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Material modelling for immaterial fruition. The virtual and augmented reality of the Aqua Augusta Campaniae and the Piscina Mirabilis

Nowadays, the implementation of complementary virtual approaches to the in situ visit of archaeological sites is a preeminent topic in the field of the fruition of cultural heritage, even more today following the pandemic restrictions.
The aim of this work is thus to present a comprehensive framework for the fruition and the digital knowledge of the archaeological traces composing the Augustan Aqueduct, the Aqua Augusta Campaniae and its terminal reservoir, the Piscina Mirabilis in Bacoli (Italy). This model aims to be not only informative, but also as both a tool supporting learners and an archive gathering the information collected during the research activities. The traces composing the route of the Augustan Aqueduct are not completely accessible to public visitors, being the Roman infrastructure built almost entirely underground, across tuffaceous banks.
Within the framework of this work, specific attention was thus paid to the communication language to be adopted for all the implemented digital tools. The vision was to conceive the framework as a complementary instrument of the physical visit, capable of providing exclusively the information that cannot be learnt directly in situ. The tool was based on the development of an applied game working in a virtual environment, as well as applications running in augmented reality (AR). The instrumental workflow was based on the interface of different commercial software and apps, such as Rhinoceros3D for 3D modelling, Augment for the augmented reality and Unreal Engine for game engines.

Keywords:
Applied Games; Virtual Reality (VR); Augmented Reality (AR); Piscina Mirabilis; Aqua Augusta Campaniae

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1. INTRODUCTION

Nowadays, the most widespread tools supporting the fruition and virtualization of cultural heritage provide the use of information and communications technologies (ICTs) through devices based on multisensory perception, active involvement of users and mixed realities. Although relatively recent as a discipline, the virtual reconstruction is, on the one hand, a scientific tool of significant cognitive worth, as it facilitates the management and understanding of a great deal of information, especially for professionals. On the other hand, it is usually associated with tools capable of disseminating the same information to non-expert users.
3D modelling of historical heritage and, specifically, of archaeological sites allows coupling the analysis of current in situ remains with a more effective scenario, closer to the original configuration (Fazio & Lo Brutto, 2020). Virtual reality (VR) can thus foster the knowledge of the archaeological sites, the assessment and validation of reconstruction hypotheses, justifying the use of techniques, materials, and structural features. In the literature, many academic and non-academic studies, prototypes, and projects provide a general overview of both the state-of-the-art of this discipline and the implemented instrumental workflows. Among others, Younes et al. (2017) tested virtual and augmented end-user reality applications to model the Roman Theatre of Byblos (Lebanon), showing, on the one side, the limitations of modelling complex structures to be navigated by users but, on the other side, pointing out the model scalability and replicability in different sites. Denker (2017) implemented a holistic virtual representation of Palmyra (Syria), remarking the great potentiality to couple 3D modelling with printing opportunities. Among several contributions and projects, it is worth mentioning the i-MARE Culture (2016-2020) project (i-MARE Culture, 2016), aimed at the social and cultural nature, raising the awareness of European identity on the intrinsically unattainable cultural heritage of underwater maritime. This project identified three main sites: the Mazotos Village (Cyprus), the Xlendi Village (Malta), and the Archaeological Park of *Baia Sommersa* in *Campi Flegrei* (Italy) (Bruno et al., 2019). It aimed at both the creation of digital archives and the analysis of the results, fostering the implementation of professional tools. In fact, an important piece of the work was the implementation and archiving of libraries of 3D objects, also useful for the story telling through digital tools. These constituted the core for the creation of digital tools devoted to for the public enjoyment of cultural heritage. They included the virtual reality technologies for enhanced immersive visits to underwater archaeological sites, the programming of two Serious Games (Philbin–Briscoe et al., 2017) and the implementation of AR on submarine archaeological finds, in the *Baia Sommersa* archaeological site (Skarlatos et al., 2016). The scenes of the virtual environment and the programming of the Serious Games were both developed using the Unity editor.
Several authors also tried to develop more systematic frameworks to emancipate the VR use for archaeological environments (Demetrescu, 2018; Kuroczynski, 2017). An essential contribution is the 'Extended Matrix' project (Demetrescu & Ferdani, 2021). It consisted of a five-step method to overcome issues that may arise during the analysis, synthesis, and interpretation of an archaeological site. The 'extended' adjective remarks that this approach included not only archaeological stratifications but also their hypothetical reconstructions. The five essential phases of the project were: 1) Data Collection; 2) Data Management and Analysis; 3) Interpretation and Virtual Reconstruction; 4) Representation Model and 5) Publication and Digital dissemination.
The need to implement structured and comprehensive tools is however even more pressing in the last few years influenced by the pandemic. The demand for the digitization of cultural heritage and the new confidence in digital technologies of the users are indeed generating impressive potential for this discipline. Nevertheless, from a methodological viewpoint, there are still no universally accepted methods and tools for data management and visualisation of 3D reconstructions.
To overcome this limitation, in this work, several contributions were analysed to implement a comprehensive framework for the digital knowledge and fruition of the archaeological traces of the Augustan Aqueduct, the Aqua Augusta Campaniae and its terminal reservoir, the Piscina Mirabilis in Bacoli (Italy). The aim was to develop an operative approach which could help the visitors and the local communities to improve the fruition of the archaeological site with easily accessible adding information and immersive tool for the comprehensive fruition of the site. The investigation of both the Augustan Aqueduct and the Piscina Mirabilis, although partially carried out in the past, was performed to implement the proposed framework relying on two different issues. On the one hand, there are the intrinsic features of the Augustan Aqueduct, which was built entirely underground, along with the fact that the traces currently known are not easily accessible and physically usable by widespread users, especially under safe conditions. On the other hand, although the Piscina Mirabilis fortunately retains its original configuration and structure almost entirely, over the years a lack of adequate communication tools has not allowed the users to exhaustively appreciate its essence, forcing the in situ visit to an incomplete experience.
Moreover, during the last years institutional and cultural interest has been widely laid on this site. In 2020 speleological surveys investigated some sections of the Augustan Aqueduct. Subsequently, the Italian Minister for Cultural Heritage and Activities and Tourism officially visited the archaeological sites of Cumae and the Piscina Mirabilis, and finally in June 2021 one of the first Italian experiments of public-private partnership for the management of cultural sites began, involving both the Phlegraean archaeological sites of the Temple of Serapis in Pozzuoli and the Piscina Mirabilis.
To achieve the aforementioned outcomes, the first need was to define the goals and to assess the methodological approaches for the virtual reconstruction available in the literature. Although trying to design a brand-new framework capable to blend the material intervention and the imma-

