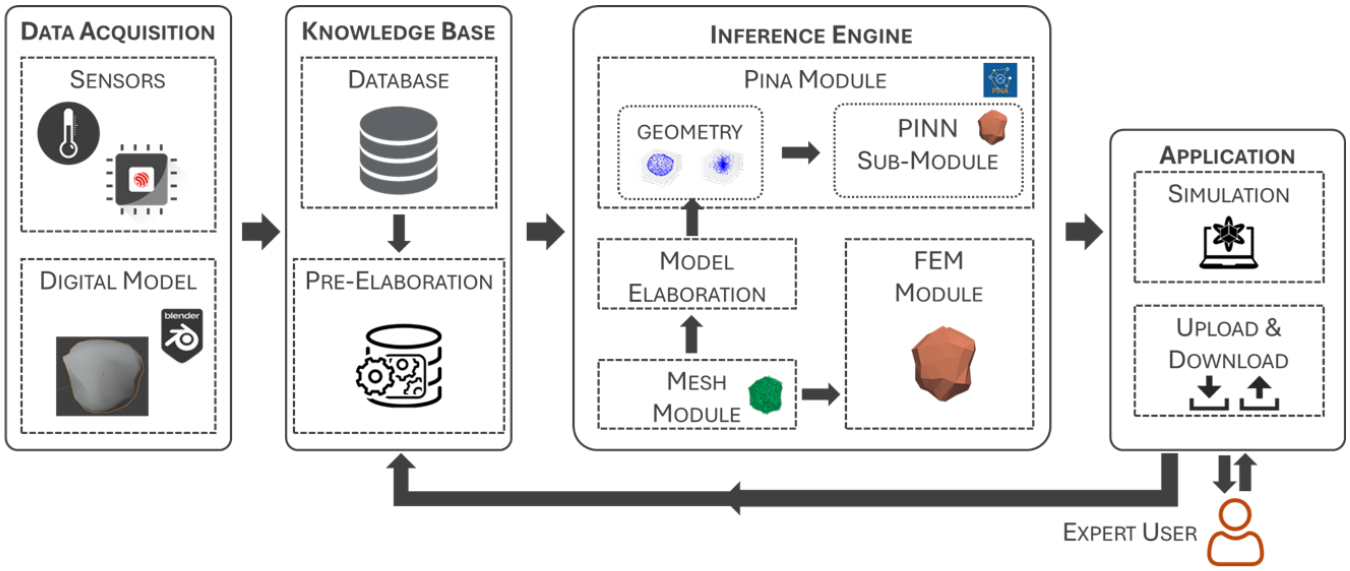
$$\frac{1}{N_\Omega}\sum_{i=1}^{N_\Omega}\|\mathcal{A}(u_\theta(\mathbf{x}_i))\|^2 + \frac{1}{N_\Gamma}\sum_{i=1}^{N_\Gamma}\|\mathcal{B}(u_\theta(\mathbf{x}_i))\|^2$$



PINA

Physics-Informed Neural Networks

Employing PINN for cultural property maintenance requires defining a platform based on four functional levels

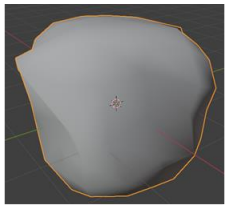


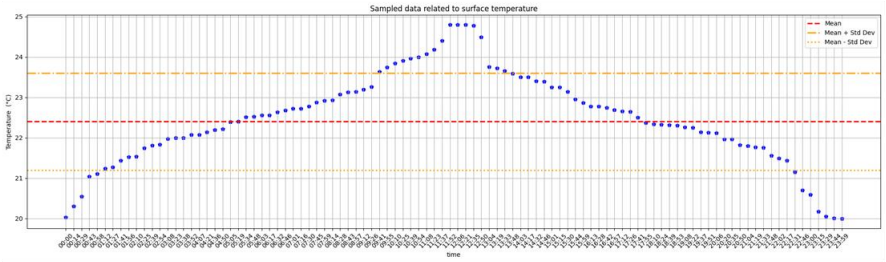
The platform complements AI-based techniques with literature approaches: FEMs

