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Table of Contents

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CONSOLIDATION

edited by Franz Fischer, Diego Mantoan, Barbara Tramelli

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Of Consolidation and Canons in a Heterogeneous Field Called Digital and Public Humanities

Franz Fischer
Diego Mantoan
Barbara Tramelli
Università Ca' Foscari Venezia, Italia

Summary 1 Shifting Plans and Unexpected Outcomes in a Consolidating Domain. – 2 Promising Perspectives, Unravelling Complexity, and Serious Games.

1 Shifting Plans and Unexpected Outcomes in a Consolidating Domain[1]

Back in the late days of 2019, when the possibility of a global pandemic was but an irrational thought, we had the privilege to ponder whether the little world of humanists needed a new scholarly journal. Caught up in drafting strategies to meet international standards which sometimes risk taking the heart out of any editorial project, our fears were that we might not intercept the true interests of researchers who were operating in the field of digital and public humanities for a decade or perhaps even more. Much to our surprise the first call for abstracts we launched in Spring 2020 on the topic "Fusions" received a warm welcome from the scholarly community, while the first COVID wave was raging across the world (Fischer, Mantoan, Tramelli 2020b). Indeed, many scholars seemed to be looking for a place that definitively merged digital and public concerns without taking the side of one single discipline in the humanities, but rath-

1 This introduction paper was mutually agreed on by the Authors who acted as editors of *magazén*'s 2021 volume, divided in two issues, with the help of the journal's editorial board.

er spanning from philology to history, from art history to archaeology, from cultural heritage to the GLAM sector. We made it our mission to turn *magazén* into an open platform collecting theoretical debates, methodological reflections, and an analysis of case studies ranging from textual to visual, and from material to ephemeral topics in the humanities. Back then, we were convinced that digital and public humanities were still evolving through ongoing fusions and cross-pollinations of different disciplines, thus shaping the various research approaches in the field (Fischer, Mantoan, Tramelli 2020a).

Encouraged by the response to our first call – and probably a little overconfident about our organisational capabilities – we considered relaunching a second call on the same subject matter to cover another volume in due course. Upon receiving several dozen proposals, however, an extraordinary thing happened that shifted our perspective on the selection of the chosen topic. As a matter of fact, scholars responding to our second call showed an impressive awareness of and self-understanding in what they were doing in the field of digital and public humanities. Their research work was far beyond the concept of 'fusion', they were not necessarily searching for new categories or scientific vocabularies anymore, but had already adopted a range of resources and modes of research conduct as their own (Drucker 2003). Hence, while we set forth to close the first two issues of for our inaugural volume in 2020 reflecting on the struggles in the field to find a truly theorised version of digital and public humanities, we decided to shift our focus in 2021 towards the consolidated research models already circulating in the international scholarly context (De Groot 2018). Truly, the term 'consolidation' suddenly appeared as the perfect concept to describe what is happening today in this particular research domain. Interestingly enough, both in social sciences and business studies this definition is used to identify a specific kind of merger that occurs when two communities (for sociologists) or two enterprises (for business scholars) integrate into one another to form a new entity (Bennett 2020). Contrary to 'fusion', which recalls the artificial melting of different chemical substances, 'consolidation' speaks of the necessary interaction and negotiation between different interest groups, cultures or positions that are essentially human. In fact, what emerges from the latter kind of merger is a social, political or organisational construct that needs to find a new balance between the different forces or stakeholders involved (Svolik 2015). The result is not an entirely new substance with different chemical properties, but rather an entity that maintains some aspects of both subjects that participated in its inception.

'Consolidation' seemed the perfect term to describe the kind of scholarship that we were experiencing in the abstracts received and then in the papers selected for the present volume. In a sense, this discovery allowed us to see that the contributions gathered together in

the following pages were effectively centred on creating a canon for the given domain. It came as a natural consequence that we decided to open this issue – and all upcoming ones – with a guest article by a renowned scholar to help us to get rid of any disciplinary shyness and finally set an authoritative tone as a platform for self-conscious digital and public humanists. For this reason, we are particularly honoured and grateful to inaugurate this editorial novelty with an exclusive guest paper by Thomas Cauvin, a foundational essay translated into English for the first time. We hope this might be the sign that our journal is becoming a crucial player in establishing the field of digital and public humanities for good, thus contributing to the international debate with the kind of openness and curiosity that characterised the varied humanity hanging out at the public house during the Venetian Republic (Tassini [1863] 1970, 364-5). The proverbial *magazén* is our aim, a place where everyone is invited to share, discuss, proclaim, and participate in a communal quest to outline the future of our daily research practice and consolidate a heterogeneous territory (Boerio [1856] 1971, 382).

2 Promising Perspectives, Unravelling Complexity, and Serious Games

The authors chosen for the first issue of the present volume address the concept of 'consolidations' from different perspectives and with different methodological approaches, presenting to the reader a varied and yet intertwined landscape.

The first contribution by Thomas Cauvin engages the reader in a compelling methodological discussion on what public history is, analysing challenges and perspectives of this 'new field made of old practices', and ultimately embracing the reality that although "not everybody can become a great historian, good public history can come from anywhere" (27). The second paper by James H. Brusuelas focuses on the process of editing texts that are 'true-born virtual' and on how to document the role of artificial intelligence in a critical edition of a virtually unwrapped papyrus scroll. He advocates a new philological approach which combines methodologies from the humanities and the sciences to ensure transparency and reproducibility in the study of machine predicted texts from hidden layers of cultural heritage objects.

Julia Elicker and Pavol Hnila, in the third contribution of this issue, analyse Digital Elevation Models (DEMs), which are widely employed in landscape archaeology, sharing their extraordinary work on Mount Aragat in Armenia. They effectively underline the constraints and challenges which they face using this technology, and they stress the need for a constant quality check of topographic visualisations.

In the fourth paper, Christian Wachter discusses the central topic of digital publishing, stating at the beginning that open access papers, books, and blogging have become rooted in the DH and reflect "a self-confident culture of open science" (103). He argues that DH need publishing media that go beyond classic texts, which could be able to encompass the complex nature of DH research by their own medial appearances. He therefore vigorously advocates the need for new publishing designs, in order to overcome the static order of texts and to offer explorable media for the visualisation of data-driven research.

Coming towards the two final contributions, Samanta Mariotti in her article talks about the immersive experience of serious games, explaining the usefulness of these user-friendly tools in order to learn cultural content (especially related to archaeological heritage) in an active and engaging way. She argues that, to benefit from these instruments, the research requires different multidisciplinary cooperations, and she proposes different hypotheses for the development of these interactive games. Finally, in their contribution, Milena Corbellini, Paola Italia, Valentina Pasqual and Roberta Priore present the interdisciplinary digital edition of the *Storia Fiorentina* by Benedetto Varchi, in the context of the project *VaSto*. It constitutes an example of a cooperative digital edition which benefited from the work of specialists in various fields. The result is a platform that aims at being a knowledge-site, supporting various interactive functionalities and tools to contextualise the text itself.

We truly hope that these six contributions will help readers to gain an overall orientation about the advancements in a complex academic landscape, where data-driven and public-related research is gaining traction within the context of Digital and Public Humanities as a transdisciplinary field in its own right. We hope that they will find practical examples and useful methodological discussions which will help consolidate their own research in an open and yet well-established theoretical framework.

Finally, as customary, we wish to express our acknowledgment to all scholars and experts involved in the making of this volume: the contributors, the many peer reviewers, all members of the editorial board and the advisory board, as well as our publisher's team. We are glad this issue arrives at a time of relaxing boundaries in social life and hope to be able soon to continue the discussions about the issues raised in this volume in a physical environment and to restart making digital and public humanities both on and offline.

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New Field, Old Practices: Promises and Challenges of Public History

Thomas Cauvin
C2DH, Université du Luxembourg

Abstract Although public history is becoming increasingly international, the field remains difficult to define and subject to some criticism. Based on sometimes long-established public practices, public history displays new approaches to audiences, collaboration and authority in history production. This article provides an overview of public history, its various definitions and historiography, and discusses some of the main criticisms of the field. Public history is compared to a tree of knowledge whose parts (roots, trunk, branches and leaves) represent the many collaborative and interconnected stages in the field. Defining public history as a systemic process (tree) demonstrates the need for collaboration between the different actors – may they be trained historians or not – and aim to focus on the role they play in the overall process. The future of international public history will involve balancing practice-based approaches with more theoretical discussions on the role of trained historians, audiences and different uses of the past.

Keywords Public history. Historiography. Collaboration. Memory. Ethics. Training.

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Let us be honest; despite recent developments in the field, public history remains largely unknown outside the circles of its practitioners. If we explain that we practise, study or work with public history, our interlocutors are likely to raise their eyebrows, confess their ignorance and ask for more details. Once we explain what we do and why we practise public history, our interlocutors may easily find examples of their own, or even acknowledge – if they work in the field – that they have been working with public history without knowing it. The rise in public history comes partly from its long-established practices. Public history is built on an apparent paradox: it is a new field based on old practices. And the fact that public history includes old practices is also a sign of the times; it reflects a changing context in the ways we preserve, research, interpret, study, communicate, use and consume the past. One of the most visible changes, the rise and use of the Internet, has revolutionised how people access and communicate knowledge. History is not immune to these profound changes, nor should it be. Questions such as who owns the past, what role historians play and who can call themselves historians are an integral part of the debates on public history. As the field of public history is becoming increasingly international – see for instance the 2020 World Conference of Public History in Berlin, Germany – it seems timely to question how, and if, one should define public history. This article proposes an overview of the field, presenting its historiography, the reasons for its success and some criticism.

