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MAPOD4D "CSSG": the first Metaverse on the skeletal recovery in the experimental field laboratory for the research on technological applications in the archaeological UNESCO site of Castelseprio – San Giovanni

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Abstract. During the 2023 excavation campaign realized by the University of Padua in the UNESCO site in Castelseprio, in San Giovanni church, the first anthropological metaverse (https://www.mapod4d.it) called MAPOD4D CSSG has been created, focused on the skeletons recovery and analysis. The article aims to present Metaverse CSSG and the methods that led to its creation. The project purposes can be summarized as the creation of a new instrument for the virtual musealization capable of including new data kinds and information, suitable also for teaching and as support for bioanthropology lectures. It allows the musealization of excavations phases and of the analysis. It also contributes to the enhancement of the scientific activities thanks to a parallel database which saves data in suitable formats and to the software for the elaboration and measurement of the points cloud. Main features will be the FLOS (Free Libre and Open Source) philosophy, base of the developing; the technological instruments used, their affordable costs and problems; the definition level of Metaverse 3D models compared to reality items; future developments; new professions connected to the Metaverse and to Cultural Heritage and the possibility to consider the excavation site an experimental field-lab for the technological research in Archaeology.

Key words: metaverse, MAPOD4D, archaeological skeletons, FLOSS, anthropological teaching

Introduction

In the excavation campaign of 2023 in the Church of San Giovanni in Castelseprio (VA) (Chavarría Arnau et al., 2022), started the project for the creation of the first Metaverse MAPOD4D, dedicated to physical anthropology with the objective of documenting all phases of the anthropologic examinations (digging, recovery and analysis of human skeletal remains), surrounding them in a digital interactive environment called MAPOD4D CSSG. The idea to dedicate a metaverse to skeletal remains is part of a series of experimental researches in the field of the study of architectures and cemeteries (identified during the examinations) which, themself are part of the project started in 2021 'Castelseprio, center of power', coordinated by Gian Pietro Brogiolo and which includes various sites in the archeological park of Castelseprio (Brogiolo, 2020). Digging and analysis of the cemeteries are also part of a series of multidisciplinary researches in the CAMIS (Cemeteries and Medieval Archeology in Northen Italy) research project which is active since 2011 from the cattedra of Medieval Archeology (http://arcmed.lettere.unipd.it/CatMedievale/CAMIS_home.html).

The term metaverse has no unique definition because it assumes different meanings and objectives depending on the context.

The metaverse was introduced in the field of Cultural Heritage in 2020 with the project Multiverse of Metaverses MAPOD4D and registered (Original work covered by copyright in accordance with the Law 22/04/1941 n. 633, G.U. 16/07/1941, s.m.i., author and holder of moral and economic rights Roberto Taglioretti, available at https://www.mapod4d.it.) in 2021 as unpublished in the register of software as an attempt to give a new digital and interactive space useful for public archaeology, didactics, training and musealization. It is the only example, in the Italian scenario (Palombini, 2023), of FLOSS (Free Libre and Open Source Software) platform that provides a final representation of activities and scientific-technology research with a focus on physical anthropology, archaeology, history, art and general culture (https://www.youtube.com/@mapod4d). The focus of the research is centred on the digital elaboration of images, data repository, digital lab and new sensors for data acquisition, to the tuning of new methodologies (Mazzucchi et al., 2018; Moderato et al., 2022; Moderato et al., 2023; https://github.com/mapod4d/docs for clearings on the digital protocol).

The Multiverse of the MAPOD4D project is inspired by the theory of a collection of universes called multiverse (Hawking & Hertog, 2018) and, with a more fantasy approach, is thought as a bundle of virtual universes called Metaverses. This virtual universe, muted, which contains spherical spaces of infinite radius, opens to visits to the inside, called Metaplanet (https://github.com/mapod4d/docs/blob/master/it/c1/it_documento_tecnico_mapod4d.pdf); it is a similar concept to 'Metaverse' described in the science-fiction novel 'Snow Crash' (Stephenson, 1992) in which the metaverse is a digital universe, parallel to the real one. MAPOD (Multi Analysis PrObe Drone) is the Probe which represents the visitor's avatar: it can move in all direction and it is not affected by gravity; the notation '4D', instead, is referred to all four dimensions (height, width, length and time).

The Multiverse is the set of Metaverses MAPOD4D, each one representing a virtual musealization built on temporal sequences and in which it is possible to interact in various ways, related to the archaeological context, with the show of an object or a place not accessible physically for the visitors, to the study of a skeleton or any other element related to Cultural Heritage.

The Multiverse of Metaverses MAPOD4D chose to use first and foremost products hardware and software which follow a FLOS (Free Libre and Open Source) policy, it represents and musealizes only facts, events or real objects, the interaction is possible, the physical laws are implemented, there are no NFT and there never will be, it is modifiable and updatable.

