

ARCHAEORAMA: Proposing a multimodal application for the documentation of archaeological excavations in situ

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Abstract—The age we live in is the age of the technological revolution: the social networks, virtual communities, 3D worlds, digital applications, immersive and collaborative games, are able to change our perception of the world as well as the way information is shared and transmitted. The shift of our society towards new technologies has greatly facilitated the integration of these technologies (Virtual Reality, Augmented Reality, Photogrammetry, etc.) in places such as archaeology, which in the past seemed like a very difficult idea. In recent years, archaeologists have begun to incorporate new technologies that can assist them in archaeological excavations. Such technologies include 3D Imaging Surveying methods (LiDAR, Mobile and Terrestrial 3D Scanners), Unmanned Aerial Systems (UAS), Photogrammetry as well as 3D Visualization Methods (Virtual and Augmented Reality) for the three-dimensional or two-dimensional display of sites where archaeological excavations are carried out. A big advantage of new technologies is the highly increasing capabilities and user friendliness over cost ratio, which encourages archaeologists to enter the emerging realm of Digital Archaeology. In this article we aim to present you our proposal on an application that will be a powerful tool in the hands of archaeologists during the excavations. This paper aims to present to you the structure and the methodology that we have followed for the creation of the ARCHAEORAMA.

Keywords— *Archaeological excavations, Visualization, Workflow, Architecture, Spatial Information.*

I. INTRODUCTION

The integration of new technologies in the excavation process has now become a very important tool in the hands of archaeologists and offer a different perspective in the field of research. The combination of new technologies in the excavation process nevertheless hides a number of challenges which should not be considered negligible. For this reason, the design and implementation of a multimodal application for the recording, documentation and highlighting of excavation work should be done with special care and to follow the procedures taken by archaeologists during excavations.

In the context of the project ARCHAEORAMA “Excavations Multimodal Surveying, Documentation, Enhancement and Promotion System”, an innovative application that connects new multimodal technologies with the documentation of archaeological excavations and mapping is proposed.

Specifically, the ARCHAEORAMA application aims at:

- the design and the development of a modern digital environment that will provide advanced possibilities of interaction to the archaeologist excavator, for multimodal recording and mapping, on site and online.
- the adaptation and the enhancement of the functionality of existing digital archaeological documentation systems, in order to receive and manage effectively the data and knowledge

captured online and onsite, development of new systems of processing and shaping the knowledge for the general public.

- the broader communication of the excavation experience, using advanced digital media and in a way that is economically viable and business exploitable.
- the increase of the knowledge and experience levels of scholars and scientists in the space-time digital, with possibilities to injecting new information.
- the composition of a complete, advanced digital environment, which will transform the experience of archaeological research into an interesting form of digital storytelling for the visitor or museum.
- the utilization of state-of-the-art devices, such as Augmented Reality headset (Hololens 2).

II. RELATED WORK

Before proceeding with the creation of the structure of our application, we carried out the necessary bibliographic review on the applications and technologies that exist for the excavation site [1]. Through our research we found a variety of applications which aims to be an important tools in the hands of archaeologists during the excavations. Applications and software such as: 3D Murale[2], VITA[3], QueryArch3D[4], Ad Hoc 3D[5], iDig-Recording Archeology[6], ArchField[7], ArtifactVis2[8], OpenDig[9], Citizen Coast Archeology[10], FieldNotes[11], ARCHAVE[12], ArchaeoSTOR[13], REVEAL [14], CASTLE3D [15] and Excavations go mobile [16]. Between the above applications we singled out four of them, which we consider to be a very good basis in order to create ARCHAEOGRAMA, namely 3D Murale, VITA, iDig and Excavations go mobile.

III. BASIC ENTITIES – ARCHITECTURE OF THE SYSTEM

The proposed modules of the proposed application are based on the following basic entities, which are interconnected with each other: Spatial Information (Excavation, Layer, Section), Findings and User (as seen in Fig. 1).

