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# 3D for Studying Reuse in 19th Century Cairo: the Case of Saint-Maurice Residence

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**Figure 1:** One of the challenge for the 3D restitution of Saint-Maurice residence (upper-right) is the collection and aggregation of multiple documents in multiple formats: colored photographs (upper-center, 1908 or 1926 by Jules Gervais-Courtellemont – National Geographic Society, Washington, D.C., US), photogrammetric 3D survey (doors at upper-right, fall 2019 – French Embassy, Cairo, Egypt), architectural blueprints (lower-left, Archives rapatriées des postes diplomatiques et consulaires, Nantes, France), watercolors of cross-section (lower-center, 1921 – location unknown), black and white photographs (lower-left, 1875-1879 by Beniamino Facchinelli – Bibliothèque de l’Institut national d’histoire de l’art, Paris, France).

## Abstract

3D restitution is now a well-known tool to validate hypotheses on historical buildings that do not exist anymore. The present project takes the method a step further in order to explore the art historical topic of ornament reuse in 19th century revival architecture, particularly in Cairo. The case study is the Saint-Maurice residence, built 1875-79, for which an extensive collection of documents in varied formats, and from multiple locations and disciplines, has been conducted. The paper presents some preliminary results on the 3D restitution, the remaining open questions and the challenges they raise.

## CCS Concepts

• Applied computing → Arts and humanities; • Information systems → Digital libraries and archives;

## 1. Context: Reuse in 19th-Century Cairo

Although mostly associated with Antiquity and the Middle Ages, architectural reuse represents a widely disseminated practice in Europe and beyond, all throughout the nineteenth century. In Middle Eastern capitals such as Cairo and Damascus, salvage purchased from dilapidated or under-renovation sites was repurposed

as rich material for flooring and dados (marble), doors and furniture (woodwork), paneling (ceramics), and ceilings (painted plaster) [Vol12]. These architectural arrangements are identified nowadays as belonging to *Islamic Revivalism* [FN17]. It was also common practice to sell installations of World’s fairs for future reuse, once the events were over: an Egyptian pavilion from the 1867



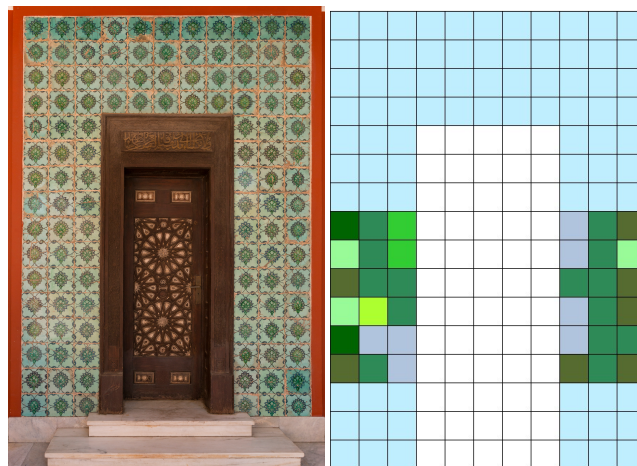
**Figure 2:** The ceiling of the main lounge as it appears in photographs (upper-left, 1887 by Beniamino Facchinelli – Bibliothèque de l’Institut national d’histoire de l’art, Paris France), in the current French Embassy in Cairo (upper-center, photographs by Dominique Roux – 2001 and upper-center, our 3D acquisition – 2019) and as cast (or original?) in the collections of the Victoria and Albert Museum (lower-right). The latter was displayed during the 1878 Universal Exhibition in Paris (as shown in the lower-left, *L’Illustration*, n° 1872, 2nd of November 1878, p. 277).

Universal exhibition was reinstalled as an artistic studio and residence near Paris [Vol09]. Part of the *Pavillon des Indes*, presented by Great Britain at the 1878 Universal Exhibition, survives today in the vicinity of Paris (Courbevoie).

Islamic reuse was promoted in Cairo by French expatriates in the 1870s, a major instance being the Saint-Maurice residence. Built in 1875-79, the structure associated salvage, with replicas of historic ornament from Cairo’s monuments and Revival pieces designed on purpose. The structure was dismantled in 1937 but partly reconstructed in another location in the same city. Although the building does not survive in its initial form, dispersed remains do exist, as well as an extensive documentation (drawings, plans, photographs, texts) on the initial project (e.g., Figure 2). The aggregation of visual and material evidence thus allows to provide with color (and more) historic views, which are mainly monochrome, while offering the possibility to simulate a large decorative scheme which no longer exists in its original condition.

