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Reverse Archaeology: A New Method †

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Abstract: Reverse Archaeology is a digital method useful for rebuilding an old excavation from its documentation. It mainly involves passing data from analogical sheets to digital feature/tables or from older sources to new and open-source formats. The idea for this paper came from the Una Quantum 2021 conference, specifically from the writing of the paper presented with Agnese Vacca at that same conference. What will be presented in this paper is a new assessment, with some other examples and a larger theoretical support, toward the creation of a community and a practical manual.

Keywords: archaeology; Reverse Archaeology; GIS

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1. Introduction

In the title, the concept of 'Reverse Archaeology' was introduced, referring to the process of converting the past archaeological archives into an information system through the study of the relevant excavation methodology and documentation system developed in the 'pre-digital' years.

The methodology introduced here, if consolidated, will enable the conscious and scientific digitisation of analogical archaeological archives. The goal is to achieve the publication of useful open datasets to enable the widest possible number of fellow workers to study and work with the documentation of the most important archaeological missions.

The symposium Una Quantum 2021 allowed the author to unveil the concept of 'Reverse Archaeology', which served as the cornerstone for the Ebla 2.0 initiative. The drafting of the compendium document facilitated numerous improvements and adjustments to the initial framework [1].

Initially, the definitions are examined in a literal manner; "Reverse Archaeology" derives its designation from the concept of 'Reverse Engineering', an engineering field that encompasses a range of examinations, such as:

Functional Assessment:

- Utility;
- Positioning;
- Configuration;
- Geometry;
- Material assessments of artifacts (for instance, a tool, electronic element, apparatus, or program).

The primary aim within this field is to create an alternative item that operates similarly or more effectively than the original or one that is better adapted to the environment (fitting). Another goal is to generate a secondary object capable of serving as a substitute for the original that can be reintroduced into contemporary society with either the original function or a modified function.

In Reverse Archaeology, an archaeological dig can be conceptualised as a "Reverse" subject of examination and can be investigated using a "regressive approach", hence employing a historical methodology [2]. Consequently, this approach enables the comprehensive examination of the entire procedural foundation of an excavation, endeavouring to systematically organise digitised records.

Therefore, 'Reverse Archaeology' delves into the methodology through which documentation was originally devised by scrutinising the history of archaeological missions, their evolution in practice over time, and the semantic evolution of the terminologies, assessing whether and to what extent they have undergone changes.

The objective is to generate a digital twin of the excavation archive, a spatial relational database (RDB) with comparable functionality that is potentially better aligned with the context of the digital era we have encountered while remaining capable of interrelating with its analogue counterpart.

We know the advantages regarding the speed of searching, the construction of complex queries, and the wide potential in data re-reading.

The method that will be explained has been applied for recent excavations, such as the one edited by Anne-Louise Blancke [3] for the excavation of the White Monastery in Egypt as part of the latest phases of the PAThs Project and, of course, in the aforementioned case study of the Ebla excavation [4].

Previous experiences recorded at Una Quantum by the author covering the archaeological excavations of Piana San Marco, Castel del Monte (Aq) [5] and the cloister of Baullo in Gagliano Aterno (Aq) [6] managed by the University of L'Aquila highlighted the critical importance of directly digitising excavation records in the field as indispensable in 21st-century archaeology [7,8], using, for example, Pyarchinit [9] in stratigraphic contexts.

Another instance illustrating the utilisation of 'Reverse Archaeology' emerged through an extensive and detailed discussion with Teresa Tescione while undertaking the digitisation, examination, and exploration of the various methodologies utilised in the excavation of Nave D at San Rossore, Pisa. The documentation for this endeavour dates back to the 1990s and continues onward [10].

Luca Mandolesi acknowledged at previous public meetings of Una Quantum that the use of data entry of older excavations on Pyarchinit was prevalent compared to the starting of GIS projects for new excavations.

The validity of this approach is undoubtedly affirmed by the routine experiences of numerous surveyors and GIS experts in archaeology. They leverage their bespoke digital platforms and IT frameworks to digitally reconstruct archaeological excavations or specific archaeological contexts.