The archaeological site of Castelseprio and, as the focus, the San Giovanni area, was chosen as a sector appropriate for this kind of scientific-technological research, it has become an experimental laboratory on field about to bring to light of the skeletons.

All the technical information described in this article are referred to the state of the project and to the software and hardware utilized in date 31/12/2023. To be updated on the current information visit https://www.mapod4d.it and the presentation article (Taglioretti et al., 2021). It is advised to download and visit a Metaverse MAPOD4D before or during the reading of the article (https://www.mapod4d.it/multiverse.html).

The MAPOD4D project follows objectives and principles of the London Charter Interest Group, (Editor: Hugh Denard, King's College London, 7 February 2009 https://londoncharter.org).

Materials and Methods

The archaeological area chosen for the Metaverse (information given by A. Chavarria Arnau)

Concerning the anthropological part of MAPOD CSSG, it was chosen to document area F, so named in the documentation of the excavation to divide the various burial zones inside and outside the religious building, it is positioned between the minor apse of San Giovanni (to the South) and the bell tower in which a series of burials were discovered. These elements are part of the architectural complex of San Giovanni which includes a great Basilica with three naves, two apses (apse major and apse south), the great cistern and a monumental baptistery (De Marchi & Masseroli, 2020).

The chronology of the various structures is still in an undefined state but in general the current Basilica should correspond to the second phase of a religious building composed in a previous time by a baptistery and a smaller Basilica (from which some torn walls were found during the excavation) which was then destroyed for the construction of a second Basilica with a single apse. In a third phase, probably after a breakdown, a minor apse which cuts the stratification of the bell tower and the burials.

Both on the inside and the outside of the burial have been documented various phases of burials, with various types of tombs (from a simple burial in dirt, to tombs in stone blocks and bricks even reused, in stone blocks, inside walls and even plastered) usually overlapped, and often already dug and emptied in ancient times, as shown in the last three excavation campaigns (2021-2023). The area F, chosen for the creation of MAPOD4D CSSG, is in a context of small dimension (equal to 1,46×3,7m). A small area was chosen for a better management of data and a better logistical running. Inside the area were various burials, including the two most ancient tombs (30 and 32) which were respected between one another, some of the few never dug before and which therefore give us the chance of documenting their collocation in respect to the surrounding structure (the church and the tower), the architecture of the tombs (both structurally and in perishable materials), the rites of burial, the taphonomical events and the buried.

The Multiverse and the Metaverse MAPOD4D

For clearings on the development technique and the history of the project visit the repository https://github.com/mapod4d e https://codeberg.org/mapod4d.

The Multiverse MAPOD4D is an archive in which are presented all the Metaverse MAPOD4D, it represents a sort of search tool that lets people find them with key word and title. From the Multiverse it is possible to download desktop (Microsoft Windows only) Metaverse MAPOD4D with a click on the link.

The Metaverse is shown as the inside of an empty sphere with infinite radius in which a semitransparent platform is floating, on it rest spheres which represent the visitable spaces, called technically 'Metaplanet'.

In the spherical spaces are rapresented three spatial cartesians variables with axis X and Z representing the plain oriented as horizontal and the axis Y as the vertical one, called height, the fourth dimension is called T or, technically, 'time' and represents a series of correlated events in a defined sequence. The Metaverse has a gravity force that pulls towards minus infinite on the Y axis.

The Metaplanet represent spherical spaces which are explorable in 3D with infinite radius and three internal dimensions (X and Z as horizontal and Y vertical).

From each Metaplanet it is always possible to return to the Metaverse and from there visit any other Metaplanet inside it, while the single Metaverse are separated and to visit another one you must return to the Multiverse. All Metaplanets must contain at least an element called 'Metaobject', which has physical consistency and it lets visitors interact in various modes and consult scientific data and studies present in reality (databases, relations, photos, drawings and others).

The interaction with a specific Metaobject called 'portal' lets visitors teleport from a Metaplanet to another.

For the development and the production of the Multiverse MAPOD4D, as in the acquisition and transformation of real data, were primarily chosen FLOS hardware and software. The main development platform, the engine mainly used, was GODOT® (https://godotengine.org) from the community coordinated by Juan Linietsky.

The productive cycle of the Multiverse is based on the implementation in GODOT® of the 3D spaces and relative interactions in GDScript with a syntax close to Python.

For the side implementations, including the online parts, the framework Django® (https://www.djangoproject.com/) and VUE® (https://v3.vuejs.org) and the languages HTML5, PHP, C++ and Javascript were used. As repository and for the debug management were used Github® (https://github.com/) and Codeberg (https://codeberg.org/). The documentation and all adjacent texts were made with LibreOffice® (https://libreoffice.org) and SciTE (https://scintilla.org). For the management of the control of version and group development was used GIT®

(https://git-scm.com) with a private self-hosted server repository self-hosted Gitea (https://about.gitea.com/) for synchronization between developers.