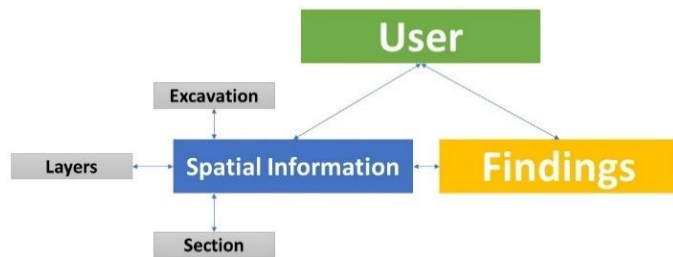


Fig. 1. The main entities of the proposed application and how they are connected.

A. Spatial Information

Spatial information refers to spatial data including certain characteristics such as location, distance, etc. Spatial information is subdivided in further subcategories, such as Excavation, Layers and Sections. Layers refer to the soil levels,

that are inherited from Excavation. Sections are the divisions that are created during the excavation and are inherited from Layers.

1) Excavation

The suggested fields for the "Excavation" section are as follows (Fig. 2):

- ID: The ID in the application is a unique feature for each excavation and is entered automatically. The following files are also attached to the ID: Map, Topographic image, Architectural plans, photos, lidar data, video and voice recording.
- Excavation type: The excavation type is defined by the user who will be through a drop-down menu.
- Location name: It is a field in which the user enters the name of the location of each find / excavation.
- Coordinates: Coordinates can be entered automatically using GPS or manually if known.
- Start time stamp: It is a blank field that the user enters at the start time of the excavation.
- Expiry time stamp: It is a blank field that the user enters the end time of the excavation.
- Space category: The choice is given whether the space of the findings is Underwater or Land.
- Weather: Weather is recorded either automatically or manually with specific menu options, as they are an important factor in any excavation.
- Excavation calendar: Every archaeologist so far has a handwritten diary for each excavation where the information of each excavation is recorded (eg description of the excavations per day etc). This diary also has a serial number. So, in this field this number is recorded.
- Comments: It is a free field where the user can write comments, remarks and generally notes about the excavation in which he is.

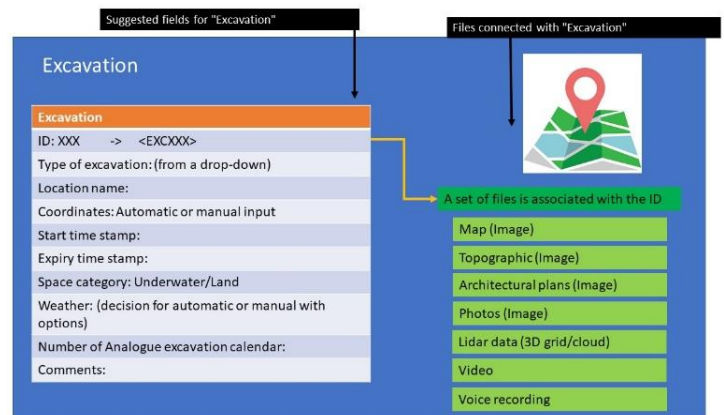


Fig. 2. Visualization of the suggested fields of the "Excavation" section and the files associated with the "Excavation".

2) Layers

Each archaeological excavation consists of soil layers. The layers can be characterized based on the description of the soil e.g. solid, sandy, smooth etc.

The suggested fields for the "Layers" section are as follows (Fig. 3):

- ID: As in the excavation, each layer has its own primary key and is interconnected with the excavation ID. For example, if the excavation with ID 1 (indicative form of ID) has been selected, then any layer can be selected, based on its ID, which is registered in the specific excavation. Again, the following files are also attached to the ID: Map, Topographic image, Architectural plans, photos, lidar data, video and voice recording.
- Layer name: Enter a name for the layer.
- Depth: Field where the user records the depth of the upper and lower finding surface.
- Soil composition: Field where the user records the soil composition e.g. if it is solid, fine-grained, etc.
- Start time stamp: It is a blank field that the user enters the start time of the recording of the respective layer.
- Expiry time stamp: It is a blank field that the user enters the end time of the recording of the respective layer.
- Period: In this field the user enters the time period of the layer.
- Number of Analogue excavation calendar: Note the number of the handwritten diary for each layer separately.
- Comments: It is a free field where the user can write comments, remarks and generally notes about the layer that is in an excavation.

