EMDB: YET ANOTHER DB FOR THE STRATIGRAPHIC RECORD

1. Why another database for the stratigraphic record?

Formalised stratigraphic documentation through the use of context sheets is considered an indispensable tool of a modern archaeological excavation alongside textual, photographic and graphic documentation. Despite recent evolutions in the field of indirect survey, especially with the introduction of photogrammetry and the return of colour in the archaeological graphical documentation as a tool to record stratigraphy (Drap *et al.* 2017), the formal description of context (stratigraphic) units still remains the starting point of any scientific investigation. It is the ability to access this information through accurate representations of archaeological excavations that have seen a steady and consistent evolution from 2D GIS to examples of interactive virtual reality (Opitz, Johnson 2016). Despite the relative simplicity of the context sheets apparatus, this requires special attention to its formal correctness and database architecture so that it remains compatible with other excavations and is re-deployable in different archaeological record management platforms.

On the other hand, the computer training that is provided within university training tracks is often not sufficient to make the archaeologist autonomous in creating his or her own working database. In addition to the dilemma as to whether a humanist actually needs to have detailed expertise on data architecture in order to do his or her job, this places a heavy burden on this professional figure. Although there are many solutions for digitally recording stratigraphic data, it should be noted that the most reliable tools are mainly based on online infrastructures and/or require specific GIS skills. Some of the current projects pushing this integration and promotion of digital technologies into the archaeological workflow and display of results include pyArchInit (Mandolesi, Cocca 2013), iDAI field 2 (Cuy *et al.* 2017), and BraDypUS (Bogdani 2022).

Following this line of projects, the ambition of this article is to open a discussion on the opportunity to have "facilitated access" to a database in order to record some vital actions that the archaeologist has to perform in the excavation. Hence the idea of sharing with the scientific community a pre-set database to create stratigraphic documentation in an autonomous way to obtain a digital output that can be shared, published, maintained for the long term, reused in other projects or imported within more evolved and performing platforms to be indexed and made searchable by the scientific community.

In this regard, the present research has extended the functionality of existing software, EMtools add-on for Blender (Demetrescu, Sala 2022), so that information can be included and visualised within the 3D space according

to the well-known 3D GIS metaphor in which semantic objects (proxies) are linked to individual records in the database and integrated with the Extended Matrix (EM) Open-Science project. In the next sections, the Extended Matrix database (EMdb) will be described from a technical point of view focusing on the USM (Masonry Stratigraphic Unit) sheet (§ 2) and on the USV (Virtual Stratigraphic Unit) sheet (§ 3), using SQLite format, and examples of 3D visualisations of the record within Blender-3D (§ 4). An analysis of the current limitations and future work will be provided (§ 5). The general conclusions of the research will close the contribution (§ 6).

2. The EMdb hypothesis: the creation of the SQLite database

The starting point for the creation of the first part of the project was the retrieval of the USM sheets from the institutional website of the Istituto Centrale per il Catalogo e la Documentazione (ICCD)[1] in PDF format. The decision to use this scheme was based on the fact that it constitutes a standard adopted by the majority of the Italian archaeological community in excavation work. From this documentation, it was decided to use, for now, only the items on the first page of the document in order to create a simplified example. The items used are indicated in Tab. 1 below.:

The decision to use SQLite[2] as the application for creating the database came about because we identified the possibility of using a Python connector to link this file format with Blender. It also allows for connecting with the open source software LibreOffice Base[3]. The SQLite database was created using the open source software SQLiteStudio[4]. Thanks to this software, it is possible to design a database without having to write command line strings. In fact, the data structure is modelled via a simple graphic interface. For each item indicated above, a column has been built, for which the properties of the data within it have been specified. All information contained must be in TEXT format, i.e. with the possibility of containing both letters and numbers. The only special feature concerns the first USM column, which may never be empty (if it is empty, the software automatically highlights its non-presence as an error) (Fig. 1).

