The contribution of the immaterial realm to the study of the material culture

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Abstract

The digital revolution endowed us with new tools to study the material culture. We are learning to use them, but with uneven results: the issue is not technical and not even simply methodological, it is philosophical. Unless we clearly define the perimeters we cannot clearly define the parameters. The research into the relationship between material objects and immaterial information must be made of theory and practice, of trials and errors. The aim is to identify a shared field of action, which is new and unexplored: what works on one realm, may not work in the other. This paper will present the research carried out in this direction in the last few years at Politecnico di Milano, in collaboration with Museo Egizio, Torino.

Keywords: *Digitisation; Digitalization; 3D survey; 3D model; remote investigation.*

1. Context

A wide range of new technologies are being applied to the realm of Egyptology. They have the power to make visible things that were, until recently, invisible: some were hidden, others were lost; some were known to the ancient Egyptians, others were not. These distinctions are crucial as they define the limits and characteristics not only of our knowledge, but also of that of the ancient Egyptians.

When discussing the relationship between material and digital culture, the contraposition between ‘real’ and ‘virtual’ may be misleading, as the virtual realm is also real. My preference goes to using the terms ‘material’ and ‘immaterial’, and to considering as a duality, rather than as two opposing elements. If we place material and immaterial realms in contraposition, the objects and their digital versions may be perceived differently, depending on the point of view. Objects may be seen as bad-looking, incomplete, breakable, fixed, whereas their digital versions may be perceived as good-looking, integer, unbreakable, transformable. The opposite may also be true: objects may be considered as true, real, original, tangible, whilst their digital counterparts as false, unreal, copied, intangible. If, instead, we consider the immaterial realm as a mirror in which the material object can see itself in a different light, then both realms may contribute to our knowledge of the object itself.[1]

One of the most obvious contributions of the immaterial realm in archaeology is to make up for the destruction. Not only to integrate missing parts, but also to address the destructive nature of the archaeological excavation itself: archaeological sites are physically demolished by excavations, finds are separated from one another and from their context, objects are stored in magazines, or placed on display in museums; in the past, groups of finds coming for the same context were often scattered among several

[1] Rossi 2019a.

museum and collections. In the immaterial realm, reality-based 3D models of each stratigraphic unit can precisely record the connections that are inevitably lost once they are dismantled; some aspects of sites and objects may be studied through their digital twins; finds and contexts can be re-connected; *disjecta membra* can be reunited.[2] Of course, this is easier to say than to do in an effective way: the theory is clear, but several practical aspects still await a solution.

The transition to the digital realm implies two types of operations: digitisation and digitalisation. The term 'digitization' refers to the transformation of analogical data into digital data, whereas the term 'digitalisation' describes the passage from analogical to digital processes. Not all data have the same origin and have been digitised following the same path. The current situation of the digital realm, therefore, is a combination of digitised data, digitalized processes, native digital data and native digital outputs. In the field of archaeology, it is unlikely that the situation will change in a significant way: there will always be inaccessible places or objects of which only paper record exists, or out-of-date digital data to be revived. It is important to accept that digital data are heterogeneous and will remains so.

The digital realm thus offers new tools and solution to three areas of the archaeological field: documentation, research and dissemination. Politecnico di Milano has been active on all these fronts alone and in strict collaboration with Museo Egizio, Torino[3] and the following paragraph describe some activities, their issues and the solutions that have been adopted.

2. Documentation: archaeological/architectural survey

Performing 3D surveys of objects is a relatively common activity nowadays, even if not always at the same level of precision and accuracy that one would wish for. In particular, the importance of producing metric models must be stressed, that is, measurable models that reflect the actual dimensions of the original object. As methods, techniques, hardware and software improve, it is important to move on from the production of data and ask ourselves what can be done with these data. Obviously, 3D surveys and models can be used to obtain the same, traditional results that could be obtained by hand-drawings and photographs, and just achieve this in a quicker and more precise way. But new tools offer also new possibilities, that can and must be taken into account and exploited.