1 Public History: A Field Full of Promise

The term public history has often been associated with the United States, where it was first coined in the 1970s. The National Council on Public History (NCPH) – the main organisation for public history in the US – lists more than 200 programmes in the country.[1] The number of programmes is such that some started to wonder if the competition between them would become an issue (Weyeneth 2013).

Yet public history is not limited to the US or North America. Public history projects, programmes and conferences exist in many European countries and also in Brazil, Australia, New Zealand, Russia and China. The International Federation for Public History (IFPH), set up in 2011, aims to connect projects, professionals, students and

This article is the English translation of: "Campo nuevo, prácticas viejas: promesas y desafíos de la historia pública", published in *Hispania Nova. Primera Revista de Historia Contemporánea*, núm. 1 extra, 2020, 7-51.

1 See the NCPH website, `http://ncph.org/program-guide/`. Unless otherwise noted, all the webpages cited in the article have been accessed on 20 January 2021.

other practitioners worldwide.[2] The IFPH's Call for Presentation for its 2018 annual conference in Sao Paulo, Brazil, attracted 54 individual papers and 15 panel submissions, with 92 authors from 26 countries around the world **[fig. 1]**. National public history associations have also been set up in Brazil (Rede Brasileira de História Pública), in Italy (Associazone Italiana di Public History, AIPH) and more recently in Japan (パブリックヒストリー研究会), attesting to the development of the field.[3] Publishers propose textbooks, collections of essays, handbooks and companions in English, Portuguese, Italian, German, Polish, Chinese and Spanish (Cauvin 2016; Gardner, Hamilton 2017; Dean 2017; Mauad, De Almeida, and Santhiago 2016; Lucke, Zundorf 2018). Peer-reviewed journals – still a ranking criterion for research and publication – now specialise in public history too. *The Public Historian*, *Public History Review*, *International Public History*, and to some extent *Public History Weekly*, demonstrate that public history has reached a level of academic recognition.[4]

While it is clear that public history is becoming increasingly international, defining the field remains challenging and open to discussion. For instance, the website of the 2020 World Conference of Public History does not provide a definition of public history. The IFPH itself only points out that international public history is "a field in the historical sciences made up of professionals who undertake historical work in a variety of public and private settings for different kinds of audiences worldwide".[5] The least we can say is that the meaning is (purposefully) unclear.

2 See the IFPH website, `https://ifph.hypotheses.org`.

3 See the Rede Brasileira de História Pública ("Rede" – RBHP) website, `http://historiapublica.com.br`, the AIPH website, `https://aiph.hypotheses.org`, and the website for the Japanese association, `https://public-history9.webnode.jp`.

4 *The Public Historian*, `https://tph.ucpress.edu`; *Public History Review*, `https://www.uts.edu.au/public-history-review`; *International Public History*, `https://www.degruyter.com/view/j/iph`; *Public History Weekly*, `https://public-history-weekly.degruyter.com`.

5 See the IFPH website, `https://ifph.hypotheses.org`.

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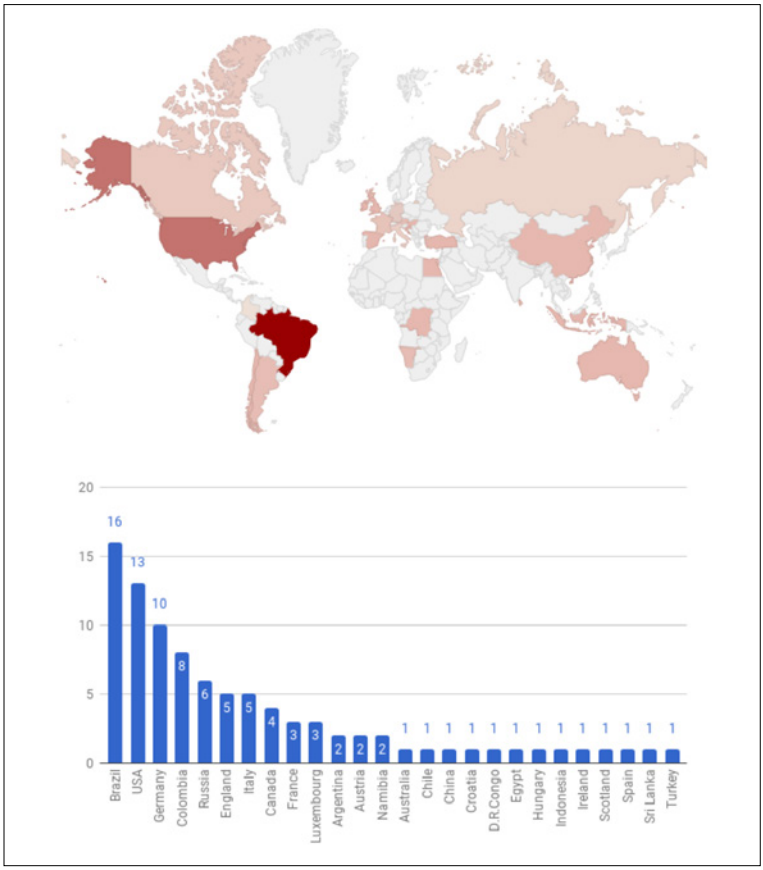

Figure 1 Participants at the 2018 IFPH Conference in Sao Paulo, Brazil (Lucchesi 2018)

2 Do We Need – or Want – a (Single) Definition of Public History?

In his 2008 article "Defining Public History: Is It Possible? Is it Necessary?", Robert Weible pointed out that "For all the talk of public history that we have been hearing for more than 25 years, it is a little awkward that historians are still uncertain about what 'public history' might actually mean. So perhaps it is fruitless to seek consensus on a single definition" (Weible 2008). I would argue that much more than a categorical, ultimate, single definition of public history, what we need is international discussions, exchanges and collaboration on what public history can become. Very much like the collaborative aspect of public history, defining the field should include various understandings, practices and theories.

2.1 Because Public History is not Like Pornography, "I Do not Know It When I See It": Reasons for Defining Public History

If we recognise that public history is a subfield of historical studies, then we can look at other historical fields for inspiration. For instance, the Oral History Association proposes a definition of oral history as "a field of study and a method of gathering, preserving and interpreting the voices and memories of people, communities, and participants in past events".[6] Even though oral history is more established and more widespread than public history, this supports the idea that we need a definition of the field.

The fact that public history is relatively unrecognised could also provide momentum for a clearer definition. Based on the 2009 NCPH survey undertaken among public history professionals, John Dichtl and Robert Townsend wrote that "Public history is one of the least understood areas of professional practice in history because the majority of public history jobs are outside of academia" (Dichtl, Townsend 2009). In the introduction to the 2018 keynote lecture at the NCPH annual conference in Hartford, Connecticut, the mayor of the city confessed that he had never heard of public history before. To prepare his speech, he googled 'public history' and found the NCPH page that compares public history to pornography, which was defined in 1964 by a United States Supreme Court Justice as "I know it when I see it".[7] The mayor confessed to a smiling audience that this definition did not really help him understand the field. If we follow this example, people looking for public history could end up with this Google search result **[fig. 2]**.[8] The NCPH's definition and website, followed by Wikipedia and Weible's article, were the four first results of my search. Although my location affected the results, they tend to show specific North American views and definitions. What is at stake here is not the validity of the NCPH's definition, but rather the fact that practitioners, scholars and students (especially outside the US) may have different approaches that should be considered when proposing international definitions of public history. The success and institutionalisation of public history in the United States can be seen as an inspiration but there is a need for alternative international understandings of the field. The NCPH cannot be the unilateral authority in defining international public history. I would strongly argue that defining public history should be an international and collaborative

6 Oral History Association website, `https://www.oralhistory.org/about/do-oral-history/`.

7 NCPH website, `https://ncph.org/what-is-public-history/about-the-field/`.

8 As geolocation matters for Google searches, I should clarify that I googled 'public history' in Mozilla Firefox on 10 August 2019 in Colorado, USA.

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process in which the variety of voices and interpretations contributes to enriching the field. However, the task of defining public history collaboratively and internationally is beset with many challenges.