After the construction of this database, it was decided to connect it with the open source software LibreOffice Base. This decision was due to the fact that it is easier to use and has a better graphical user interface than SQLite. Unfortunately, to enable the SQLite capabilities in LibreOffice, it is mandatory to download an external ODBC (Open DataBase Connectivity) driver: the

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[1] http://www.iccd.beniculturali.it/it/ricercanormative/170/us-usm-schede-%20per-il-rilevamento-sul-campo-delle-unit-stratigrafiche (accessed 01/09/2022).

[2] https://www.sqlite.org/index.html (accessed 14/01/2023).

[3] https://it.libreoffice.org/ (accessed 14/01/2023).

[4] https://sqlitestudio.pl/ (accessed 14/01/2023).

SQLite field names - (table: "USM_sheet")	
Italian	English
USM	MSU
Ente responsabile	In charge institution
Anno	Year
Ufficio MIC competente per tutela	In charge MIC office for protection
Identificativo del saggio stratigrafico/dell'edificio/ della struttura/della deposizione	ID of stratigraphic test pit/building/structure/burial
Località	Location
Area/edificio/struttura	Area/building/structure
Saggio	Test pit
Ambiente/unità funzionale	Room/functional unity
Posizione	Position
Settore/i	Sector
Quadrato/i	Square
Quote	Altitude
Piante	Map
Prospetti	Prospects
Sezioni	Sections
Fotografie	Photos
Misure	Measurement
Superficie analizzata	Analysed surface
Definizione	Definition
Tecnica costruttiva	Building technique
Funzione statica	Static function
Modulo	Module
Criteri di distinzione	Distinction criteria

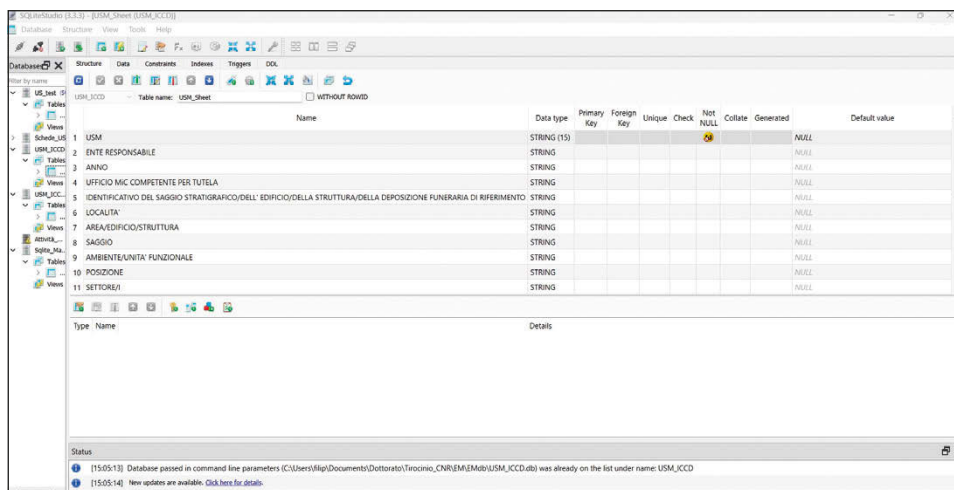Tab. 1 – Items inserted in the SQLite database.

Fig. 1 – The SQLite database of the USM sheets.

connector setup C:\Programmes\LibreOffice\program\odbcconfig.exe (tested only on Windows, but a version of the driver exists for MacOS) allows LibreOffice Base to be configured with SQLite. Once this step has been taken, it is possible to open the previously created database directly with this software by changing its display through the creation of a mask. We decided to create a block mask imitating the USM tab of the initial ICCD in such a way as to make it as user-friendly as possible and already prepared as a print layout.

3. EMdb template for virtual reconstruction

Another strong aim of this article is to make a working prototype database that is versatile and inclusive to the incoming information of an archaeological/heritage project, rather than making the projects have to adapt to a system. The study of the historic and archaeological record is made of different disciplines that require recording diverse details and perspectives: archaeological fieldwork, as explored above in this paper, field survey, conservation and preservation, geographical studies, restoration, public engagement, and virtual reconstructions, to mention a wide range. Therefore, the next step was to build a workflow that permitted different subject areas to cooperate and integrate data into a centralised system.