In essence, the computer system employed for the Ebla project in 2017 closely mirrors the operational structure of BraDypUS (https://docs.bdus.cloud/, accessed 7 March 2024), an exceedingly adaptable tool proficient in accommodating various forms of ER schema [11]. In collaboration with Giuseppe Guarino, we successfully initiated efforts to integrate BraDypUS and Pyarchinit through PostgreSQL [12]. The significance of establishing this connection, as well as its potential for further advancement, is underscored by the imperative to digitally preserve analogue documentation from previous excavations, a topic extensively addressed in this article. This bridge facilitates the seamless integration of traditional archaeological records into digital formats, ensuring their preservation, accessibility, and usability for future research endeavours.

2. Materials and Methods

From an epistemological perspective, this methodology seamlessly aligns with the expansive disciplinary realm of the Humanities, offering intriguing insights into our understanding of human culture and history. Comprising two distinct phases and several internal sub-steps, the method not only facilitates archaeological inquiry but also prompts broader philosophical reflections on the nature of knowledge acquisition and interpretation within the Humanities.

2.1. *Investigation*

The first phase, referred to here as 'Investigation', is directly inspired by Carlo Ginzburg's concept of the '*paradigma indiziario*' [13], embraced by Umberto Eco and Thomas A. Sebeok [14] within the realm of Historical Sciences. This entails reconstructing the past through meticulous examinations of historical sources obtained from archaeological archives, delving into the original documentation generated from the onset of excavation.

This approach is supplemented by a social science technique, namely, the interview technique [15]; this entails posing focused inquiries to the directors of archaeological expeditions and team members who have focused their research on sites and/or territories. Additionally, conducting a bibliographic survey is essential to gather further insights into the excavation methodology and procedures employed in a specific excavation. Overall, it becomes evident that the first hand experiences of participants in an excavation play a pivotal role in piecing together the intricate puzzle of such investigations.

Moreover, the first phase involves harvesting archaeological archive material. It is possible to find such material in museums, central state archives, universities, libraries, private patrimony. Finding only analogic material is to be expected. Another important step is to establish an agreement with the institution/private owners. The key is to offer a win–win deal, digitisation to material access. In this phase, it is crucial to insert regarding the final copyright and license of the work into the agreement. It is recommended to use Creative Commons licenses (https://creativecommons.org/ accessed 16 May 2023) for clarity, international unambiguity, and ease of choice and application. One should strive for maximum openness of the data; however, it is recommended to propose the CC BY-SA-NC 4.0 International license.

Paper sheets, notes, and book-based notes are common. For photographs, many hardware types could be available. There can be a multitude of image formats and types of photographs (depending on the age of the images and the technology used to them). Photographic negatives and slides are the order of the day. On the digital side, floppy disks (in all their formats), CDs, and DVDs are hardware formats that are no longer supported by modern computers; they can usually only be read via external reading devices.

The first part of the work is essentially archive-based. Having a digitisation lab could be crucial (often, public institutions have them). It would be useful to have scanners of different sizes, tools for balancing whites and colours, or software that can do the balancing. The metadata and storage order of each piece of information must be followed through contemporary techniques, ontologies, and methods. Thoughtful metadata and orderly archiving are essential for searching and publishing data. Standard filings and public ontologies are recommended to best communicate the digitised object. The final openness of the digitalised dataset ensures the possibility to use Linked Open Data ontologies and techniques.

For heritage ontologies, it is recommended to use the Getty Museum standard (https://www.getty.edu/research/tools/vocabularies/lod/ accessed 16 May 2023).

That part of the work may take a long time, but the attention you invest in it is crucial for the subsequent parts.

From an open science perspective, it would be useful to follow open validation reports and research notes processes. The aim is to allow any other research group to be able to replicate the process followed by the research team. It would be useful to create a site and publish the various steps of progress, including the difficulties and problems.

The aim is to reconstruct an archaeological excavation.

2.1.1. Archive Survey

The crucial materials to collect mainly include the following:

- Reports and notes

The aim of the first phase is to search for and discover traces of the excavation methodology used in the field. Obviously published reports are important, as they could be crucial to understanding how an archaeological mission carried out its survey and excavation. Is interesting to collect the bibliography and its evolution through the years to understand the growth of the debate, the scientific environment, and the research impact of the mission. Archaeological notes are often unpublished and only made in personal books and research books. In the notes, one could find sketches, pre-print reports, excavation journals, pre-inventory notes for pottery statues, and other material.

