Cultural Sprawl: The Opportunities of AR for Museum Communication

Fabrizio Lamberti, Roberta Spallone, Davide Mezzino, Alberto Cannavò, Gabriele Pratticò, Martina Terzoli, Giorgio Da Vià, and Roberta Filippini

1 Introduction

Extended Reality (XR), a term used to refer to complementary set of technologies including Augmented Reality (AR) and Virtual Reality (VR), offers a wide range of possible methods, techniques, and tools that may open new research opportunities in the cultural heritage field including museums and cultural institutions.

F. Lamberti · A. Cannavò · G. Pratticò · G. Da Vià · R. Filippini
Department of Control and Computer Engineering, Politecnico di Torino, Turin, Italy
e-mail: fabrizio.lamberti@polito.it

A. Cannavò
e-mail: alberto.cannavo@polito.it

G. Pratticò
e-mail: filippogabriele.prattico@polito.it

G. Da Vià
e-mail: giorgio.davia@studenti.polito.it

R. Filippini
e-mail: roberta.filippini@studenti.polito.it

R. Spallone (✉)
Department of Architecture and Design, Politecnico di Torino, Turin, Italy
e-mail: roberta.spallone@polito.it

D. Mezzino
Faculty of Cultural Heritage, Università Telematica Internazionale Uninettuno, Rome, Italy
e-mail: davide.mezzino@uninettunouniversity.net

M. Terzoli
Dipartimento di Collezione e ricerca, Fondazione Museo delle Antichità Egizie di Torino, Turin, Italy
e-mail: martina.terzoli@museoegizio.it

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Within the XR domain, AR is now considered also in the Cultural Heritage field as a strategic technique that allows the visualization of digital elements (informative layers) overlapped with real objects or sites. Thus, this technique can implement the dissemination of cultural heritage knowledge to a broad public engaging different visitors' targets.

In this process, the concepts of edutainment and gamification become relevant in the design of the users' experience.

Within this framework, this contribution illustrates an educational and entertaining experience, deploying AR technology to communicate the tangible and intangible aspects associated with some of the objects of the Museo Egizio collection.

Thanks to the collaboration between the Fondazione Museo delle Antichità Egizie di Torino, the Department of Control and Computer Engineering, the Department of Architecture and Design, and the VR@POLITO Laboratories, an AR app has been developed. The multidisciplinary research group involved experts and scholars from different fields including archaeology, art history, computer science, computer graphics, digital representation, graphic design, visual communication, and film engineering.

These heterogeneous competencies have been fundamental to achieve the research objectives providing the theoretical knowledge and the practical skills needed.

Proposing an interaction between indoor museum environments and outer spaces, the app enables users to connect urban spaces in the city of Turin to the museum collection.

Focusing on the funerary set of Kha and Merit, part of the permanent exhibit of the museum, users are given the possibility to interface with their avatars for the entire duration of the experience, going through some moments of Kha and Merit's past life, thanks to an effective choice of their stories and an accurate setting of the storytelling. Each stage of the app path—accessible from different points of interest displaced in the Turin city center—includes a description of the exhibit, to explore past historical contexts, as well as social and religious meanings.

2 State-of-the-Art Analysis on the Opportunities of AR Applications in Museums

In defining the term Onlife, in 2015, the Italian philosopher Luciano Floridi understood the transformation of contemporary reality where the separation of the real from the virtual became practically impossible [1]. Considering the deep integration of the two categories, Floridi suggests that would be more appropriate to speak of a single reality derived from the hybridization of digital into reality. Moreover, as described by several scholars, this Onlife reality is, at the same time, visual, sensorial, and with an ever-increasing degree of interactivity and intelligence [2, 3].

Digital techniques and tools demonstrated their opportunities in defining new approaches allowing users to augment their perceptions and experiences. This new

condition is currently defined as post-media in reference, among others, to the overcoming of traditional media devices [4].

Concerning the advantages of digital visualization, including AR and VR, a recent study—developed by Cuseum [5] and the Massachusetts Institute of Technology (MIT) in the Boston Museum of Fine Arts—demonstrated the benefits of digital interfaces on the brain activity of the users. The study titled *Neurological Perceptions of Art through Augmented and Virtual Reality* measured the non-conscious engagement of users in four discrete environments: AR, VR, two-dimensional photographic reproduction, and real environment. The study exposed the participants to observe original works of art and their reproduction in 2D or 3D in virtual or augmented reality, recording the neurological activity of each participant [6]. The results showed that digital interfaces enhance user experience augmenting brain activity in comparison to the simple vision of original artistic/historic objects or artifacts [3].

