Role of 3D Models' Representation to Understand, Communicate and Valorise Italian Eclecticism in Egypt

Nada Mokhtar Ahmed
Alfonso Ippolito
Sonia Giovinazzi

Abstract
This research explores the importance of 3D digitizing, modelling, and building representation as a base for enhancing the understanding, communication, and valorization of cultural heritage. In particular, reference is made to the representation of Italian Eclecticism, which flourished in Egypt during the 19th and 20th centuries, due to a blend of European architectural styles influenced by Italian migration to Egypt. This blend of styles reflected the cultural exchanges of the time and the selective integration of historical models. The Zafraan Palace in Cairo represents an example of this architecture and highlights the richness of Italian Eclecticism. Through a systematic methodology, a 3D model of the palace has been created, and the potential of the tools for communicating and preserving architectural Italian Eclecticism in Egypt is showcased and discussed.

Key Words:
Italian Eclecticism, 3D modeling, Culture Heritage Communication, representation, digitization.

An interior view of the palace showcasing its stained glass, with the silhouette of the Khedive statue.

Introduction

The aim of this paper is to understand how the integration of 3D models as a tool for tangible cultural heritage documentation plays a crucial role in fostering understanding, communicating, and valorising it. Integrated 3D models can be highly effective in supporting the representation of cultural heritage and in enhancing a deeper engagement and mutual cultural understanding among users from different cultural backgrounds and enhance their awareness toward its significant value.

The rise of Italian Eclecticism in Cairo during the 19th and 20th centuries was particularly influenced by Italian migration to Egypt and the subsequent establishment of a diverse community over there. It stemmed from a fusion of architectural styles influenced by European trends with the Mamluk and Ottoman architecture which already existed in Egypt [Cacciatore 2019]. The Eclectic style spread widely in Cairo's buildings, is distinguished by its architectural richness, including elements such as spherical shapes surmounted by royal crowns and columns that fill the facades and arches of windows and balconies (fig. 1). These unique characteristics make it an important heritage building that reflects the progress of architecture in Egypt at that time.

Towards the preservation and communication of both the aesthetic and functional aspects of the buildings influenced by Italian Eclecticism in Egypt. The case study is Zafraan Palace one of the richest palaces that is located in Cairo Governorate, Abbasia district, inside Ain Shams University, that was designed by the architect Antonio Lasciac in 1901 [Volait 2004] during the reign of Khedive Abbas Helmy II and was designed in an Eclectic style.

The Zafraan Palace case study illustrates the use of 3D models to understand, communicate, and valorize cultural heritage. This study can serve as a reference for similar research aimed at enhancing knowledge, preserving, and communicating the cultural, humanistic, and artistic values of such buildings. This approach fosters public awareness, deeper understanding, and appreciation of cultural heritage, ensuring the continuity of cultural and historical education.

Fig. 1. Image showing the Eclectic elements in the Facade of the Zafraan Palace, in Cairo, Egypt, that was designed by the Italian architect A. Lasciac in 1901.

Methodology

This study employs a multidisciplinary approach that integrates advanced digital technologies with historical and cultural research to document, analyze, and communicate the architectural heritage of Italian Eclecticism in Egypt. The methodology follows a structured process encompassing data collection, 3D modeling, analysis, and interpretation.
Initially, extensive historical and archival research is conducted to gather information on Italian Eclecticism, particularly focusing on Zafraan Palace. This includes architectural drawings, photographs, historical documents, and literature review to provide a comprehensive background. Next, digital documentation techniques such as Terrestrial Laser Scanning and Structure from Motion (SfM) photogrammetry are employed to create accurate and detailed 3D models of the palace. These models serve as a basis for analyzing architectural elements, spatial organization, and stylistic features.
The 3D models are then enriched with contextual information, allowing for better visualization and interaction. This facilitates an enhanced understanding, communication, and valorization of tangible cultural heritage (fig. 2). Finally, the study discusses the role of 3D models in cultural heritage preservation and education, ensuring their significance is recognized and appreciated by diverse audiences.