The EM methodology offers the possibility to integrate many involved experts through the usage of the EMdb acting as a pivotal tool able to ingest different dataset within the Blender 3D visualisation experience. Any interested research group will be able to create a customised EMdb "adaptor" for their own database of records and make them readable in Blender. Nevertheless, certain ongoing projects are also creating EM compatible templates of context sheets shaped for different subjects that will ease this procedure. An example of the latter will be explained below. Thus, the aim of expanding and popularising the usability of the EMdb is to improve the standardised recording of information, but also to allow the scientific community to keep building future research on top of it.

The first database that has been included within the EMdb is one related to the documentation of virtual reconstructions. The recording of these models through the use of USV is quite novel and still in development through the Extended Matrix project. With the EMdb proposal, we have tried to gather the most important information of these units into a single table. The suggested database will help to document virtual reconstruction models using the accessible and FLOS (Free Libre Open Source) software LibreOffice and following a similar structure to the archaeological Stratigraphic Units (US) extensively to ease their understanding and usage. Nevertheless, the information is adapted to the new requirements of virtual elements and combines previous methods of recording USV such as the forms presented by the University of

USV.v0 database elements		
General information	Virtual Stratigraphic Unit	Metadata and Paradata
Number of USV	Type of unit	Documentation
Type of nodes	Subtype	Related EM nodes
Site name	Chronology (in years)	Level of knowledge
Site area	Period	Primary hypothesis
Recorded by	Phase	Alternative hypothesis
Date recorded	Description	Image
	Virtual Activity	

Tab. 2 – Information requested in Version 0 of the USV database.

	Name	Node	Chronology Start	Chronology End	Period Start	Period End	Description	Level of Knowledge
1	6312#	USV	98 AD	300 AD	Roman	Roman	Mirrored Reconstruction of the Amb.14, underlayer of the pavement	7. Basic Archaeological Info / Simple planimetry
2	6317#	USV	98 AD	300 AD	Roman	Roman	Mirrored Reconstruction of the Amb.14, north-south orientated wall on the western side of the room, separating Amb.15-Amb.16.	7. Basic Archaeological Info / Simple planimetry
3	6318#	USV	117 AD	300 AD	Roman	Roman	Mirrored Reconstruction of the Amb.14, north-south orientated wall on the western side of the room	7. Basic Archaeological Info / Simple planimetry
4	6319#	USV	98 AD	300 AD	Roman	Roman	Ricostruzione speculare de la struttura muraria in opera listata, con orientamento est-ovest, costituisce il limite sudest dell'ambiente 14	7. Basic Archaeological Info / Simple planimetry
5	6320#	USV	117 AD	300 AD	Roman	Roman	Reconstruction of the eastern marbol stairs	6. Detailed Graphic Reference
6	6321#	USV	117 AD	300 AD	Roman	Roman	Reconstruction of the eastern wooden stairs	3. Simple Textual Reference
7	6322#	USV	117 AD	300 AD	Roman	Roman	Reconstruction of the eastern wooden stair handrail	2. Simple Parallel Hypothesis
8	6323#	USV	98 AD	300 AD	Roman	Roman	Mirrored Reconstruction of the Amb.14, east-west orientated wall on the southern side of the room	7. Basic Archaeological Info / Simple planimetry
9	6324#	USV	117 AD	300 AD	Roman	Roman	Reconstruction of the eastern wooden stair handrail	2. Simple Parallel Hypothesis
10	6325#	USV	117 AD	300 AD	Roman	Roman	Mirrored Reconstruction of the western wooden stairs	3. Simple Textual Reference
11	6326#	USV	117 AD	300 AD	Roman	Roman	Mirrored Reconstruction of the western wooden stair handrail	2. Simple Parallel Hypothesis

Fig. 2 – Version 0 of the USV template.