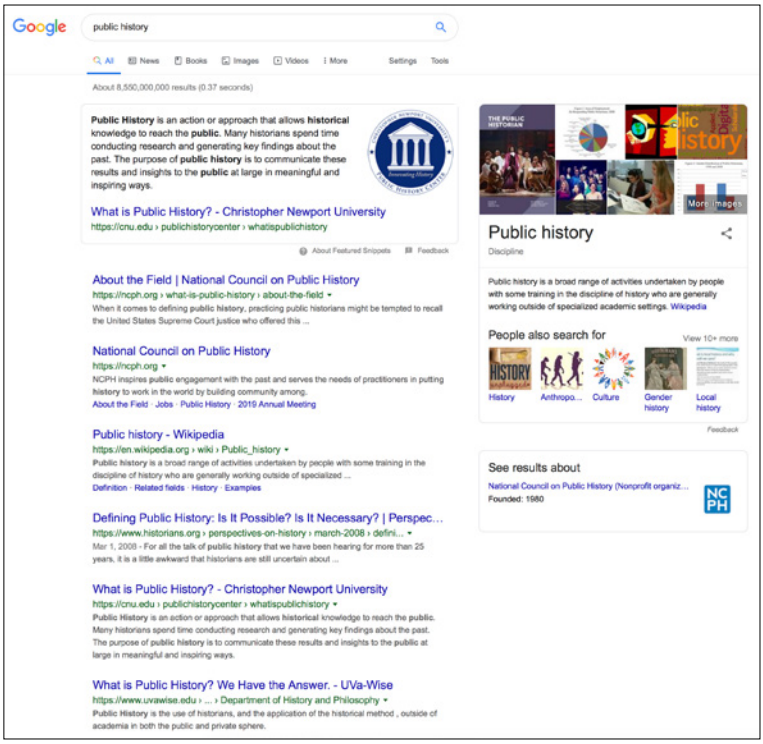

Figure 2 Google Search result for 'public history', 10 August 2019

2.2 Problems in Defining Public History

One challenge in defining public history comes from the breadth and variety of practices involved **[fig. 3]**. This word cloud produced by Anita Lucchesi presents some of the many concepts, practices, tools and issues in public history that arose during the 2018 conference of the International Federation for Public History. This diversity challenges any strict definition of the field. Defining public history creates tensions. In 2007, the NCPH proposed that public history should be defined as "a movement, methodology, and approach that promotes the collaborative study and practice of history; its practitioners embrace a mission to make their special insights accessible and useful to the public" (Corbett, Miller 2007). This prompted strong criticism, with Kathy Corbett and Dick Miller claiming that the statement assigned

public historians the role of "missionaries" and denied "lay people a creative role" (Corbett, Miller 2007). The criticisms can partly be attributed to the role of the NCPH in the United States. The organisation was established in the 1970s in response to the variety and heterodoxy of historical practices outside academia. Although it initially contested the idea that academic historians were missionaries bringing knowledge to the public, when it attempted to propose a fixed definition of the field in 2007, the NCPH somehow repeated the same mistake in assigning a 'mission' to public history practitioners. The challenge in defining public history is to balance the need to identify and frame the field while offering space for discussion, collaboration and disagreement.

Figure 3 Word Cloud of Keywords of 2018 IFPH proposals, 2018 (Lucchesi 2018)

Moreover, national trends and historiography can make the task of agreeing on an international definition of public history even more problematic. There are debates about the translation of the term itself. For instance, while the English term 'public history' is often translated in French (*Histoire Publique*), Portuguese (Brazil) (*História Pública*) or Dutch (*Publieksgeschiedenis*), the Italian Association for Public History (AIPH, Associazione Italiana di Public History) and some programmes in Germany keep the English expression.[9] In Italy, one argument for not translating public history was so that Italian

9 See the website of the German programme at Freie Universität Berlin, `http://www.fu-berlin.de/en/studium/studienangebot/master/public_history/index.html`, and the programme at the University of Amsterdam, `http://www.uva.nl/en/disciplines/history/specialisations/public-history.html`. For the programme in Paris, see `http://www.u-pec.fr/pratiques/universite/formation/master-histoire-parcours-histoire-publique-644604.kjsp`.

e-ISSN 2724-3923

practices could be connected to broader international networks.[10] As Serge Noiret (president of the AIPH) explains, "individuals are open to the field in Italy and have no problem at all in importing solutions from other countries and readapting them locally", whereas the term *storia pubblica* would instead be understood as referring to the controversial uses of the past.[11] Although public history is often translated in French, it raises some specific issues, as in French and some other languages the term 'public' can indicate close links with the state and its administration, partly because of the long history of the welfare state in Europe. Public history may therefore be understood as either state-sponsored history or even the history of the state administration. Likewise, in post-colonial contexts, using a term that is rooted in British and North American practice can raise tensions.

There is therefore a definite ambiguity about whether or not we should define public history. I personally do not think it is necessary – or even possible – to provide a strict one-size-fits-all definition of the field that encompasses the multiple international approaches. However, I do think it is necessary to create spaces to discuss what public history can be and how it relates to local, national and thematic practices and theories of history.

3 Public His(tree): An Interconnected and Collaborative System

Several definitions of public history have used metaphors. British historian Ludmilla Jordanova pointed out that "public history must be an umbrella term, one which, furthermore, brings together two concepts 'public' and 'history' which are particularly slippery and difficult to define" (Jordanova 2000, 149). She presented the field as a way to gather practices under a common name. More recently Italian historian Marcello Ravveduto proposed travelling from land (academia) to the archipelago of public history (Ravveduto 2017, 136). Using this metaphor, Ravveduto posits that public history, much like an archipelago, is made up of small islands (practices) that are distinct but close to one another, connected by the sea. In a similar vein, Jennifer Dickey has recently compared public history to a "big tent", borrowing the metaphor used for digital humanities (Dickey 2018; Pannapacker 2011).

Using metaphors to define public history has given rise to criticism. Recently, Marko Demantowsky argued for instance that Jordanova's use of the umbrella metaphor can be persuasive but lacks

10 Interview with Chiara Ottaviano (board member of the AIPH), Ravenna (Italy), 4 June 2017.

11 Interview with Serge Noiret (President of the AIPH), Florence (Italy), 28 July 2017.

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theoretical grounding and is therefore limited in defining public history. But metaphors can often provide useful insights into the development of the field. They reflect a willingness to see public history as a fragmented field united by a common understanding of the historical process. These definitions depict public history as broadening the traditional historical process, "from land to archipelago", through specific practices. The focus on practices is also present in the English Wikipedia definition: "Public history is a broad range of activities undertaken by people with some training in the discipline of history who are generally working outside of specialized academic settings […] Because it incorporates a wide range of practices and takes place in many different settings, public history proves resistant to being precisely defined".[12] In all these definitions, the question remains of how practices are connected – or to adopt Ravveduto's metaphor, which sea connects the archipelago.

3.1 From a Trunk to a Tree: Enlarging the Historical Process

Attempting to visualise public history has pros and cons; visualisations are limited in showing the complexity of the historical process. The objective in presenting public history as a tree has no claim to be exhaustive or to present a theory-rooted definition of the field but rather to provoke discussion. Trees have often been used as symbols and metaphors. Many genealogical associations and history departments have used trees to show the connection between past (roots) and present **[fig. 4]**. Such metaphors have elicited some criticism as well. Proposing a natural element – a tree – as a metaphor of a human-based activity can initially seem surprising. However, the point is to show public history as a system of interconnected parts. The tree represents more than just actors; it shows stages of a process. Others have criticised the metaphor of the tree because it offers a linear and (overly) logical view, from roots to leaves, that does not leave space for ruptures, conflicts or exchanges (Deleuze, Guattari 1987). While the tree image may indeed be problematic for representations of kinship, transmission and ethnic identity, it works well as a metaphor for complex interconnected systems. For instance, Allan Johnson proposes explaining patriarchy and gender systems through the metaphor of a tree (Johnson 2014). He uses the different parts of the tree (roots, trunk, branches and leaves) to explain the articulation of the patriarchal system. Comparing public history to a tree argues that the field is based on interconnected actors – or thousands of hands as Raphael Samuel once described it (Samuel 1994, 15).

12 Wikipedia, "Public history": `https://en.wikipedia.org/wiki/Public_history`.

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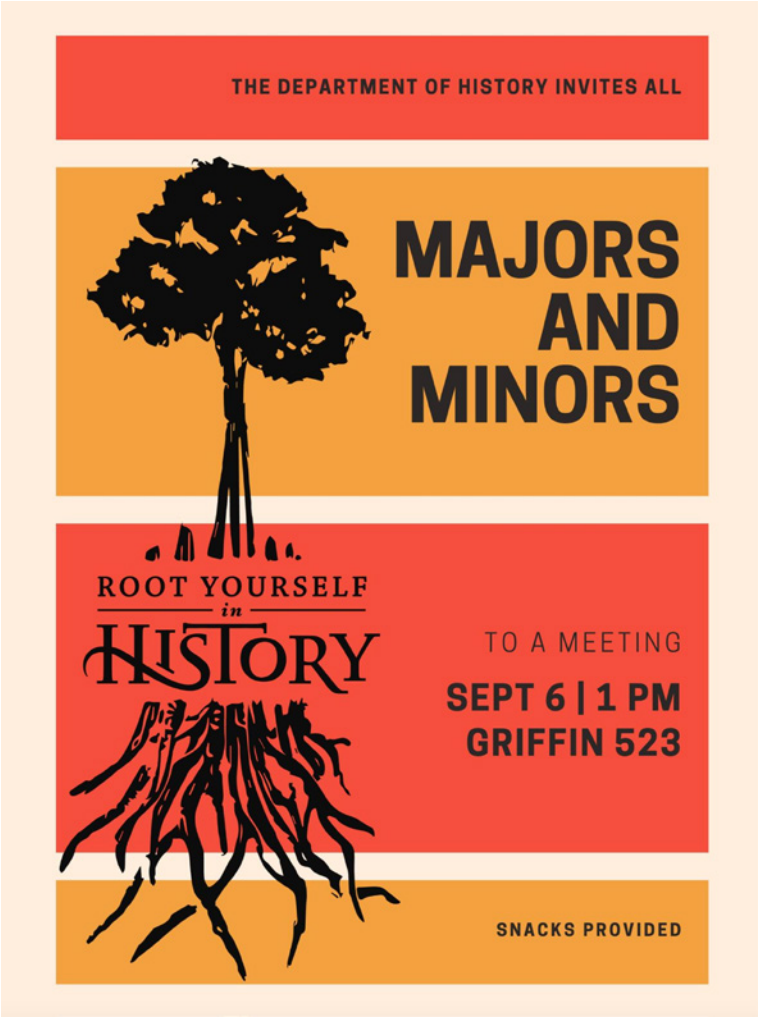

Figure 4 History Department logo, University of Louisiana at Lafayette, 2019

Rather than competing and conflicting relations between actors, the tree is built upon a necessary interconnection between roots, trunk, branches and leaves – see the dotted lines on the right of the tree **[fig. 5]**. The tree is divided into four parts: the roots, the trunk, the branches and the leaves. These parts are different but belong to an overall system; they cannot exist without one another. While history has traditionally been defined as the rigorous and critical interpretation of primary sources (the trunk), public history is broader and includes four parts. The roots represent the creation and preserva-

tion of sources; the trunk is the analysis and interpretation of sources; the branches are the communication of those interpretations; and the leaves are the multiple public uses of those interpretations. The more the parts are connected, the richer and more coherent public history becomes. The structure is not linear; uses (leaves) often influence what we deem important to collect and preserve (roots). The Public His(tree) should not be seen as a purely linear process but rather as an interconnected system.