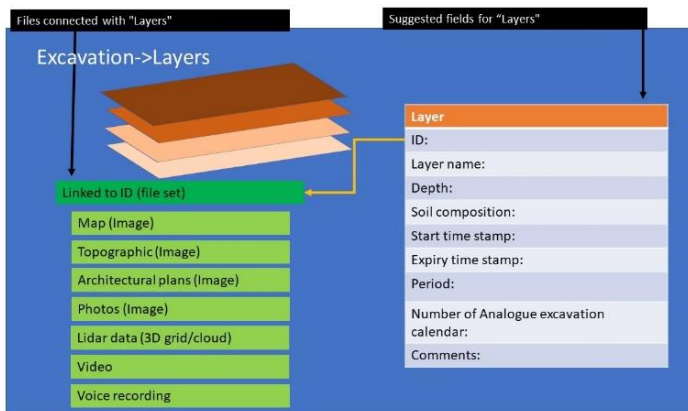


Fig. 3. Visualization of the suggested fields for the Layers section and the files associated with the Layer ID.

3) Sections

During the archeological excavation, the layers are then divided into square sections. It should be noted that it is located in the section "Excavation", "Layers" (Fig. 4).



Fig. 4. "Inheritance" of the Excavation process.

The suggested fields for the "Sections" section are as follows (Fig. 5):

- Section ID: Each section is a one-layer square during archaeological excavation. Thus, the field ID of the section square is automatically entered in this field. The ID also connects a number of files that are similar to those in the subsection of «Layers» like Map, Topographic etc.
- Grid: Enter the grid number that belongs to a specific excavation, layer and section.
- Boundaries: The user enters the vertices of the section.
- Section Name: Defines a section name.
- Start time stamp: It is a blank field that the user enters the start time of the recording of the respective section.
- Expiry time stamp: It is a blank field that the user enters the end time of the recording of the respective section.
- Period: In this field the user enters the time period of the section.
- Number of Analogue excavation calendar: Note the number of the manuscript log for each section separately.
- Comments: It is a free field where the user can write comments, remarks and general notes about the section.

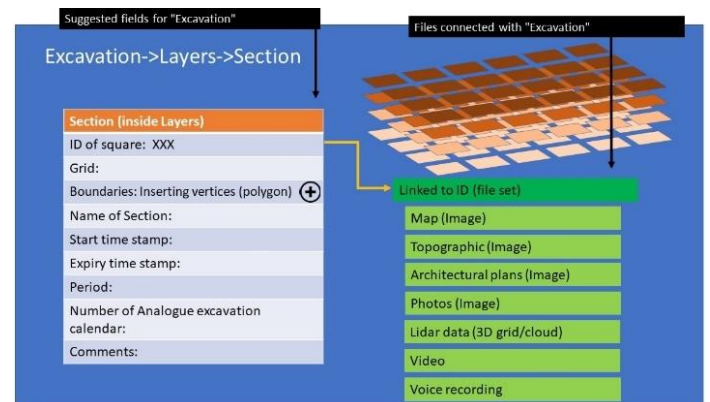


Fig. 5. Suggested fields for the "Section" section located within the "Layer" section and the files associated with the ID.

B. Findings

"Findings" (artifacts) is an important category during the archaeological excavation and it is registered in a separate hierarchical level according to the archaeologists. Moreover, it is a field dependent on the excavation, the layer and the section. It can be of any form such as tomb, vase, etc. and with different, obviously, characteristics.