Within this framework, museums became places where technological mediation—whether it is proposed by the curatorial choices or introduced by the users themselves, for instance, the autonomous visitor's choice to use media devices—is part of the experience of a visit. In a new media logic, museums assume that the encounter with the collections now takes place in an extended and diffused space, with no clear distinctions between material and virtual [7].

In this context, the Museo Egizio tested different visual communication strategies in the domain of XR, focusing on AR solutions.

Considering the potential of AR for dissemination and its interaction with physical space, the museum developed several projects heterogenous for narrative strategies, topics, AR techniques, and interaction with physical space that have been tested in different empirical applications. These include the app Stone. Pietre Egizie, the projection mapping on the Butehamon coffin, a section of the temporary exhibition Archeologia Invisibile [8], and the installation developed for the new exhibition space In search of life.

The app Stone. Pietre Egizie consists of a new tool available to the public to understand and know the type and properties of the rocks of the collection's statues, sculptures, and objects as well as those employed for the museum's building. The app allows visitors to observe different rocks, discovering their nature, composition, origin, and the reasons why they were chosen by the Ancient Egyptians [9] Regarding the project mapping of the Butehamon coffin, the installation was set up as a section of the temporary exhibition Archeologia Invisibile. The exhibition—opened on March 13th, 2019—illustrates the principles, tools, and results of the meticulous work of recomposition of information, data, and knowledge made possible today by the application of science to other disciplines and, in particular, to the study of archaeological findings. The installation consisted of a projection mapping on the copy of Butehamon's coffin, reproduced through 3D printing. The 3D printing of the coffin has been used as support to represent and visualize, through dynamic projection mapping, the transformations, and construction processes as well as the needed know-how to realize [10].

The installation In search of life is a permanent exhibition space that expands the visit path of the museum. It is dedicated to life in ancient Egypt through the study

of human remains. The fulcrum of the new space is a showcase set up to contain 91 mummies that are part of the museum's collection. It performs the double function of deposit and showcase. Therefore, it was designed to guarantee the highest conservation standards for the extremely fragile human and organic remains conserved inside the showcase.

Thanks to a special film in Liquid Crystal Display (LCD) applied to the glasses of the showcase, six of these mummies are revealed to the public, to represent the fundamental stages of life. The revelation of the object inside the showcase is temporized with a video projection on the showcase that anticipates the story and the features of the object that is going to be shown. Indeed, the Liquid Crystal Display (LCD) film on the showcase allows to use of it as a projection surface (when the LCD is off) or simply as glass (when the LCD is on) (Fig. 1).

In the broader framework of the application of digital visualization techniques and tools in museums, the described examples, characterized by a common transdisciplinary approach, underline the potential of digital representation and its role in the development of AR solutions.

The common feature of the mentioned creative AR applications, developed by the Museo Egizio in a cultural sprawl logic, is the dissemination of humanistic and technical knowledge embedded in archaeological objects.

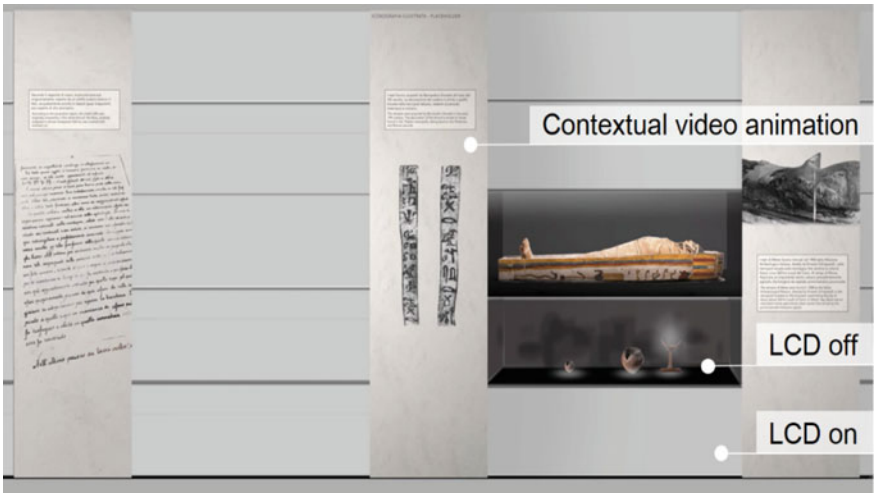

Fig. 1 The installation In search of life, in the permanent exhibition path of the Museo Egizio. *Source* Museo Egizio, processing: D. Mezzino