For data acquisition, in some cases, commercial products were used because there were no FLOSS effective alternatives capable of getting such quality. Some hardware required commercial software to run, or were given in bundle with the hardware, in these cases, regular licenses were bought from the software manufactures of author, and bought with regular licenses from the software manufacturer or author. Digital media from third parties are even under license CC0 (https://creativecommons.org/publicodomain/zero/1.0/deed.it).

The realization of the Multiverse had the following technical specs: the IDE (Integrated Developing Environment) used for the development of code were GODOT Editor and VSCodium (https://vscodium.com/). The desktop development platforms were 'Microsoft Windows 11 pro®' and 'Linux' distribution Bookworm 12.4 (https://www.debian.org). As debugging spaces we used GODOT Debugger, VSCodium and those inside the browsers Opera® (https://www.opera.com), Firefox® (https://www.mozilla.org), Chrome® (https://www.google.com), Edge® (https://www.microsoft.com) and 'Chromium' (https://www.chromium.org).

Specifically for MAPOD4D CSSG, for the acquisition of the visible image inside the Metaverse surface end for the photogrammetric acquisitions was used the Sony DSC-HX400V with filter promaster spectrum 7 55mm 1A and the drone Autel Robotics EVO Nano+® with Propeller Guards (total weight 261g; Max Wind Resistance: Level 5 with camera CMOS: 1/1.28inch Effective pixels: 50MP; Pixel size: 2.44μm*2.44μm (Bin2); Accurate measurement range 0.5~20m; Visual hovering range: 0.5~40m; FOV: 85°; Equivalent focal length: 23mm; Aperture: f/1.9; Focus range: 0.5m ~ ı; Focus mode: PDAF+CDAF/MF; Stabilization: 3-axis; Angular Vibration Range: ±0.003°). The digital images was worked on with GIMP (https://www.gimp.org) and made in a panorama with HUGIN (https://hugin.sourceforge.net).

The acquisition of other digital images were done with: scanner piano Epson Perfection V550 Photo; cameras: Nikon D300s and lenses AF S Nikkor 18-200mm f/3.5-5.6GII ED and AF S Micro Nikkor 60mm f/2.8 G ED, Sony DSC-HX400V con len ZEISS Vario-Sonnar T 24-1200; drone Autel Robotics EVO Nano+®. The material was worked on with GIMP and Darktable (https://www.darktable.org/), where necessary rectified and repositioned with QGIS (https://qgis.org/it/site), and mounted in 3D with Blender® (https://www.blender.org).

The photogrammetric material was worked on with MESHROOM (https://alicevision.org/#meshroom), OpenDroneMap® (https://www.opendronemap.org/) and Blender® for texture correction of the UV maps. Some commercial software were used in this case: Metashape® (commercial version Professional Edition, https://www.agisoft.com) to shot remains and interns.

For the video shots some smartphones where used: realme® 8i 5G, Xiaomi Mi 10T Pro 5G with the support of a stabilizator Insta360 flow.

The scanner with structured light Eiscan-SP® (https://www.eiscan.com/desktop-3d-scanners/eiscan-sp) was used for the acquisition of digital models in 3D with the related software bundle and, for high poly and low poly scansion in laboratory the scanner was reconfigurated (we thank the manufacturer SHINING 3D® Technology GmbH Stuttgart Germany for making the SDK tools available). The material was modified with GIMP and made 3D, when necessary, with Blender®.

3D models developed in digital form or rebuilt from previous sources, including the model for the probe MAPOD, were built with FreeCAD (https://www.freecadweb.org), Blender® and GIMP. The pre-existing multimedial material were adapted with GIMP and 3D modeld with Blender® where necessary.

For the 3D information, where possible, the acquisition and any processing were always carried out in high poly and low poly mode: the former obtaining photo-realistic models used for advanced study and analysis purposes, and the latter to allow use in the MAPOD4D Multiverse.

The acquisition of the electromagnetic mappings was carried out with: Garret ACE i300® Metal Detector; Metal Detector Impact Pro®; System Imaging Nokta Invenio Pro® equipped with an IPTU (Integrated Positional Tracking Unit) sensor and was rectified and correctly positioned with QGIS, corrected with GIMP and, where necessary, edited in 3D with Blender®.

The text files were converted to pdf and later to raster images with LibreOffice and PDF24 Creator (https://tools.pdf24.org/it/).