The suggested fields for the "Findings" section are as follows (Fig. 6):

- ID: Each finding has its own ID which is related to the same group of content (e.g. map, video recordings, lidar data etc.)
- Type: The user has to choose between Non-portable and Portable artifacts. If the non-portable category is selected, a dropdown menu appears with the following options: Architectural remains, Grave, Constructions and Other. However, if the portable category is selected then the following choices are arrayed: Ceramics, Stone, Metallic, Bone, Glass, Coins, Inscription, Sculpture, Other.
- Kind: "Kind" depends on the "Type" field and depending on what the user chooses from this field, it is registered in "Kind".
- Period: The user enters the time period to which the finding belongs and depends on the "Type" of the finding.
- Spatial info: The Excavation ID, Layer ID and Department ID are automatically entered in this field.
- Location: The user enters the exact location of the find as the location is important because each find can be retrieved from a different point in an excavation. Specifically, it records the depth of the upper and lower search surfaces or a point if there is 3D information such as a point cloud or 3D grid (Figure 6).
- Color: The user in this field can record the color of the find.
- Dimensions: The user in this field can record the dimensions of the finding.
- Analogue excavation log number: Note the number of the manuscript log for each find separately.
- Comments, detailed description: It is a free field where the user can write comments, remarks and a detailed description of the finding.

Fig. 6. Suggested fields for the "Find" section and the files associated with the ID.

C. User

"User" refers to an archaeologist or curator that operates the application. The operator has specific rights for content managements (either for simple view or for full management options). The suggested fields for the "User" entity are as follows:

- ID: The ID defines all the information and rights of the user and is created automatically after entering the following fields (Username, Password, Name, Attribute, Role, Rights, Comments). Based on this it performs within the application.
- Username: The user enters a desired Username at his discretion.
- Password: The user enters a desired Password in order to secure his account.
- Name: The personal data of the user are entered by himself, ie his Name and Surname
- Attribute: The attribute determines whether he is an archaeologist or a museologist, etc.
- Role: The role determines whether he is a curator or a member of a team etc during an excavation.
- Rights: The editing/permission rights corresponds to a user's access level that is assigned to every account.
- Comments: It is possible to add comments about his account.

Fig. 7. Indicative visualization of the main parts of the application(up) and Indicative visualization of the application with selected "Excavation" with ID2 and display of registered information(down).

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D. Basic parts of the application

The application consists of six main parts, which are the fields of the entities, their display area and / or their completion, the display area, the sub-menu, the main presentation-visualization screen and the activation area of the log functions (Fig. 7, up).

As mentioned above, each entity has a separate function and may have additional sub-groups of entities. In the data display, the fields are "displayed" depending on the user's choice. For example, if the user selects an excavation with ID 2 then the fields for that excavation will appear in this box. The indications include information such as date, time and GPS, as well as search, location and navigation icons. The sub-menu consists of a set of files that if the user selects a button from them the corresponding information will appear on the presentation-visualization screen. Capture functions are buttons that the user can select to capture image, video, audio, screen capture, and draw lines and dots (Fig. 7, down).

IV. APPLICATION USAGE SCENARIOS

A. Original scenario

Initially, the user using his/her personal credentials (username and password) performs log-in to the platform. After the successful login, the user will be able to select the working excavation, the current layer and the specific section. All these selections are made via a dropdown menu. Depending on the privileges assigned to him/her by the central administrator, the user is able to add new information to the respective levels. In Figure 8 we notice that at the top right there is the field where the user fills all the necessary options of excavation, and the corresponding artifacts that are found there.

In the center of the application, there are some necessary indications, such as the compass (always indicating the north direction), the map, the timestamp, the GPS data as well as the search option. The user depending on the management rights that he/she has, may add new information to the necessary fields.