3D Models, Digitization to Understand, Communicate and Valorize

The multifaceted nature of a heritage building allows us to perceive it through various lenses: as a dwelling, a repository of memories, and an embodiment of ideas. Traditionally, buildings were regarded primarily as physical entities as a tangible extension of human existence. However, the advent of technology over the past half-century has revolutionized our approach. Architects and researchers now have the methods to capture buildings in digital form, allowing for deeper understanding and interactive exploration [Bonacini 2013].
The case study of Zafraan palace as an example of eclectic architecture was chosen to apply the digitization and modelling tools and methods.
The utilization of diverse 3D scanning technologies has afforded us a unique opportunity: to capture architectural structures not only as a forms, but as compositions of space, and RGB. These digital representations, residing within our computational realm, enable meticulous examination of architectural element revealing intricate details through close-ups (fig. 3).
Beyond surface aesthetics, these 3D models serve as conduits for deciphering the architect's latent intentions [Attenni *et al.* 2022]. The spatial arrangement of a building conveys the designer's intentions to its users. By analyzing how spaces connect and relate to each other, we can understand the underlying concepts that shaped the building's design.
From an architectural perspective, digitization and 3D models emerge as potent tools that allow us to read the building like a layered narrative, analysing its form, function, and cultural significance. Simultaneously, these digital foundations serve as springboards for subsequent endeavours: the creation of 2D drawings, analytical investigations, and comprehensive documentation.
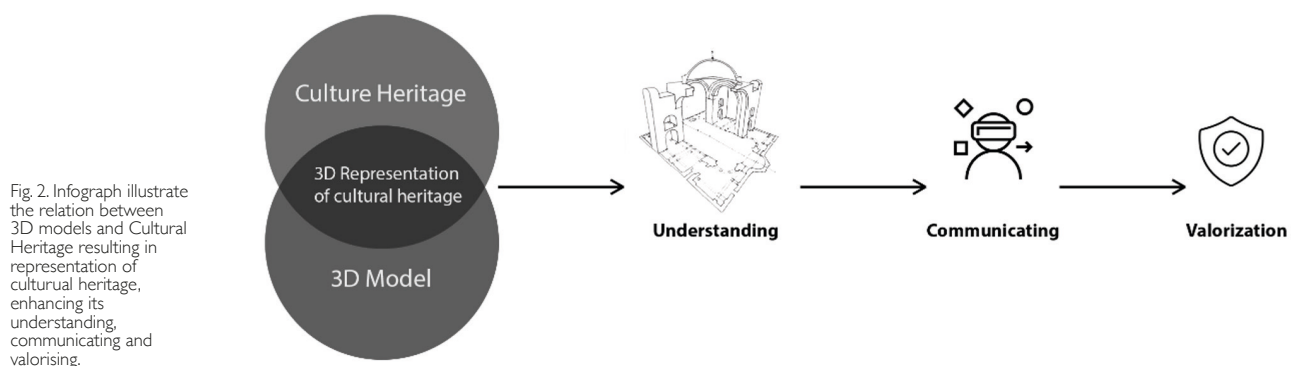

Fig. 2. Infograph illustrate the relation between 3D models and Cultural Heritage resulting in representation of culturual heritage, enhancing its understanding, communicating and valorising.

Fig. 3. Pointcloud of Zafraan Palace, the Main Entrance (image by the authors).

In this convergence of technology and heritage, architects and researchers find a shared canvas that bridges the tangible and the intangible, the historical and the contemporary. Conversely, the adoption of 3D models and digitization has significantly enriched the communicative experience surrounding architectural structures and cultural heritage [Bianchini, Russo 2018]. In this paper, the authors study from a theoretical and practical point of view and state of art, as well as discuss how 3D models as a base to facilitate understanding and valorisation of a building's intrinsic worth, cultural significance, and historical context. This approach democratizes access, rendering complex architectural narratives both comprehensible and approachable to the wider public.

Fig. 4. Perspective view of the 'numerical' model of the Zafraan Palace (imagine by the authors in 2023).

Data Acquisition, Elaboration, and 3D Models

To go through the data acquisition, a combination of surveying methodologies and tools are used during the acquisition process including long and short-range scanning and photogrammetry for Structure From Motion.

Based on the architecture survey that is done Zafraan palace and the data gathered in form of point-clouds generated from either Terrestrial Laser Scanning or Structure from Motion photogrammetry, two-dimensional (2D) and three dimensional (3D) representations are the result of a massive data aquistion process. The elaboration of those models allows us to move around it through the model using 2D and 3D elaborations in a transitive manner. The survey and analysis of the Zafraan palace, was conducted by the Department of History, Design and Restoration of Architecture Sapienza University of Rome combining different technologies to obtain a point cloud (Fig. 4) the 'numerical' model.

The term point cloud refers to a model whose shape is described through the *x, y, z* spatial coordinates of individual points. The survey was done in March 2023 as a part of international student workshop in Ain Shams University in Cairo.