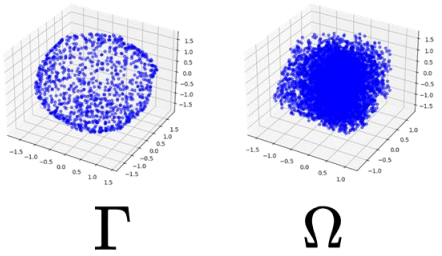
Physics-Informed Neural Networks

The experimental phase consists of a simulated case-study based on the monitoring of the temperature of a cultural asset

$$\begin{cases} \frac{\partial T}{\partial t}(t,x,y,z) - \Delta T\,(t,x,y,x) = 0 & (t,x,y,z) \in [0,1] \times \Omega \\ T\,(0,x,y,z) = T_0 & (x,y,z) \in \Omega \\ T\,(t,x,y,z) = \text{data} & (t,x,y,z) \in (0,1] \times \partial\Omega \end{cases}$$







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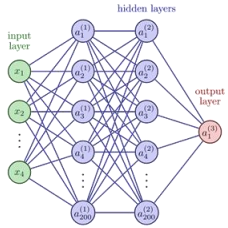
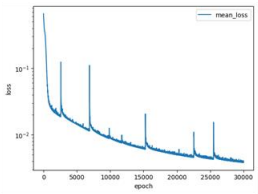
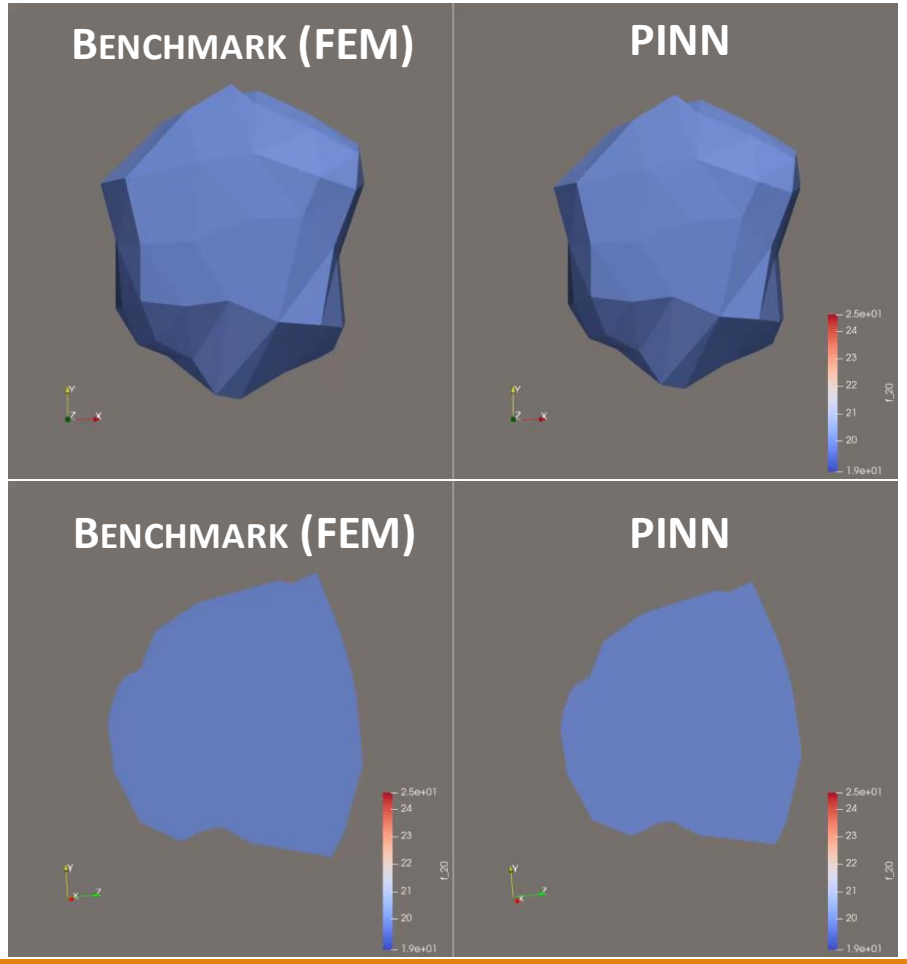
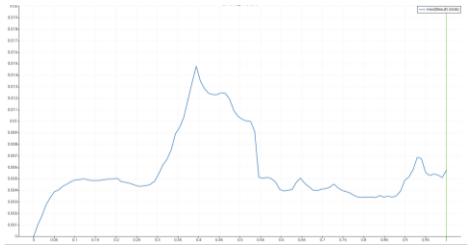