Also, the user, by clicking on the refresh option (i.e a button that synchronizes the data), may send or receive appropriate information related to the excavation fields. This entity (excavation) contains the fields that are described previously in section 3.A.I:

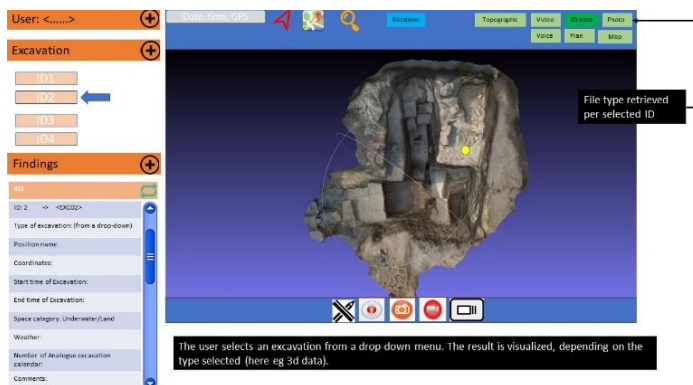


Fig. 8. View 3D information.

Having now selected the excavation, the user is presented the visualization results. At this point, at the top right of the screen there is information about the selected excavation (e.g. topographic map, video, 3D - data, photos, voice recording, plan and map. These are the items retrieved from the database depending on the selected id. As we see in Figure 8 (top right), the information that will be displayed will be marked for reasons of navigation and user friendliness of the application.

Each piece of information (three-dimensional, two-dimensional, sound, etc.) requires specific processing. For example, he/she can make some basic edits to an image, such as noting something on it using a shape or writing a note. Moreover, users, depending on their management rights can manipulate information in the respective entities and in their fields. Information and data such as: audio, photos, video and audio. Choosing the corresponding buttons they can add information of multimedia files in the appropriate section (excavation, layer and section). The application offers the following: choices:

- Voice recording.
- Uploading/Downloading photo.
- Uploading/Downloading video.
- Typing notes.

Figure 9 portrays the result of photo selection in a specific excavation, which are displayed in the central part of the screen.

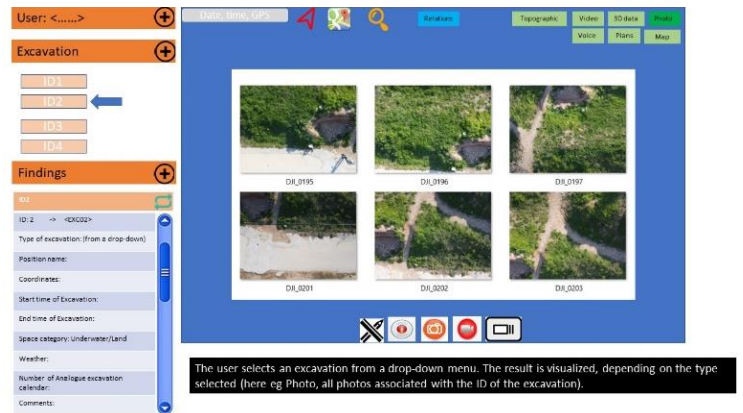


Fig. 9. View excavation images.

Once users select an excavation ID, they can proceed to the next level, which is the layer selection. The available layers of the excavation are displayed via a drop-down menu. Each layer is uniquely identified by an ID as well. The layer inherits the properties of the excavation, since "Excavation" is parent and "Layer" is the descendant. The layers contain the fields described in Section III.A.2 above,. A screenshot is shown in Figure 10(up):

Since "Layer" inherits properties from "Excavation", users may navigate through all levels of hierarchy information, such as topography maps, videos, 3D data, lidar data, photos, audio, drawings and sketches. On all screens in the application, the buttons remain fixed at the top.

Figure 10 (down) demonstrated how the users may select multiple layers of an excavation and visualize the result in 3D. In the 3D section, each layer is numbered accordingly with a serial number associated with a timestamp. Users can also see, in exactly the same way, the visualized information from the sections on the top left.