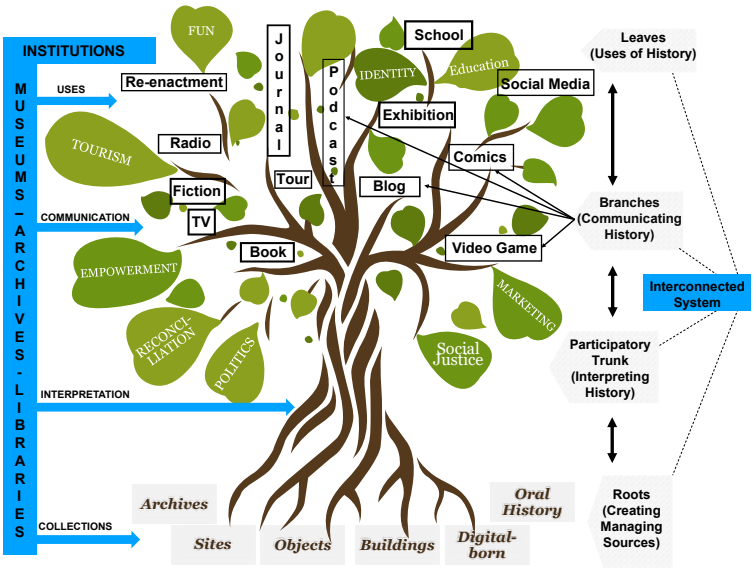

Figure 5 *Public History Tree of Knowledge* (Cauvin 2019)

Rooted in the Past: Public History as Creation and Preservation of Sources

Public history goes beyond the simple interpretation of primary sources. It helps to create, record, manage and preserve sources. Public history includes archiving, managing collections in museums and other repositories, preserving sites and historical buildings and digitising sources. Creating, managing and preserving sources involves public-oriented objectives that require historical skills – we need to ask if the source is reliable and if it is relevant for our understanding of the past. Without the creation and preservation of primary sources – in the broadest sense, also including buildings, sites, objects, digital-born archives such as emails, and interviews – historical interpretations would not be possible. Roots and trunk are interconnected.

Interpreting Sources, the Trunk of Public History

The trunk is perhaps the most visible part of the tree, and historical interpretation is similarly what has long been considered as the main activity of historians. Although some would set public history against academic history, the two should not be considered as mutually exclusive. In fact, historical research – an expression of academic scholarship – is an important part of public history. Without initial research, public history would have no rigorous methodology for the critical analysis of primary sources and no credentials to deal with the past. Public history has even encouraged particular research methodologies. For instance, with the broadening of primary sources (the roots), historical research is increasingly moving away from only using written sources and is embracing visual, material, built and digital sources.

Communicating History: A System with Many Branches

Historians always have an audience, even if it is a niche of a few experts. But public history encourages historians to communicate to large, often non-academic audiences through multiple media, or branches of the tree. In order to share historical interpretation (trunk) with audiences, practitioners make use of a broad range of communication tools including radio, books, exhibitions, journals, tours, fiction, comics, and more recently digital and new media. A willingness to communicate beyond academic peers and a consideration for new modes of communication and how they affect content are crucial for the development of the field. Communicating with various audiences forces historians to reflect upon their approach, moving away from a jargon and concept-oriented academic style to become user-friendly and engaging.

A Tree with Many Leaves: Uses and Applications of History

Leaves provide trees with glucose through photosynthesis. The fact that history is consumed – and used – in many different ways is not new (De Groot 2008). History is used for many purposes, some of which may include marketing, politics, education, identity, empowerment and simply fun. I would argue that the multiple uses and applications of history must be considered as an important part of public history. One limit of this visualisation is the fact that many leaves connect to each type of communication. Instead of single leaves, the tree could have included areas with multiple uses for each type of communication. However, for the sake of clarity, I decided to design individual leaves. This does not mean that all uses and applications

of history are valid and equally significant – there are many debatable political and marketing-related uses of history for instance –, but it emphasises that practitioners cannot ignore how historical research and interpretation are used, consumed and applied by various public groups and individuals.

Trees have many leaves; history has many uses and applications. Public history can therefore sometimes be referred to as applied history. The latter term has been around for much longer – it was proposed by historian Benjamin Shambaugh in 1909 to discuss how history could inform present-day issues and policy (Conard 2013). Applying their skills to present-day issues, historians can work as consultants for governments, agencies, cultural institutions or companies to create and manage archives, to manage historical sites or as expert witnesses in trials (Delafontaine 2015). In North America and the United Kingdom in particular, historians are called on to contribute to public policy, bringing their expertise to the interpretation of past examples (Green 2016).

Visualising public history as an interconnected system also shows that some sites and institutions, such as museums or archives (on the left of the tree), belong to several parts. For instance, by creating collections, producing interpretations and research and also producing narratives – in particular through exhibitions –, as well as offering the possibility of using and consuming the past – for instance in gift shops –, museums demonstrate the richness of the public his(tree). The ways in which people, groups and companies use and consume history have barely been part of history discussions, but they should be part of public history. David Thelen and Roy Rosenzweig show in their study how audiences understand, make sense of, engage with and use history (Thelen, Rosenzweig 2000). Public history practitioners need to consider how their narratives are used and consumed by different audiences and therefore how they impact societies.

3.2 Collaboration, Shared Authority and Public History

While the roots, trunk, branches and leaves of the tree are clearly connected, public history also encourages collaboration within each stage. Public history is not only about working for the public; it is also about working with the public. The public is not a passive audience; it can become an actor in the process. Conceptualised by Michael Frisch to describe the dual authority in oral history – narrator and interviewer –, the notion of shared authority exemplifies how public history invites historians to reconsider the participation of a variety of actors in interpreting the past (Frisch 1990). The crucial challenge is to balance public participation with rigorous and critical methodology at all stages of the process.

When it comes to the roots of the tree, public participation can help in collecting new sources to document the past. For instance, I have organised several history harvests **[fig. 6]** in which scholars and students work with local communities to document and collect sources about a given topic. This is why the trunk of the tree is composed of several intertwined channels that represent the participatory and collaborative process. Historical interpretation – the trunk – requires more complex skills and public participation can become more challenging. However, some examples show how members of the public can participate in analysing primary sources and identify sites, actors or materials.[13] Public participation in communicating history is also quite widespread. Through the concept of "participatory museums", Nina Simon has demonstrated how public interaction and public engagement can help visitors to become actors of knowledge production in museums (Simon 2010).

Figure 6 Public history student collection of artefacts about the history of beer in Colorado, United States, 2019

The collaborative approach of public history is part of a broader process of democratisation of knowledge production that was encouraged by the rise of the Internet. Beginning in the early 2000s, the proliferation of Web 2.0 technologies has allowed users to easily create, edit and share content through crowdsourcing and citizen science

13 See for instance Patrick Peccatte's project, PhotoNormandie, `https://www.flickr.com/people/photosnormandie/`.

projects. With crowdsourcing and user-generated content, cultural institutions and other public history projects have developed collaborative practices in which members of the public can upload and share historical documents, contribute to the process of researching collections and engage with primary sources to interpret the past.[14] Such collaborative practices make public history highly engaging as well as subject to criticism since they call for a new definition of the role of historians.

3.3 "Not Everyone can Become a Great Artist, But a Great Artist can Come from Anywhere" (Anton Ego, *Ratatouille*, 2007)

> In the past, I have made no secret of my disdain for Chef Gusteau's famous motto: Anyone can cook. But I realize, only now do I truly understand what he meant. Not everyone can become a great artist, but a great artist can come from anywhere. (Bird 2007)

This quote from the blockbuster movie *Ratatouille* can be applied to the development of public history. Not everyone can become a great historian, but good public history can come from anywhere. It also means that one does not have to be an academic historian to practise public history. Curators, archivists and other professionals can produce extremely useful collection-based research. Many historical narratives are communicated and shared by non-academic historians. This does not mean that academic historians are not necessary for public history, but they should not be the only actors involved in the process.

