Handbook of Digital Egyptology: Texts

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4. Annotating texts on 3D (coffin) models

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Abstract
Photogrammetry and 3D visualizations are currently used as tool for the preservation and study of cultural heritage. In the case of inscribed objects such as the ancient Egyptian coffins, the 3D models can be supplemented with annotations providing, among other metadata, also the text transcription, transliteration and translation. This article discusses the way text annotations could be used and displayed on a digital viewer, presenting a few case-studies of 3D models of ancient Egyptian decorated wooden coffins and stone sarcophagi, which have been built for the Book of the Dead in 3D project.

Key words
ancient Egyptian coffins – funerary texts – Book of the Dead – photogrammetry – 3D annotations.

1. Introduction

The use of 3D techniques is currently widespread in Egyptology. Tridimensional models of artifacts of various shape and dimensions are increasingly populating the websites of museums that host ancient Egyptian collections; sketchfab, a popular 3D viewer online, is populated by pages built by Egyptologists and Egyptological project members with the aim of sharing 3D visualizations of the ancient Egyptian cultural heritage, from artifacts of different kind (statues, stelas, coffins, etc.) to monuments, buildings and archaeological settlements.

The popularity of the 3D visualizations of artifacts, in particular, is due to the peculiar way in which 3D models allow every single object to come to life by allowing

the viewer to flip it around and observe it in its entirety, within a space dimension that can be reconstructed and scaled as well, similar to the objects represented.[1] When an object is also decorated with iconographical elements and inscribed with texts, its optimal 3D model should offer a chance to study the decoration as well, through the use of annotations that can be associated to different areas on the model and help the user to interactively read and understand the function and layout of the decoration. In other words, the 3D model with its annotations becomes a new medium, an "object" of study in itself, where the annotations function as a tool of understanding and scholarly/educational interaction between the user and the model's creator.[2]

Annotated 3D models are a new frontier for 3D visualizations and are being implemented in software as well as on webpages presenting the models.[3] Technically, the annotations are used on 2D images as well and refer to "a mechanism that links a sub-portion of the geometrical representation of an object to some related information".[4] On a 3D model, such a mechanism opens up to a broader spectrum of use of the metadata referring to the represented object.

In particular, when dealing with large objects with extensive textual decorations, the annotations need to be carefully organized on the surface and on the model texture in order to create a hybrid space where the user can easily access and view and at the same time interact with the model in an immersive 3D experience.

On the 3D model, annotations become the optimal way to point to specific sections of the object and to dynamically track them while moving the model around and changing its views.[5] One of the major challenges when annotating ancient Egyptian objects with texts, is the encoding of the hieroglyphic signs,[6] as well as adding its translations, transliterations and, when needed (in case of texts written in cursive variants such as hieratic or demotic), its transcription. Extensive annotations are, as a matter of fact, not easy to display together with the model, especially when we are dealing with large and densely decorated objects.

While techniques for tridimensional visualizations have started in the 90ies with the advent of virtual and cyberarchaeology[7] and are by now very advanced, the techniques

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[1] Similarly, building 3D visualization of monuments and archaeological sites allow a re-contextualization of each of them in a larger landscape and environment, providing a full engagement of the viewer into space. See the digital monograph of Elaine Sullivan (2020): <http://constructingthesacred.supdigital.org/cts/exploring-an-ancient-site-with-a-3d-model?path=introduction> [accessed: 6/16/2020].

[2] On the virtual versus physical models and their role as objects in digital reconstructions, see Münster, Hegel and Kröber 2016: 9–10.

[3] On sketchfab a few annotations can be inserted on each model; annotating models is becoming central also in other 3D modelling software on the market, such Blender, 3DHop or Maya by Autodesk.

[4] Ponchio et al. 2020, in particular p. 89.

[5] Marsh 2020.

[6] On encoding and formatting of hieroglyphic texts in general, see the paper of Mark-Jan Nederhof in this volume.