Results

The creation of the MAPOD4D CSSG followed a workflow (Figure 1), the key stages of which include the storyboard (Figures 2, 3) and storytelling: these are respectively the design of the project and the description of the content of the Metaplanets with their purpose and the technical-informatics instructions on how to create them. The process of creating the Metaverse from an IT point of view, as well as the design work took place simultaneously (and not consequentially) with the fieldwork, using the Agile working method.

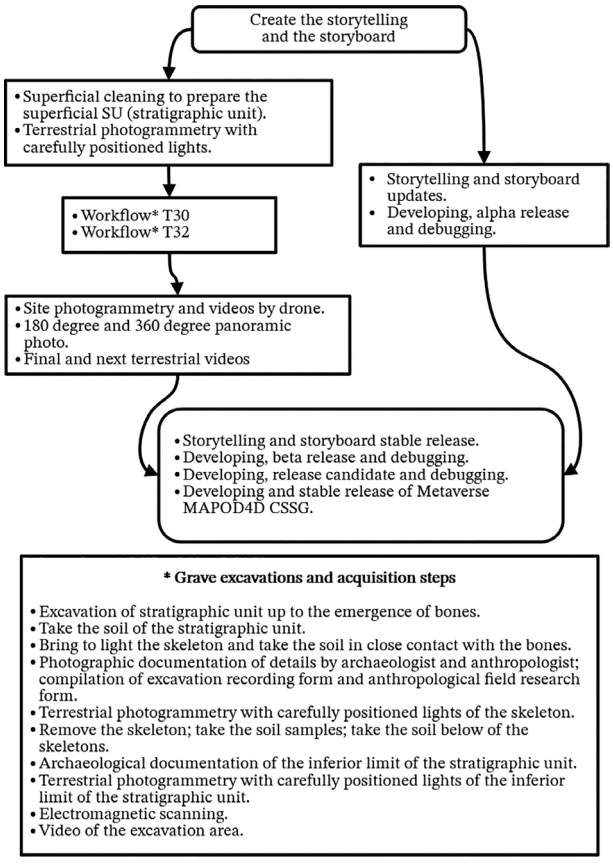

Figure 1. Workflow of activities to create the MAPOD4D CSSG Metaverse for the area F of San Giovanni in Castelseprio.

As for the aim of the storytelling of the MAPOD4D CSSG, it consists of the purpose, avatar and general outline sections of the Metaverse, which follow the guidelines of the MAPOD4D Core version 1 project, and the Mataplanet history, description of the 'Metaverse accesso' (Entry Metaverse) and the 4 Metaplanets sections. The 'Metaverse accesso' looks like the inside of a Metaplanet with a spherical surface represented by the image 'clearing' and with a transparent, non-solid parallelepiped in the centre, on the top of which the Metaplanets are placed in chronological order. The Metaplanets are immovable, solid, non-crossable and each one bears an indication of its content in the form of yellow text on the top. The purpose is to reproduce the temporal sequence of presentation of anthropological activities.

In chronological order, the first Metaplanet is called 'Basilica di San Giovanni' (Basilica of St. John) and its purpose is to present the context of the area where the burials are located and to show images of the general activities related to the archaeological excavation. This Metaplanet has as its spherical surface the high-resolution image of the 'Basilica di San Giovanni'. It also contains a solid rectangular base on which rests a Metaobject called 'Time Machine' with 2 time steps: the first (default) showing, in the background, some photographs representing the beginnings of the phases of the archaeological and anthropological activities, and the second with photographs representing various phases of the archaeological and anthropological activities. On the right there are two portals, one to teleport to the Metaverse and the other to teleport to the Metaplanet called 'a nord del campanile' (North of the bell tower). At the entrance MAPOD automatically positions itself to observe the time machine. The second Metaplanet is 'A nord del campanile' (Figure 4) and is intended to show the excavation and excavation phases of the burials. The spherical surface has the image of the area of the tombs north of the bell tower of the 'Basilica di San Giovanni' acquired in high resolution. Upon entry, MAPOD automatically positions itself to observe a solid plane with an irregular hole in the centre containing a representation of the excavation area. In the bottom left-hand corner of the plane there is a Metaobject called 'Time Machine' showing the following time steps: in the default, the first phase