The metaphor of the tree posits that historical interpretation (the trunk) is crucial but that it is not an end – or a beginning – in itself. One can be an actor in the system without being a researcher or a professional historian as long as one connects to other stages of the process. For instance, YouTubers who communicate interpretations of the past are actors of public history when they make use of sources (roots) and historical interpretations (trunk) provided by others.[15] Through their communication, they also contribute to interpreting the past. Communication is never a neutral process. Just like in a tree, every stage – creating and preserving sources, interpreting sources, communicating history, using and applying history – has a function and is connected to the whole system. Public history practitioners have to be aware of one another and accept collaboration. Develop-

14 See the Children of Lodz Ghetto project at the United States Holocaust Memorial Museum (Frankle 2013).

15 See for instance NotaBene in France, `https://www.youtube.com/channel/UCP46_MXP_WG_auH88FnfS1A`.

e-ISSN 2724-3923

ing public history helps to connect archivists, researchers, history communicators, audiovisual producers and their audiences. There can be no communication of history to large audiences without previous research and interpretation, but conversely, research without audience-centred communication can lack public engagement. This is why the development of public history is helping to foster awareness and collaboration between various practitioners, even though some practices have existed for a long time. Public history is the result of a collaboration between many different practitioners, not necessarily professional or academic historians, who are identified by their role, which might be curating objects, writing historical fiction or preserving a historical house, for instance.

The question of whether or not public history can be done without professional historians is therefore less relevant than the question of how the different layers relate. Instead of asking whether or not a practitioner is a historian, we should ask which stage of the public history process they are engaging with and how it relates with others. This is why I now tend to refrain from using the term 'public historian' – broadly used within the NCPH – and prefer to use the term 'practitioner', as not all individuals involved in public history define themselves as historians. I admit that this structure of public history as an interconnected system may sound optimistic – ignoring conflicting practices, interpretations and uses of the past – but it aims to connect the many long-divided practices of history.

Professionally trained historians should not feel disempowered by this approach to public history. On the contrary, the collaborative approach reasserts the need for academic and professional historians, but with different roles. Instead of acting as missionaries bringing knowledge to passive audiences, professional historians could be responsible for sharing methodological skills to study sources. Helping to contextualise and interpret sources is one of the most useful tasks that historians can bring to the field. Historians can participate in the construction of collaborative spaces for interpretation. In 2006, Barbara Franco – President of the American Association for State and Local History – pointed out that the "role of the historian or scholar in civic dialogue must be focused on creating safe places for disagreement rather than on documenting facts or achieving a coherent thesis" (Franco 2006, 3). I agree, but I think that this is not limited to civic dialogue and rather refers to public history at large. Historians can connect the different stages and actors of public history, in other words they can become the sap that connects the roots, the trunk, the branches and the leaves.

e-ISSN 2724-3923

4 The Rise of Public History: A Short Historiography

As historian Ian Tyrrell confesses, "scholars tend to see public history as something new" but "historians have long addressed public issues" (Tyrrell 2005, 154). Tyrrell reveals an important misunderstanding. Although the term 'public history' was first coined in the US in the 1970s, the practices of 'doing history in public' go much further back. Historian Paul Knevel asserts that "ever since the activities of the Italian humanist historians of the fifteenth century, Western historiography had had a public function" and he considers humanists like Bruni and Guicciardini as the first 'modern' European public historians, using history to show their fellow burghers important civic duties and the merits of the city-state they were living in (Knevel 2009, 7). The question is not whether or not these humanists were (public) historians; the point is that there has clearly been no lack of publicly-engaged scholars interacting with broad audiences in the past.

Despite these much older examples, the professionalisation of history in the late 19th and early 20th centuries affected the relationship between professional historians and their audiences. History became a scientific and professional discipline for which academic journals became the preferred vehicle of dissemination. Inspired by German historian Leopold von Ranke, professional historians aimed to produce factual historical narratives disconnected from present considerations (Novick 1988, 43). Professional historians addressed more and more specific audiences – their academic peers – and moved away from popular writing styles. This specialisation lay the groundwork for the 'ivory tower' that the founders of the public history movement were so keen to dismantle.

The rise of public history as a field in the 1970s was the result of an international re-examination of history-making. As James Gardner and Paula Hamilton rightly explain, "The history of public history as a term and concept is told in the United States as an internal story in which emissaries from the United States introduce it as a practice to the rest of the world. In fact, from the 1970s and 1980s many western countries experienced similar expansion in professionalization of heritage, expansion of history interpretation, and also the oral history movement, the method that provided the most impetus for broader community projects" (Gardner, Hamilton 2017, 4). It is indeed necessary to set the creation of the public history movement in a broader, more international and comparative context.

Some historians developed new publicly-engaged practices in the 1960s and 1970s. In Britain, although the term public history was not used until very recently, new approaches to public participation emerged (Hoock 2010). Historian Raphael Samuel created the History Workshop at Ruskin College (an adult-education institution in

e-ISSN 2724-3923

Oxford, Britain, strongly rooted in trade unions). His approach came from a "desire to lessen the authority of academic history and thereby further a democratisation of the study and uses of history" (Jensen 2012, 46). In giving voice to under-represented social groups, Samuel was, in terms of participatory process, more radical than the public history movement that emerged in the United States in the 1970s (Schwartz 1993). Comparing historical practices in the US and in Britain, Tyrrell explains that "the British tradition facilitated popular and working class recording of their own historical experiences and involved important contributions to this process by trade unions, workers' education, and local history groups" (Tyrrell 2005, 157). Less based on radical history and activism, the movement in the US is characterised by its capacity to institutionalise the field through academic training.

Robert Kelley first coined the term public history at the University of California in Santa Barbara in the 1970s. A university professor, environmental historian, consultant and expert witness on matters related to water rights, Kelley wanted to redefine the history profession to include practical applications – and jobs – outside education. He wrote that "public history refers to the employment of historians and historical method outside of academia" (Kelley 1978, 16). According to Wesley G. Johnson, another founding member of the movement, training up public historians was an answer to the isolation of academic historians. Johnson explained that "increasingly the academy, rather than historical society or public arena, became the habitat of the historian, who literally retreated into the proverbial ivory tower" (Johnson 1978, 6). The public history movement in the US set out to create new historians who would break free from the 'ivory tower' in which academic historians had been working.

The roots of the movement were also very pragmatic. In a context of global economic depression during the 1970s, universities experienced a major employment crisis. Jobs in higher education fell dramatically. There were too many historians for too few jobs in academia. Public history appeared to be one possible solution to the crisis. The vocational tropism of public history – proposing jobs outside education – matched this context of diversification in higher education.

The unity of the public history movement in the US can partly be explained by the development of university training in the field. The first postgraduate programme in public history opened at the University of California in Santa Barbara in 1976. Two years later, Wesley Johnson launched the first issue of *The Public Historian* and organised several conferences about public history (Johnson 1999). Held between 1978 and 1980, the conferences contributed to the creation of the National Council on Public History (NCPH) in 1979. The new association, the journal and the creation of university programmes institutionalised public history as a specific field of study.

While the institutionalisation of the field progressed in the US, the concept of public history also resonated in other parts of the world, although public history was often considered as an American model. In 1984, French historian Henry Rousso speculated: "created in the United States, public history is crossing the Atlantic. Is this the future of history?" (Rousso 1984, 105). In Australia, Graeme Davison later argued that public history was mostly informed by the American public history movement (Davison 1998).

Wesley G. Johnson, one of the founding members of the movement in the United States, participated in several international events in which he attempted to bridge various understandings and practices of public history. From 1981 to 1983, he went on several international tours in Europe and Africa during which he listed different programmes that had public history components (Johnson 1984, 91, 95). He met with some historians who were already accustomed to applying history to present-day issues. British historian Anthony Sutcliffe met him in 1980 and immediately saw "the mutual, and understandable, sympathy between public history and urban history in North America" (Sutcliffe 1984, 9; Stave 1983). Sutcliffe explained that he "sensed a potentially constructive common interest between public history and the discipline of economic and social history which, in its distinctive British manifestations, already acknowledged some of public history's perspectives" (Sutcliffe 1984, 9). But despite this initial convergence, public history practices in Europe did not really materialise until the 2000s.

In 2009, some historians within the NCPH created a working group to internationalise public history (Adamek 2010, 8). While the group was formed within the NCPH, the goal was to go beyond North America. The group evolved into a committee and was formally named the International Federation for Public History (IFPH) in 2010. Although the IFPH initially involved some long-time advocates of public history in the US like Arnita Jones and Jim Gardner, it slowly evolved into a more international network of practitioners. Unlike the process of internationalisation in the 1980s, which mostly attempted to spread a specific approach from the US, the IFPH aims to connect different local and national understandings of the field. The IFPH does not propose a single definition of what public history is or should be. Instead, a recent project created a space for discussion in which practitioners from all over the world can present their sometimes very different views of the field. Since public history is based on collaboration, it makes a great deal of sense to apply this approach to defining the field itself.

e-ISSN 2724-3923

5 Public History Under Criticism

This overview of public history should not hide the many debates within – and sometimes harsh criticisms of – the field. Public history has always been a highly contentious field, and these criticisms can help improve our understanding of the issues at stake. While some of the criticisms are based on valid arguments, others demonstrate a reluctance to reconsider the way history is done, performed, taught or communicated. Some of these criticisms and possible responses can be found below. Needless to say, I do not claim that this list is exhaustive. Likewise, each criticism calls for a response developed at length, which would be ill suited to the format of this article. Instead of providing clear-cut, definitive answers, I explore some options to further inform discussions.