[7] See Forte 2010: 9–13.

of digitally annotating 3D models are still in course of development. At the time of writing this essay, there are no standardizations as yet for adding annotations to 3D models. Different projects have developed independent digital viewers, each adding annotations in a different way.[8] Annotations are in fact useful not only in cultural heritage and digital humanities studies, but also in medical imaging, biology and other scientific projects where there is a need for 3D mapping (which are also considered annotations), as well as videogames and other interactive, VR applications.[9]

The importance of annotating models of historical artifacts in cultural heritage studies is especially clear when dealing with inscribed objects, whose full understanding requires a user-friendly access to the model's metadata and paradata,[10] which could function as pop-ups within the model.[11]

When annotating a historical, inscribed and decorated object, the annotations should provide basic information on provenance, current geographical location and date, as well as any other historical, prosopographical or textual data available. The number and type of annotations on a 3D model generally mirror the intent of the model's creator and the kind of audience that the former wishes to address. 3D models for a wide and non-specialized audience, for instance, do not need a high number of annotations in order to help the user understand the general whereabouts of the visualized object. This is the case for many models on sketchfab, for instance, where pages on ancient Egyptian artifacts with a mainly educational scope for cultural heritage dissemination are very popular.[12]

Annotating a model becomes more challenging, however, when the intention is to share research results within a scholarly community of specialists in need of all the available metadata on the object or the monument or the archaeological site reconstructed.

The case-study of an annotated sarcophagus lid, which will be examined in this paper, is part of the "Book of the Dead in 3D Project", which is coordinated by the author, together with a team of graduate students of the University of California, Berkeley.[13]

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[8] See, for instance, the MayaArch3D Project: <https://www.researchgate.net/project/MayaArch3D> [accessed: 5/22/2020] on a multi-resolution and multi-source documentation and digital reconstruction of the Maya kingdom of Copán in Honduras.

[9] See Ponchio et al. 2020: 90–91.

[10] The *London Charter* for the computer-based visualization of cultural heritage (<http://www.londoncharter.org> [accessed: 5/22/2020]) defines paradata as "an information about human processes of understanding and interpretation of data objects". They differ from "metadata" since they do not focus on the object's interpretation but rather on the interpretation's *process.* See Bentkowska-Kafel et al. 2012: 262.

[11] See Bentkowska-Kafel 2012: 245.

[12] See for instance the pages of the British Museum and their use of annotations; one among others: <https://sketchfab.com/3d-models/seated-statue-of-amenhotep-iii-53bbed1b8c034cb5ba4f719b5a98e771> [accessed: 5/22/2020] where only three annotations provide information about the historical context of the object and its use, beside to providing a general description of the decoration.

[13] See <https://3dcoffins.berkeley.edu> [accessed: 5/22/2020] and the Sketchfab page of the project: <https://sketchfab.com/bookofthedead3d> [accessed: 5/22/2020].

2. The Book of the Dead in 3D

The "Book of the Dead in 3D" project applies photogrammetry to the study of the ancient Egyptian coffins in order to realize annotated 3D visualizations of these artifacts and of their decoration, which consists mainly in texts and iconography taken from the so-called ancient Egyptian "Book of the Dead." The latter is a corpus of magical spells and ritual texts complemented by images, intended as a tool of protection for the deceased and whose tradition is related to other similar collections of a funerary texts from ancient Egypt attested during the Pharaonic and Greco-Roman periods. In particular, the Book of the Dead occurs on a number of media (papyri, coffins, stelas, amulets, tomb and temple walls) from the beginning of the New Kingdom (about 1500 BCE) onwards.[14]

Up until now, the project has produced about eighteen 3D models[15] of previously unpublished ancient Egyptian coffins, which are mainly kept in the storage rooms of the Phoebe A. Hearst Museum of Anthropology at UC Berkeley but also in other Egyptological collections in California and in the US. The main aim of the project is to annotate the coffins' 3D models and share them through a digital platform, in order to make them available for the scholarly community as well as for museum educational programs.

These were a central and essential item in the burial assemblages of the Egyptian elite since they were protecting the mummified body of the deceased; moreover, the texts and iconography decorating their exterior and interior played a role in empowering the rebirth of the deceased and her/his journey in the netherworld.

Studying the coffin's decoration, material and function is not always easy; due to their considerable size and weight, only major museums are able to have them on exhibition and document them properly.[16] Photogrammetry is facilitating coffin studies greatly on many levels, from their typological analysis to their data collection, comparison and dissemination.[17]

Ancient Egyptian coffins are fascinating artifacts whose rich and complex iconographic and textual decoration provide a central source for the study of the ancient Egyptian religion and funerary culture. The ancient Egyptians believed in the magical protection of the deceased body, which had to stay intact in order to allow the spiritual part of the dead to travel in the netherworld and reach the final

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[14] On the ancient Egyptian Book of the Dead and the funerary literature related to it, see Bickel – Díaz-Iglesias 2017. For a recent English translation of the Book of the Dead, see Quirke 2013.