An interesting example is the 2018 3D survey of the external coffin of Butehamon, held at Museo Egizio.[4] The software offers the chance to switch off the colour of the surface and see just its geometry: this allowed to see, thanks to a click, the geometrical facial features of that coffin, significantly different from those painted over. This is probably due to the re-use of older components of other coffins, that were re-painted according to the wishes of the new owner. This was the same principle that led to the creation of the

[2] Greco 2019.
[3] Rossi 2019b; Greco, Rossi, Della Torre 2020; Mandelli, Gobeil, Greco, Rossi 2021.
[4] Mandelli *et al*. 2019.

project Faces Revealed, that investigated in detail the facial features of a large number of yellow coffins by exploiting just this software option.[5]

Equally promising is the survey and modelling of archaeological excavations. Since 2018, Politecnico di Milano has been in charge of the survey of the concession of the joint Dutch-Italian archaeological mission to Saqqara of Museo Egizio (Torino) and Rijksmuseum van Oudheden (Leiden), that includes a number of New Kingdom tombs.[6]

Two types of surveys have been performed on the field: those of already excavated structures and those of the ongoing excavation. The first type concerns more or less fixed situations (even if small variations occur more frequently than one would perhaps expect), whereas the second type is, by definition, a situation in continuous evolution. This sequence of reality-based models constitutes a 'double' digging diary: as the excavation proceeds, it captures the progressively older layers but also the daily evolution of the excavation with a hitherto unavailable degree of precision and accuracy. A widespread, effective way to visualise and handle such a sequence of contexts is, however, still missing, thus holding back the spread of this method to record the excavations.

3. Research

3.1. Digital models

Surveys and models of 'fixed' structures are easier to handle as individual, digital objects. The interesting and challenging part of the work starts when we wish to use them all together and for a purpose that goes beyond turning them on a screen. The collection of surveys and models of the various parts of the Saqqara concession represents an ideal case-study to experiment with these issues.

A first, and rather obvious operation, was to digitally remove the most invasive modern superstructures from the individual models of the tombs. The decision was taken to limit this activity to a minimum: going back to the original state in which the tombs were found would be impossible without a substantial operation of deconstruction and reconstruction, that would fall beyond the scope and interest of our research. Therefore, modern shelters and roofs were removed, along with the doors of the wooden lockers which protect the decorated orthostats, in order to show them inside.[7] Only one tomb is endowed with a different type of modern structure, that of Meryneith, that being smaller than the others was encapsulated into a box-like building. The latter was digitally removed and the tomb exposed like the others (Fig. 1).

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[5] Mainieri, Mandelli, Rossi 2022; Mainieri 2024a; Mainieri 2024b.

[6] Del Vesco, Greco, Müller, Staring, Weiss 2019; Del Vesco, Greco, Soliman, Weiss 2020; Del Vesco, Greco, Rossi, Soliman, Weiss 2020.

[7] Rossi 2019b.

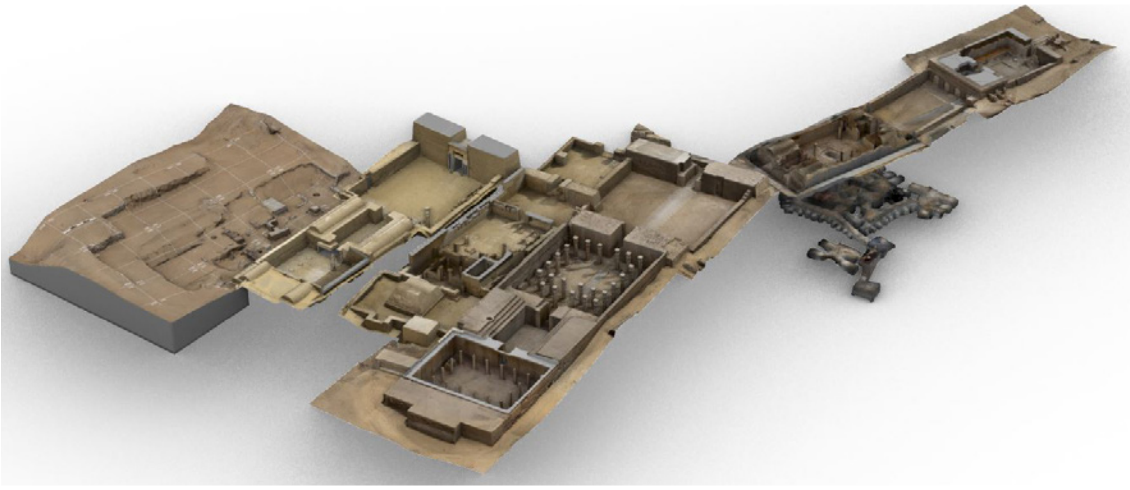

Fig. 1: 3D models of five tombs of the Turin-Leiden concession, plus the area under excavation, as of 2020 (elaboration by A. Mandelli, 2021).