The survey was performed using a 3D laser scanner Leica BLK 360 on the exterior of the palace, which has a high accuracy when registering the various point clouds (in this case, registration error was less than 3 mm). Once this stage –acquisition, registration, and 'cleaning' of the data– was completed, the general point cloud consisted of 150,700,000 points. The 3D scanning was mainly for the exterior 4 elevations missing the detailed scanning for the roof and the interior as the palace was going through renovation works, the scanning was done through 23 scan positions with average distance 18 m (fig. 5). And to merge all point cloud we used *Leica Cyclone REGISTER 360 PLUS*.

The *Autodesk Recap pro* was the software used to review the scans, point cloud, and clean the noise caused by the extra scanned point. For the 2D elaboration *Autodesk AutoCAD* was used going through UCS modification and sectioning the point cloud to have clear point cloud for each elevation individually (fig. 6), those methods were the starting point to make cognitive progress prior to elaborating a mathematical model.

Fig. 5. A layout illustrating the quantity and locations of the scans conducted to document the exterior of Zafraan Palace.

On the other hand, to obtain more data and details, we had done the Structure from Motion photogrammetry processing using the *Agisoft Metashape pro* software, to generate the dense cloud and orthomosic image. It was used in the next step of the 2D models. This point-cloud was used to develop 2D model and drawing that was done to understand on a deeper level the elevations of the palace with its significant eclectic solutions and patterns used by Lasciac, introducing a new architecture style in Egypt (fig. 7). thereby creating 3D models with a level of detail in line with their scale of representation.

This allowed us to create different scale 3D models, ranging from 1:200 to more detailed 1:20 scale models. The 3D point cloud and 2D elaborated models were used to understand the building and to elaborate the 3D mathematical model using rhinoceros 3D modelling software, which is used to deeper understanding of the palace's eclectic architecture and solutions and is used further works that will be mentioned later on in the paper (fig. 8).

The Use of 3D Digitization and Modelling to Understand Italian Eclecticism

Digital models of Zafraan Palace are proposed to identify its distinctive features, which is done to study the representation's goal and the similarities between the drawn and built model. It is evident that the terms 'design' and 'representation' are closely linked, both in a theoretical point of view and operational practice.

Focusing on this issue highlights the crucial role of architectural representation in design culture and the knowledge of what exists. Graphic models often reflect the way we interpret architecture and summarize different features, thereby conveying knowledge of expertise (as researchers and architects) as well as the public users.

Fig. 6. Screenshot from *Autodesk AutoCAD*, illustrating the insertion of the pointcloud to the software to start with the next phase, which is the 2D modelling .
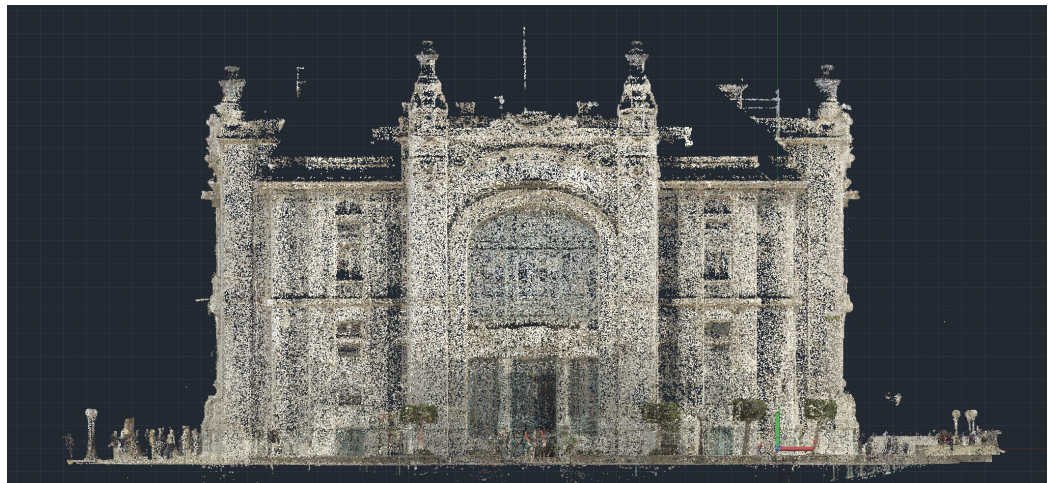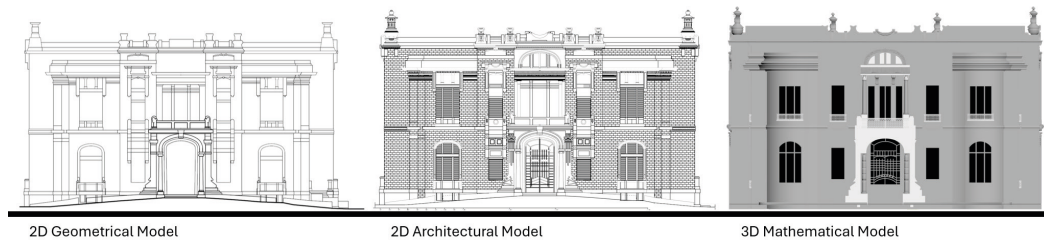