Physics-Informed Neural Networks



AVERAGE RELATIVE ERROR



AI for supporting tourists: Adapting Visiting Path

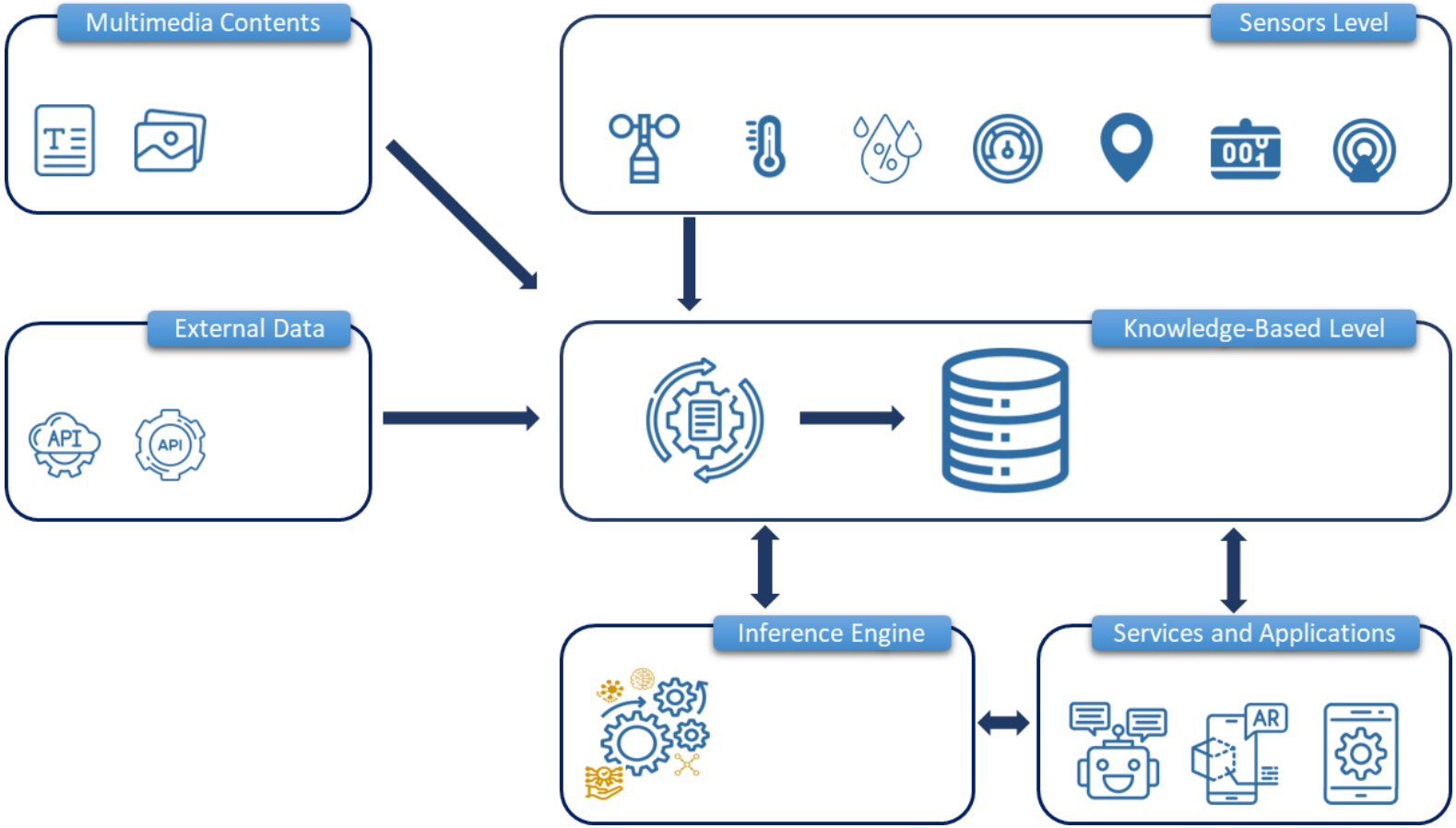
AIMS

- User Flow Control
- Personalised Path
- Improve Interaction