Once all the reality-based models were addressed, we turned to the issue of the inaccessible parts. Our ongoing project focuses on constructing an overall model, joining together the above-ground structures and the underground portions of the tombs. This general model cannot be achieved on the basis of reality-based surveys only, as most of the underground parts are inaccessible for various reasons, either because they are closed by the authorities or because they were backfilled or blocked. These parts are being modelled in a different software, starting from the two-dimensional plans and sections published by the archaeologists who excavated them in the recent past (Fig. 2).

Being able to deal with this type of composite model, in which data are derived from different sources, represents a significant step in a future perspective: combining data from different sources will allow us to combine data gathered in different historical moments, thus giving us the chance to construct a really comprehensive model, able to go beyond the range of the currently visible remains. A parallel project is also being carried out: it consists in attempting a geometric reconstruction of the missing parts of the tombs. This is being achieved without any mimetic intent: the bare geometry of the missing parts, accurately designed on the basis of a metrological study, is added to the point-cloud.

Finally, it is worth mentioning that digital handling of 3D models is starting to gain space also in the field of epigraphy, even if with some limitations. The possibility to digitally regulate the light in the 3D models may offer a significant help to epigraphists and archaeologists to improve their study of reliefs and inscriptions, especially in case they are faded and barely visible with the naked eye. The software Real-Time Suggestive Contours (RTSC) by Princeton University,[8] for instance, was used to enhance scenes on a sequence of orthostats from the tomb of Meryneith and to register the state of the blocks located in the courtyard, on the east wall, to the left of the entrance, that are suffering from weathering.[9]

[8] De Carlo *et al.* 2003.
[9] Lori, Rossi 2020.

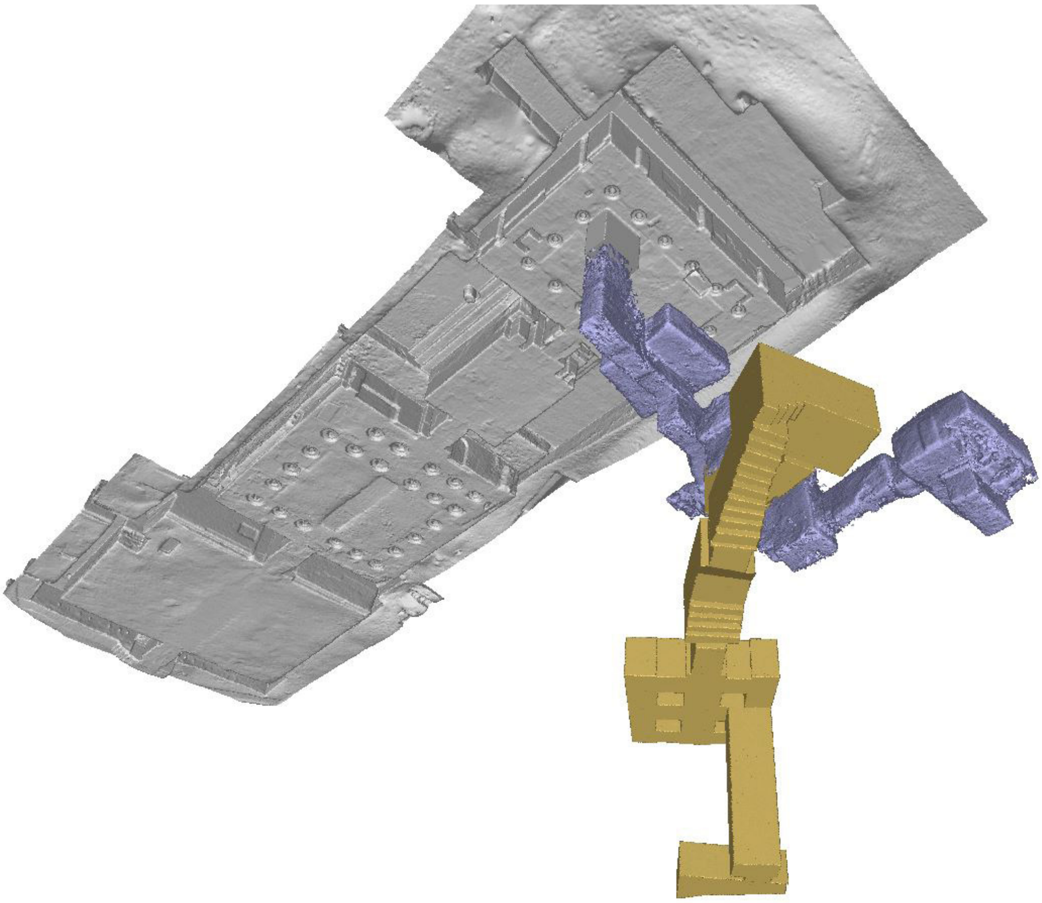

Fig. 2: Composite 3D model of the tomb of Horemheb, combining reality-based (grey and lilac) and reconstructed (yellow) models (elaboration by A. Mandelli, in Rossi 2020).