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terial proposal, other tools, such as the mentioned Extended Matrix (Demetrescu & Ferdani, 2021), were considered and the same principles basing each phase were critically followed.
Section 2 provides a brief overview of the main features of the historical site; Section 3 introduces the developed framework, Section 4 discusses the main outcomes of the research, whereas Section 5 briefly sets the conclusive remarks.

2. THE AQUA AUGUSTA CAMPANIAE AND PISCINA MIRABILIS

The west region on the gulf of Naples known as Campi Flegrei shows fascinating historical and archaeological elements, being rich in Greek and especially Roman remains. Specifically, the *Baiae - Misenum* peninsula was the place of Roman villas, thermal complexes, and military headquarters. The water demand of the Phlegraean peninsula was fulfilled by designing one of the greatest works of Roman engineering, the Augustan Aqueduct, with its terminal reservoir, the Piscina Mirabilis.
The Aqueduct and all its works were built between the years 33 and 12 B.C. at the behest of Augustus after the battle of Actium (De Feo et al., 2010) and it was intended primarily to supply water to the *Classis Praetoria Misenensis*, the military fleet located in the *Portus Miseni* and consequently to the whole Campania region. It was supplied by the *Serino* springs (fig. 1), located in the limestone mountains of the Apennines, and, through several branches, it delivered water to the cities of Nola, Atella, Acerra and probably Pompeii. The main branch moved around Naples and reached Pozzuoli, Baia and Misenum, as well as Cumae (De Paola et al., 2016) (fig. 2). It was 105 km long, making it the largest Roman aqueduct of that time and the only one for both military and civil use (Ferrari & Lamagna, 2015).
Its terminal reservoir, the Piscina Mirabilis, was the largest reservoir for military use in the Roman age, with a water capacity between 10,700 m3 (Caputo & Costagliola, 2016) and 12,600 m3 (De Feo et al., 2010). Despite the importance of the subject matter, which has attracted the attention of learners and travellers over the centuries, to date the functioning of this site still shows critical unsolved issues, beyond its conformation. Its structure is divided into 5 longitudinal naves and 13 transversal naves and consists of 48 cruciform columns, which support the roof, made of barrel vaults sustained by arches. The access, designed to both regulate the water level and clean the bottom, was via two staircases, supported by three arches: one located in the south-east corner, currently obstructed, and the other located in the north-west corner, where the access still takes place today. The general paving is composed of three different levels, the side close to the longitudinal access aisle is at a higher level and slightly sloping, adjoined to the rest of the paving with steps between the columns. The part of the pavement at the central cross aisle is located at a deeper level of about 1.10 m, 20 x 5 m wide, and makes up the *piscina limaria*, a decantation device for the deposit and removal of mud and debris reaching the tank, with a sloping plane of 0.5% (fig. 3). All the vertical surfaces were covered by *cocciopesto* or *opus signinum*, which

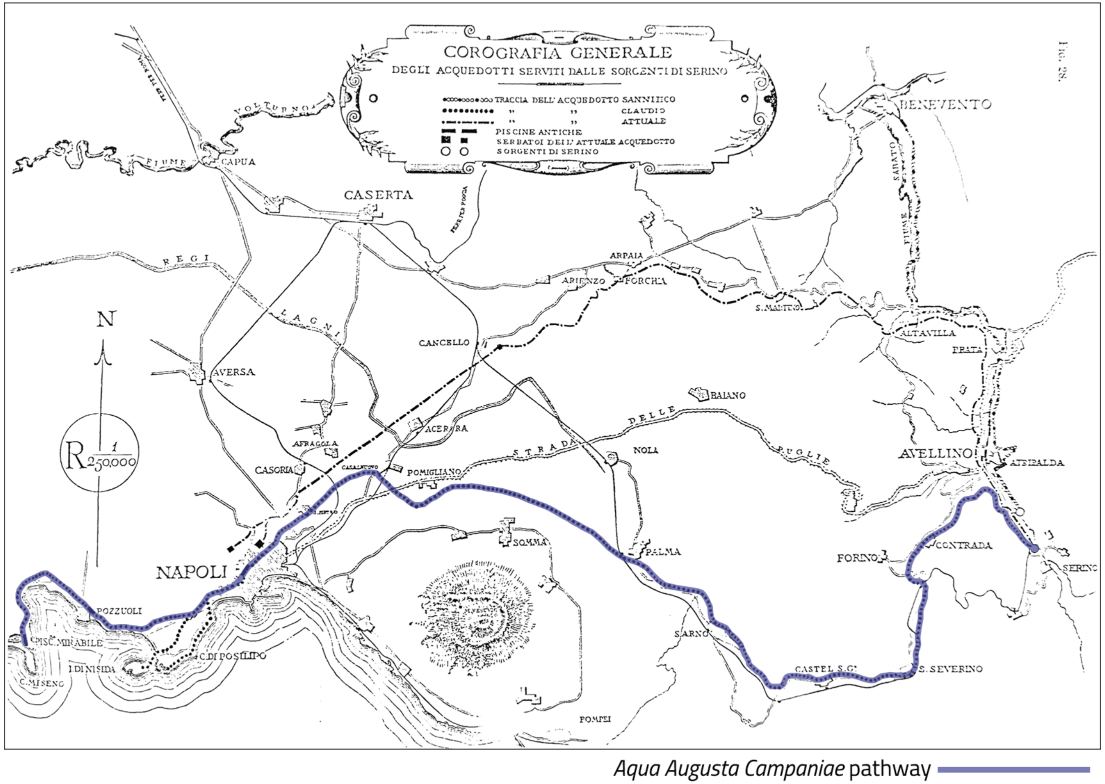

Fig. 1 - General choreography of the aqueducts served by the Serino sources (in Italian), 1842, Felice Abate, ink drawing on paper, from “Gli acquedotti di Napoli”, AMAN, 1994.