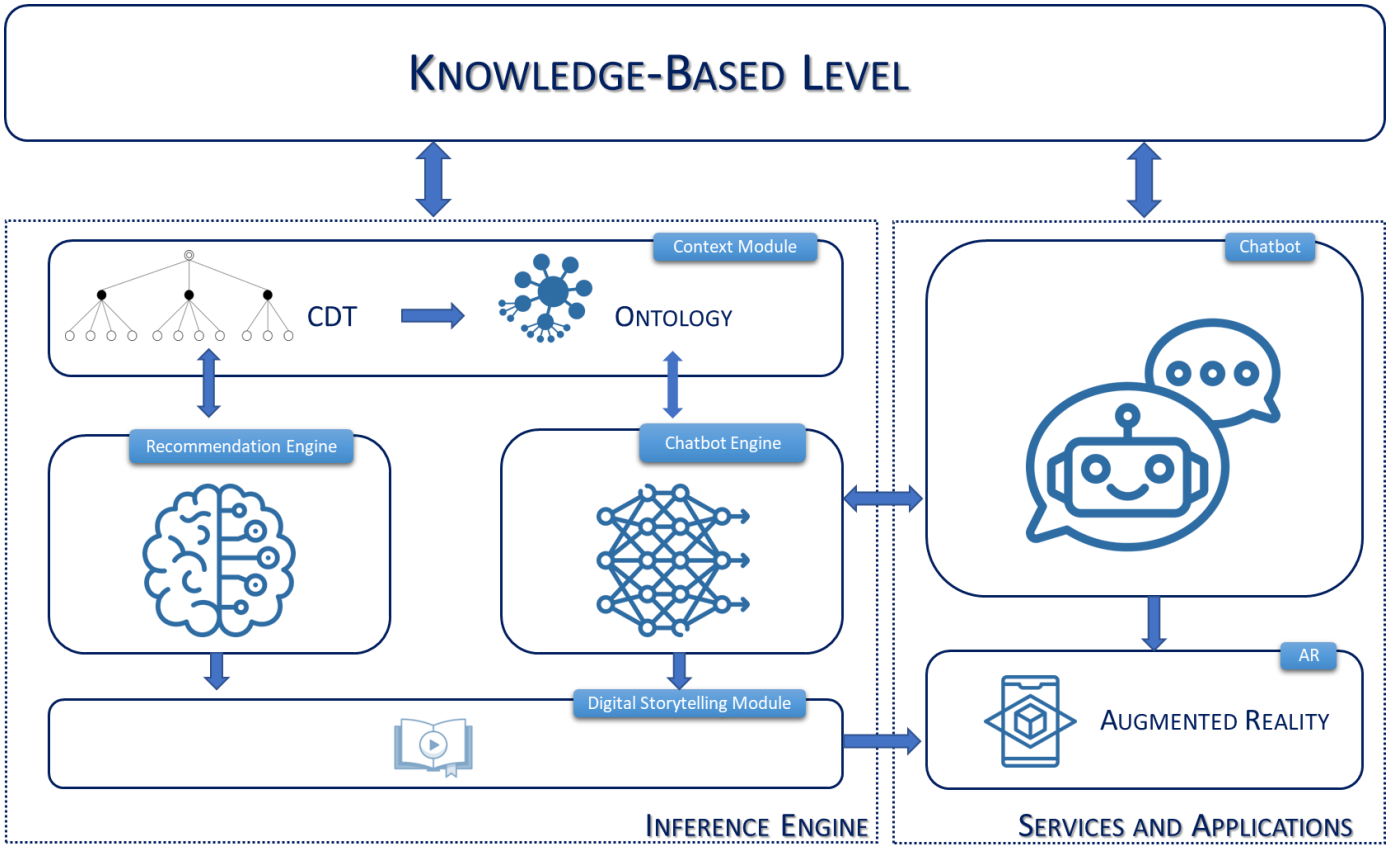
TOOLS

- Internet of Things
- Situation Awareness
- Ontological Layers
- Recommender Systems
- Chatbot
- Context Awareness
- Machine Learning
- Augmented Reality
- Data Storage