3.2. Remote investigation

The digital realm offers also the chance to implement what we named 'remote investigation', a combination of remote sensing and archaeological study carried out on digital data, to be attempted when the actual site is not accessible. This methodology was envisaged during the ERC-funded project LIFE,[10] dedicated to the Late Roman site of Umm al-Dabadib, located at the northern outskirts of the Kharga Oasis, in Egypt's Western Desert, dating to the Roman Period. The deterioration of security in the Western Desert led to the interruption of any archaeological work from 2016 to 2022 and forced us to adopt alternative methods to continue to investigate the site.

Remote sensing is not new in archaeology, but here it was necessary to work with already available material: the most productive source of information was represented by Google Earth images, that provided evidence and inspired several lines of investigation. One was the study of the orientation of the chain of Late Roman forts, to which Umm al-Dabadib belongs. From the study of the satellite images, it became clear that all these sites had the same

[10] ERC CoGrant 681673, www.life.polimi.it

orientation as the barchan sand dunes that flow across the oasis in a north-south direction: this means that the forts were aligned to the prevailing northern wind[11] (Fig. 3). This can be clearly see not only at Umm al-Dabadib, but also at other contemporary fortified settlements built in the Kharga Oasis: beside their orientation, they share a number of architectural features that suggest that they were part of a single strategic design of control of the oasis.[12]

Fig. 3: Orientation of Umm al-Dabadib on the prevailing northern wind (Rossi, Magli 2019).

The 3D survey of the Fort allowed the construction of a precise and accurate model that was instrumental to perform a metrological study of this building[13] (Fig. 4). The study demonstrated that the Fort was built using the ancient Egyptian cubit as unit of measurement; to be precise, the reformed cubit, divided into 6 palms, larger than the older 7 palms into which the cubit was divided from the beginning of the Egyptian history until the 26th Dynasty.[14] This is, at the moment, the latest attestation of the use of the ancient Egyptian cubit in architecture.

[11] Rossi, Magli 2019.
[12] Rossi *et al.* 2022.
[13] Fiorillo, Rossi, Galli, 2020; Fiorillo, Rossi, Morandi 2021.
[14] Fiorillo, Rossi, 2018; Rossi, Fiorillo 2018.