[15] Updated to June 2020.

[16] Among the most recent studies on coffins and their documentation, see Strudwick – Dawson 2019; Taylor – Vandenbeusch 2018.

[17] See for instance the 3D visualization built by the new "Egyptian Coffins Project" at the Harvard Museum of the Ancient Near East: <http://www.digital-epigraphy.com/projects/three-ancient-egyptian-coffins-at-harvard-university> [accessed: 5/22/2020]; the Fitzwilliam Museum's Ancient Egyptian Coffins Project: <https://egyptiancoffins.org> [accessed: 5/22/2020]; the work on the coffin of Butehamon in: Mandelli et al. 2019.

assimilation with the gods. For this reason, the wooden coffin-ensembles (consisting generally in one outer and one or more inner coffins) and stone sarcophagi were considered "houses of eternity," as mentioned also in the ancient Egyptian sources. Most of them belonging to the elites and were fully decorated with magical texts and illustrations and those produced in the First Millennium BCE (from the Third Intermediate Period to the Greco-Roman periods), which are the focus of this project, were anthropoid in shape and decorated with spells and scenes mainly taken from the already mentioned ancient Egyptian Book of the Dead.[18]

While some of these coffins and sarcophagi were removed from Egypt as a consequence of a legal distribution of finds from foreign excavation projects, a huge number of them were pillaged from cemeteries during the 17th to early 20th centuries and sold on the antiquity markets to museums and private collectors, often together with the human remains of the mummified deceased buried in them. During the removal from their archaeological context, the provenience and contextual information concerning the coffins was almost always lost. For such a reason, many ancient Egyptian coffins are currently scattered in museums all over the world, where many of them still lie in storage rooms and are not exhibited in the gallery spaces, nor have they been fully published. Documenting and disseminating 3D models of coffins now lying in museums all over the world and publishing through the annotations any information available on each peace, allows scholars to re-establish links between objects that are now geographically separated, to better understand the historical record, and increase the visibility of the forgotten individuals who once lay in these beautiful "chests of life", as they were called by the ancient Egyptians.

The focus of the Book of the Dead in 3D project is therefore to create interactive annotations on the models themselves, in particular providing the text transcription and translation of the magical spells and other inscriptions (offering formula, captions to the images with names of deities and of the coffin owner, etc.) inscribed on the outer and inner surface of the coffins.

Currently the project's models and their annotations are hosted on a model viewer developed by Mark-Jan Nederhof (University of St Andrews), which uses JavaScript and the three.js library.[19]

While experiencing the 3D coffin models online, the user of this digital platform can at the same time consult the hieroglyphic transcription, transliteration and translation of the texts decorating the coffins and access a variety of other metadata. What follows is a case-study presenting one of the typologies of the artifacts under consideration, namely an inscribed stone sarcophagus lid.

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[18] On the Third Intermediate Period coffins and their archaeological context, see Aston 2009; on the Late Period coffins and sarcophagi: Elias 1993; Brech 2008; Leitz et al. 2018.

[19] For details on the functionality and the kind of control implemented for this viewer's navigation, see: <https://3dcoffins.berkeley.edu/content/making-javascript-model-viewer> [accessed: 5/22/2020]. I wish to thank Mark-Jan Nederhof also for providing feedback on this article.

3. Intangible words and images on stone: annotating a sarcophagus lid

When annotating the 3D model of an inscribed ancient Egyptian object, the major challenge is providing all the information in a user-friendly way where one can interactively localize the image's section to which each annotation refers while rotating the model on the digital interface; the links between the annotations and the models need therefore to be clearly detectable without obstructing the visibility of the model itself. When inscriptions are present and their translation and transcription need to be visualized though interactive annotations, the latter become part of the whole "narrative" on the model; their appearance, disappearance and transition on screen can be controlled by the user, since visualizing all the annotations at once would result in a poor visualization and understanding of the full object.