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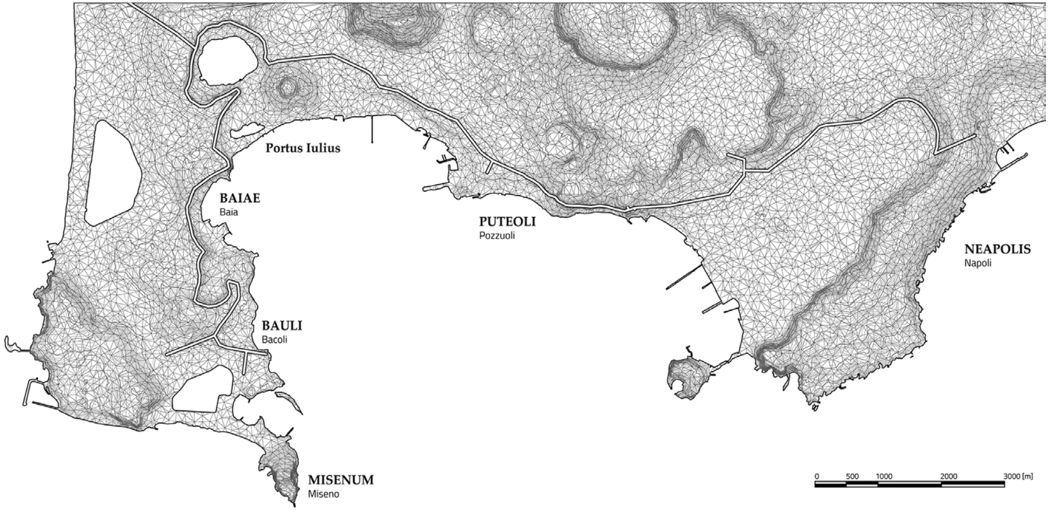

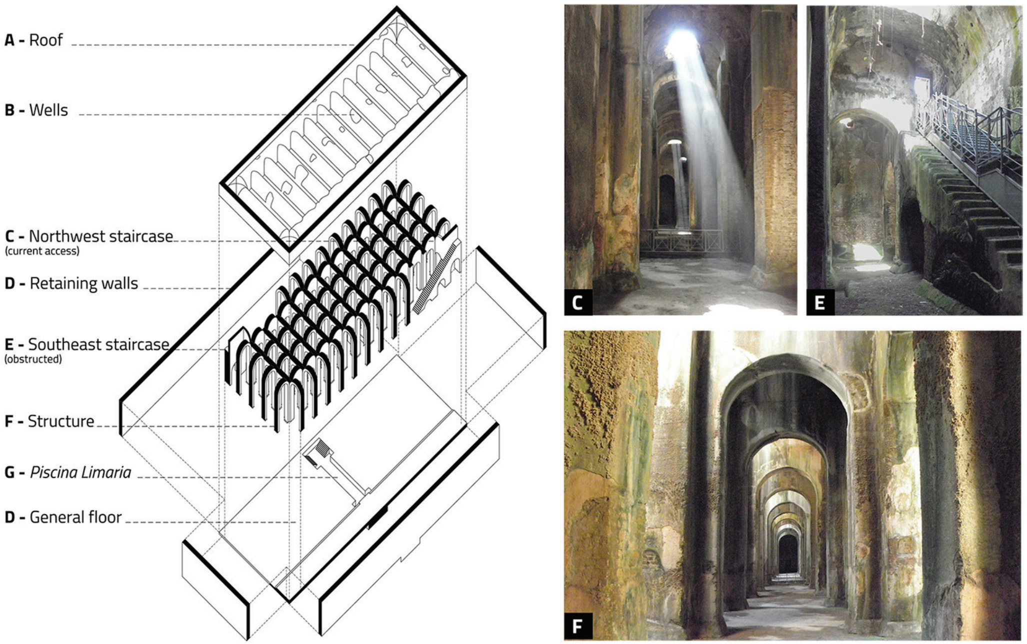

Fig. 2 - Aqueduct pathway in Campi Flegrei.

Fig. 3 - Axonometric exploded view and internal photographs of Piscina Mirabilis.

made them waterproof. As far as the ancient functioning of the reservoir is concerned, the induction duct was located at the north-west corner (Caputo & Costagliola, 2016). Finally, the water was lifted through the roof openings of the tank's central aisle. The water lifting from the inside to the outside occurred, regardless of the height of the free surface of the water stored, by amphorae which were probably moved by hydraulic wheels.

3. MATERIAL AND METHODS

The general workflow of the framework is structured of two subsequent and closely related phases, the data collection, and the virtual reconstruction, which represent the sequential stages to reach the set goals of the procedure (fig. 4). Once the bibliographical research phase was completed, the work was integrated with further information attained by in situ inspections and photogrammetric surveys of some sides of the artifact above-ground walls. These data, along with some hypotheses on the hydraulic functioning of Piscina Mirabilis and the simultaneous 3D modelling, allowed the virtual reconstruction of the site. To achieve the goals, specific tools were implemented, based on AR and applied games commercial technologies.

3.1. GOALS AND COMMUNICATION

The general concept of the proposed methodology was to create 3D interactive models that, as a result of historiographic, archaeological and topographical analyses, were suitable to simulate environments and architecture to the general public, at the same time, fostering the information collection for future research.
Different technical models were implemented for the Augustan Aqueduct and the Piscina Mirabilis.