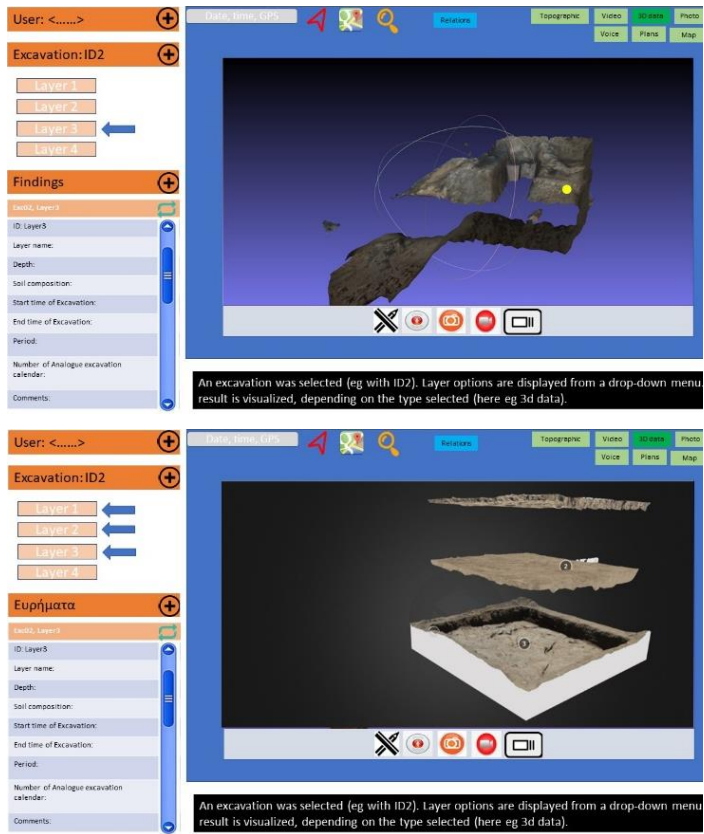


Fig. 10. Layer selection (up) and Selection and display of multiple layers in an excavation (down).



Fig. 11. Topographic plan.

Figure 11 portrays the result of visualizing the topographic plan on an excavation when the user has selected an excavation (e.g. excavation with id2) and a specific layer from a drop-down menu that displays the existent layer information.

In another example, (Figure 12), the user has selected the excavation with ID2 and Layer 2. Depending on the choice

he/she has made, a drop-down menu is displayed with the available sections (in this example there are four). Again, the result is visualized depending on the type selected (e.g. 3D data), and the user is presented with the specific layer and section. The fields contained in the section are: Section ID, Grid number, Limits, Section name, timestamp.

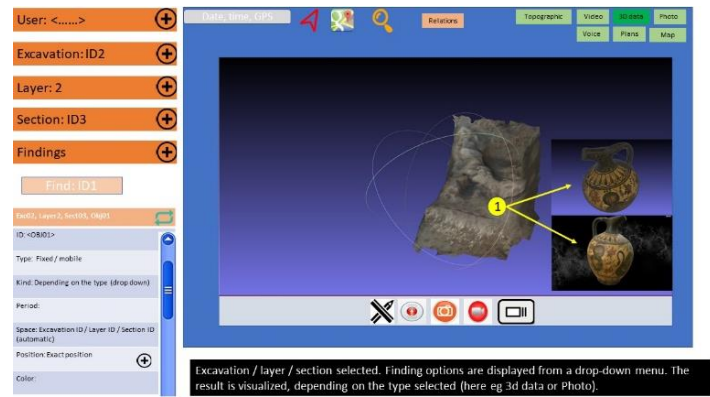


Fig. 12. Display of Findings in central screen.

At this point, the user may navigate to the possible artifacts/objects that are found in the specific section through a drop-down menu. In Figure 12, we may see that based on the selections made (e.g. excavation ID, layers ID and section ID) the user may select the position of a finding. In that case, visualized information (e.g. 3D model or photos) is displayed in the center of the screen.