A relevant case-study for annotations is the 3D models made for a stone (basalt) sarcophagus lid belonging to an official of the Twenty-sixth dynasty (about 664–525 BCE), Psamtik, kept at the Phoebe A. Hearst Museum of Anthropology of the University of California, Berkeley (Pahma 5-522, fig. 1).[20]

Fig. 1.

Intro | Context | Persons | Text | Vocab | Help

Introduction

PAHMA 5-522

Psamtik was an overseer of an enclave of Libyan mercenaries (the Temehu), as well as chief physician. He had the wealth and proximity to the king to build himself a magnificent tomb in the form of a room-sized underground sarcophagus, with this basalt sarcophagus lid of about 2.46 meters long, weighing approximately 3 ton. Strangely, he was never buried in his tomb, and the lid was left propped above its basin, waiting for his body to be deposited inside.

The lid is anthropoid in form but with squarish broad face, large ears and a smooth unarticulated body and slightly protruding feet. Much of the inscription consists of (fragments of) spells from the Pyramid Texts, the Coffin Texts and the Book of the Dead. In addition, there are speeches of gods in favor of the deceased.

An almost identical text is found on the stone anthropoid coffin of Tiannahebu, published by Pernigotti (1977).

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- L. Gestermann. *Grab und Stele von Psametich, Oberarzt und Vorsteher der* **Ṯmḥ.w**. Revue d'Égyptologie 52, 127-149, 2001.
- S. Pernigotti. *La tomba di Ciennehebu, capo della flotta del Re*. Pisa: Giardini, 1977.

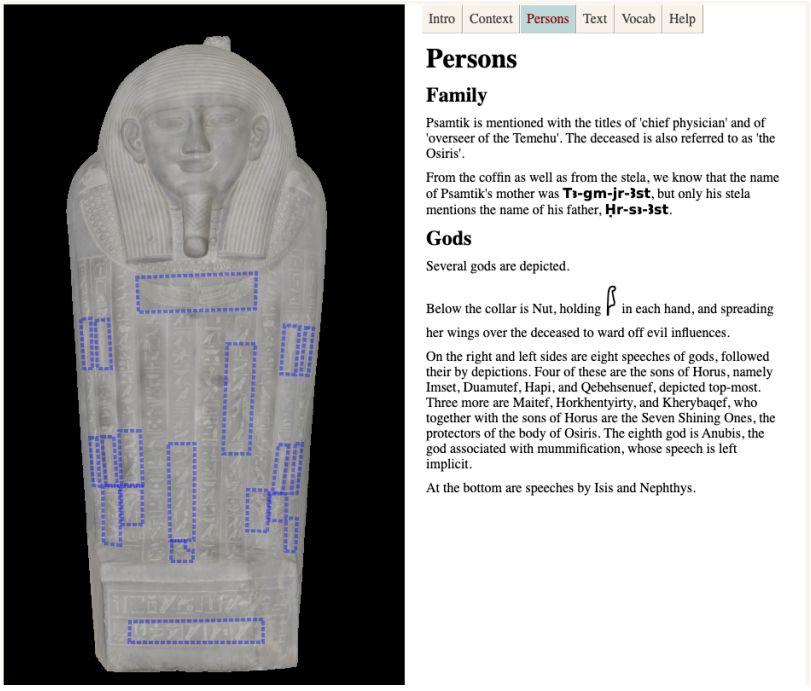
Acknowledgements

The coffin belongs to the Phoebe A. Hearst Museum of Anthropology. These pages were prepared by Rita Lucarelli, Kea Johnston and Mark-Jan Nederhof, for the Book of the Dead in 3D.

[20] A full study of this coffin and edition of its text, written by the author of this article, is currently in course of preparation.

In this case, since the sarcophagus belongs to a known archaeological context of a well-documented tomb in Saqqara, the information on the whereabouts of the piece is too extensive and need an articulated series of interactive annotation. Therefore, on the project's page for this piece,[21] the "Introduction", which includes the bibliographical references and the acknowledgements, is presented next to the model in a section of plain text and not as an interactive annotation. Similarly, a second section of text, to which the user can switch through a menu bar placed on top of the screen, provides information on the context of the piece (provenance, geographical location and map, historical period). The prosopographical information, accessible through the "persons" tab on the same menu bar, is where one can find the first interactive annotations consisting in the prosopographical information occurring on the lid (fig. 2), namely the name and epithets of the coffin's owner, the name of his mother and father; the deities mentioned and depicted on it are also listed in this section, and can be interactively linked and found from the annotation to the model.