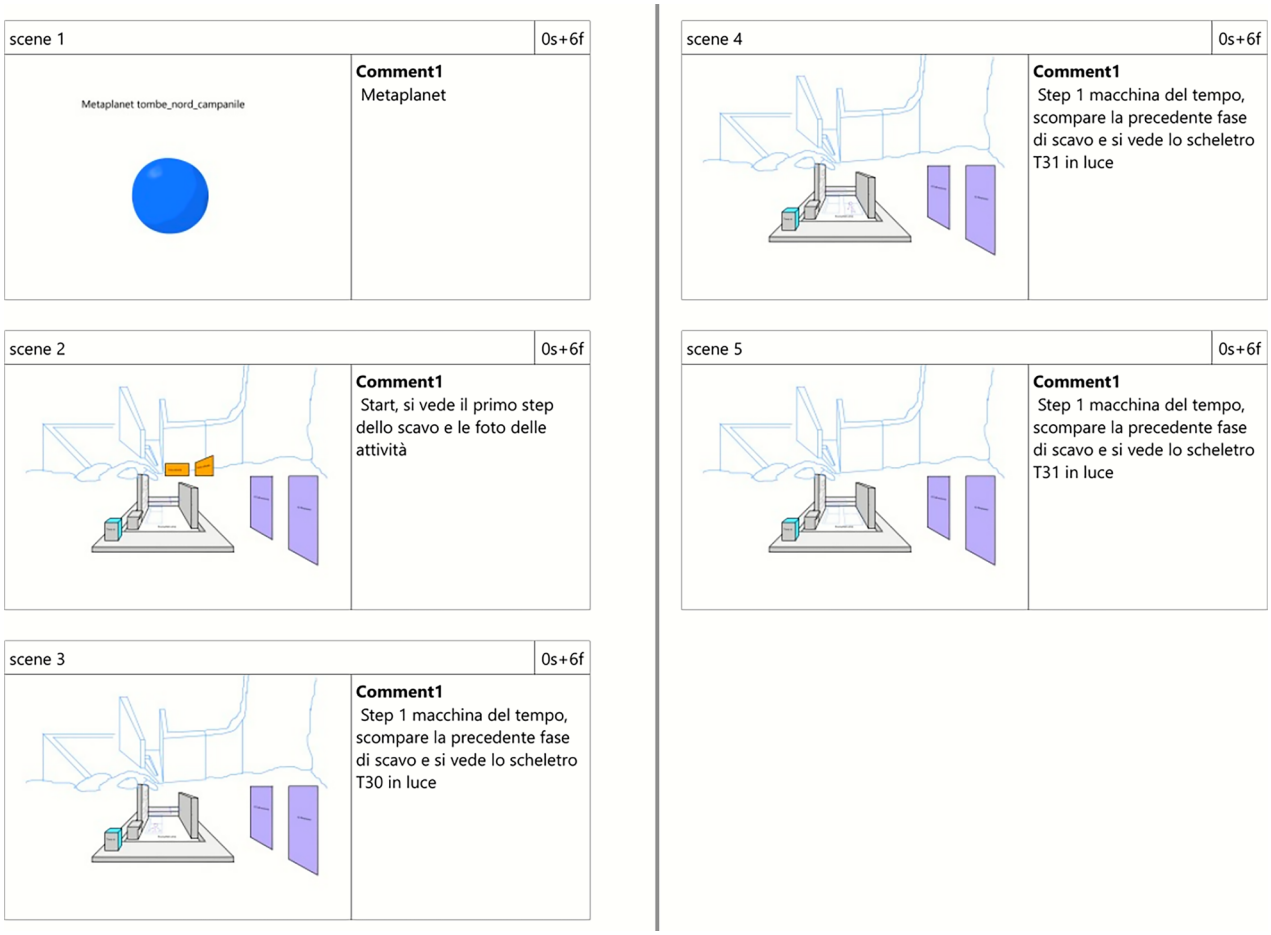

Figure 2. Storyboard of the second Metaplanet called 'A nord del campanile'.

of excavation of tombs 30 and 32 and a series of photos of the fieldwork activities relating to physical anthropology; the cleaning and removal of the surface stones; the discovery of the skeleton of tomb 30; the skeleton of tomb 30 brought to light; tomb 30 after removal of the skeleton; the skeleton of tomb 32 brought to light. When the new step is loaded, the previous one disappears. On the right-hand side of the floor are two portals, one for teleporting to the Metaverse and the other to the Metaplanet 'a nord del campanile'.

The third Metaplanet is called 'Laboratorio di Antropologia T30' (Anthropological Laboratory T30) with the purpose of displaying the osteological material studied in the laboratory and the information of the analyses related to it. The 'A nord del campanile' Metaplanet has as its spherical surface the image of the exterior of the anthropology laboratory acquired in high resolution and contains a solid rectangular base building with carefully positioned lights. At the entrance MAPOD automatically positions itself to observe a 'Time Machine' Metaobject snap (to snap, in informatic language, is the action of placing an object touching something) to the floor to the left, which shows the time steps of the skull and jaw of the last deposed person in tomb 30 before and after washing: skull and jaw are dissectable and show visible surfaces. When the new time step is loaded, the previous one disappears.