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Recent studies on users' feedback showed that diversifying the use of techniques is a relevant strategy from a communication viewpoint, although it needs proper calibrations at varying the use type (interactive or not) and the target of active users (Smith et al., 2018). Conversely, a recent neuroscientific research questioned how digital technologies may change the experience of cultural heritage. It pointed out that nowadays the society, marked by the incessant use of digital technologies, has any information at one's fingertips, namely the so-called "Google Effect" (Del Curto, 2017).
From this consideration, the aim of this work was to improve the in situ visit of an archaeological attraction, aimed at mentally redesigning the image of buildings or of lost cities starting from the remains. This is an attempt needing specific attention and orientation skills. In this perspective, the faithful and realistic reconstruction of the architecture, the city, and the setting limits restrict the imagination of the general user (Del Curto, 2017). To overcome this issue, an effective digital representation, and thus a suitable communication language, must be properly implemented. These basic goals have led to the core of this project. The aim was to use digital technologies and make them coexist with the in situ experience, by integrating it. The digital tool may have a dual role: on the one hand, it should add information and not repeat what can be gathered on site and, on the other hand, it suggests, and not passively provides, information that is not easily understandable.
The approach applied for the Piscina Mirabilis, namely the immaterial fruition, aims at an intervention of digital anastylosis, formal, geometric reconstruction of the architecture, and easy visualisation and interpretation. It is based on the principles of architectural restoration, of "distinguishability of the interventions", with the aim of discerning what does exist from what has relentlessly been lost. Everything usable in its essence in situ is represented in an essential way, and only the geometry of the remains, that are still preserved today, is shown in the virtual environment, using the language of transparency typical of Tresoldi's works (Tresoldi, n.d.), taken as a reference for the genesis of the design concept. This artist is renowned as a creator of evanescent anastylotic sculptures, devoted to reconstructing the lost form of architecture, which has now become a ruin. In this case, the transparency simplifies the understanding of the main features of the site, not making difficult their explanation but, rather, enhancing its knowledge. Given the immaterial fruition of this language, it shows cost-effective peculiarities in terms of computational effort and strategic operation.
The viewer has the opportunity to appreciate what is still there and to imagine the complexity and majesty of the archaeological sites through the suggestion of "missing information". So, the experience of visiting acquires a priceless added value. Conversely, for the dissemination of ancient linear engineering works, such as individual archaeological sites crossing the territory even for hundreds of kilometres (e.g., ancient roads or aqueducts), a tool usable exclusively in a digital way was accounted for. In the literature, one of the most impressive approaches was conceived by Trubetskoy (2017) who schematically designed the Roman road layouts through the current language of underground routes. The designer's aim is to convey the complexity and grandeur of Roman roads to the public through graphic representations. The same communicative approach was adopted for the Augustan Aqueduct via AR. It aims at offering the additional possibility to interact with these representations, viewing 3D models and, when desired, downloading information sheets for the individual traces of the water infrastructure.

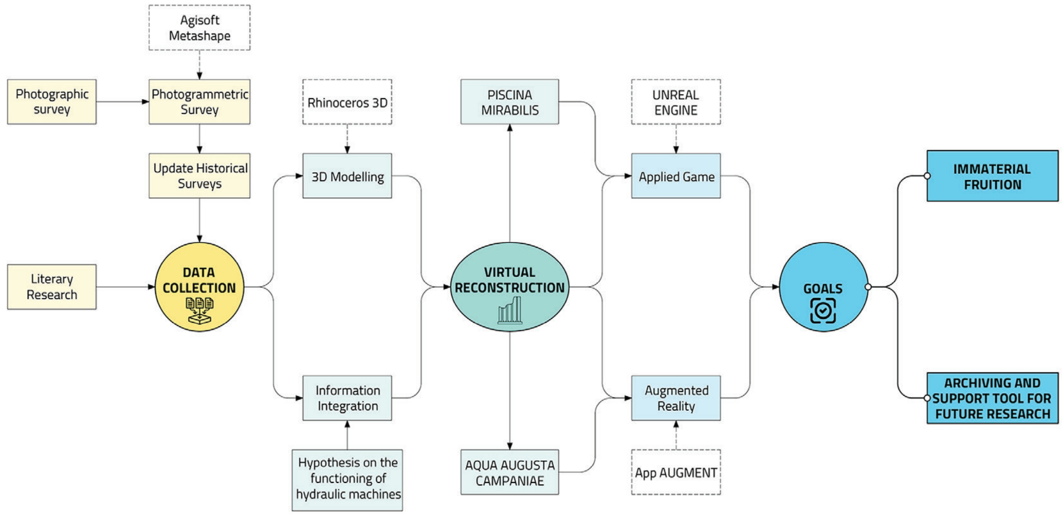

Fig. 4 - Flowchart of the implemented comprehensive framework.

3.2. DATA COLLECTION

The starting stage of the project was the information collection. Once the historiographical research phase was completed, the need was first to search for geometric and material surveys of the archaeological sites. For the Piscina Mirabilis, the historical surveys and previous graphical data from the literature preserved in public archives were analysed. Specifically, the Paoli (1768) studies (fig. 5), the more recent surveys carried out

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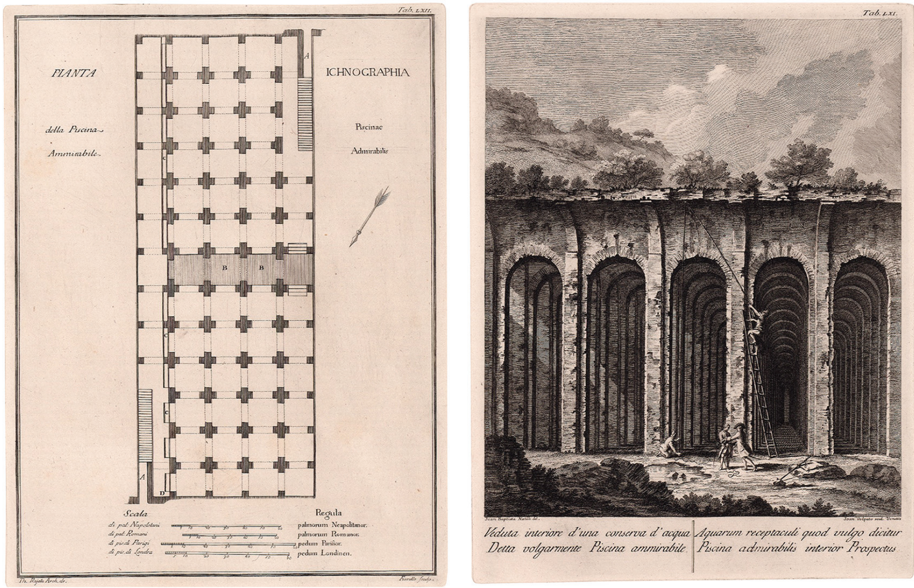