Fig. 2.



[21] <https://3dcoffins.berkeley.edu/coffins/pahma-5-522> [accessed: 5/22/2020].

The main and most challenging section is that indicated as "text" on the menu bar. The annotator here has to deal, as often happens when documenting ancient Egyptian inscribed objects, with sections of script copied on the lid according to different reading directions. In order to correctly map the annotations that provide the transcription, transliteration and translation of the text on the model, it is necessary to indicate each text section. In the case of the sarcophagus lid of Psamtik, one can label the different textual sections according to their position on the lid, namely "front", "right side", "left side", "bottom right", "bottom left" and "feet" (fig. 3).

Fig. 3.

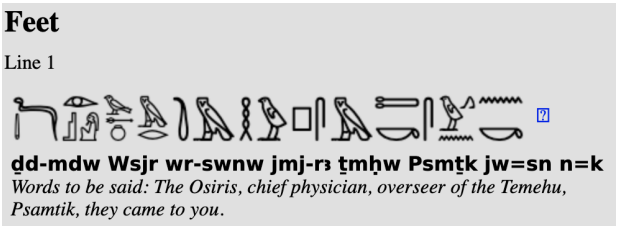
Such a terminology indicating the spaces related to the annotations is highly variable according to the object and it reflects the terminology also used to describe a cultural heritage artifact in a printed publication, which in the case of coffins could be a museum catalogue or typological study.[22]

It is also possible to add a varying number of references within each annotation; in the case of Psamtik's text, for instance, the type of spells, if known, are indicated as well (i.e. Book of the Dead spells and Pyramid Texts); another text section contains the

[22] Among others, the study of van Walsem 1997: 65–68, provides an excellent resource for the ancient Egyptian coffin-related terminology.

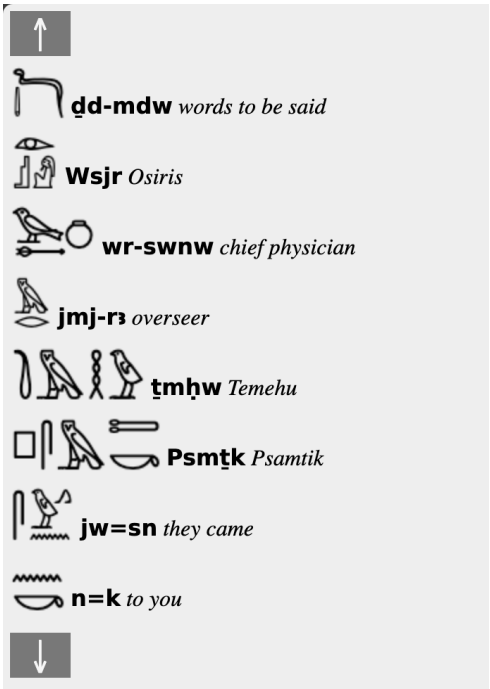
translation of each word, in order to facilitate the use of the annotations for teaching purposes or on an educational level. For instance, by clicking on the annotation referring to the passage labelled as "Feet" > "Line 1", one can first see the full rendering of the text transcription, transliteration and translation as following (fig. 4):

Fig. 4.