- Context/level/SU sheets:

They are mainly divided into categories based on the archaeological methodologies used (e.g., no methodology used, excavation by trenches, detecting levels, using the Wheeler squares, or the modern open field excavation and stratigraphic context sheet). Contained in the Context/level/SU sheets is useful information that can be used to identify the positions of sites, buildings, and materials; altitudes; typologies of archaeological findings; and inventory or pre-inventory numbers. But there is other interesting information and also personal considerations to account for, including the name of the archaeologists in the various mission, the prices of materials, the positions of geodetical points and stations, diplomatic reports, documents, etc.

- Findings, epigraphy, object, and pottery reports:

These are useful elements that are crucial in archaeological research for finding context-relevant information such as dates, culture, and function. Findings can be used to reconstruct how an archaeological mission worked. Pottery products, statues, and objects are mainly stored in museums or in museums' depots. The study and collection of these materials have become more conscious and more advanced following the establishment of the 1970s' "New Archaeology" methodologies and prehistoric studies. Accuracy and consciousness have increased. Moreover, accurate reports on pottery and objects from archaeological missions from the first half of the 20th century can be discovered. If both findings and reports have survived, it could be possible to study archaeological series and date the contexts with modern powerful techniques and catalogues, considering studies that could be considered "milestones" in a certain area.

- Maps, cartographies, prospects, sections, plans:

Finding unpublished geographic or topographic sources could be interesting for the reconstruction of an archaeological excavation in the "Reverse Archaeology". It could be possible to digitise the paper sources and georeference them though several methodologies based on coordinates, known points or buildings in the field, and knowing the nearby monuments. It could be possible to reconstruct survey and excavation missions. It is useful to use GIS programs to rebuild the original position of the context; rebuild levels and stratigraphy; and draw areas stratigraphy boundaries, altitude points, and finding positions. Using special GIS tools, it could be possible to reconstruct the stratigraphical diagram or, from the stratigraphical diagram, correctly draw the stratigraphical succession [16,17].

- Photography, slides:

Photos are fundamental historical documents that can be used to ascertain the story behind an excavation mission. Photos come in several types and formats. In archaeological archives, it is possible to find photos about findings catalogues, contexts, and monuments. Each type needs its own scanner or technique of digitisation. Normally, photos can be stored in cloud storage systems, and metadata can be managed in GIS and DBRMS.

2.1.2. Experience and Bibliographic Survey

- Interviews with leading researchers (if alive and reachable; otherwise, see Section 2.1.1)

The historical memory of archaeologists who have experienced missions and met people who are the focus of the research for the construction of the theoretical–methodological framework useful for the reconstruction of an excavation is of great importance.

Of course, direct oral sources are most valuable. The most valuable testimonies are those that can be derived from mission directors and from those who eventually continued their research. These are the most important archaeological historical records needed to reconstruct the excavation and topography information. The direct interview method is the most apt and efficient method; this method involves meeting the protagonists of the excavations, taking notes on the main methodological information, gaining the respondent's permission to share such information, and recording the answers. It may be useful to repeat this interlocution and dialogue several times during the "Reverse Archaeology".

- Research assistance provided by experienced archaeologists with extensive first-hand experience at the site or, alternatively, enrichment of the literature survey with comprehensive methodological documentation of the excavation (including investigations conducted at other sites).

Secondly, collaborating with and interviewing those responsible for mapping topography and areas and writing essays could be fundamental. If the principal investigators are not still alive or reachable, they could be the only mission members available for the "Reverse Archaeology" process. Alternatively, if the direct memory of the activities, the method, the topography has disappeared, the only way forward is in-depth archive research combined with bibliographic reinforcement on the published or unpublished writings of those who conducted the excavation missions at the site or at other sites where the team members worked.

- Bibliographic Metadata

Organise all the reachable material in an easy-to-search way using bibliography (articles, maps, notes, books, essays, interviews, etc.) metadata methods by recording data in a self-made system or using platforms such as Madeley or Zotero. Metadata are crucial for maintaining, developing, and sharing scientific information, as well as for organising and clarifying ideas.

Archaeological Methodology, Archivistics, Historical Research Methodology, and Anthropology are prerequisite disciplines for this phase.