Alicante in 2015 (Molina-Vidal, Muñoz-Ojeda 2015), the Graphic Scale of Historic-Archaeological Evidence (Aparicio-Resco, Figueiredo 2016) and the information of the graphML[5] from the Extended Matrix (Demetrescu 2015; Demetrescu, Ferdani 2021).

In this version 0 of the USV context sheets, the fields that have been suggested are divided into sections or areas. Some fields will have a vocabulary that will ease the usage and standardisation of the files, while other fields will allow free input of information. The basic structure of the record is shown in Tab. 2.

The information recorded through this table (Fig. 2) has provided positive results for the recording of reconstructive models. This template aims to simplify both the creation of the reconstruction through the organisation of ideas and the recording of the USVs. Furthermore, this information will be directly visualised over the 3D representation thanks to its link through the EMtools, as will be explained in the next section of this article.

4. 3D representation of stratigraphy

The focal point of the project is the use of this new feature of the Extended Matrix add-on (EMtools version 1.3.1) within the open source software Blender. The use of this new feature will make it possible to link all data contained in databases (Fig. 3) with individual 3D objects represented by the EMgraphdb

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[5] http://graphml.graphdrawing.org/ (accessed 14/01/2023).

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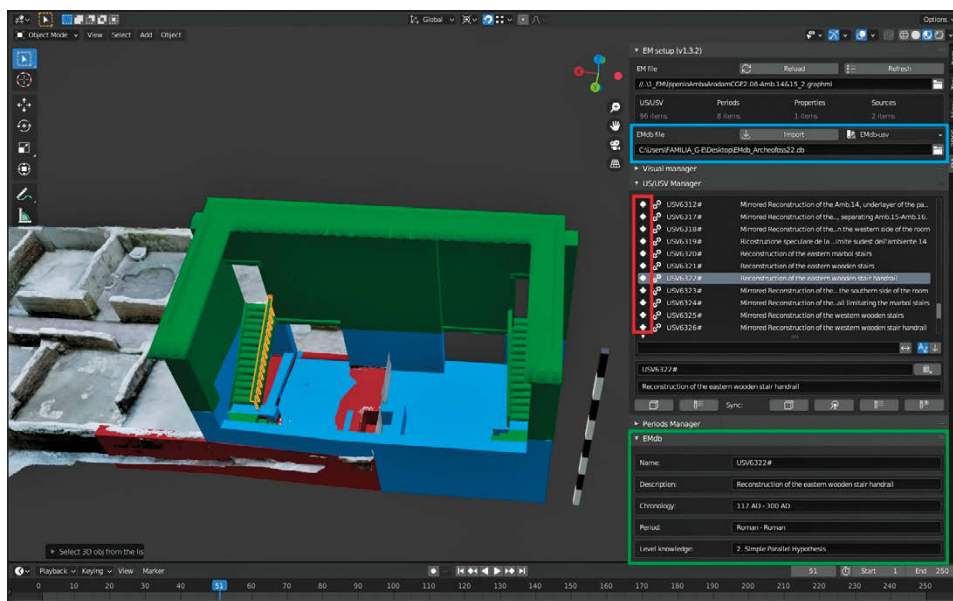Fig. 3 – Example of a USV database in tabular format using SQLiteStudio.

Fig. 4 – Screenshot of the Blender EMtools displaying a linked USV database through the EMdb feature.

(graphML file) and to visualise them in Blender. The following is a step-by-step description of the procedure and the resulting graphical representation.

The first step is to import the SQLite file (in our case saved with a *.db extension) into the software environment. To do this, it is necessary to select the file via the feature (called EMdb file) immediately below the field relating to the *.graphML file (squared in blue in Fig. 4) and then click on import. Once this operation has been carried out, if there is a match between the database and the data contained within the graphML file, a white diamond-shaped icon will be displayed in the panel called US/USV Manager (squared in red in Fig. 4). If there is no such correspondence, the icon will remain empty. By clicking on each entry of the US/USV Manager panel, the related information will be displayed in the form of a table shown below called EMdb (squared in green in Fig. 4).