5.1 "There is No Need for Public History"

Some scholars have claimed that there is no need for public history. In a now-famous article published in 1981, Ronald Grele, albeit acknowledging the need to engage and communicate with large audiences, explained that "[i]t is probably obvious to point out that historians have always had a public. From its earliest times, the study of history has been a public act" (Grele 1981, 41). He criticised the proponents of public history, claiming that they had forgotten that many historians had long been working in cultural institutions, archives, museums and historical societies. In his view, the creation of a public history movement was partly the result of university-based historians trying to reassert their control over existing local historical practices.

Grele's assertion indeed raises important issues about how we define public history. Although the term public history was coined in the 1970s, practices of 'doing history in public' had been around for much longer, as seen above. In addition to early 20th-century examples of applied history, many other historians had been working in cultural institutions or had been employed by governments and military services. In the United Kingdom, the War Office, the Admiralty and the Committee of Imperial Defence had "their own historical sections before the First World War" (Offer 1984, 28). Historical sections were extended to other departments after WWII (Beck 2006). Other historians worked in companies. In Germany, the Krupp Company developed internal archives as early as 1905 with the help of historians. Likewise, historian William D. Overman became a permanent employee of the US-based Firestone Tire and Rubber Company in 1943 to "establish the first professionally staffed corporate archive in the United States" (Conard 2013, 161). So the public history movement did not invent the wheel; some of its practices already

existed and should be included in the historiography of the field. But despite the fact that public history is to some extent based on long-held practices, the movement has served to connect these practices and to enlarge the overall process of history.

Grele's argument was recently used by Irish historian John Regan to criticise the need for a specific field of public history. According to Regan, "an assumption of public history's advocates is that the public does not engage with scholarship" and "in the Republic of Ireland, there exists a healthy practice of disseminating historical knowledge from the universities to general audiences". He cites historians appearing on radio and television or writing for newspapers (Regan 2010, 268). The argument that we do not need a specific field because history is already public resembles the argument of another Irish historian, Gearóid Ó Tuathaigh, who claims that "this notion of an incompatibility between professional and public history (is) fundamentally misconceived" (Ó Tuathaigh 2014). I agree that the strict opposition between the supposedly well-demarcated public history and academic/professional history is problematic. Indeed, what would be the distinction between a public historian and a non-public historian? Going back to the metaphor of a tree, academic scholarship is an integral part of the process if connected to the other stages of public history. John Regan's vision of public history is, however, limited to communicating history to large audiences. It still represents a top-down approach in which 'experts' bring knowledge to passive audiences, with very little public collaboration or participation. What is more, some skills are necessary to practise public history. Designing exhibitions, making audiovisual productions and compiling and managing archives and collections are, for instance, some of the skills that need to be learned to practise public history. We need public history because it helps raise awareness of what it takes to research, interpret, communicate and share historical knowledge.

5.2 "Public History is not History"

"Public history is not history, it is communication". Another criticism levelled at public history has addressed its alleged lack of historical methodology. I was recently invited to discuss public history training at a public history summer school in Belgrade, Serbia, with students and historians from different parts of Europe.[16] I presented the various skills that I want my public history students to acquire during their training. During the discussion with participants, a clear line

16 Applied European Contemporary History website, `http://aec-history.uni-jena.de/?timeline_post=2nd-summer-school`.

e-ISSN 2724-3923

emerged between public history practitioners – archivists and curators, for instance – and some academics. For the latter, what I had presented was not history but merely communication. They saw the role of historians as primarily carrying out original research and becoming experts in a clearly defined subject area.

To be fair, in my talk I had not insisted on the historiography and methodology training that my students also receive. However, those criticisms mirror a broader view that public history is too focused on communication and media. I disagree for several reasons. First, just as public history is grounded – the roots and the trunk of the tree – in primary sources and research, public history students receive training in research and historiography. But public history students also learn skills to communicate history to large audiences and to collaborate with various partners and public groups. In the same way that a good researcher does not necessarily make a good teacher, a historian is not necessarily equipped to practise public history. If historians want to work in and with the public, they have to learn skills such as how to curate and design historical exhibitions, write 150-word panels or produce audiovisual projects. History is not communication, but it can learn from communication. Jason Steinhauer thus created a group of history communicators to raise awareness and discussion about communication skills for historians. He explains that "[j]ust as the sciences have prepared a generation of scientists to be Science Communicators, so too is history preparing History Communicators to communicate new historical scholarship to non-experts in today's complex media environment".[17]

More challenging is the view that public history is not history but rather a sort of memory production. During a seminar on museums and public history held in Quito, Ecuador, one historian argued that public history had more to do with group memories than professional history:[18] professional historians write history while communities develop memories. This opposition between history and memory is nothing new. It reflects the rise in memory studies over the past four decades. Some historians, like David Lowenthal, have distinguished between history and memories. In Lowenthal's comparison, he sets historians who "while realizing that the past can never be retrieved unaltered [...] still strive for impartial, checkable accuracy, minimizing bias as inescapable but deplorable" against those – he does not call them historians – who "see bias and error as normal and neces-

17 Jason Steinhauer's personal website, `https://www.jasonsteinhauer.com/history-communicators`.

18 Universidad Andina Simon Bolivar, "Museos, historia publica, y politcas culturales", `https://www.uasb.edu.ec/contenido?museos-historia-publica-y-politicas-culturales`.

sary" (Lowenthal 1997, 32). He claims that there is a multiplicity of memories emanating from groups and individuals, and that it is the task of historians to research those memories as case studies.

In Lowenthal's view, public history would closely connected to memories because it involves working with groups and communities. For example, I was working with local communities to study the history of the legacy of immigration in Colorado. Working with groups and communities can be challenging as it involves testimonies, individual recollection and emotions such as pride and anger. Peter Novick is critical of a version of public history that he defines as seeking "to legitimize historical work designed for the purposes of particularistic current constituencies". This definition of public history contrasts with what Novick presents as the "noble dream" of "the universalist ethos of scholarship" (Novick 1988, 471-472, 510). I would argue that, going back to the metaphor of the tree, public history is not simply uncritically remembering the past; as James Gardner stressed in his critique of radical trust, (public) history is not mere opinion (Gardner 2010). Communication and uses of the past – branches and leaves – are connected to primary sources and their critical interpretation. Historians help public groups and communities develop skills to use, interpret, contextualise and compare evidence of the past. The role of trained historians is more than merely sharing their knowledge of the past; it involves sharing their skills to interpret and understand the past.

According to the criticism outlined above, working with multiple partners and public groups could lead to the fragmentation of the narratives of the past, resulting in plural memories rather than a single history. However, simply contrasting a plurality of memories with a singular history is a naive presentation of the field that ignores the many 'history wars' and debates when interpreting the past. Besides, multiple perspectives do not necessarily mean a lack of critical rigour in developing views of the past. For instance, the *Their Past Your Future* exhibition presented the Second World War from the perspective of UK veterans through testimonies (Sayer 2019, 14). But the exhibition, as a public history project, was not merely a collection of uncritical memories. Testimonies were coupled with other primary sources, footage and contextualisation. The project had the benefit of showing specific interpretations of the war while connecting them to a broader context and historical narratives. This balance between several interpretations of the past and the broader context is vital for public history as it shows how events may have a variety of valid interpretations. Sarah Lloyd and Julie Moore have proposed the concept of "sedimented histories" which can "hold different accounts of the past alongside one another, accommodating both the histories that people choose to live by and the histories that everyone lives with" (Lloyd, Moore 2015).

e-ISSN 2724-3923

Public history can contribute to reconciling history and memory. Its participatory practices provide a space for individual and collective memories in the production of historical narratives. In 1996, historian David Glassberg led a discussion on the links between public history and memory (Glassberg 1996). The discussion explored how individual and collective memories can be part of public history projects. For instance, it is common in historical preservation for members of local communities to take part in discussions about what should be preserved, why and how. Public memories of sites help us discover new layers of interpretation and strengthen the authenticity of narratives. The production of public understanding of the past is more complex than a simple confrontation between history and memory. In his answer to Glassberg's article, Robert Archibald pointed out that "the new memory research is especially important because it is audience-focused and recognizes that examining how humans receive information and construct memory is critical to our work" (Archibald 1997, 64). Different public uses and interpretations of the past are crucial to understanding how audiences make 'sense of history', or as Glassberg put it, as evidence of the intersection of the intimate and the historical (Glassberg 2001, 6).

5.3 Public History, Consultants and Clients

Because of its multiple connections with partners, public history has also been criticised for being present-centred. Regan argues that "Public histories popularize the past, but they are conditioned by the needs of the present. They may want to win votes for the government or loyalty for a cause, or just pay their way as commercial ventures. Public histories pander to the expectations of mass audiences, whereas historical research is more interested in the past for its own sake" (Regan 2012). Although this opposition between multiple public histories and a singular and objective historical research is highly debatable, it raises important questions about ethical issues.

Criticising public history for being market-oriented is not new nor specific to the field. There have been debates on how heritage management is influenced by marketing and commercialisation. Some scholars have denounced the packaging of the past through heritage management (Baillie, Chatzoglou, Taha 2010). In 1996, Michael Wallace criticised the 'disneyfied' history proposed at some museums and historical sites in the US (Wallace 1996). He claimed that some heritage projects proposed 'edutainment', a mix of education and entertainment, to attract more audiences, to the detriment of historical accuracy. The rise of entertainment as a policy driver for historical and heritage sites has been deplored by some scholars because of its commercialising of history. As Faye Sayer points out, "public historians have been accused of using the media and its techniques to sen-

sationalize and romanticize the past in order to create an unrealistic, yet publicly appealing, version of history" (Sayer 2019, 15). The close links between public history and historical sites, museums and other cultural institutions – sometimes for-profit companies – make those criticisms important for ethical discussions.