On the front, right and left walls there are three portals that teleport to the 'Shop' Metaplanet, the 'A nord del campanile' Metaplanet and the Metaverse respectively, while on the rear wall there is an exit that leads outside the building. The fourth Metaplanet is called 'Shop' and has as its spherical surface the standard 'flying field' image of a airmodel and contains a

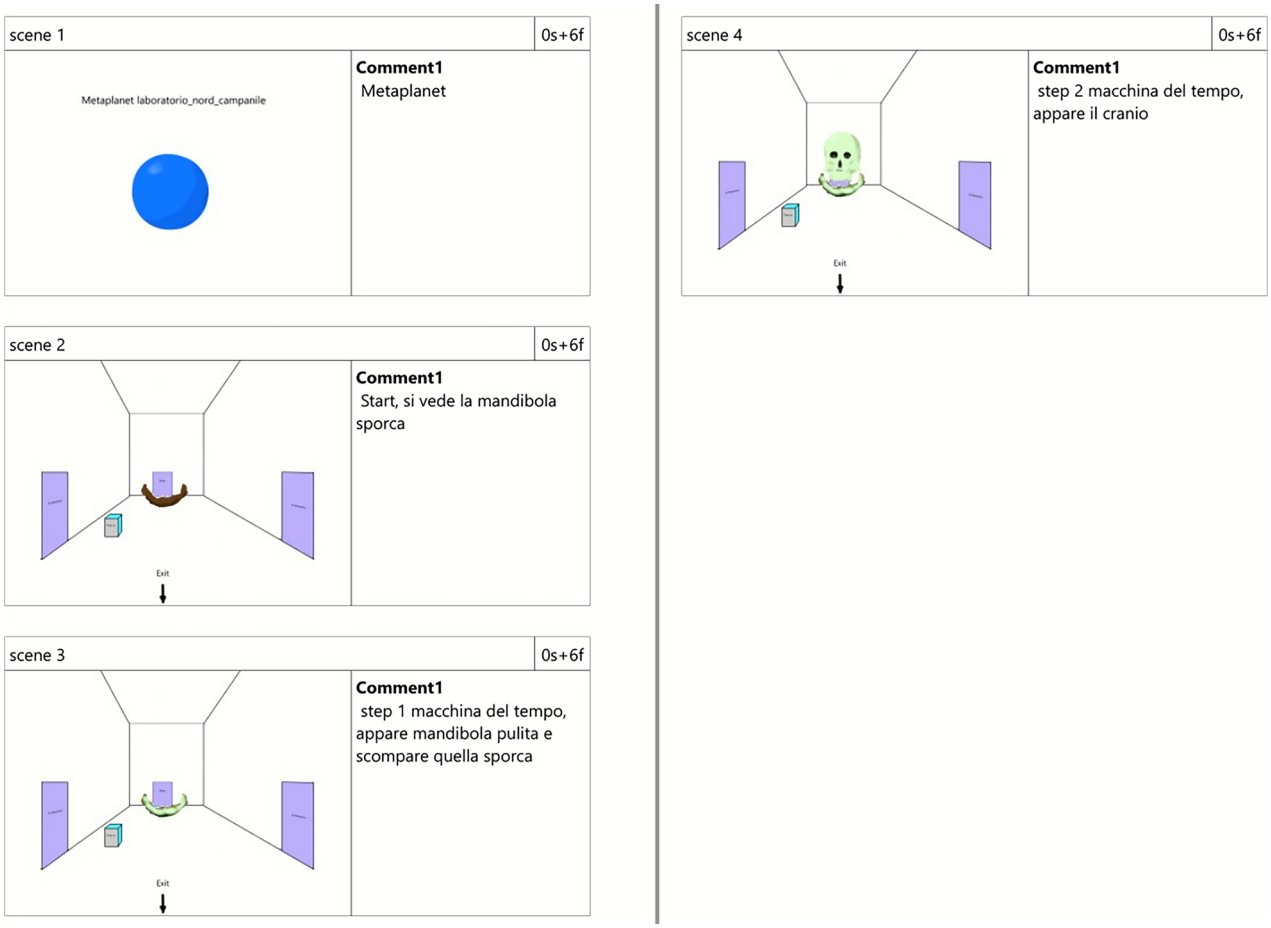

Figure 3. Storyboard of the third Metaplanet called 'Laboratorio di Antropologia T30'.