AI for supporting tourists: Adapting Visiting Path



AI for supporting tourists: Adapting Visiting Path



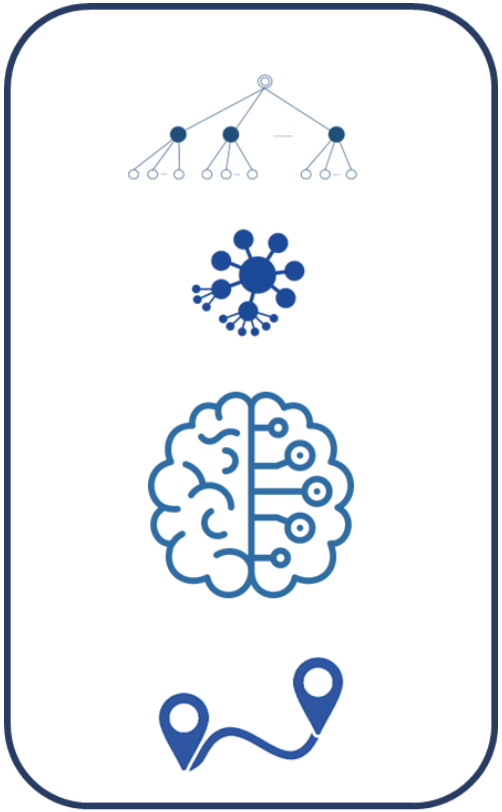
AI for supporting tourists: Adapting Visiting Path

The Recommendation Engine takes advantage of the contextual analysis thorugh the **Context Dimension Tree**.

Contextual data are filtered through the **Ontology** to acquire knowledge from data.

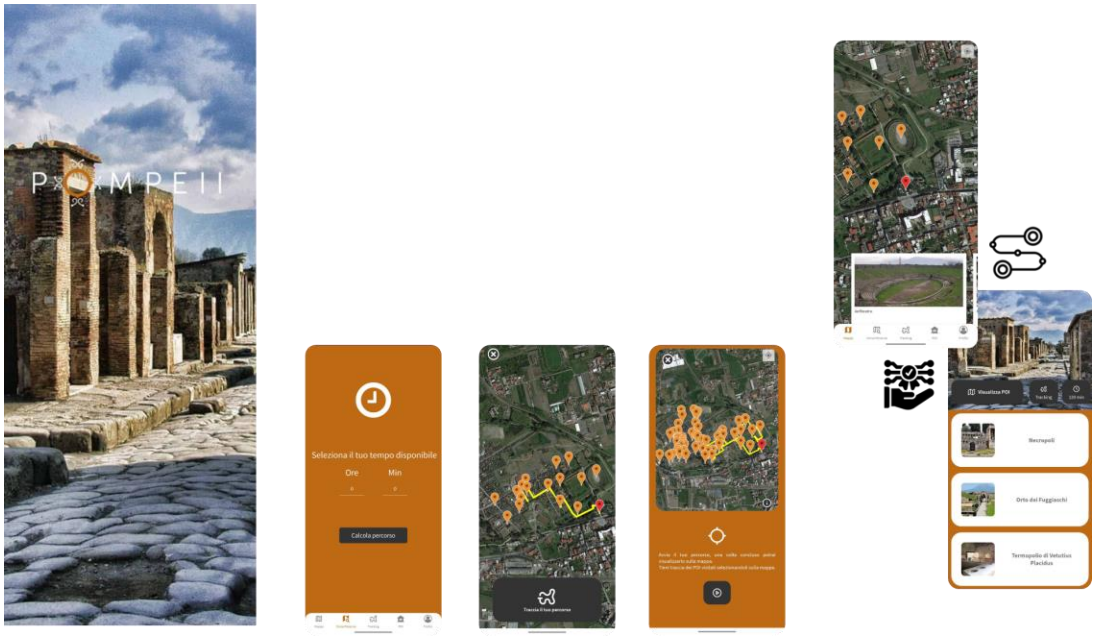
Then the recommendations exploits a **Context-Aware Recommendation** method based on Machine Learning techniques.