Ethics and ethical practices are crucial for public history, especially when partners and clients have multiple non-educational objectives, some of which may be profit-based. Discussions on ethics are also important for historians who work as individual consultants isolated from large structures such as universities, cultural institutions, national parks or other public agencies. From the outset, historical consulting – for instance the US-based firm Historical Research Associates – has been closely associated with the NCPH.[19] In the early 1980s, Johnson noticed reluctance and criticism regarding the application of history during his tours in Europe. He observed that German students and scholars were sceptical about "historians working with business corporations" and openly hostile "to the idea of historians working with federal government agencies" (Johnson 1984, 90). Similarly, Novick wondered whether consultants, under the pressure of their clients, would focus merely on the historical records that "support the case they were making, and [would do] their best to sweep under the rug or trivialize discrepant findings" (Novick 1988, 514). Criticisms focused on the fact that historical narratives would become a product and, like any product, would be sold for marketing or political purposes.

However, pressure and interference are not limited to consultants. Fuelled by the recent upsurge in populism and political uses of the past, every historian – including those working in universities – can be affected by interference and pressure (Etges, Zumdorf, Machcewicz 2018). The founding members of the public history movement in the US did not ignore ethical questions. Every article of the first issue of *The Public Historian* mentioned ethical issues in public history.[20] The NCPH set up an Ethics Committee in the early 1980s that led to the development of the first NCPH Ethical Guidelines in 1985 (Karamanski 1986). Theodore Karamanski led a round table on Ethics and Public History and later published a collection of essays entitled *Ethics and Public History* in 1990 (Karamanski 1990). In 2007, the NCPH updated its *Code of Ethics and Professional Conduct*, highlighting public historians' responsibility towards the public, their clients and employers, and towards the profession and colleagues.[21]

19 The NCPH provides specific resources for consultants: `https://ncph.org/publications-resources/for-practitioners-and-consultants/`.

20 *The Public Historian*, 1(1), 1978.

21 `https://ncph.org/about/governance-committees/code-of-ethics-and-professional-conduct/`.

e-ISSN 2724-3923

While those resources are available to all historians, it is still essential to engage in discussions about the role of historians and the uses of history. Ethics are so crucial that they must be discussed and practised in public history training. A recent proposal for an online Master of Public History at the State University of New York proposes an entire course on *Ethics and Public History*, an initiative that should also be introduced in any public history training programme.[22] But ethical issues remain challenging for two reasons. First, the broad range of public history practices, formats and partnerships makes it difficult to provide one single code of ethics for the whole field. Ideally, codes of ethics from other related fields such as museums and archives should also be consulted.[23] Working for/with museums requires a different set of ethics from historical preservation or audiovisual production. Second, ethical practices may vary from one country to the other depending on laws and regulations. It is important for the international public history movement to provide help, resources, guidelines and institutional support for historians working outside academia all around the world.

5.4 "Public History is a Set of Blind Practices"

Some historians have asked for more theoretical understanding of public history. During an international workshop at the University of Wroclaw, Poland, in March 2018, three experts in the field – David Dean, Jerome de Groot and Cord Arendes – underlined the need for more theorisation of the terms 'public' and 'history' and the links between the two.[24] De Groot points out in a forthcoming article that "public history historiography has been driven by pedagogical models that privilege skills, ethics, and a 'professional-based practice approach'". He goes on to say that "it remains the case that public history lacks a model for critical engagement with corporations, or a flexible way of 'reading' their contribution to historical awareness".[25]

22 Although the Master is not available yet, more information can be found on the website for the certificate in public history: `https://www.esc.edu/graduate-studies/advanced-certificates/certificate-public-history/`.

23 For the US, see for instance the American Alliances for Museums' *Code of Ethics*, `https://www.aam-us.org/programs/ethics-standards-and-professional-practices/code-of-ethics-for-museums/`, and the Society of American Archivists' *Core Values Statement and Code of Ethics*, `https://www2.archivists.org/statements/saa-core-values-statement-and-code-of-ethics`.

24 Applied European Contemporary History, "The Public in Public and Applied History", University of Wroclaw, March 2019, `http://aec-history.uni-jena.de/`.

25 Forthcoming article in *The Public Historian*. I am grateful to Jerome de Groot for giving me access to his article.

As early as 1984, while comparing practices in France and in the US, Henry Rousso stressed that "pragmatism is not a French quality (or impairment)" – implying that historians in the US were – perhaps too eagerly – driven by public practices (Rousso 1984, 114). In his view, before any application of public history, French historians would need to engage in major theoretical debates.

At first glance, a lack of theorisation is a fair criticism. Many panels of public history conferences, at least in the US, are about 'how to' practice in the field.[26] Public history teaching also focuses a great deal on skills and practices. The NCPH confirmed this trend by recently undertaking a survey of public history employers to list the main skills that public history students need to find jobs (Scarpino, Vivian 2017). However, this lack of theory is only partially true. Many university training programmes on public history propose introductory courses that discuss theories and approaches to the field. Public history courses provide excellent opportunities to develop self-reflective practices among historians and history students. I would also argue that the opposite, namely a lack of practices, can paradoxically challenge the development of the field. Many academic historians are not used to practising history outside academic circles, and one initial reflex may be to study – and not to practice – public history, focusing merely on the theories of the field without engaging or collaborating with audiences. Public history should not become a new form of memory studies in which historians merely study representations of the past.

The need to balance theories and practices can help when discussing specific challenges in the field. We should develop and propose new theories to accompany public collaboration, co-production and shared authority. Although some books have been published recently, more discussion is needed on how to balance public participation and rigorous critical methodology to interpret the past (Adair, Filene, Koloski 2011). Working with several European partners, I have been developing a collaborative research project to find new approaches and theories on how to practise public history.[27] We should not see the 'public' as a singular notion, we should instead consider the many 'publics' – the variety of groups, actors and partners – that take part in public history. While Michel-Rolph Trouillot proposed an excellent interpretation of the power relations and agencies at stake in the creation and preservation of archives, other themes must also be debated (Trouillot 1997). In 2002, Jill Liddington proposed that public history should be connected with theoretical discussions on the public

26 See the NCPH website for the programmes of past conferences: `https://ncph.org/`.

27 Public History as the New Citizen Science of the Past, Luxembourg Centre for Contemporary and Digital History, `https://www.c2dh.uni.lu/projects/public-history-new-citizen-science-past-phacs`

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sphere, popularised in 1962 by Jürgen Habermas (Liddington 2002, 89). Various questions may arise: How do we define and identify these audiences and participants? Are practitioners collaborating with all or only a few public groups? Should Holocaust deniers and racist or fascist groups be part of the collaboration? If not, who decides, and on what basis, with whom to collaborate? Are we only collaborating with groups with whom we share values? If so, we need to discuss our approaches to and definitions of audiences and participants and their role in public history.

More theory also means some self-critical assessment. By comparing practices and approaches, international public history can encourage self-reflection. For instance, public history tends to focus on contemporary – especially 20th-century – history. Stefanie Samida, an archaeologist and media studies scholar, rightly argues that limiting public history to a certain era may be one of its weaknesses (Samida 2011). However, this is not true for every national context. In Italy, the AIPH includes many examples of projects and actors connected with antiquity and public archaeology.[28]

It would be presumptuous to make hasty conclusions about a field – public history – that is so recent and diverse. If anything, the internationalisation of public history has demonstrated the existence of various approaches and understandings of the field. The multiple approaches pave the way for rich and complex debates about broader uses, practices and theories of history. Some of those history practices were in existence long before the term public history was coined, but the conception of public history as a field offers several advantages. Comparing public history to a tree helps to present the field as a system in which all parts – roots, trunk, branches and leaves – are connected. Each part, and every player, of public history benefits from the whole system. The fact that primary sources and critical methodology are at the basis of public history is particularly important in a context of fake news, mistrust and disinformation, in which historians can bring expertise. Public history calls for a general reappraisal of trained historians' role. Developing public history will involve trained historians sharing authority with other actors and questioning how history is used and consumed by individuals, communities, groups, institutions, agencies and governments. Far from denying the role of historians, public history provides them with new opportunities to engage and interact with the public. Rather than merely giving lectures and providing truths about the past,

28 See also the conference *Medievalism, Public History, and Academia: The Re-creation of Early Medieval Europe, c. 400-1000* (Malmö University, 26-28 September 2018), `https://exarc.net/history/call-papers-medievalism-public-history-and-academia`.

historians can work on building collaborative spaces and projects in which all actors can learn, practise and share skills to collect, analyse, interpret and communicate history. If successful, the tree of public history has the potential to contribute to the democratisation of knowledge production while maintaining a critical and methodological understanding of the past.