2.2. Digitisation

The next phase, called 'Digitisation', delves into the epistemological domain of the Digital Humanities, which has experienced significant practical progress in recent decades, although it lacks formalisation. This field remains a discipline that has yet to fully contemplate its knowledge (γνῶθι σεαυτόν), its limits (ὁρίζων), and its potential (γίγνεσθαι).

The journey of 'digitisation' unfolds through three methodological phases: 'Systematisation', 'Computation', and 'Enrichment'. The final phase, 'Enrichment', emerges as the pivot to unlock the full spectrum of possibilities inherent in digitising an archaeological archive. This phase not only improves accessibility and preservation but also enables advanced analytical capabilities and engagement with the digitised data, fostering deeper insights and the wider dissemination of archaeological knowledge.

2.2.1. Systematisation

The initial method, "Systematization", traces its etymology to the French word "*Ordinateur*" (translated as "Computer" in English), stemming from the Latin "*ordinat*". This term holds a pivotal role in Digital Humanities, embodying the humanistic approach to employing digital methods, encapsulating the systematic organisation of data, information, archives, and sources. The second method, "Computation", is closely intertwined with informatics and mathematical logic. Conversely, the final method, "Enrichment", is associated with the field of Communication Sciences.

Utilizing digital tools, the "Systematization" method meticulously reproduces analogue archives. This phase involves constructing the excavation schema utilising the ER Diagram, necessitating the meticulous reconstruction of primary records, fields, glossaries, and relational logic extending beyond the excavation site. Subsequently, database development/programming, normalisation, and thorough testing ensue.

The reconstruction of grids and cartographic systems essential for anchoring the site's graphical documentation within the GIS framework. Graphic documentation must be seamlessly integrated into the ER Diagram, correlating with represented tables such as buildings, contexts, stratigraphy, and materials. These elements must be translated into spatial layers (points, lines, polygons, raster) for GIS utilisation. Upon completion of this phase and initial massive data entry, a stress test can refine and enhance the Relational Database (RDB).

Upon concluding the initial phase, progression to the "Computation" stage becomes viable. Leveraging computing capabilities for filtering, querying, data, spatial, and predictive analysis, as well as algorithm and workflow construction, offers significant advantages in contextual and chronological reinterpretation.

- Writing the statement, entities, and ER diagram

At the beginning of every digitisation search, an ordering system for the search data is needed. This is entrusted to databases and, in our case, specifically to spatial relational databases (DBRMS). The database to be constructed needs all the information gathered in the first phase of the search (Section 2.1). Without going into the details of database construction, the salient steps are as follows: Firstly, there is the writing the statement, i.e., writing in full what the database is to be written for, is the first step. We then proceed with the extrapolation of the entities/tables needed to cover the statement. The analysis of entities differs from excavation to excavation, from mission to mission, according to the needs that archaeologists have or have had in the past. There are two types of entities, those with alphanumeric content, such as collections of records, collections of descriptions, collections of metadata (including bibliography), and spatial ones, such as maps, surveys, aerial photographs, plans of monuments, phase, period, context, and stratigraphic units. Finally, there is the construction of the Entity/Relation (ER) schema, which is fundamental to the engineering of the DB construction process.

An expert in "Reverse Archaeology" knows how to proceed from the statement to the construction of the ER schema, how to distinguish these entities, and how to design and develop open relational databases capable of managing filing and data entry in dialogue with archiving and research metadata platforms (Zotero or Mendeley).

- Develop and compiling the DBRMS.

Many tools available today can be used to develop the Database Relational Management System. The most powerful systems are certainly the most complex ones, for which knowledge of programming languages is mandatory. It is strongly recommended to build one's own databases using open tools and format to implement them directly in the geographical and spatial systems. This would be useful since, among the many layers collected, the crucial ones are georeferenced or geo-referenced data. Geopackage formats in QGIS or creating the database directly in PostgreSQL are recommended. These systems can be developed independently or by a computer scientist. After the development of the DBRMS is finished, it is possible to conduct tests, compile the database, fix bugs, and pass to the operation called normalisation. Only by going through normalisation is it possible to finalise the development of a useful, non-redundant spatial DBRMS. Normalisation makes it possible to eliminate unnecessary tables or fields in the database by optimising it for data entry. This process must be carried out within the testing phase. Once optimised, one can move on to compilation.