Fig. 7. 2D geometrical model of the South Elevation of Zafraan Palace, based on the pointcloud.

50

Fig. 8. Infograph illustrates the stages of the data elaboration, starting with 2D geometric model passing through the detailed 2D architectural model, reaching the 3D mathematical model.

| 2D Geometrical Model | 2D Architectural Model | 3D Mathematical Model |

The study of the role of the 3D model played with its integration with the different concepts and methodologies, revealing how the representation can make it possible to propose new interpretations of the building from all angles, starting with its spatial and contextual comprehension and thus its structure and proportions as an architectural organism.

To accomplish this, it is necessary to highlight several of its unique characteristics in a virtual environment. For instance, the objective of the digital model was to bridge the gap between the current era and that of Lasciac's by analysing and interpreting the architect's architectural solutions and ideas (fig. 9).

Acquisition of survey data done by the authors using integrated methodologies as laser scanning and Structure from Motion photogrammetry and the analysis of ensuing numerical models which is summary of the survey data that records every single metric and RGB information acquired. This method involves dismantling the physical structure into its individual components and then reassembling them within a digital environment. It calls for recognizing a specific language to identify the formal arrangement of the parts. The palace's mathematical model was created by the author based on survey data. The numerical model was analysed, and its primary elements were identified. (fig. 10).

Although the 3D model provides a visual representation of the palace, it also highlights how representation techniques shape our understanding of architecture. The choice of using 2D or 3D models affects what data we prioritize during the survey and how we interpret the building, often leading to new questions and insights.

The Use of 3D Models as a Base for Cultural Heritage Communication

Technology and graphic communication, particularly through 3D models, have consistently driven innovation in architectural representation. Regarding the dissemination of architectural information, 3D modeling allows for the virtualization of unbuilt designs or complex architectural structures, giving form to concepts that previously existed only in the designers' minds [Ippoliti, Meschini 2010] (fig. 10).

These digital tools not only facilitate efficient management and monitoring of cultural heritage but also offer new possibilities for public engagement and education, ultimately contributing to the valorisation and sustainable preservation of cultural assets. Since Zafraan Palace is one of the richest palaces that follow the Italian Eclectic architecture, that Italian architect Antonio Lasciac was very creative while designing it, that appeared in his choice

Fig. 9. Images depicting the eclectic ornaments in the palace's interior. Right: ceiling painting; left: ornament with the abbreviation of the name of Khedive Ismail.
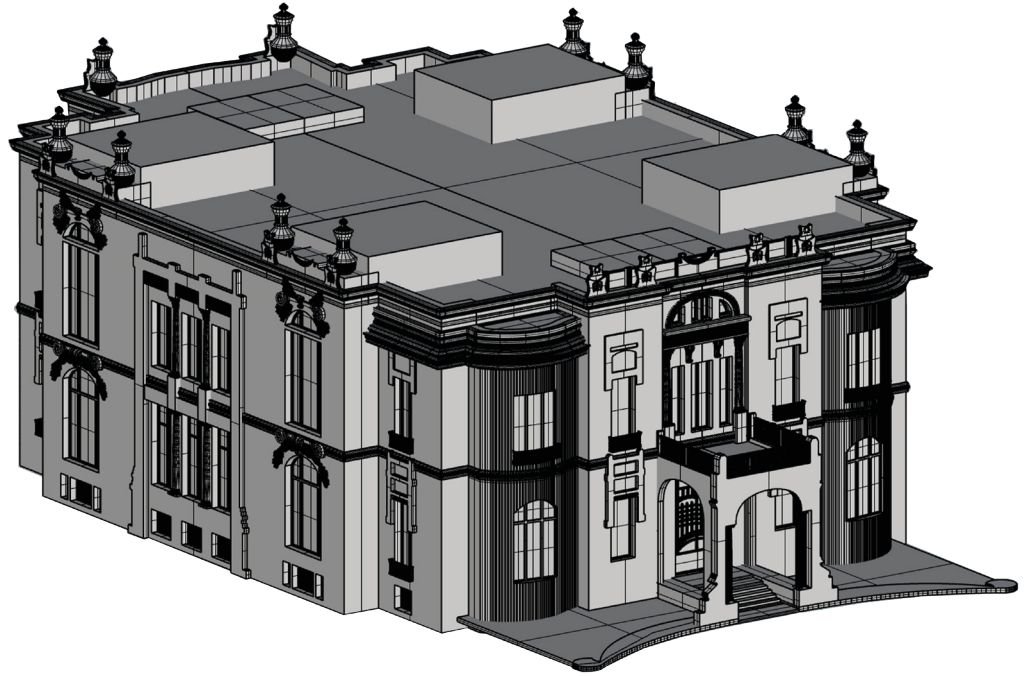
51