A

B

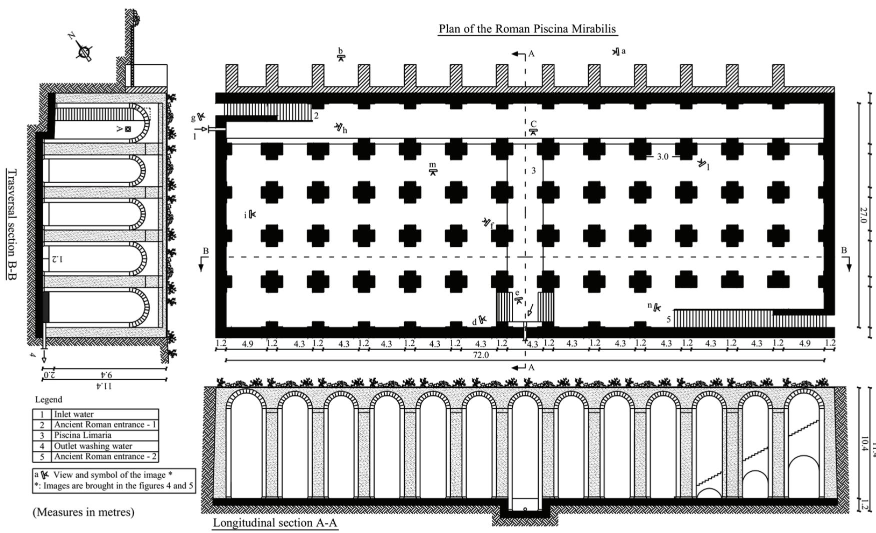

Fig. 5 - In the picture: A - TAB LXI, B - TABL LXII, Plan and interior view of "Piscina Ammirabile" (Paoli, 1768).

Fig. 6 - Plan and Sections of the Piscina Mirabilis (De Feo et al., 2010).

during the restoration of the early 20th century kept in the archives of the municipality of Bacoli, and the De Feo ones (De Feo et al., 2010) were accounted for, in the investigation (fig. 6).

To integrate these references and having the specific purpose to compare and update the 2D graphical dataset provided by the municipality of Bacoli with direct in situ measurements, the above-ground area of the archaeological site was surveyed. Nevertheless, the lateral rooms of the north-eastern side, which were most likely designated as a deposit, were not detailed because of the few information available. Even though the scope of the tool did not require a high level of detail, an ex-novo photogrammetric survey of the rooms was performed. 176 photos were taken in parallel acquisition, using a SLR calibrated camera (exposure time and focal distance of 1/50 sec and 18 mm, respectively).

Since the front was located in the north-east and the survey was carried out on a spring sunny day, the rooms did not get direct light, thus making the graphic output reliable. A typical SfM workflow was performed by using the Agisoft Metashape (2019) software architecture, providing the photo alignment and construction operations, first, of the point cloud (135'780 points), then of the dense one (147'021'795 points; fig. 7).

The 3D modelling of the archaeological site was carried out by implementing the historical surveys with the new ones. Operationally, the historical surveys, once vectorised, were the basis of a structured b-rep modelling, carried out in Rhinoceros (n.d.) environment. The implemented model was then integrated and corrected with the point clouds attained by SfM survey.

The topographical and geometrical information on the Augustan Aqueduct traces derived from explorations and speleological surveys carried out over the last decade by the Cocceius Association (Ferrari & Lamagna, 2015), which also supported

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the partial exploration of the traces done in the frame of this work (fig. 8). It allowed enriching the photographic documentation of some sections of the main branch of the Aqueduct located in the Archaeological Park of the Baths of Baia.
The analysis of the information collected is surely complementary to the data collection stage. As far as the Piscina Mirabilis is concerned, at present, the sources all agree on its use and functioning, and these are corroborated by its state of preservation, which allows appreciating it in its entirety. The only uncertainties concern its periodic emptying and the type of hydraulic machine used to move the water from inside to outside.
Different hydraulic machines were analysed from the literature. Vitruvio (1992) and Tölle-Kastenbein (1993) discussed the machines used to lift water, mainly investigating the functioning of the water wheels and of the screw designed by Archimedes. Vitruvio identified two types of water wheels: the oar-like blades type and the slap one. The former did not lift water to relevant heights, even if in significant quantities, and then poured it into a connected channel. The latter worked in the same way but reached greater heights, needing to be equipped with small tanks (Vitruvio, 1992). However, these machines were not well suited to lift water from the Piscina Mirabilis reservoir because they worked well when the water level was constant overall. A more suitable solution was the Archimedes screw. Its use at the Piscina Mirabilis would be, in any case, pretty forced because it effectively worked when inclined. So, its location in the shafts of the Piscina Mirabilis roof was quite unfeasible, given the relevant height of this reservoir.
Finally, the attention turned to the "Saqiya" (Tölle-Kastenbein, 1993), a widely used Egyptian machine, which well suited the Piscina Mirabilis operations. Indeed, it effectively worked both in steady and dynamic operations, even if a significant variation of the water level occurred inside the tank. The technological design of the "Saqiya" was thus carried out by means of a dimensional analogy, comparing the size of the wells characterising the Piscina Mirabilis by using the units of measurement of that time (fig. 9).

