# Advanced Technologies for the Conservation of Cultural Heritage: An Application of the Digital Twin


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## I. INTRODUCTION

The increasing demand for digitisation, championed by various sectors including the cultural heritage sector, has propelled the concept of a Digital Twin (DT) into a significant role. A Digital Twin is a comprehensive digital representation of a tangible asset or environment, offering a multitude of functionalities, including conservation, monitoring, and predictive maintenance. This thesis is dedicated to exploring the potential of 3D Vista Pro software in the creation and implementation of the Digital Twin of the Leproso Bridge in Benevento, Campania, thereby demonstrating the transformative power of advanced technologies in the realm of cultural heritage.

The project starts with an in-depth study of the state of the art on Reality Capture systems and IoT technologies applied to cultural heritage. Different tools and methodologies currently used for three-dimensional surveying and data management were examined, identifying the most advanced solutions suited to the specific needs of the case study. Due to its detailed acquisition capabilities and integrated data management via a cloud platform, this preliminary study made it possible to select 3D Vista Pro as the leading technology for creating the digital model.

The main objective of this research is to demonstrate how advanced technologies can be applied to cultural heritage to improve its conservation and enhancement. In particular, the Leproso Bridge, an important historical infrastructure, was chosen as a case study to evaluate the Digital Twin's effectiveness in monitoring the bridge's structural and environmental conditions. IoT sensors and three-dimensional acquisition tools make it possible to create a dynamic virtual model that reflects the state of the cultural asset in real-time..

## II. PROPOSED WORKFLOW

The workflow proposed for creating the Digital Twin of the Leproso Bridge consists of several key steps. First, an in-depth analysis of the state of the art in Reality Capture systems was conducted, identifying 3D Vista Pro software as a valuable tool due to its ability to capture three-dimensional environments and manage virtual models through a cloud-based IoT system. The ThingsBoard platform was chosen for data management and acquisition for this case study. ThingsBoard, with its customizable dashboards equipped with dedicated widgets, allows real-time visualization of the data collected by the sensors installed on the bridge.

The methodology adopted in the case study followed several steps. First, a detailed survey project was carried out, considering the structural and environmental characteristics of the Leproso Bridge. Then, using the 3D camera of 3D Vista Pro mounted on a tripod, 46 scans were taken to capture the entire structure of the bridge. The precision of the 3D camera's LiDAR sensors, which can take precise measurements even in low light or direct sunlight, ensured the accuracy of the data collection process and the quality of the resulting three-dimensional model.

After the acquisition phase, the scans were uploaded and processed by 3D Vista Pro's deep learning neural network, which generated a detailed virtual model in .obj format. This model was then integrated with comprehensive time series data from various IoT sensors installed on the bridge. These sensors, including those for measuring temperature, humidity, atmospheric pressure, air quality, wind direction and speed, precipitation and UV radiation, were all connected to a weather station located on the east side of the bridge. This station collects and transmits data in real-time via a WiFi connection to ThingsBoard, ensuring the Digital Twin is constantly updated with the most current information.

Implementing the data in ThingsBoard enabled the creation of interactive dashboards displaying real-time conditions on the bridge. Two different Digital Twins have been developed for different user categories: one for basic users, with historical information and characteristics of the cultural asset, and one for expert users, providing advanced tools for continuous monitoring and predictive maintenance of the bridge. Both DT models include 3D virtual tours enriched with real-time data and historical information, which can be visualized through customized tags (Fig.1). The technology allows the model to be easily explored and automatically updated with data collected from sensors, thus improving the accuracy and reliability of the information provided.

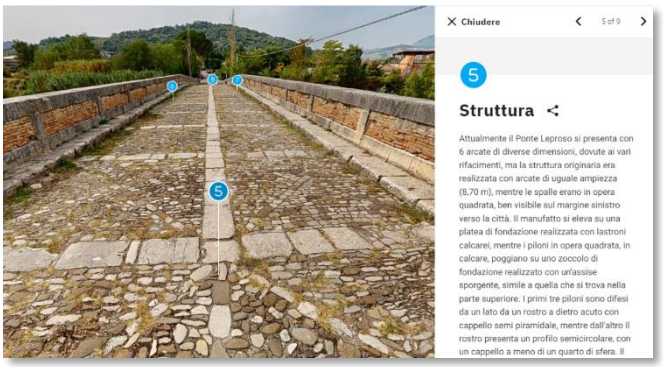


Fig. 1. Example of Visualization VT.

## III. Conclusions

The successful application of the Digital Twin for Ponte Leproso has proven its worth by achieving several key objectives. Real-time monitoring has provided immediate data on the environmental and structural conditions of the bridge, enabling early identification of any anomalies or deterioration. Predictive maintenance, facilitated by analyzing historical and real-time data, has allowed for targeted and planned interventions to prevent significant damage. The cultural asset has been enhanced through 3D virtual tours, offering visitors an immersive and informative experience, thereby improving their knowledge and appreciation of the historical heritage.

In conclusion, 3D Vista Pro proved an effective technology for capturing and implementing outdoor environments in the context of Digital Twin creation. Despite some limitations in terms of scope, alignment, and implementation costs, the combination of 3D Vista Pro and ThingsBoard achieved the objectives of the case study: to improve the monitoring, predictive maintenance, and enhancement of the Leproso Bridge, while providing easy and intuitive access to detailed and up-to-date information in real time. This experience highlights the importance of adopting advanced technologies for conserving and managing cultural heritage, paving the way for future applications and developments in the sector.

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