3 Case Study: The Funerary Set of Kha and Merit

The case study considered in this work focuses on the funerary set of Kha and Merit, part of the permanent exhibit of the museum.

The intact tomb of Kha and Merit (TT8) was discovered on 15 February 1906, by the Italian Archaeological Mission (M.A.I.) headed by the then director of the Museo Egizio, Ernesto Schiaparelli [11–13]. The burial was found in the necropolis of Deir el-Medina, a village founded at the start of the 18th Dynasty, around 1500 BC, on the western bank of Thebes. The settlement housed the workmen in charge of building the tombs of the pharaohs in the nearby royal cemeteries known today as the Valley of the Kings and the Valley of the Queens. Kha, who lived in the second half of the 18th dynasty (1425–1353 BCE), was Overseer of works and directed the construction of the royal tombs. His whole burial assemblage, consisting of more than 460 objects, is today preserved at the Museo Egizio in Turin. It is one of the most important discoveries displayed in the museum, a perfectly preserved funerary context, shedding light on aspects of Egyptian culture such as religious and funerary beliefs and the concept of life beyond death. The artefacts within the tomb are of a variety of types: coffins, furniture (such as beds, tables and chairs), clothes, food, work tools and everyday objects. Everything inside the tomb was meant to help the deceased continue his journey in the afterlife and reach the god Osiris, obtaining eternal life (Fig. 2). The importance of this extraordinary untouched grave assemblage lies in its ability to reveal the story of Kha and Merit, who lived over 3000 years ago. More specifically, it reveals many details concerning the fears and desires of the ancient Egyptians and their conception of life and the afterlife.

For this reason, it is of fundamental importance to share the cultural and material heritage preserved at the Museo Egizio not only with the scholarly community but with all the people who visit the museum every day. Starting from the idea of creating new links between the city and the museum, the proposed AR app focuses on some important artefacts that were part of Kha's burial assemblage, linking them to specific urban spaces in the city of Turin. The user will be able to easily approach the rich history of these artefacts and their symbolic meaning and function while moving around the city. Once outside the museum, he or she can decide to learn more about them by visiting it. The three selected objects are: the game of senet, the Book of the Dead and Merit's toiletries. These finds are representative of the great variety of artefacts found in the tomb of Kha and Merit. Each has a specific function, aimed at assisting the deceased in their afterlife journey.

The game of senet consisted of a grid of 30 squares drawn on a surface. The rules of the game are still not completely clear, but we could compare it to the modern Game of the Goose. *Senet* also means to pass, and the game is called thus because the player had to eventually get all his or her pawns off the chessboard. The concept of passing was also associated with the journey of the deceased into the afterlife and therefore the game had a symbolic value linked to the funerary world.

The Book of the Dead is one of the most spectacular objects among Kha and Merit's grave goods. It was found folded above the middle coffin of Kha. It is almost

Fig. 2 Kha and Merit's funeral chamber, at the time of discovery. *Source* Torino, Archivio Museo Egizio, C. 02,070

14 m long and lists 33 spells, some of them illustrated with colourful vignettes (Fig. 3).

These 33 spells were magical-religious formulas that help the deceased on their way to the afterlife, to face any kind of danger they might encounter. Some of them provide protection against dangerous animals, while another series of spells address the ability of the deceased to move between the earthly world and the afterlife. Merit's toiletries were inside a beauty-case fitted with internal compartments (Fig. 4 left). Among the objects it contained was a small tube made of blue glass, with white and yellow decorations, containing kohl and a small stick applicator. Kohl was a black substance resembling our modern kajal, which was applied to the eyes as a protective filter against the rays of the sun and as an antibacterial agent (Fig. 4 right).