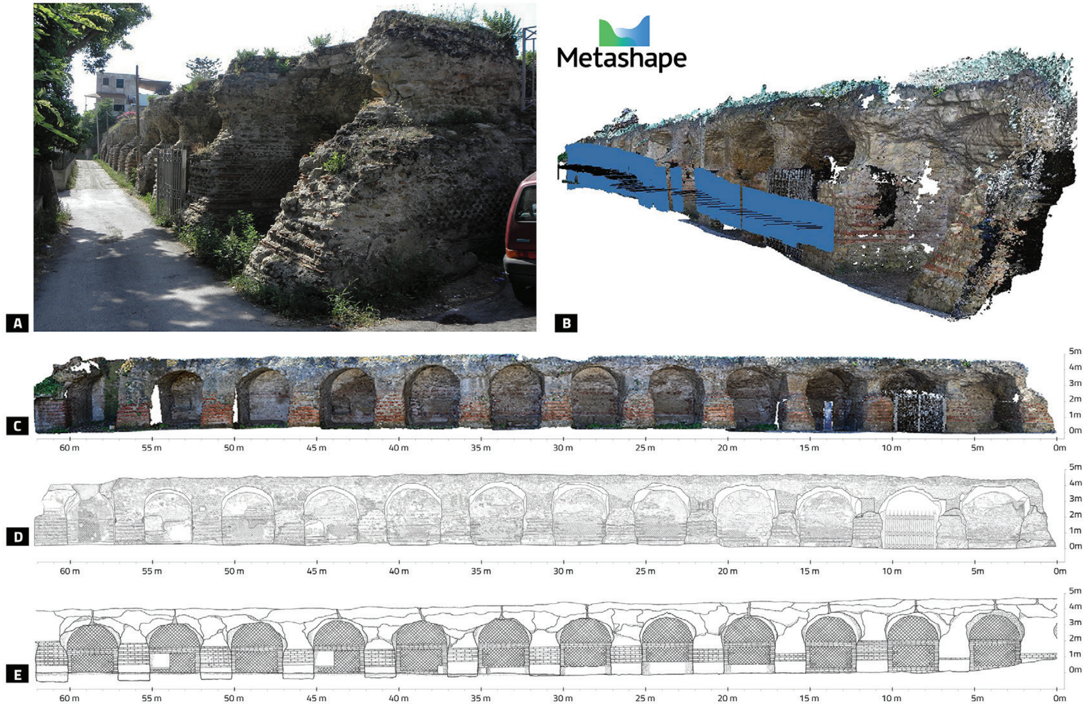

Fig. 7 - In the picture: A. Photographic survey; B. Photogrammetric survey; C. Dense Cloud; D. Material Survey; E. Comparison and updating of the survey filed at the Municipality municipality of Bacoli.

Fig. 8 - Exploration on site at the Archaeological Park of the Baths of Baia: A. Eng. R. Merone and Dr. G. Ferrari; B. C. Sections of the Aqueduct in Baia.

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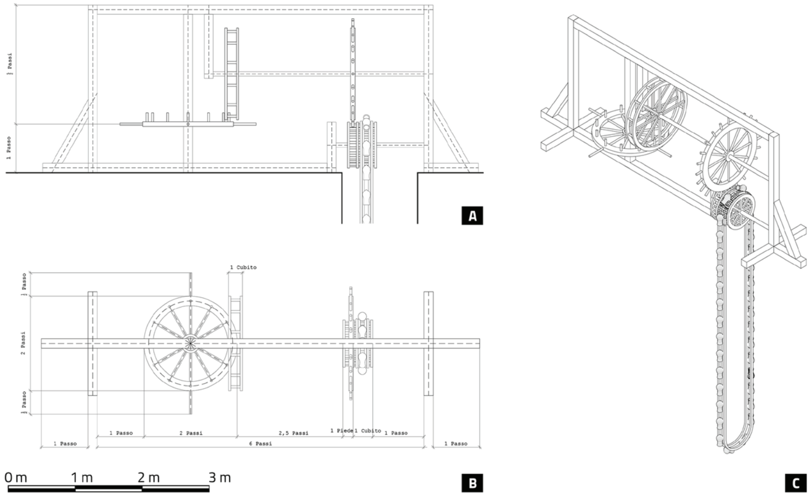

Fig. 9 - Reconstruction of the "Saqiya": A. Front; B. Plan; C. Axonometry.

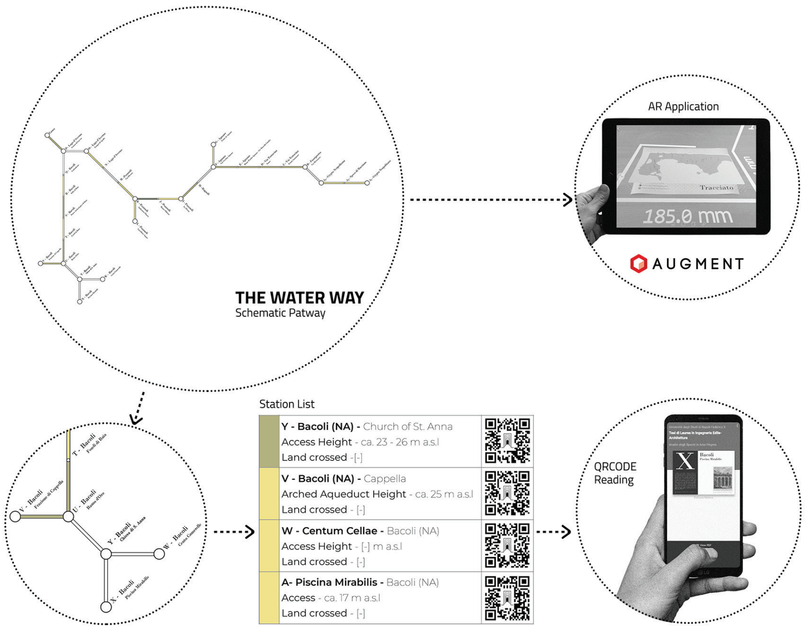

Fig. 10 - The Water Way - AR Tool.

3.3. VIRTUAL RECONSTRUCTION – THE WATER WAY

To reproduce the Augustan Aqueduct traces, AR was applied (fig. 10). The first step was to graphically schematise the route using the graphic language of underground railway routes, taking up the Trubetskoy (2017) language. Given its detailed scope among the size of Aqua Augusta Campaniae, the reading legend was structured in accordance with the state-of-the-art previously defined and the knowledge of the traces found so far (Table 1).