Fig. 10. 3D mathematical model of the Zafraan Palace (image by the author based on the pointcloud).

of significant elements (fig. 11) as the Corinthian orders to add at the elevations, the use of the stained glass and the ornamental window steel, moreover the different horizontal entablature, cornice and vertical ornaments.

This research it experiments with the possibility of interfacing the model in ways that offer the user the possibility of obtaining information from it in a dynamic and interactive way, acquiring a spatial and volumetric awareness of the object studied, which would otherwise be difficult to understand (fig. 12).
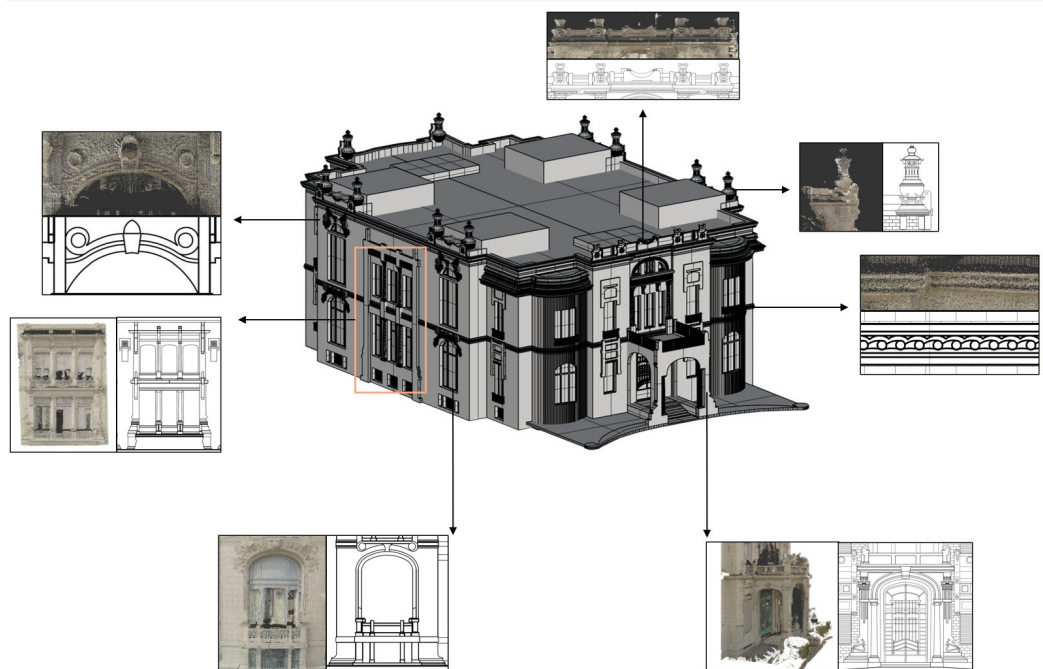
Fig. 11. Photo done by the author, to clarify the use of 3D model to manifest the eclectic features at the Zafraan palace.
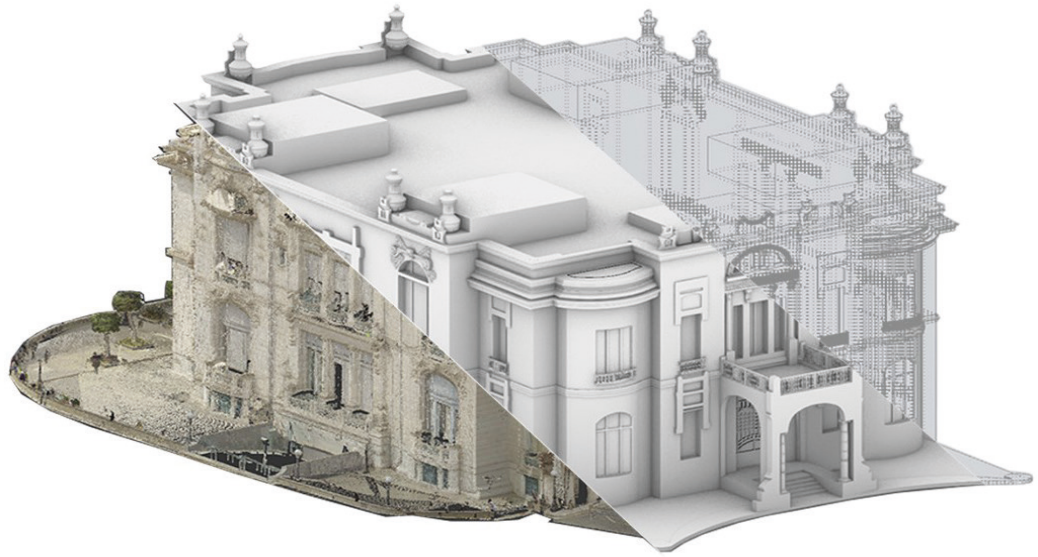
52