The data displayed will vary depending on the database type (USM, USV, etc). In the case of USMs, the main information will be the name of the USM, its summary definition, its chronology/period and the construction technique. However, in the case of USVs, other data relating to its level of knowledge or documentation will also be displayed since they are part of the data recorded in the above-shown USV.v0 template.

5. Limitations and future work

During the development of this project, the authors encountered a series of limitations that should be highlighted for future works. At present, it is possible to connect only one external database into Blender (through EM-tools); hence, currently, it is not possible to connect both information coming from USM data sheets and from USV data sheets. Furthermore, data from related tables (lists of stratigraphic relations for each US, lists of photos or other sub-elements) are not yet considered. Another limitation is the poor flexibility of the user interface that exposes the content of the fields of the database due to the fact that it is currently hard-coded in Python and it is not customizable (i.e. through a configuration file).

Therefore, the natural next step for this project will be to develop a robust "EMdb importer" with the following features: multiple db import and manage, the possibility to work directly with SQLite files and 3D models (even without an EMgraphdb file) for quick visualisation and inspection of datasets, support for JSON based configuration files to make compatible different databases as well as to customise the UI to show information more smoothly. Furthermore, the ideas started during this project will be continued by the PhD studies of two of the authors of this article.

Promoting the use of the EMdb could open up new developments in the use of this plugin. An example of this can be seen in the work-in-progress PhD project of one of the authors of this contribution (Sala 2020-2023).

The potential of being able to link external databases developed using SQLite would allow additional information to be connected to the proxies in the Blender environment that would better describe the archaeological architectural characteristics of the elements represented, thus starting the fusion of the EM methodology with Building Information Modelling (BIM).

In addition, the integration and complementarity of different disciplines and studies within the EM methodology are one of the main topics of the PhD from Cristina Gonzalez-Esteban. She will promote and test the possibility of adding different databases linked through 3D visualisations. Her study area focuses on the historic landscape around Lake Yaxha (Guatemala), aiming to increase large-scope studies of the settlement patterns of the Maya Archaeological Sites of the area.

6. Conclusions

This contribution highlighted some limitations that are still present within the Digital Archaeology domain, namely the accessibility of open source, ready-to-use and standardised desktop-based database tools for data ingestion, management and sharing related to archaeological stratigraphy sheets. The idea is to provide the community with an interoperable and customizable series of "Plug & Play" templates within the main Extended Matrix repository (DEMETRESCU 2022) in order to operate in different scenarios, some of which are presented in this paper, namely the USM sheet (Italian Masonry Stratigraphic Unit Sheet) and the USV (international Virtual Stratigraphic Unit at its tentative version 0). We encourage the community to start from the templates and modify them to provide back new templates customised for other different scenarios (e.g. the creation of new context sheets for the analysis of the degradation of the surfaces within the restoration domain). Thus, with this contribution, a full set of instructions to create from scratch a compliant database that can be imported in Blender 3D (via the EMtools add-on) is provided. This project, still in its initial phases, aims to continue developing more customizable options to make the reuse of the described approach easier.

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ABSTRACT

The collection of stratigraphic data has been done for years with offline tools like the Microsoft Access software, which was considered a user-friendly tool with the ability to print standardised context sheets (like the Italian ministerial US sheets) directly and 'without' the need for technical expertise. It is well known to the scientific community the limitation inherent in this type of approach: the data is not shared online and is not easy to be collaboratively edited; the data is locked within a proprietary format with repercussions on medium- to long-term preservation; and it is not immediately possible to integrate the data with other projects due to a lack of precise reference standard. Despite these issues, the offline approach remained viable in a whole range of situations where it is necessary to have a fast and easy-to-manage database. This contribution starts from the hypothesis that an offline standardised and encapsulated tool

in an open format (such as SQLite, LibreOffice Base or MySQL), editable with open source software, can offer additional solution because it is easy to use and disseminate in the form of a free, downloadable template. EMdb aims to collect and manage not only stratigraphic data but also reconstructive unit sheets to cover the need to analyse, interpret and validate scientific hypotheses in the field.