4 Relationship Between City and Museum

Among the Museo Egizio's programmatic goals, that of bringing the museum outside the museum, explained as the aim of making the contents of the collections accessible to those who cannot visit the museum, was the main inspiration for the present project. Taking tourism as the target audience, the idea was to build strong links between the museum and the city through a pathway.

Fig. 3 Kha's Book of the Dead, detail of the couple worshipping the god Osiris. Cyperus papyrus, ca. 35 × 1380 cm. New Kingdom, 18th Dynasty. Deir el-Medina, Tomb of Kha (TT8). *Source* Torino, Museo Egizio, S. 8316/3 = S. 8438

Therefore, the concept expressed by the institution was interpreted through a different declination in two interrelated ways. On the one hand, an effective link was created between the city and the museum; on the other hand, the metaphor of the museum outside the museum was made effective by visualizing from outside the building some of the objects in it, contextualizing them in interactive experiences with digital representations of Kha and Merit themselves.

Therefore, the objectives pursued are broadened from those enucleated by the museum, allowing, first, for the museum to be perceived not as a closed place but, conversely, as an opportunity to create new links of meaning with other places and buildings in the city. This implies, among other things:

- That the museum is also active at times other than when it is open.
- That certain cultural points of interest in the city are enhanced.
- That the invitation to enter and repeat the experience can be scaled up to other content offered by the museum.
- That other places in the city can be included in different itineraries, establishing additional sense-making relationships.
- Not only that, the app, currently focused on the step-by-step game centered on a few artifacts on display, could be enriched with an explanation of the places visited and the activities contained at the buildings as well as recommend visits to other places depending on users' interests.

Fig. 4 On the left, Merit's toiletry box, wood, ca. 22 × 29.5 × 49 cm. New Kingdom, 18th Dynasty. Deir el-Medina, Tomb of Kha (TT8). *Source* Torino, Museo Egizio, S. 8479. On the right, Kohl tube with wooden applicator. Glass, ca. 9.2 × 3.7 cm. New Kingdom, 18th Dynasty. Deir el-Medina, Tomb of Kha (TT8). *Source* Torino, Museo Egizio, S. 8489

The tourist route involves three points of interest, in the central area of the city (Fig. 5): the Sambuy gardens in front of the Porta Nuova station, the façade of the stables of Palazzo Carignano, in whose building the Biblioteca Nazionale di Torino (National Library of Turin) is housed, the Mole Antonelliana, which currently houses the Museo Nazionale del Cinema (National Museum of Cinema), and, of course, the palace of the Collegio dei Nobili, a portion of which is home to the Museo Egizio of Turin.

The entire route, done on foot, takes a little more than 30 min, to which must be added the time to carry out the experiences.

The tour ideally starts right from the gardens, imagining that a portion of the tourists come from the city's main train station or otherwise via public transportation, including the subway line, of which the station is an important junction.

The small Sambuy gardens, of late nineteenth-century design like the area of city expansion in which they are located, conform to the model of the green oasis, and are equipped with a pond, gazebos, meandering paths, centuries-old trees and English lawn. They constitute the passageway, an alternative to porticoes, to the streets leading to the first expansion of the Baroque city (Carlo di Castellamonte from 1621), hinged on the northern section of the current Via Roma. It is precisely because of this character, and the fact that it represents an initial stopping point for