Conclusion

After studying the Italian Eclectic architecture in Egypt and focusing on Zafraan Palace by Antonio Lasciac as a case study, the research obtained a comprehensive understanding of this architectural style in its 1D, 2D, `and 3D aspects and characteristics. This study opens the path to further exploration of the 'Architect, Element, and Pattern' paradigm. By analysing Lasciac's work, we can discern the specific elements he employed and the patterns he followed, revealing how Italian eclectic architecture was influenced by and, in turn, influenced the surrounding context.

As a result, 3D models have proven indispensable in understanding, communicating, and valorisation this style of architecture. They offer a dynamic and interactive means of exploring architectural details that might be challenging to grasp through traditional 2D representations. 3D models were used for facilitating a deeper appreciation and understanding of Lasciac's design choices and the broader context of Italian eclecticism in Egypt especially in Zafraan Palace. These digital tools also bridge the physical and virtual worlds, enabling continuous information exchange and promoting sustainable preservation practices.

In conclusion, the study of Zafraan Palace through the lens of 3D modelling theories, practices and state of art underscores the importance of advanced digital techniques in preserving architectural heritage. These models not only serve as educational and communicative tools but also ensure that the rich legacy of Italian eclectic architecture in Egypt is accessible to future generations. Reading the intricate patterns and cultural narratives embedded within these historic structures by understanding it and raising awareness of the users about its significant value.

Reference List

Attenni M., Bianchini C., Griffo M., Inglese C., Ippolito A. (2022). Learning through models: Sapienza campus in six shots. In C. Bartolomei, A. Ippolito, S.H.T. Vizioli (Eds.). *Digital Modernism Heritage Lexicon*. Springer Tracts in Civil Engineering. Cham: Springer, pp. 643-660. https://doi.org/10.1007/978-3-030-76239-1_28.

Bianchini, C., Russo, M. (2018). Massive 3D acquisition of CH. In *Digital Heritage* 2018, pp. 1-8. https://doi.org/10.1109/DigitalHeritage.2018.8810069.

Bonacini E. (2013). Communication and enhancement of Italian cultural heritage by Google. In *Palabra Clave (La Plata),* 2, pp. 49-63.

Cacciatore N. (2019). Missed connection: Relations between Italian anti-fascist emigration and British forces in Egypt (1940-1944). In *Modern Italy,* 24. https://doi.org/10.1017/MIT.2019.3.

Ippoliti E., Meschini A. (2010). From the '3D model' to the '3D scene': Perspectives and opportunities for the enhancement of architectural and urban cultural heritage. In *DisegnareCon,* 3(6), pp. 77-91.

Volait M. (Ed.) (2004). *Le Caire - Alexandrie. Architectures européennes. 1850-1950.* Cairo: Institut Français d'Archéologie Orientale (IFAO).

Authors
Nada Mokhtar Ahmed, Sapienza Università di Roma, nadamokhtar.ahmed@uniroma1.it.
Alfonso Ippolito, Sapienza Università di Roma, alfonso.ippolito@uniroma1.it.
Sonia Giovinazzi, ENEA Centro Ricerche, sonia.giovinazzi@enea.it