Legend Colour	Route
White	Hypothetical Path
Yellow	Documented and Detected Path
Brown	Documented but Not Accessible Path
Green	Probably Lost Path

Tab. 1 - Legend of traced pathway.

The diagram was then integrated by a list of the singular "stations". The latter includes a QRCODE, useful to download an information sheet, specifically created for each trace. The QRCODEs were generated using a tool generator (n.d.).

Each dataset provides a brief description of each route, the elevation above sea level, the type of ground crossed, the photographic documentation and the graphic representation (e.g., the section of the specus or its historical iconography).

An alternative approach concerns the use of the "Augment" app (n.d.). It allows first designing a 3D model to be uploaded to the cloud, and then creating a link, using the marker technology, on any device supporting the app. It was suitable for testing the digital framework even before of a specific multi-platform toolkit design.

In the frame of this work, the 3D model uploaded consisted in the mesh surface of the Campi Flegrei, themed three-dimensionally with point positions, which identify the location of the individual traces of the Augustan Aqueduct. The marker used for the connection corresponded with the route pathway. By analysing 2D vector data in the 1:5000 scale cartography of the Campi Flegrei (whose definition appeared adequate to the simulations),

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the 3D Delaunay mesh was modelled by integrating a software workflow based on meshing algorithms in Grasshopper (n.d.). A preliminary step was performed to easily export the digital outcome in the Augment App in collada. dae format.
The conceived framework was thus capable of satisfying both objectives of the research, by enhancing the integration of the immaterial fruition with the data collection and archiving of gathered information.

3.4. VIRTUAL RECONSTRUCTION – IMMATERIAL FRUITION

As aforementioned, the aim of the applied game was to provide the user with a discretisation process of the constructive and technological elements of the Roman infrastructure. This outcome was achieved through the visual scripting approach implemented in the Unreal Engine platform (n.d.) (fig. 11). The Unreal Engine game editor was chosen because of the relevant results of a recent research that compared several game editors for the design of tools supporting cultural heritage. Moreover, this platform is intended as "cost effective, offering an inexpensive solution with high visual fidelity and user support" (Smith et al., 2019).
The game was conceived as being composed of two levels: the first level took place entirely inside the Roman reservoir, useful to provide the player with all the information required to analyse the constructive elements of the Piscina Mirabilis. The second level allowed the player to admire the reservoir in its full working order (Table 2). It was set in the external part, on the reservoir roof (fig. 12). Five and two points of interest (POIs) were identified for the first and the second level, respectively (Table 2).

1st LEVEL	2nd LEVEL
Pulvini	The Tank
Piscina Limaria	
The Structure and *Cocciopesto*	
The Roof and wells	Hydraulic Machine - The *Saqiya*
The Access	

Tab. 2 - POIs of the two levels composing the applied game.

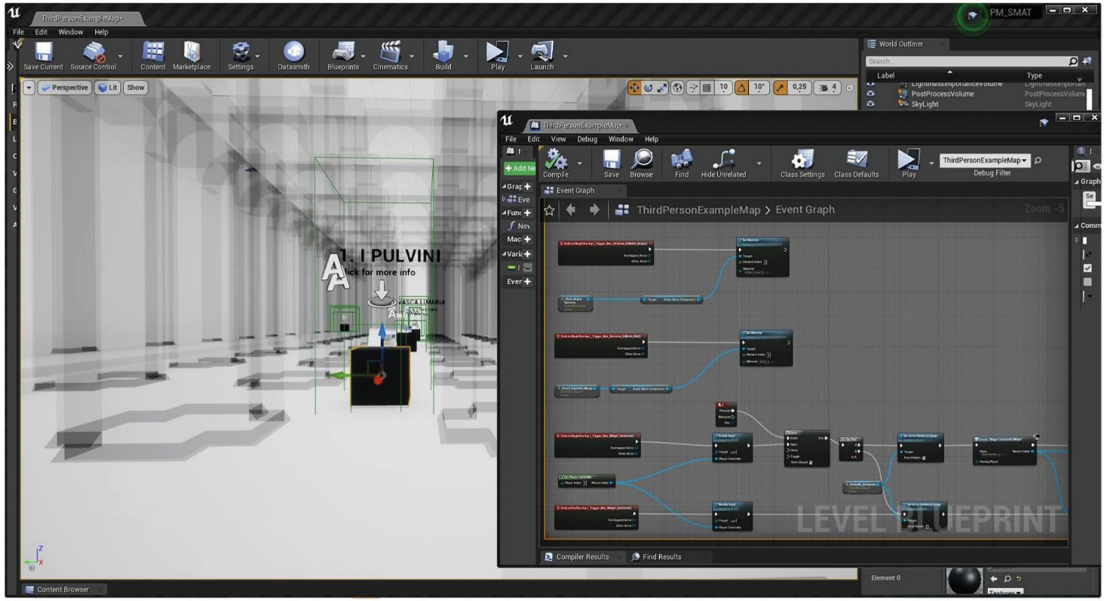

Fig. 11 - The Unreal Engine interface during visual programming operations.

The player passes the first level when he "unlocks" all the POIs. This was possible by introducing elementary objects, namely reference cubes, which the visitor can interact with. Each cube corresponds to a specific construction and/or technological element. A double interaction was programmed for each cube: first, when the user approaches the cube, the reference element appears. This was the first phase of the knowledge process, namely the visualisation and thus the awareness. Then, the user can ask the cube for further information, by clicking on it.
Given the pivotal role of Rhinoceros platform, the 3D model herein created was imported into Unreal Engine using the Datasmith plug-in to convert any vector format in solid gaming instances. Then, the final stage provided the game exporting, to make it suitable for any 64-bit laptop. For this purpose, the Visual Studio C++ plug-in was chosen for the automatic modelling of executive files under the Blueprint programming language.