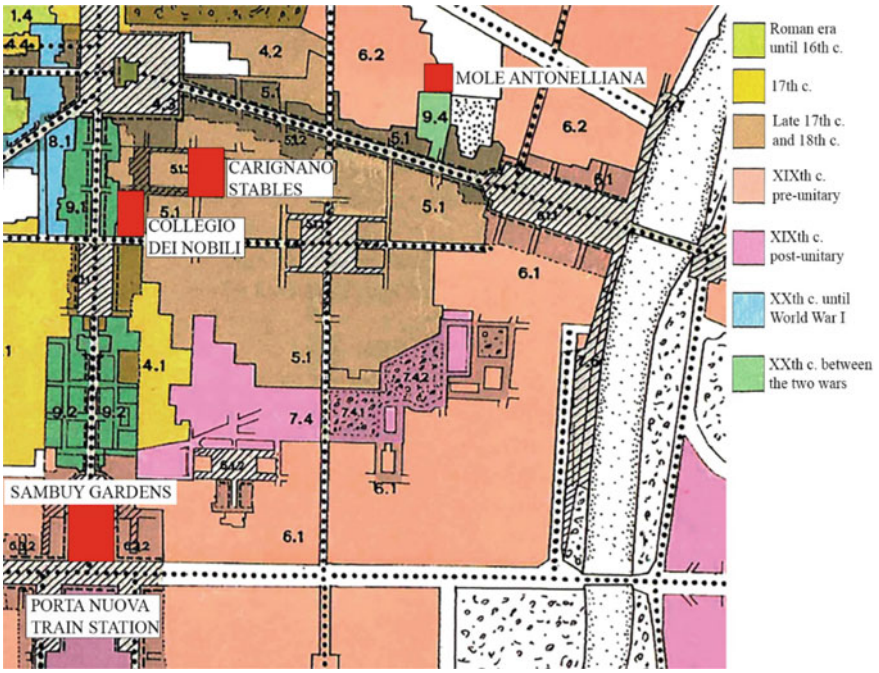

Fig. 5 Excerpt of the map of historic urban settings in the central area of Turin [14] with localisation of the points of interest: Porta Nuova (Turin train station), Sambuy gardens, Mole Antonelliana (Museo del Cinema), Carignano Stables (Biblioteca Nazionale) Collegio dei Nobili (Museo Egizio) (Editing: R. Spallone)

visitors to the city, that it has been paired with the table game of senet intended as the emblem of the stopover.

The other two destinations, the Mole Antonelliana and the stables of Palazzo Carignano, can be reached along the way in no particular order.

The Mole Antonelliana, a bold 167.5-m-high symbolic construction of the city, is named after its designer, Alessandro Antonelli, who undertook its construction in 1862. It originally served as a synagogue, but was taken over by the city before the construction site was closed and now houses the Museo Nazionale del Cinema, one of the city's main museum attractions. The Mole is located in the area of the second expansion (Amedeo di Castellamonte from 1673) that has Via Po as its axis. Reaching it from the gardens allows you to explore the streets and palaces of this urban portion. The building's current function has made it juxtaposed with experience related to Merit's toilet accessories.

The façade of the stables of Palazzo Carignano (1750), now separated from the palace by a large garden, is also part of this area. It currently serves as the front of the contemporary building, seat of the Biblioteca Nazionale. The similarity in content led to the idea of anchoring the long scroll of the Book of the Dead to the facade.

The Collegio dei Nobili (1679), built by Michelangelo Garove still in the area of the second expansion, is the seat, as noted above, of the Museo Egizio, the repository of the artifacts that are the subject of the digital experience. The room of Kha's tomb is located on the first floor of the building and overlooks Piazza Carignano. The depth of the square made it possible to carry out the experience by completely framing the façade and superimposing in AR the digital models of the display cases placed in the room and the exhibits, as if it were viewed in X-Ray.

5 Storytelling and Gamification

The app, which has been created using Unity, is designed to be accessible from the personal mobile device of potential users before visiting the museum, to introduce the public to Egyptian culture and intrigue them enough to get in in person. The idea was to introduce gamification elements, creating real interactive playful experiences, at the center of which there is a particular element of Kha and Merit's funerary set. The aim was to create a connection between the museum and the city of Turin. Hence, as said, four key locations were selected to display the artefacts in question, seeking a link between the object and the place where it is displayed.

- In the Sambuy garden it is possible to engage in the game devoted to playing the senet game. This choice was made because of the proximity of the location to Porta Nuova train station, a place of passage for travellers. In fact, the word senet means to pass and is mentioned in several funerary scenes to indicate the transition between life and death.
- The Mole Antonelliana was chosen as the location for playing with the Merit's dressing table, which contains several items used daily by women. This choice is motivated by the fact that the Mole Antonelliana hosts today the Museo Nazionale del Cinema, and makeup and hair is a department of the entertainment industry.
- On the walls of the Biblioteca Nazionale it is possible to engage in the experience related to the Kha's Book of the Dead. Although it is not a real book in the modern sense of the term, it contains a series of religious formulas for surviving the journey to the afterlife and, thus, was placed there as a binder of knowledge.
- Finally, the museum building (precisely, its façade on Piazza Carignano) was conceived as the final stop as a connection and culmination of the experience that could entice visitors to enter it for a visit. In this case, an X-Ray like experience has been conceived, to remove the walls and let the user have a preview of (and engage with) elements contained in the physical exhibit rooms.