Such a restitution [GBC\*21] is a challenge since it extends the notion of 3D puzzle (e.g., [PH14]) with documents in multiple formats, together with existing salvage scattered in distinct locations, either originals or copies, in modified form or not. It requires large surveys to collect and complete the required documentation. By putting together all available evidence, the 3D representation can help to explore some hypotheses regarding ornament reuse.

A colored 3D model leads to a visual restitution of the richness of the studied object. However, there is a need to go beyond classical 3D survey and closer to physical characteristics in order to formulate hypotheses on salvage reuse. A first step is the acquisition of appearance (e.g., [SWRK,SKM12]). However, the metrologic aspect of existing technologies and models [GGG\*16,Don19] are not sufficient to answer the art historical questions raised by such type



**Figure 3:** Left: Photo of one of the exterior door in the French Embassy, framed by Iznik ceramic tiles. Right: Clustering realized on these tiles by hyperspectral classification of pigments.

of architecture: a visual model is not sufficiently for characterization of the underlying physical, chemical and optical properties. Indeed, as for metamerism in color, multiple physical compositions can lead to the same visual appearance. This is the second challenge of the study: how to acquire information that links more closely the visual aspect with the physical characteristics, in the limited field of study. Moreover, this acquisition has to be on-site, in a non-invasive and non-destructive way.

## 2. Intensive Documentation

### 2.1. Iconography and Photogrammetric 3D Survey

As illustrated in Figure 1, the 3D restitution relies on an extensive collection of numerous multi-modal records. Access has thus been gained to original architectural blueprints and plans (for the first floor), watercolors, paintings, black and white or color photographs, texts, etc. The trove has been complemented by modern photographs of potential casts, copies, or originals of some decoration elements identified on-site or in museum collections (e.g., Figure 2). More pictures of related decorative elements and documents are progressively being made publicly available for further research [VCM\*21] thanks to the Archeogrid platform [TVD20].

During Fall 2019, a large photographic and 3D survey was conducted inside the French Embassy in Cairo where part of the initial structure had been relocated. Due to limitations in working time (we had access to the embassy only during 4 days for the whole survey) and available access, we opted for a photogrammetric survey, with special focus on potential reused decorative elements, such as doors, ceilings, facings of the main lounge, and exterior fountains.

### 2.2. Beyond Classical 3D Survey

The acquisition mission conducted at the French Embassy offered the opportunity to go further in terms of on-site measurement. Special attention was devoted to the ceilings and Iznik-like ceramics that raise substantial questions in terms of art history.

The current ceiling displayed many features, such as gilding and painted wood (or plaster?). At closer look, it appeared that some parts differed when compared to historic photography (see Figure 2). These decorative elements may have been replaced, reused



**Figure 4:** Left: An hyperspectral image of an Iznik ceramic tile (converted in RGB). Right: Image obtained by classifying each spectrum of each pixel in 8 groups.

with or without cutting, with or without repainting. The issue of repainting required some material and appearance characterization in order to achieve a more realistic visualization. An acquisition of appearance was thus carried out in order to characterize the reflectance of the materials used. However, such an acquisition has several constraints. First, it is an on-site acquisition of SVBRDF with a ceiling over 10 m long at 7-m high. Light dome methods (e.g., [SWRK]) cannot be applied at such a scale and on-site, because of portability and sample size. Moreover, as mentioned before, there were significant time limitations to our measurements. Reflectance Transformation Imaging (RTI) [MP18] therefore seems to be interesting because of its speed and its installation in an uncontrolled lighting environment. However, RTI only uses a single light probe, approximates the light source used as being at infinity and has only one point of view. Rigorous appearance acquisition implies to multiply images with different points of view and positions of light, and to record precisely these positions with respect to the studied object. For this, we adapted the method of Corsini *et al.* [CCC08] by placing two lights probes and a fixed camera in front of the scene.

We intended to proceed further regarding the study of Iznik glazed ceramic tiles. The tiles (e.g., Figure 3) surveyed in their current site present patterns characteristic of the Iznik production that can be found on many historic buildings in present-day Cairo [AV17]. To identify their provenance, there is a need to acquire data beyond 3D and RGB images of many tiles: as opposed to [BRFPV14], the availability of on-site spectral imaging (e.g., Specim IQ) leads to the potential identification of the pigments used. The challenge is to seek the possibility of highlighting groups, or identifying somehow clear tendencies within groups of ceramics sharing similar patterns. Hyperspectral imaging of ceramics seems to be an interesting, fast and, non-invasive method to achieve such goal according to conclusions of Farjas *et al.* [FRMZ]. The hope is that hyperspectral images of ceramics will be used to perform semi-automatic classification. First, a pixel-based segmentation may lead to an image of pigments which would allow classification by pattern in a second step (e.g., [Bic18] – see Figure 4). Second, a clustering of tiles by similarities on spectra (i.e., pigments) would help to identify groups with higher probability of distinct origins in workshops or craftsman’s hands. First experiments using k-means shows some coherent trends (see Figure 3) that need to be validated by art historical research.