Finally, the **Personalized Path** is elaborated in order to maximize the number of POIs.

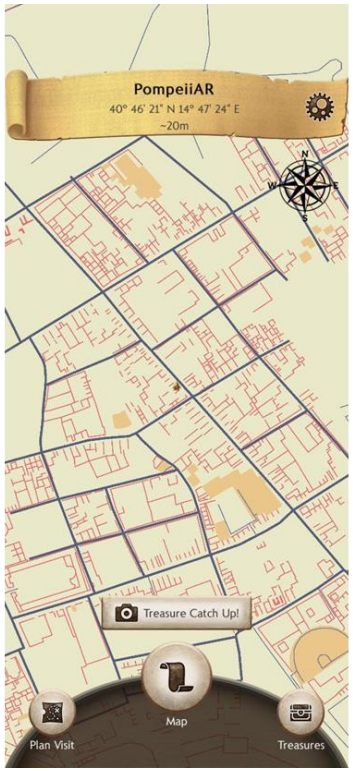


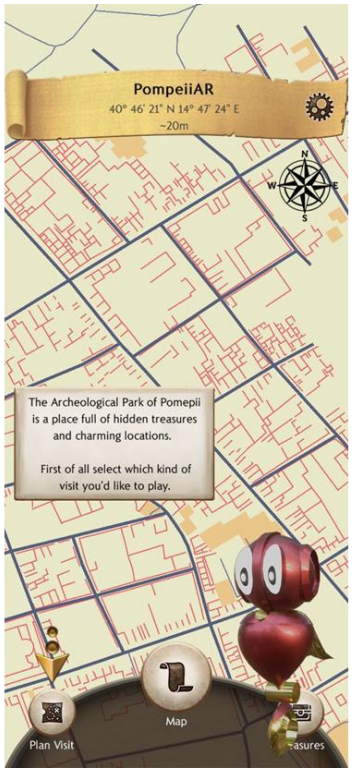
AI for supporting tourists: Adapting Visiting Path

Aim: From the need to support users who visit complex structures composed of different points of interest, the need arises to identify tools capable of suggesting attractions adapted to user preferences. Through the Recommendation Systems it is possible to identify such attractions and, by means of optimization algorithms aimed at maximizing the points of interest visited, ad-personam paths are elaborated capable of guiding the user during the visit, managing both the time available and the environmental conditions in which the experience develops.