In these four designated locations, the user has to locate and frame a QR-code (identifying the particular experience) to see two ancient Egyptians, i.e., Kha and Merit, appear in the city overlapped to today's real content using AR, inviting him or her to live the interactive experience with them.

It was chosen not to set a predefined order to engage with the four experiences, in order to let the user choose the most convenient path through the city according to his

or her plans. The X-Ray experience, however, is suggested to be the last one, so that the user can engage in a game that requires him or her to recall what was presented in the other three experiences and recognize the artefacts encountered while playing with them.

As said, the focus of this project is the funerary set and, more generally, the story of Kha, an architect working in the village of Deir el-Medina, and Merit, his wife. Based on available information, researchers believe that Merit died prematurely and Kha donated one of his coffins in order to let her survive in the afterlife.

The story is introduced through a video, which is played automatically when the user launches the app. In this brief snapshot of the couple's daily lives, it is possible to sense the affection that binds the two, but also get aware of the conclusion of Merit's earthly life. The video concludes with Kha's words declaring his undying love for his wife and inviting the user to visit the places indicated on the app's map to relive their happy memories. Each of the four experiences features one of the characters, or both, and focuses on different subsets of the objects in their funerary set.

At the end of the experience located near the museum, a closing video is shown in which Kha's coffin is placed next to Merit's one, thus reuniting the couple thirty years later. The video ends with the final call to action to enter the museum to learn more.

Each experience can be regarded as split into three, similar parts:

- An initial part in AR, where the user can interact with the avatars of Kha and/or Merit, which are superimposed on real city elements and invite him or her to play.
- A central part, which is the most interactive one, where the user is first provided with a tutorial about the game and its mechanisms, then he or she has to play it.
- A final part (for all the experiences except the X-Ray one), in which the avatars provide an explanation about the history, use, and meaning of the objects seen/used in the previous parts; in the X-Ray experience, an explanation is not provided since, as said, the game is about what tackled by the other experiences.

The tutorial and the explanations are supported by static and animated images as well as by textual descriptions, which are displayed on the app's screens but also uttered by the avatars, who are depicted in front of their home.

6 App Design and Technological Choices

The design of the app started with a search of references that could be used for the creation of a moodboard, i.e., a visual presentation or collage of images, text, and samples of elements that are used, in the design of digital experiences, to convey a general idea or feeling about a particular topic. This output was exploited to create a design for the aspect of Kha and Merit.

To this purpose, a picture from Kha's Book of the Dead was used as inspiration, not just for Kha and Merit's body features and colours, but also for their jewellery and wigs.

Fig. 6 Reconstructive 3D models of the senet game, Merit's toilet set, Merit's sarcophagus and funerary mask, and furniture of Kha and Merit's home (Modelling: R. Filippini)

Then, the assets required for the app were created. Almost all of the 40 objects displayed in AR were modelled in Blender [15] (Fig. 6). A key objective was to keep the complexity of the 3D models low: to this aim, low-poly modelling techniques were used [16], in combination with a careful texturing stage. Thus, textures were created ad hoc with Substance 3D Painter [17] by using many different channels (colour, normal, displacement, etc.), and prepared for UV mapping.

Specific care was devoted to recreate the appearance of materials: to make an example, for wood, reference images have been used to properly align the fibres to preserve philologic coherence.

Objects and texture were modelled and textured starting from the references in the museum's collection, with the exception of two boxes which had been digitized by the museum via photogrammetry and were recreated from scratch to reduce the number of polygons while preserving the visual quality [18].

For the modelling of Kha and Merit's home, inspiration came from a video produced by the museum, in which the curator Cédric Gobeil illustrates real life and habits of the New Kingdom, with a special focus on the Deir el-Medina site and its houses. Just the façade was modelled since it is the only part shown in the app.

2D animations used, e.g., in the tutorials, were built in After Effects. 3D animations, in turn, have been created in Blender or directly in Unity. The rigging and skinning of avatars [19] were managed using Mixamo [20]. Models and rigs were then imported into Blender, where animations were created using key-framing and blend shapes. Animated models were finally imported into Unity, where they are activated using finite-state machine-based scripts. Facial animation (e.g., lip synch) is handled with SALSA [21].