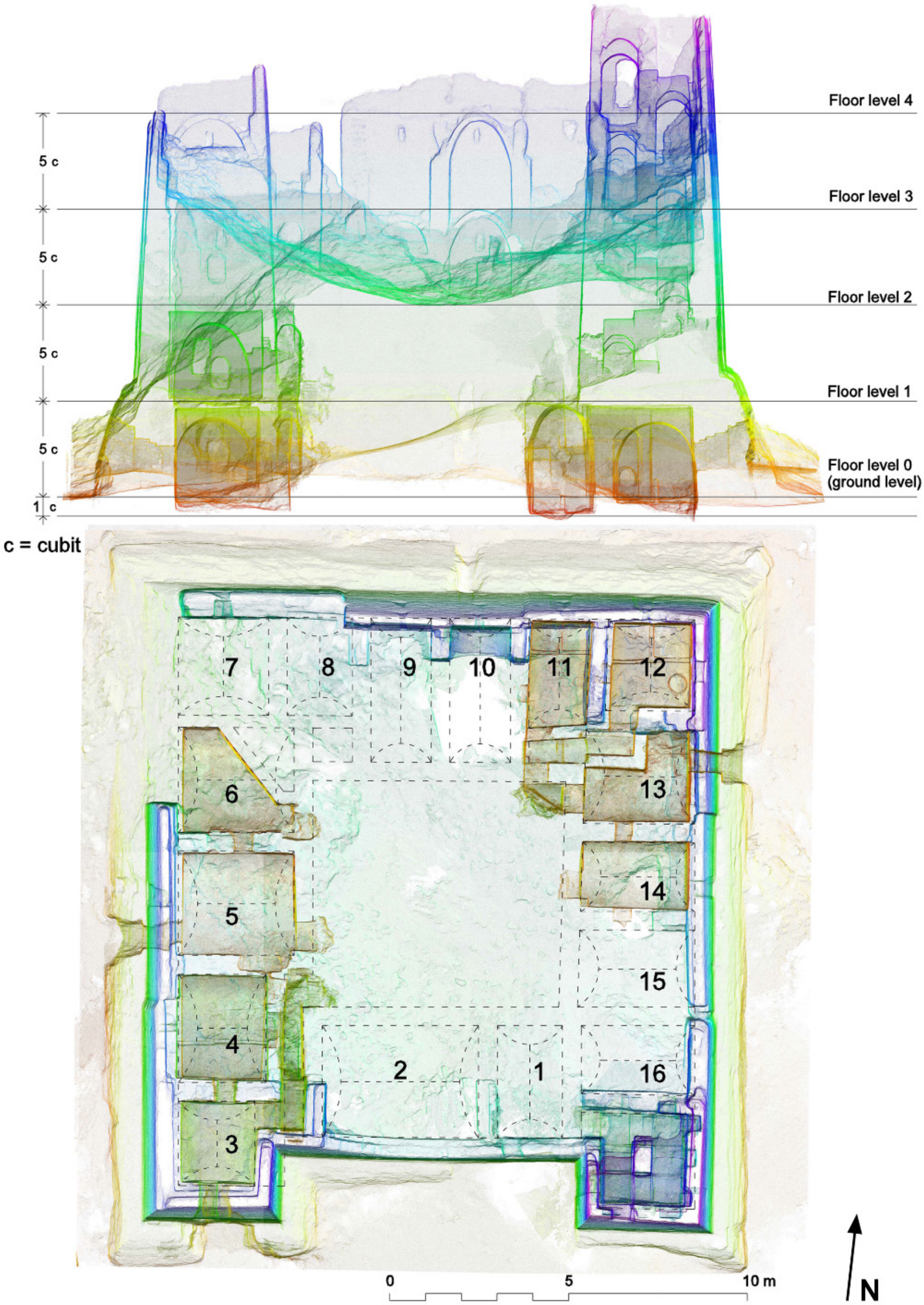

Fig. 4: Elaboration of the 3D model of the Fort of Umm al-Dabadib (elaboration by F. Fiorillo, in Fiorillo, Rossi, 2020).

It was later possible to demonstrate that the same unit of measurement was also used in the construction of the Fortified Settlement, as well as of the other forts that punctuate the northern portion of the Kharga Oasis.[15] The subsequent metrological analysis of the house of Serenos in the nearby Dakhla Oasis revealed that also in that case, the unit of measurement was the same.[16] Future studies are likely to reveal further instances in which the cubit was used in the constructions dating to the Late Roman Period.

Another possibility offered by the level of accuracy and precision achieved by the computerized 3D model, that would be extremely difficult to achieve by eye and hand, was to perform a geometric analysis of the vaults of the Fort. It was possible to demonstrate they are elliptical, and to suggest the actual method that was used by the workmen to draw their outline of the back wall of the rooms in which they were constructed.[17]

The metrological study of the Fort and the geometric analysis of its vaults opened the way to an overall study of the entire Fortified Settlement from an architectural point of view. We developed an *ad hoc* conceptual and operative approach that we defined 'semantic and parametric modelling': each element of the building is named and defined from a (geo)metric point of view. In this way, each named element is reconstructed according to precise parameters: this system allowed us, starting from the visible portions of the buildings emerging from the debris, to make precise hypotheses on the portions that lie still buried (Fig. 5).[18]