Similarly to the other basic entities, the users may update the information (if this is necessary) and synchronize the new information with the database or receive extra information. The findings (artifacts) contain the following fields to be documented: ID, Type (portable or non-portable), Kind, Period, Spatial info, Position, Colour.

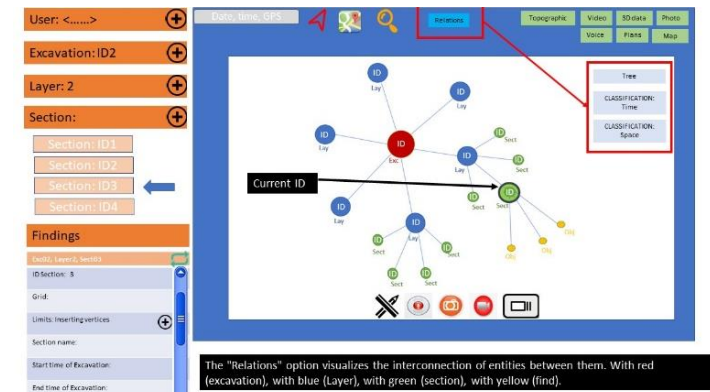


Fig. 13. Visualization of linked data – relations between entities.

Moreover, the ARCHAEOGRAMA application offers a visualization module to illustrate the hierarchies and the relations between entities. Selecting the "Relations" option, the user gets a visualization of the linked data between entities, structured in a way that it becomes more useful through for queries. Figure 13 shows a star-based structure in which the excavation is represented in red, the layers in blue, the sections

in green and the findings in yellow. This hierarchy may also be represented in tree or in graph form.

Finally, there is a search module in the application. Through this tool the archaeologist/user is able to identify a specific information, or perform an advanced/combined search in text fields, images, videos, 3D models, files and notes.

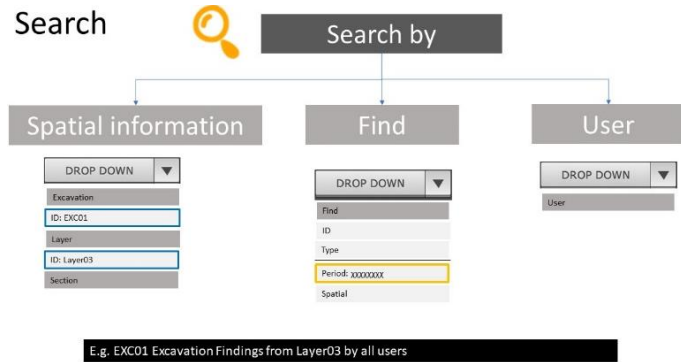


Fig. 14. Search structure and fields. Search example.

At this point, the user can search for information based on IDs (excavation, layer, section), types, periods and places where a finding was found. An example search is demonstrated in Figure 14, where we see a query for artifacts (findings) from the EXX01 excavation period, found in Layer03 from all users engaged.

B. PC and Mobile Application

The application runs on android devices (tablets and smartphones), and PCs (Figure 15). There is at least one archaeologist/curator who has full administrator rights to manage the database. Simple users (i.e., archaeologists in the field), are connected to the application with specific rights, will be able to configure their own input files (Images, Videos, Notes, Audio Files and 3D models), perform data management in a restricted level. Simple users will be able to record data in situ (i.e., directly during archaeological research) using a tablet, or a smartphone, provided that the Archaeorama App is installed in those devices.

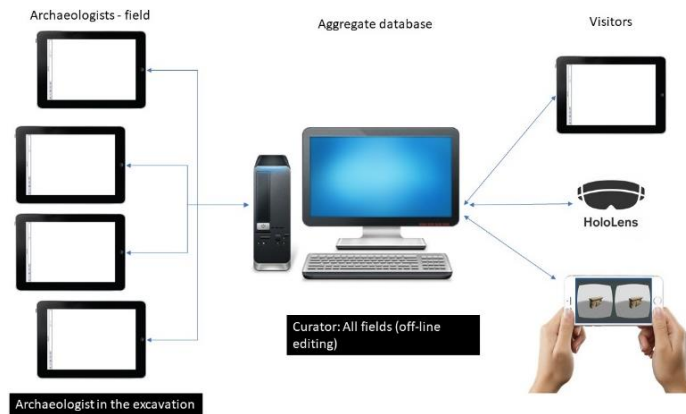


Fig. 15. Application management by archaeologists and users.