The user interface was created directly in Unity. The colour palette includes warm tones, aligned with the colours of the desert and of Ancient Egypt. The background of windows and banners displayed during interactions with Kha and Merit as well as during explanations include a papyrus texture. In the experiences, different types of user feedback are provided, using visual and aural cues. In order to let the user interact with the app at his or her own pace, at any time the app displays buttons that allow the exit the game, activate/deactivate the sound, as well as to complete the current game and move directly to the final part with the explanation by Kha and Merit. Music is based on Egyptian melodies. Similarly, for the sound effects, tunes from string and wind instruments were used. Kha and Merit's voice-over was created using text-to-speech, by leveraging the services provided by TTS Free's website.

Regarding the building of the app's core, i.e., the AR part, the choice of the framework to use was greatly influenced by the requirements related to the case study. Being the experiences targeted to casual users interested in the museum field, the hardware selected for the use case was the personal mobile device (i.e., AR-enabled android smartphones and tablets) in order to reach the widest possible audience. The version of Unity chosen was 2020.3, and development was grounded on AR Foundation [22] and Google ARCore [23]. These two solutions allowed to manage the 6 Degrees-Of-Freedom (6-DOF) positional tracking of the device (via Simultaneous Localization and Mapping, SLAM), as well as the anchoring of the virtual elements onto the real world (Fig. 7).

Fig. 7 The senet AR experience (Processing: R. Filippini and G. Da Vià)

As mentioned, the four experiences were designed to be accessible at predetermined locations throughout the city center. Two of them (that on Book of the Dead and the X-Ray one) were designed as Mixed Reality (MR) experiences and built around the interaction between real and virtual elements. To achieve this functionality, the Vuforia [24] AR engine was exploited. Vuforia allows the recognition of particular targets in the real world, being images (Vuforia Image Target) or 3D shapes of real objects (Vuforia Model Target).

Regarding the Book of the Dead, the use of a Model Target was immediately discarded due to the lack of visual features on the wall of the Biblioteca Nazionale (Fig. 8). Thus, it was decided to resort on a Vuforia Image Target (a QR code printed and placed on the wall), as it proved to be a valid 6-DOF marker-based tracking solution for handheld AR devices [25]. For what it concerns the X-Ray of the museum, the initial idea was to use some of the elements present inside Piazza Carignano (e.g., streetlamps, parts of the building, the advertising boards) (Fig. 9).

However, the test provided poor results due to the variable availability of these elements (some requalification interventions were underway in the square, and most of the potential targets were covered by scaffolds).

To cope with this issue, it was decided to rely again on a QR code to initiate the experience. The other two experiences (the one on the senet and that on Merit's toiletry) were designed as mobile games. However, to uniform the user experience among the four scenarios, it was decided to maintain the QR code recognition as starting trigger for them too.

Fig. 8 The Book of Death AR experience (Processing: R. Filippini and G. Da Và)

Fig. 9 The X-Ray AR experience (Processing: R. Filippini and G. Da Vià)

7 The Gaming Experiences

In the following, a description of each of the four experiences is provided, in the order they have been introduced above.

Near Porta Nuova, by framing the QR code, it is possible to view in AR Kha and Merit while they are playing the game of senet (Fig. 10). After talking to Kha via the appropriate button, the user can play against him directly. The rules, laid out in the tutorial, refer to modern senet, since it is not known exactly how it was played in antiquity: the goal is to get all one's pawns off the board by choosing which pawn to move from time to time after the two astragals are thrown. The simple and intuitive interface allows the user to throw the astragals using the appropriate button and choose which pawn to move from those that can be moved with the result obtained from the throw (highlighted in yellow), briefly reminding the user of the rules each time a new situation is encountered (e.g., attacks or special squares). The game is played on the screen of the user's mobile device, not in AR, for greater usability; in addition, the user can decide whether to play the game to the end or switch at any time to the final part of this experience, going to listen to Merit who recounts the origins and evolution over time of the ancient board game, dwelling in particular on the historical, socioeconomic and religious aspects.