4. DISCUSSION

The framework application to the case-studies remarks the flexibility of the proposed approach to be, on the one hand, strictly related to the case-specific characteristic of the site and, on the other hand, easily replicable and scalable to similar contexts. The framework is thus based on a multi-scale logic suitable to integrate bibliographic information with specific surveys and update and achieve a comprehensive overview of the case analysed. The relevant interoperability of the tools then allows customizing the operative steps and the levels of detail, at varying both the aim of the research and the information available. Starting from the principle of the Extended Matrix (Demetrescu & Ferdani, 2021), all the stages were indeed completely re-conceptualized to confer greater evidence to the multi-modelling aims and the interoperability of the framework. All these reasons brought to validate its reliability on a case-study which could

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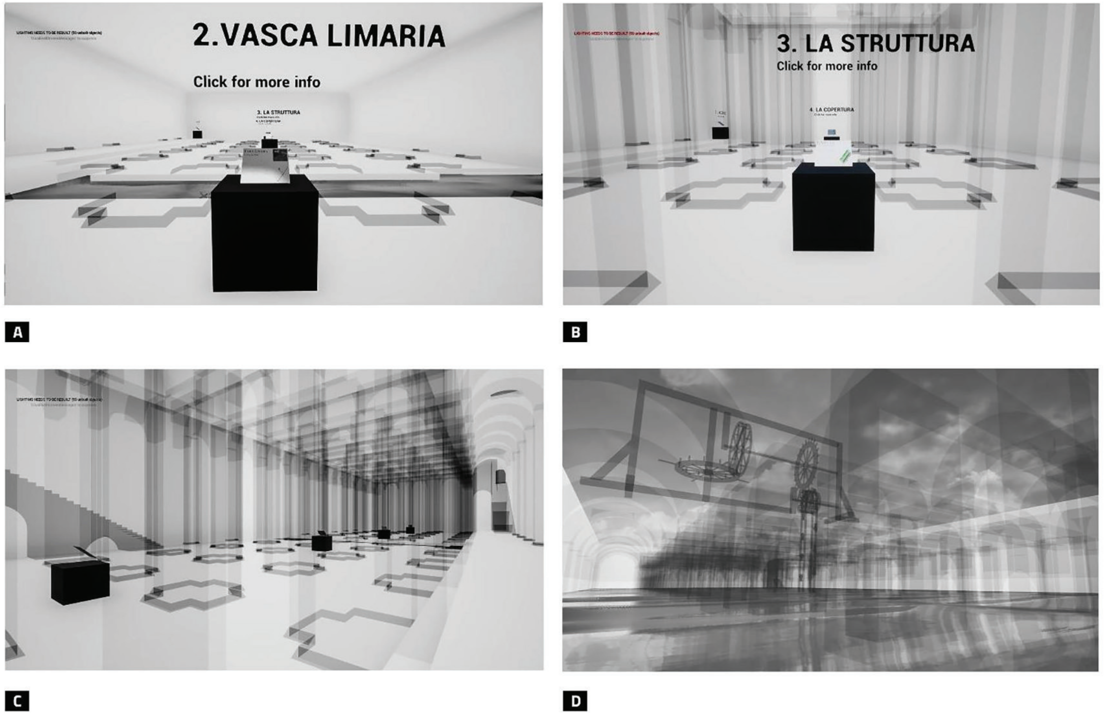

Fig. 12 - Screenshot of the Applied Game: A. B.C. First Level, D. Second Level.

easily allow testing different operative approaches (e.g., augmented reality, serious game).
As far as the Augustan Aqueduct modelling is concerned, the proposed pathway proved to be an effective method to schematically reproduce such a long historical infrastructure, giving the change to generate in-depth information sheets of the main points of interest. From the communicative viewpoint and, especially for the future developments of the proposed approach, the choice of the immaterial fruition through the Tresoldi's language of transparency (Tresoldi, n.d.), was useful to raise the aim of developing a complementary tool to the in situ visit. This technique helped to remark that the virtual modelling should be intended as an integrative, multi-users opportunity of archaeological fruition. Conversely, given its additional but not stand-alone feature, it may risk failing to be widely adopted by the youngest categories of users. Thus, the effectiveness of the modelling of Piscina Mirabilis inevitably needs the inquiry of users' feedback on their level of satisfaction.
With specific reference to the Piscina Mirabilis, the preliminary data collection involved the drive of an information database strongly disaggregated. Thus, starting from the historiographic analysis and the study of ancient engineering techniques, the methodology provided the application of photogrammetry, aimed at defining the cornerstone for the 3D modelling and the visual programming. The performed photogrammetric survey was adapted to the required level of definition. However, future deeper investigations may improve the collected data, e.g., deepening the surveying stage through the laser scanning of the entire artifact.

5. CONCLUSION

In this paper, a comprehensive framework to get archival and digital fruition tools supporting the understanding of the ancient functioning of archaeological sites is presented and discussed. The intrinsic features of the investigated sites show relevant complexities in being affordable and available to general end-users. Indeed, the Piscina Mirabilis, although preserving its structural and architectural facility, exhibits technological and engineering properties, not completely solved so far. Whereas the Aqua Augusta Campaniae, being not visible and physically accessible, cannot be appreciated in its complexity. Based on these matters, the developed framework allows overcoming site-specific hidden peculiarities. In this case-study, there was not the need to faithfully reconstruct in a virtual environment either the material textures or their original appearance. The implemented tools, as conceived, aim exclusively at the discretization and, thus, at the simplification. They could foster the assessment of the reservoir operations and, on the other side, the awareness of the engineering complexity of the Roman aqueduct. This research, resulting from a careful analysis of the state-of-the-art of such technologies, highlights the efforts to implement a univocal approach to combine the in situ visits of an archaeological site with its virtual fruition. The cultural heritage is highly diversified, in terms of current knowledge of the individual asset, state of conservation, and accessibility and physical use of the site. So, although specifically applied to the case-studies of Augustan Aqueduct and Piscina Mirabilis, the framework revealed a robust structure based on operative steps which are easily replicable to archaeological sites with comparable features. The implemented approach can be thus intended as a dynamic and flexible tool supporting the in situ visit.

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