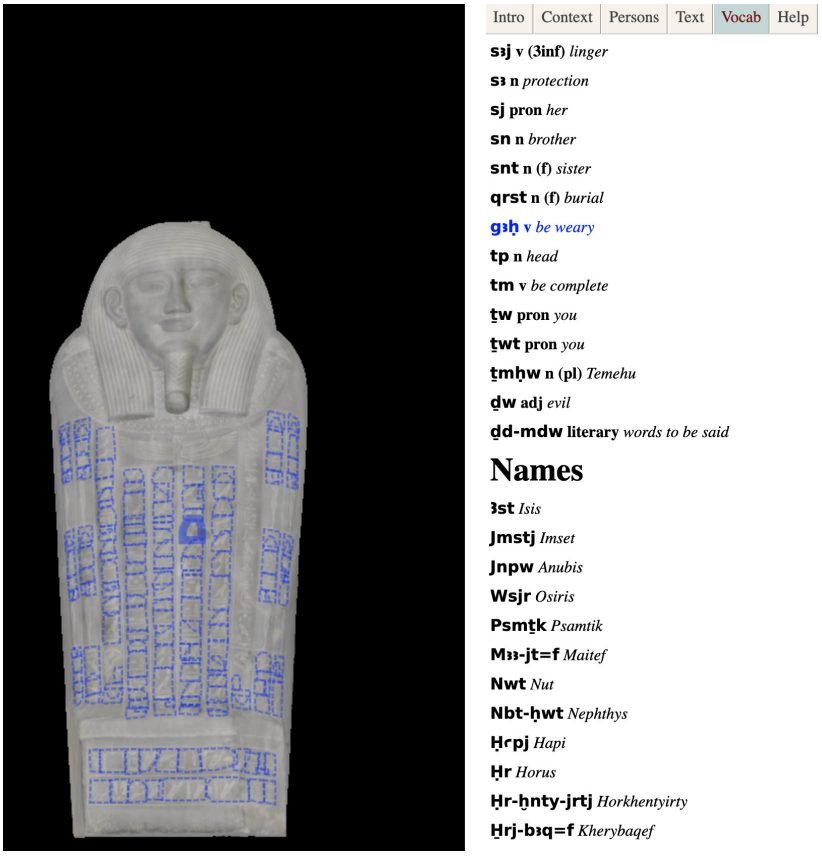
By continuing to the next annotation through clicking on the question mark at the end of the hieroglyphic text, one can access the analytic translation of the same passage (fig. 5):

Fig. 5.



With a similar educational purpose, an extended vocabulary is also available, where each term is also described grammatically (indicating if it is a verb, a noun, an adjective, a preposition, etc.) and linked to the sarcophagus model as well (fig. 6):

Fig. 6.



In order to use the model and access the annotations on it properly, some basic instructions are also included in the menu bar through a "help"-tab where one can learn how to zoom in and out, tilt the object up or down, as well as measuring the distance between two points. It also guides the user who is viewing the model on tablets, since the latter have become popular devices for access to any kind of digital resources for study and research.

The text carved on the sarcophagus lid of Psamtik, before the current digital study described above, was only transcribed (but not translated) around the time of its

discovery, in 1900.[23] The facsimile of this early publication alone could not render the materiality of the text and its intimate relationship to the object as it does when viewed and "read" through the annotations on the 3D model; in other words, the annotations show how the text is completely embodied in its media, namely the two tons-heavy lid, which had to protect Psamtik's mummified body; it also allows to view exactly which portions of the lid were inscribed and which ones were filled only with images complementing the text.[24]

4. Conclusions

When digitally reproducing and sharing cultural heritage through computer-generated imagery (CGI), a major challenge is to provide easily accessible data and metadata, both for the scholar/specialist as well as for the non-specialist user; data standardization and a well-defined and clear terminology avoiding too specialized jargon are important.

CGI is very popular in video games and entertainment software, where the users need to instantaneously catch the visual message as well as individuate the information (metadata and paradata) connected to it. Similarly, when applied to heritage visualization, CGI needs to reproduce and communicate different levels of historical knowledge unambiguously, in order for the intellectual transparency of the study to be recognized.[25]

In particular, when dealing with text-annotations in 3D visualizations of historical objects, the need for transparency and clarity about the text-based study and documentation of the object becomes central. Building up annotations becomes a creative process finalized to provide the best way for the user to immerse into the text description, paleography and translation, next to the other metadata, which can all be explored through the annotations of the 3d model.

For visualizing the text annotations of the Book of the Dead in 3D Project, we have opted for a Java tool with 3D functionality, originally developed for 3D computer games. However, no matter which text input tool one chooses, what is important is to enable the linkage of the text to the 3D model and to obtain the most optimal visualization of both. In particular, when dealing with text annotations of hieroglyphic texts, it would be important to be able to have the same text searchable through the implementation in OpenType fonts with Unicode representation of the language.[26]

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[23] Barsanti – Maspero 1900: 185–187.