Near the Mole Antonelliana, it is possible to meet Merit intent on choosing what to use among the items on her dressing table for her daily beauty routine (Fig. 11). The experience, in this case, experienced on the screen of the user mobile device and therefore not in AR, is divided into two parts: in the first one, the user has to prepare kohl, a substance used for eye makeup, thanks to the step-by-step instructions provided (it involves dragging or hitting several times certain items present in the funeral equipment visible at the museum), while in the second, he/she has to apply to Merit's eyes the substance he/she has just helped prepare, tracing with his/her finger the character's eye contour.

Fig. 10 The Senet game enjoied in the Sambuy gardens (Processing: R. Filippini and G. Da Và)

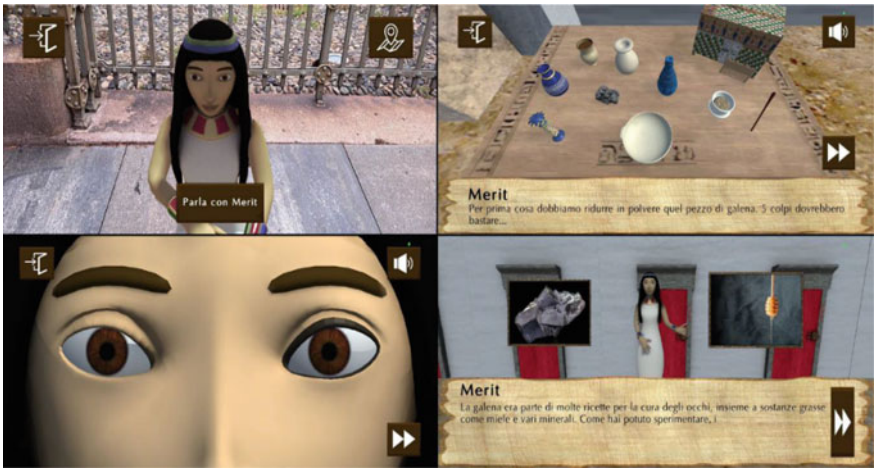

Fig. 11 The Merit's toilet game enabled on front of Mole Antonelliana (Processing: R. Filippini and G. Da Và)

When both parts have been completed, Merit explains what the kohl is. She does so by paying particular attention to its dual aesthetic and antibacterial value, as well as to help against the glare of the desert sun.

The Book of the Dead appears on the walls of the Biblioteca Nazionale by framing the QR code, with Kha and Merit intent on reading the long papyrus (Fig. 12). Interacting with Merit through the appropriate button allows the experience to begin following the viewing of the tutorial. In this case, AR is used more intensively than in the previous scene, as the experience takes place entirely in AR: moving with the mobile device along the walls of the building makes it possible to view the papyrus in its entirety. The goal here is to associate a set of definitions with the images in

Fig. 12 The Book of the Dead game anchored to the façade of Biblioteca Nazionale (Processing: R. Filippini and G. Da Vià)

the Book of the Dead by first touching the label in the user interface and then the papyrus itself. The images represent the different magical formulas in the Book of the Dead that the deceased could use to survive in the Afterlife, for example, turning into a swallow or a snake. Once all the formulas have been associated with the relevant depictions, the experience concludes. Shortly afterwards, Kha talks about the meaning, history, and use of the Book of the Dead, dwelling in particular on the content of the formulas.

Finally, at the stop near the Museo Egizio, framing the QR code allows the user to see three display showcases on the walls of the museum containing some of the many artefacts that are part of Kha and Merit's funerary equipment in the room of the museum dedicated to them, especially all the items in the other experiences. The experience consists of an AR quiz with two types of questions: multiple-choice questions regarding what has been learned from the explanations available in the other experiences around the city, or requests to select one of the objects displayed in the showcases, which can be observed in more detail by approaching one showcase at a time at a fixed distance from the virtual camera of the device used.

8 Conclusions

In the present project, AR constitutes the central technology for achieving the goals of expanding the museum experience through gamification and creating new connections between exhibits and urban space. The different digital products involved in the project (i. e. point clouds resulting from the artefacts scanning, reconstructive models of artefacts and s contexts of the experiences, 2D graphics and 3D models of the characters with movement animations, animated sequences and their montage

including written and spoken texts) are integrated into a digital *continuum* adapting to the storytelling that frames the project. AR allows the enjoyment of such content.

The project, currently in the prototype stage, is scalable to other museum and urban settings, easily implemented and usable by a wide audience through personal mobile devices.

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