Compilation may require very simple or advanced methods in GISs, especially when it comes to finding the reference system; entering material data; drawing monuments, environments, and squares; inserting altitude levels, stratigraphic units, and section lines; and drawing layers by sections. The 'Reverse Archaeology' is completed when the process of pouring the entire collected material into the DBRMS is completed. Subsequently, we will possess a digital replica of the archaeological inquiry, depicting a particular period or phase thereof, thereby enriching our understanding and interpretation of the historical context.

To successfully reach this stage, it is necessary to know the rules and logic of writing a database for Topographical Methods and Computer Geography for Cultural Heritage.

2.2.2. Calculation

- Data analysis

Having arrived at a comprehensible and searchable alias of the original excavation, the data analysis proceeds through a fundamental set of tools available from geographic software, which, compatibly with the data entered, can be used for filtering, selection purposes, complex queries, and literature searches in alphanumeric data, as well as spatial and predictive analyses of geospatial vector data. This is the first step that succeeds in creating new research and new data and in overcoming the limits of the human intellect linked to the analogical storage methods. This is therefore the moment when the method starts to add something new and rethink the excavation with greater rigour, having everything at its disposal.

- Development

The development of statistical analysis tools, workflows and plug-ins tuned specifically for old and new questions arising from the excavation aliases can be another and an innovative product of research. Sharing these tools with the scientific community through GitHub under open licences is necessary to improve them, make them perform better, fix bugs, and grow the entire excavation and research community.

The basics of data analysis, geomatics, logic, geometry, and programming are required.

2.3. Enrichment

The 'Enrichment' phase involves the generation of new insights and their dissemination using contemporary methodologies, thus advancing our understanding and the dissemination of knowledge.

2.3.1. Publication of New Results

- Editorial

Archaeological, methodological, and innovative findings can be disseminated through editorial platforms. Opting for the open access publication of papers and books enhances accessibility. Open access accelerates dissemination, reaching a broader audience and yielding a more substantial impact within the scientific community.

- On the web

DBRMS and metadata can be published online under CC BY licenses. It is crucial to communicate the project purposes, targets, results, main characters, and researchers. It should be made clear that a 'Reverse Archaeology' process can be used for the rigorous reconstruction of excavation missions by tagging in the keywords.

2.3.2. Rigorous 3D Reconstruction of Site Phases

Included in this are the careful 3D reconstructions of site phases, the creation of new multimedia content, the development of innovative communication approaches for excavations, and the establishment of fresh museum spaces or virtual exhibits. Notably, for the 3D reconstruction stage, the Extended Matrix CNR-ISPC method, renowned for its meticulous attention to detail, is highly recommended [18].

Required areas of knowledge include an in-depth knowledge of web publishing licences, web publishing tools, the basics of Open Data, archaeological data publishing practices, Extended Matrix basics and practice, communication strategies, museology, and cultural heritage management.

3. Conclusions

This paper provides a systematic approach to the digital reconstruction of historical archaeological excavations, leveraging the emerging tool and methodology of "Reverse Archaeology". This innovative method offers a means to effectively organise and manage complex datasets from past excavations, transforming analogical data into a coherent digital framework within a GIS environment. By incorporating diverse information on stratigraphy, architecture, materials, archaeometry, and bioarchaeology into a relational database, a holistic understanding of archaeological contexts emerges.

The utilisation of relational databases and GIS analysis proves invaluable in enhancing the informative potential of archaeological contexts. Through the integration of disparate datasets within a unified framework, this approach facilitates a multidisciplinary perspective on the reconstruction and interpretation of archaeological sites. Moreover, the adoption of open GIS systems enhances data accessibility and encourages collaboration, fostering a culture of data sharing within the archaeological community.

Looking ahead, future advancements in archaeological research will likely include the integration of valuable sources such as dense point clouds and meshes derived from photogrammetry and laser scanning. However, the complexity arising from the storage and management of these datasets poses significant challenges that will need to be addressed to fully leverage their potential for enhancing our understanding of archaeological sites.

However, it is essential to note that analysis methods using techniques from the philosophy of science are only in their nascent stages and that they will require further exploration in the future. As our understanding of these methodologies deepens, we can expect even greater insights into the reconstruction and interpretation of archaeological data, paving the way for continued advancements in the field.

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