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### 3. Restitution of the Saint-Maurice Residence

#### 3.1. Approach

This 3D restitution was difficult due to the available fragmentary documentation: while there was abundant historic iconography, there were no rigorous architectural plans nor detailed surveys of ornament. The building possessed yet a relatively singular plan, but a complex decorative scheme. In order to reproduce the structure faithfully, the approach followed was to make an extensive use of a particularly valuable ground plan. This document allowed correctly placing the first floor of the building, while the two upper floors were modeled on existing sections. The decorative scheme was modeled based on historic photographs. Concretely, we manually superimposed the old photographs on the 3D model in order to place the architectural decoration carefully.

Finally, it is important to highlight that the restitution was enhanced by the acquired photogrammetric 3D models, which keeps part of the Saint-Maurice residence. These data guided and solved certain issues linked to the modeling process.

In brief, the shortage of detailed architectural data obliged to make full use of the plans, surveys, and photographs at our disposal. Thus, the approach consisted in creating a synergy between all available data by synthesizing them in a 3D model, which also raised important questions about the restitution.

#### 3.2. Questions to answer

This restitution revealed several differences between the plans and cross-sections of the building (see Figure 1). It is certain that the available plans record the original condition of the Saint-Maurice residence. The available cross-sections may describe however an earlier version of the building. These differences raise a number of issues about the 3D model: in particular, which sources should be favored? In this case, priority was given to the plans. In addition, the cross-sections provided an idea of height, but could not offer precise dimensions. If such data are valuable, they yet come up with questions about their fidelity to the original building.

#### 3.3. Results

Although not all documents offer the same guarantees, it is possible to model the upper floors using common sense. In other words, it was essential to use the most accurate first floor plan as the most accurate basis. From there, the upper floors could be modeled by extruding the load-bearing walls. In addition, we used the plan of the first floor to complete the whole process. Moreover, the fact that the photogrammetric model of *main lounge* ceiling matches the 3D model (see Figure 2) has validated this approach. This room centralized the distribution of the other rooms on the first floor. The proportions of the ceiling of the *main lounge* were essential to determine the position of the different walls around.

Concerning the elevations, the photogrammetric surveys of the doors on their current location (French Embassy) have made it possible to refine the data proposed by the sections, and at the same time to consolidate our hypothesis of restitution.

Lastly, the rectified photographs provided valuable textures for the floors and walls of the entire building. This is the case namely for the patio and for the *main lounge*. Similarly, we replaced the photogrammetric surveys of the polychrome tiles at their initial place, thanks to a corpus of old photographs. The combination of all



**Figure 5:** Two views of the 3D restitution of the Saint-Maurice residence compared with historic photographs. Left – the main lounge decorated all the ornaments we had acquired. Right – an external view.

these data, together with our approach based on the full use of this information and the supervision of an expert of the Saint-Maurice residence, has led to a first and rigorous 3D restitution (Figure 5).

#### 4. Open Questions and Future Work

As pointed in Figure 2, the ceiling of the *main lounge* exists in multiple versions. One of our goals was to check if the version in the French Embassy corresponded to the original one. The conclusion is that all the acquired decorative elements are fully compatible in terms of geometry with the Saint-Maurice residence. This does not solve the still open question of their origins: reuse, copy, or cast.

After a careful review of the appearance in the French Embassy, it is now clear that some repainting at least took place. The current investigation with as close as possible physical characterization will help in simulating the appearance for visual cross-checking with original photographs. For this purpose, we need to improve our acquisition methodology in terms of speed, accuracy, and amount of data to process, for larger scale survey (on all the decorative elements) than the initial ones (limited to samples).

Moreover, we have already demonstrated that collecting documents from multiple formats, sites and research domains, within the goal and the support of 3D restitution, is a path to explore, validate and track the potential reuse of ornament in 19th century architecture and beyond. To ease the use of such documentation and the restitution, we investigate 3D referencing directly on the model.

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