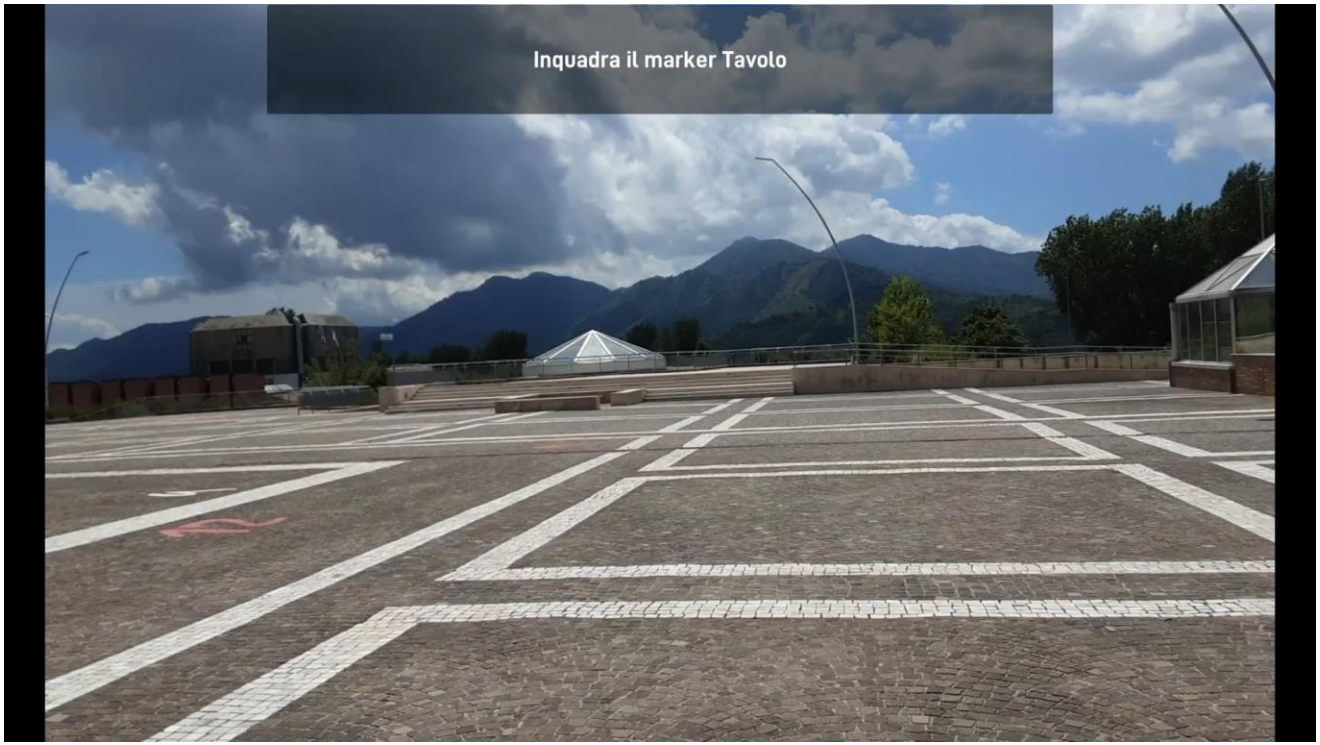


AI for supporting tourists: Serious Game





AI for supporting tourists: Serious Game



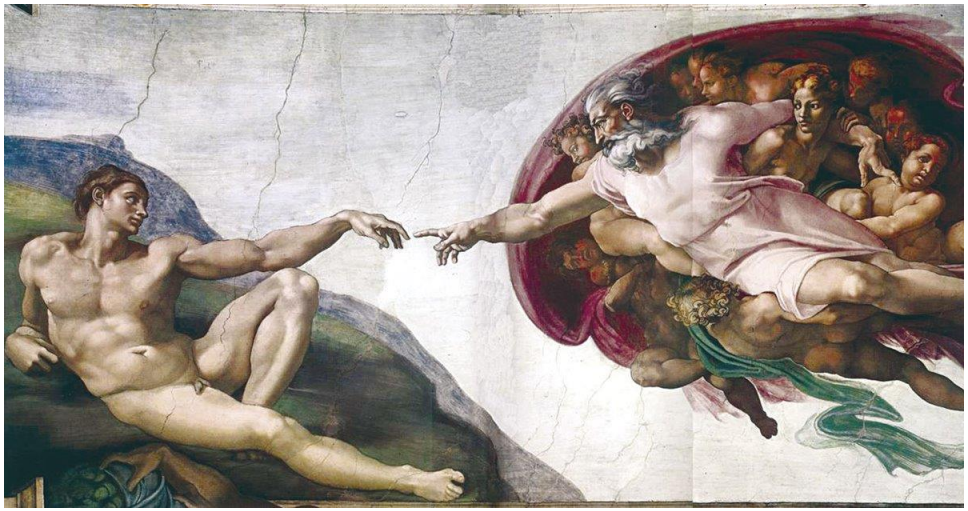
Developed by Professor Vittorio Scarano's Research Group within the PAUN Project

AI for supporting tourists: a Meta-Human Bot

Aim: to create Meta-Human Bots capable of supporting a visitor during activities in an archaeological park or museum. Through the technologies made available by 'Unreal Engine', it is possible to create digital assistants capable of dialoguing with users, in natural language, within real or virtual environments.

Conclusions

"As Socrates said, 'Wisdom begins in wonder.' With AI, we rekindle the wonder of cultural heritage, transforming ancient wisdom into innovation for tomorrow."



Conclusions

"As Socrates said, 'Wisdom begins in wonder.' With AI, we rekindle the wonder of cultural heritage, transforming ancient wisdom into innovation for tomorrow." [ChatGPT]