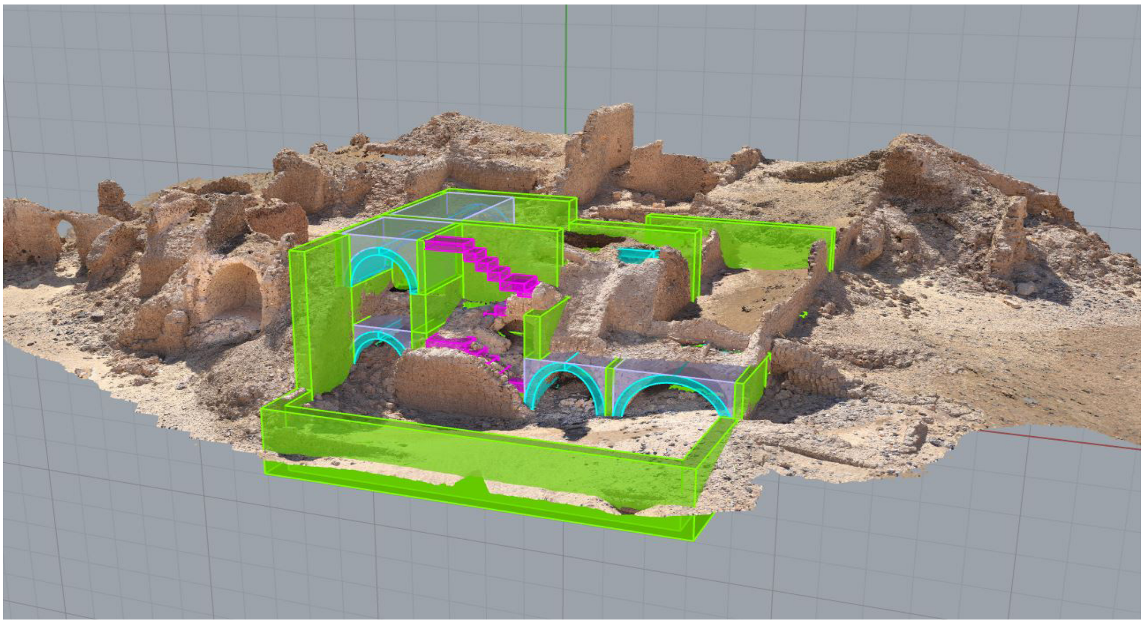

Fig. 5: Semantic and parametric modelling applied to Unit C at Umm al-Dabadib (elaboration by F. Fiorillo, in Fiorillo, Rossi 2021).

[15] Rossi 2019c.
[16] Davoli 2022, 44-6.
[17] Fiorillo, Rossi 2020; Fiorillo, Rossi 2023.
[18] Fiorillo, Rossi 2021.

As we worked on the construction of these models, we realized that the 'recipe' to construct and model that eventually 'clicks' together is to proceed following the same steps that the ancient builders made: starting from the plans drawn on the floor level, then building the back wall up to the top, then building the lateral walls up to the impost of the vault, then add the vault, etc. The digital model thus mirrors the construction process and can provide interesting information also on that subject.

4. Dissemination: combination of material and immaterial components

3D models may be very useful to disseminate the results, not only among the academic community but also for the general public. The multimedial installation centred on the external coffin of Butehamon prepared for the temporary exhibition *Archeologia Invisibile* (Museo Egizio, 2019-2022)[19] represented a significant example. The submillimetric survey and the ensuing model allowed the creation of a video explaining the construction of the coffin that worked in connection with an operation of videomapping of the decoration of the coffin projected onto a 1:1 physical model of the coffin itself.

The final product was the result of a long and complex work that saw the participation and the collaboration of different specialists, including Egyptologists, surveyors and videomakers. The installation was so effective and successful that it was re-presented on the occasion of the temporary exhibition *I creatori dell'Egitto eterno* at the Basilica Palladiana, Vicenza, and is now an integral part of the permanent exhibition path of Museo Egizio, located at a short distance from the set of coffins of Butehamon himself.

In order to achieve a successful result it is important to stress that experts from different fields must be involved, as none of them, alone, would be sufficient. In this respect, the fields of augmented and virtual reality can offer a wide range of possibilities to further explore and elaborate new and innovative ways to disseminate the results of scientific research to the wider public.

5. Conclusions

The immaterial version of a material object is made of its digital image and of all the information that may be attached to it. One way to define this combination of elements is 'digital twin'. Material object and digital twin have a number of elements in common, but they are not equivalent: digital twins are tools, instruments, ways to represent and describe the physical object, that remains the original source of information, progressively retrieved as technologies and knowledge evolve.

In the digital realm, known, 'old' operations (such as archaeological and architectural surveys) may be performed quicker and better. But in order to really exploit the potential of the digital realm, we need to operate a shift of paradigm, leading to the identification and implementation of new operations, inspired by the newly available tools. Examples are composite models, as well as the semantic/parametric modelling described above.

The results illustrated above demonstrate that the collaboration between museums, where the material culture is held, and universities, where experimental research can be performed at controlled costs, represents a successful example of joining forces to achieve

[19] Ciccopiedi 2019.

result that neither of them could have otherwise obtained. Hopefully, more institutions will follow this example and increase the number of collaborative projects able to push the boundaries of our knowledge further. This means performing ground-breaking specialistic research, as well as dedicating the same amount of energies and time to the dissemination of these results to the wider public: knowledge can only advance if both aspects are properly addressed.

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