C. Augmented Reality (AR) headset application

In parallel to the mobile device app, an AR application is currently undergoing development using HoloLens 2 AR stereoscopic glasses. The basic idea is that through HoloLens 2, the archaeologist may record necessary documentation information such as photos, videos and voice recording during excavation works.

For instance, when the user activates the HoloLens camera, he/she will be able to operate the headset in a special mode for photogrammetry (batch mode) or in video mode. In addition to these basic functions mentioned above, as long as the headset is worn, there is always the possibility to activate a series of useful measurements and survey tools such as: a) date and time, b) GPS information, c) scale measurement, d) rough 3D scans, e) editing tools, f) content display, g) notebook activation, h) multimedia visualization. All the above information may be furnished to the archaeologist in situ (in the field), in real time, with information synchronized with the database on the cloud. Some prototype screen shots though HoloLens 2 are displayed in Figure 16.

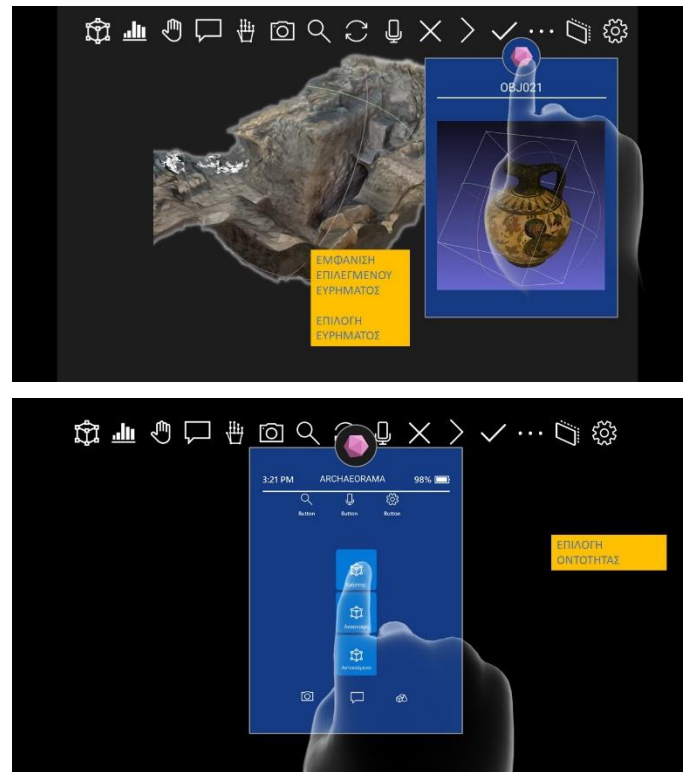


Fig. 16. Prototype screenshots of the AR application.

V. CONCLUSION

Thanks to the technological advancements in recent years, the field of Digital Archaeology is experiencing an unprecedented growth, judging from both the published scientific papers, as well as the large investments from Departments and Ephorates of Antiquities worldwide. This would not be possible without advancements in technologies such as 3D Imaging, 3D Data Visualization and modern mobile

technologies that implement VR and AR modules, which are now the most important catalysts for digital cultural heritage.

The ARCHAEOGRAMA application is an innovative platform, which aspires to give a new dimension to excavation mapping, documentation and surveying using state-of-the-art technologies. Specifically, it includes: a) In situ, online digitization and recording of archaeological data by the archaeologists who operates it, b) Data processing and documentation, c) Content editing and synthesis of digital products in three-dimensional Augmented Reality spaces and d) In situ information presentation and digital browsing.

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