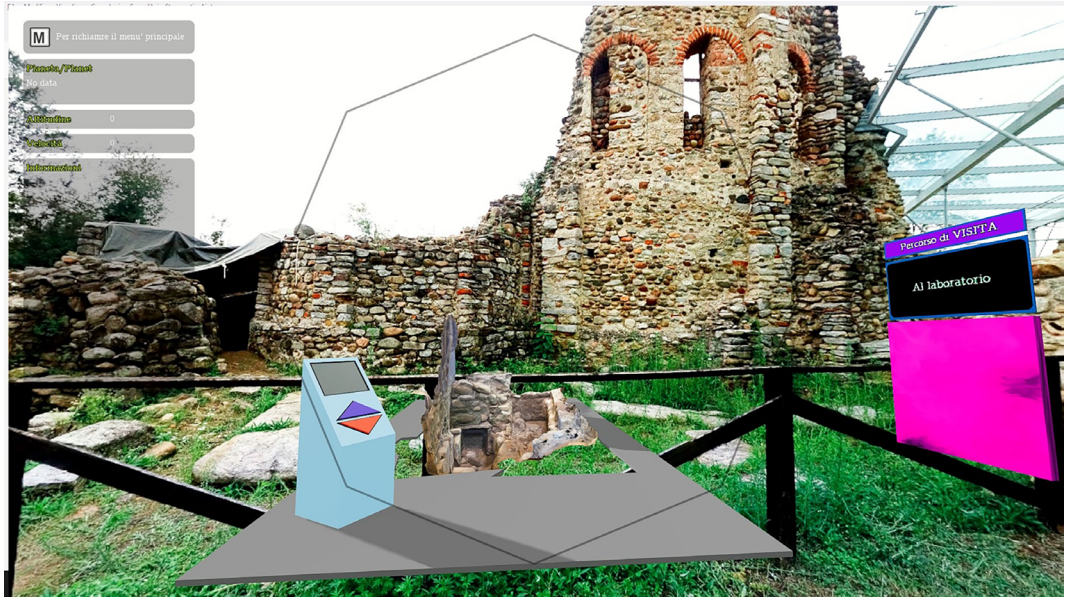

Figure 4. The Metaplanet called 'A nord del campanile': on the right you can see the portal to access to the third Metaplanet and on the left the Metaobject called 'macchina del tempo' (time machine).

solid rectangular building representing a room, from which it is not possible to exit, with carefully positioned lights. Upon entering, thanks to the reference of a vertical rod, MAPOD automatically positions itself in front of the counter, solid and with MAPOD4D written on it, so as to observe the wall of acknowledgements on which there are four areas containing: logos and names of the software and hardware tools used for the production of the MAPOD4D Metaverse; the financial backers with logos and names; the working group with the people who contributed to the general realisation of the project, with photo, title, name and role for each; patronage, participating associations and thanks to the competent Superintendency. The other walls have only the windows necessary for lighting, and a solid wooden cupboard snappend to the rear wall. A multi and interdisciplinary working group, consisting of archaeologists, physical anthropologists, computer technicians and students, contributed to creation of MAPOD4D CSSG. Contribution to the project is also made by the Community (https://discord.gg/ns4GGuVG5Y).

In order to create the MAPOD4D CSSG, the digital materials produced, which are also useful for scientific-technical analysis, currently amount to more than 1,500 ground-based photographs, 8 360-degree panoramic photographs, about 1,300 additional aerial and ground-based photographs taken to define the context, more than 50 videos and more than 10 3D models. The latter are based on clouds whose number of points, compared to the acquired originals, is reduced by between 0.025% and 0.65% for the excavation and by 30% for the bone material.

Discussion

The MAPOD4D CSSG Metaverse created is intended to be, first and foremost, a musealization and educational tool, but above all a teaching aid for bioanthropology lessons. It can be used as an interactive presentation and, at the same time, as a study aid for students: the interaction and three-dimensionality promote understanding of concepts and enhance the ability to transform theoretical information into practical application. In this way, it will be possible to show all the information related to the burial, both archaeological and anthropological, during a lesson. It will be possible to use the 3D model to give an idea and reconstruct the internal architecture of the burial, to observe in detail the possible taphonomic events that affected the bones, to investigate laboratory analyses, to go over the methods of investigation and, finally, this computer tool can be a valid support for further considerations on the arrangement of the skeletons or in more complex contexts such as collective burials, where the skeletal material can be referred to several individuals, some of whom in secondary deposition (reduction). The MAPOD4D CSSG project also provided the opportunity to contribute to the creation of a permanent field laboratory for the experimentation and fine-tuning of digital methodologies and protocols for archaeological excavation, focusing initially on the recovery of skeletons. A further step will be to apply this method also for the documentation of other types of contexts and for the study of elevations.

The need for the experimental field laboratory arises from the fact that any data source can be used in the MAPOD4D Metaverse, but it is preferable to create them according to a precise digitalisation protocol. For example, MAPOD4D Metaverses can be created from dated excavations where no acquisitions have been made for 3D reconstruction. In such cases, it is possible to reproject a 3D model, for example of a tomb, using all the photographs taken during the excavation, the elevations and the reliefs; then the photographs are superimposed, reconstructing a kind of three-dimensional view, making it possible to observe the inclination of the ground and the skeleton, as well as to walk with the MAPOD probe over the surface and the layer.