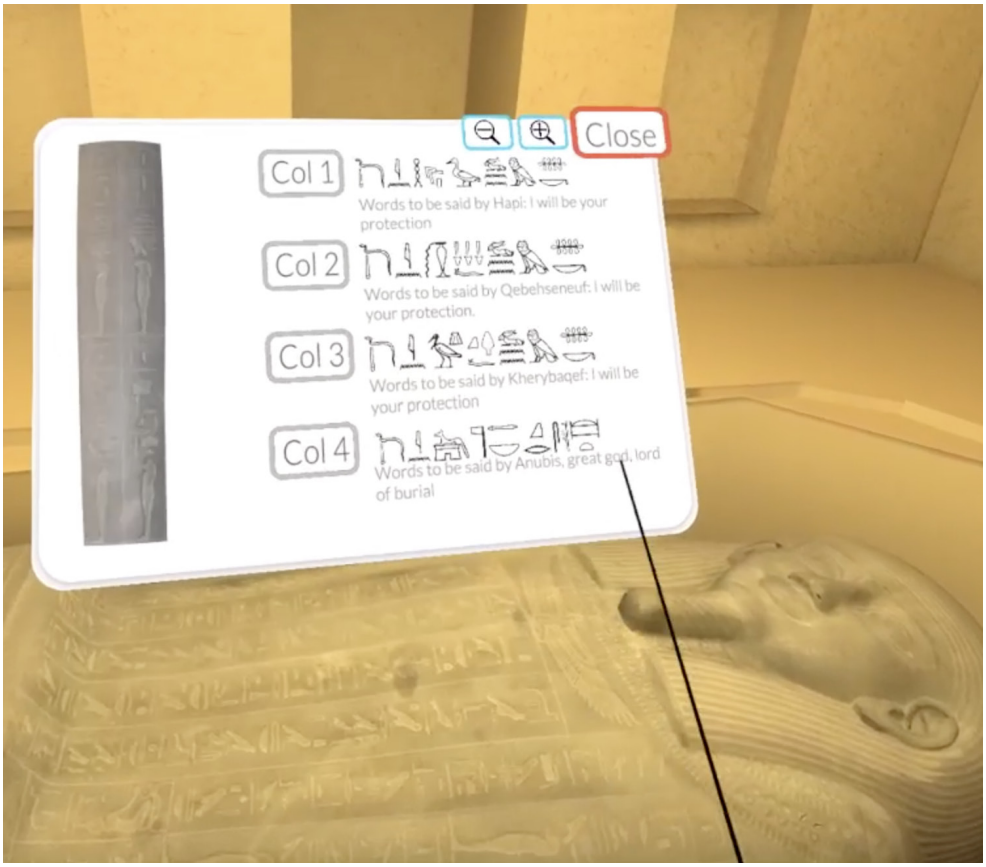
[24] In the case of Psamtik's sarcophagus lid, for instance, the images of some deities mentioned in the texts, such as the Four Sons of Horus, Isis and Nephtys, which seem to follow the deities' names as a sort of determinative, are depicted in a larger scale than the hieroglyphs themselves.

[25] On "transparency" in heritage 3D visualization processes, see Bentkowska-Kafe et al. 2012.

[26] The unicode control characters for ancient Egyptian have been released in March 2019 as part of Unicode 12.0: <https://www.unicode.org/charts/PDF/Unicode-12.0/U120-13430.pdf> [accessed: 5/22/2020]. Mark-Jan Nederhof is currently working to the implementation of Unicode for the Book of the Dead in 3D project.

Finally, thanks to the continuous progress of the technology for 4D and Virtual Reality visualizations, it is currently also possible to use annotations in VR apps that re-contextualize the annotated object. This is the case of the upcoming app "Return to the Tomb", which has been built by the author in collaboration with Elaine Sullivan (UC Santa Cruz) and Chris Hoffman (UC Berkeley) and which will be launched in 2021.[27] In this app, currently tested on VIVE headsets, the user can experience the above-mentioned sarcophagus lid of Psamtik by virtually visiting his necropolis and tomb, where the lid has been digitally re-placed. Navigating from the cemetery landscape through the tomb and viewing the lid, the user can also point to the text on it and visualize the annotations that provide a transcription and translation of the spells (fig. 7).

Fig. 7.



[27] This project is part of the CITRIS Connected Communities series: <https://citris-uc.org/citris-banatao-institute-award-600000-ten-information-technology-projects> [accessed: 5/22/2020].

The text annotations, used in 3D as well as in 4D and VR visualizations, add a new dimension to the digitalization of the ancient Egyptian objects inscribed with text of historical, literary or religious character. They allow access to the artifacts and their inscriptions while contextualizing them in time and space and producing a new inspiring approach and methodology in the study of the materiality of texts in general.

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