However, since the data has to be made available not only for the creation of Metaverses for educational, virtual museum, public archaeology and training purposes, but also for scientific purposes, it is essential to develop protocols to be used during excavations, laboratory investigations or on archaeological sites (whether indoors or outdoors) for the use of instruments and for the optimisation of procedures in terms of reducing working time and costs, volume management (quantity of data), supporting the variety of digital data, guaranteeing the veracity and preventing data

variability. Currently, MAPOD4D is subject to technological limitations (which will be overcome in the future) such as, for example, the need to use less detailed 3D models, based on point clouds that are decimated compared to the originals acquired and stored in the archives. This entails a processing with respect to the original, which introduces errors that are often not verifiable and, consequently, the impossibility of using MAPOD4D for technical and scientific analyses such as, for example, taking reliable measurements with known measurement uncertainty. The need to develop protocols for the use of instrumentation and data acquisition is therefore precisely aimed at collecting more and more data, with reduced time and costs, with the possibility of knowing and working on the algorithms on which the reprocessing software is based, and improving accuracy, reproducibility and precision by minimising error to make digital scientific data usable in the MAPOD4D Metaverse as well.

The lines of research are based on the FLOSS policy and with a focus on sustainability in particular with respect to the quality of work, economic growth, innovation, responsible consumption, collaboration and the quality of education. The basic idea is research into how to use low-cost instruments, which are therefore accessible to the majority of those working in the archaeological sector but meet scientific standards of precision, accuracy, reliability and usability. The development of the use protocol is carried out in the field during the archaeological excavation or in the laboratory, planning the workflow and the methodologies to be used. The protocol is then validated by repeating it with instruments that have already undergone validation of the use protocols. More specifically, the excavation campaign in Castelseprio in 2023 made it possible to start experimenting with a series of protocols aimed precisely at optimising the use of digital data, including one for producing photographs for photogrammetric purposes in the field but with carefully positioned lights, one for detecting the induced electromagnetic field, and one for digital sieving, preparatory to manual sieving and flotation, of the excavated soil of tomb contexts.

MAPOD4D, thanks also to the methodological research behind this creation, is fostering the emergence of professional figures linked to the media and the technology sector, i.e. with a technical course of study, but who also have access to professional training courses that enable them to understand the problems of the Cultural Heritage sectors and to be able to interface with specialists. Among these new professional figures, professionalizing courses are currently being planned by the LabDig3A Academy Association (https://www.labdig3a.it/academy.htm), which specialises in the training of technological-digital aspects for Cultural Heritage, in collaboration with universities, technical institutes and other secondary schools, Superintendencies, museums and companies in the Cultural Heritage sector. These new professional figures include, for example, the archaeo-full stack software developer, the archaeo-analyst and systems analyst, the archaeo-hardware designer, the archaeo-digital project manager, the archaeo-digital director, the archaeo-digital sound engineer, the archaeo-digital museum curator, and the archaeo-computer mediator FLOSS.

As for the value of the IT work so far, it is estimated to be around 5,000 euros. This estimate is given by the cost of the work tools and the working hours, while the commercial value is difficult to estimate as there are currently no commercial forms of this type of activity.

By using FLOS hardware and software, there is a 40% cost reduction compared to using exclusively commercial software.

Conclusions

In conclusion, the creation of the MAPOD4D CSSG Metaverse is not to be considered terminated, but rather an expandable tool, capable of providing up-to-date and constant information on future excavation campaigns in area F of the San Giovanni (or other areas) and on osteological investigations.

The work done so far, with this project, is only a small part of all the digital technological innovation that could be of use in the field of Cultural Heritage. Tracing the history of the relationship between archaeology and digital technologies and of the related professional specialisations of archaeologists that have emerged since the 1990s, the situation is analysed as

"an inability on the part of a good part of the so-called 'archaeoinformaticians' [...] to fully participate in the more general dynamics of the scientific communities, participating as protagonists in the many debates that characterise the production of historical knowledge. On the contrary, there is a more or less conscious desire to isolate oneself, locking oneself in caste instances that are as harmful to applied informatics as to archaeological disciplines more generally' (Valenti, 2014). As mentioned above, in our opinion, in order to better integrate archaeology and technology, one way is to train 'archaeoinformaticians', understood as technicians, with a specialised educational and professional background in digital technology, but who are able to understand the needs and problems of archaeology, both research and dissemination. However, in a field such as archaeology, which may have fewer human and economic resources than in other sectors, it is important even in the case of digital technology to open up to a kind of participatory archaeology: for the Metaverse MAPOD4D and other IT projects, it is essential to contribute and to have as many people as possible, each according to their possibilities, contribute to the research, including through community support, be it economic, development, or contribution of ideas.

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