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Scholarly Editing and AI: Machine Predicted Text and Herculaneum Papyri

James H. Brusuelas
University of Kentucky, USA

Abstract In 2016 the Digital Restoration Initiative (DRI) at the University of Kentucky, under the direction of Professor Brent Seales, virtually unrolled a carbonized parchment scroll from Ein Gedi, revealing a copy of Leviticus written in iron gall ink. In 2019 the DRI applied a new machine learning method to reveal a Greek character written in carbon ink from an actual Herculaneum papyrus fragment. Virtual unwrapping of cultural heritage objects is a reality. The application of machine and deep learning methods to enhance difficult-to-detect ink signals in tomography will continue to evolve. This raises an important question. How will the process of editing texts that are 'true-born virtual' (the object can never be opened to verify the results) change to reflect the presence and dependency on AI? This paper produces a theoretical model for how a critical edition of a virtually unwrapped papyrus text must document the role of the machine. It also engages the possible requirements, in terms of Data Science, that this new type of text compels in order to ensure transparency at the level of its 'birth'. Put simply, a new virtual edition model that is a fusion of humanities and science is needed.

Keywords AI. Tomography. Born-virtual text. Scholarly editions. Textual criticism. Herculaneum. Papyri.

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1 Editing with AI: Essential Methods First, Not Fantasy[1]

Editing an ancient language with artificial intelligence. It sounds like a scene in a science fiction movie. But before we get distracted with any fanciful images of sitting at a computer terminal, or perhaps just a screen in a post-keyboard world, and talking with an Alexa, Cortana, or Siri type of entity with expertise in ancient human languages, let us step back and remember that we have been assisted by computational resources for some time now. Regardless of the language of a given manuscript, advanced imaging techniques and image processing have been critical in the scholarly editing process. In the fields of Classics and Greek and Latin Papyrology, which will be the focus of this paper, that process produces the first edition of a papyrus manuscript (the *editio princeps*), the subsequent versions as papyri are constantly re-edited over time, and the collation of manuscripts in the critical edition of one work, such as Aeschylus' *Agamemnon*. As a papyrologist, a basic example would be the use of multispectral imaging and software like Adobe Photoshop (or even just Mac Preview) to enhance the contrast between the ink and the substrate surface. Reconstruction of a text is thus often made possible because the editor is viewing a spectral image of a manuscript produced by imaging it under incident light that has a wavelength of 940 nanometers, for example, and at various contrast settings within an image viewing application. Yet when we read the *editio princeps* or the critical edition, whether it is found in the *Oxford Classical Texts* series, the *Teubner* series, or in a papyrus edition series like *The Oxyrhynchus Papyri*, documentation of the spectral bands used in the editing process is not always added. The software applications used to manipulate the images, let alone the contrast settings used, are most definitely omitted. Put simply, documentation to reproduce the conditions under which the text has been reconstructed, or seen, is seldom, if at all, provided. No metadata. No scientific reproducibility. And while we have survived relatively well without providing such metadata in our editions, the current situation requires change. The introduction of machine learning and its 'black box' of prediction requires adjustments in the methodology of constructing an edition. Even more so, the process of virtually unwrapping and extracting text from cultural heritage artefacts that cannot be opened – due to their fragile state – requires a general re-assessment of how that extracted text should be edited. After all, one cannot verify the text with the human eye. This new kind of text, which I will refer to as born-

1 For comments and suggestions on earlier drafts, I give thanks to Seth Parker and Dr. W. Brent Seales. The Andrew W. Mellon foundation must also be acknowledged for providing research funding.

virtual text, will only exist virtually and is the product of an artificial intelligence; although born-digital might be the expected term, virtual seems more nuanced for a digital text that is not the product of direct observation.

The purpose of this paper is both to start the discussion about the editing of born-virtual text and to put forth some possible ways of presenting such text in our editions. First things first, virtual unwrapping is real. A carbonized parchment scroll from En-Gedi was virtually unwrapped by the Digital Restoration Initiative, which has now evolved into EduceLab, at the University of Kentucky in 2016, revealing an early copy of Leviticus (Seales et al. 2016). Moreover, the technique is no longer considered a unique methodology, or a concept that still must be developed. It is being applied by many research groups.[2] Second, although iron gall ink so far tends to be fairly visible in micro-CT scans, as in the case of En-Gedi, carbon ink is not. Enter machine and/or deep learning and the prediction of the presence of ink in tomography. To even see the text, the human eye requires the aid of artificial intelligence; for the purposes of this paper, we will use artificial intelligence (AI) as a generic term inclusive of both machine and deep learning methods. Humanities scholars must now embrace further a concept that their colleagues in the sciences have been aware of for ages: scientific reproducibility. To interrogate a scholar's reconstruction of the text, one must be able at any time to reproduce the initial findings or, at the very least, be aware of what produced the output. To do so, means not simply knowing where to access the data, but, more importantly, being aware of key aspects of metadata associated with the output of both the AI and the algorithmic process involved. What was responsible for detecting and enhancing the ink? Where is it located within the physical object that cannot be opened? Accordingly, in current print and digital edition models we will need supplementary conventions to account for this metadata. A reader would thus have the essential data that is a traceback to the 'what', 'where', and 'how' regarding the born-virtual text before them. That said, extracting text in 3D space – from voxels rather than pixels – should also make us consider augmenting existing digital edition models. For example, we will likely need to move beyond the level of 'behind the scenes' metadata markup, JSON or XML files stored somewhere on a server or downloadable via a website, and one image as the 'canonical' representation of the object. To fully grasp the data which we are looking at – and subsequently making scholarly arguments based upon – one needs the full context of this virtual birth, i.e. structured data. We will need access to multiple image datasets and visualizations that facilitate the

2 E.g. Ziesche et al. 2020; Stromer et al. 2019; Liu et al. 2018; Bukreeva et al. 2016.

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comprehension of the digital provenance. Only then can we achieve transparency. To explore these ideas and to put forth some possible methods, I will now offer a few hypothetical scenarios based on current research at EduceLab on the virtual unwrapping of carbonized papyri from Herculaneum and the detection of carbon ink therein.

2 Herculaneum Papyri and AI

The problem of seeing carbon ink in tomography is well documented, especially in the context of the carbonized papyri from Herculaneum (Parker et al. 2019). The ink and the papyrus substrate have different densities; the chemistry is different. And so, one will often hear how ink is, or should be, brighter in micro-CT, i.e. the density of the ink should attenuate x-rays more than the density of the papyrus substrate. Great for iron gall ink, as it is generally visible to the human eye in tomography. But the density of carbon ink just seems to resist being 'bright' enough to appear. At one point the idea that carbon ink is actually invisible in tomography even emerged (Gibson et al. 2018). That idea, however, has been proven to be inaccurate (Parker et al. 2019). Still, the problem persists. How does one make the carbon ink from an actual Herculaneum papyrus appear in tomography? Well, this has also been done using AI. In 2019 Brent Seales' presentation at the Getty Museum included a video showing how a Herculaneum fragment was used in an AI experiment to accurately reveal a Greek character in a micro-CT scan. Using a 3D Convolutional Neural Network (3DCNN), our AI was trained on one half of the visible layer of P.Herc.Paris Objet 59, while the other side was reserved for evaluation and prediction. To the human eye, a carbon ink Greek omega was made visible. It is not just the fact that virtual unwrapping is real. The visualization of carbon ink in x-ray scans is also becoming a reality, though much work remains to be done. And even though iron gall ink is generally visible, we are also applying AI to further enhance its signal in micro-CT for greater legibility (Gessel et al. 2021). AI is indeed poised to become a persistent entity or assistant in reading damaged manuscripts **[figs 1a-b]**.

e-ISSN 2724-3923

Figure 1a P.Herc.Paris Objet 59.
A: fragment under natural light conditions

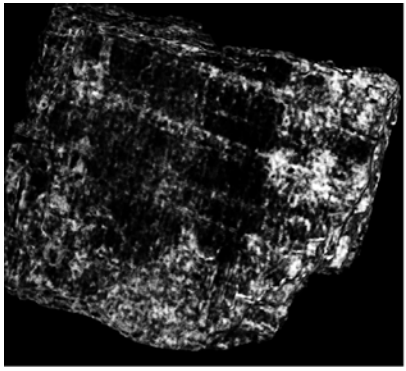
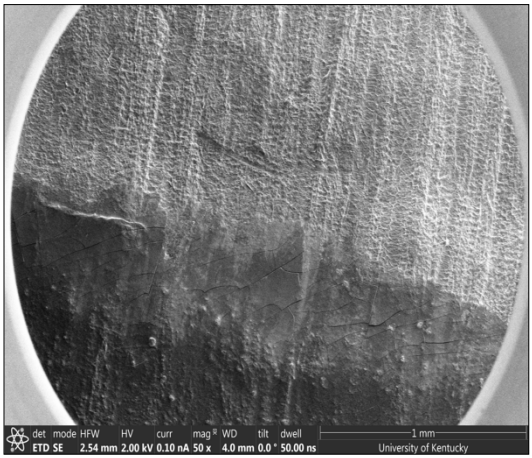


Figure 1b P.Herc.Paris Objet 59.
B: a Greek Omega revealed
in a micro-CT scan via AI

The initial AI method created at EduceLab has been published (Parker et al. 2019). Without diving too deep into the science, to be repetitive, a summary of the approach is warranted here, especially to convey the process to the general papyrological and digital humanities audiences. Morphology is the key term. Now, although this is not the kind of morphology of which papyrologists might immediately think – inflection/conjugation of verbs, nouns etc. – there is a fundamental similarity: change in structure, albeit at the micro-level this constitutes papyrus fibers *vs* papyrus fibers with ink. If the density of carbon ink will persist in not attenuating x-rays to be bright enough for the human eye, then perhaps the morphological pattern of ink on papyrus substrate is, or should be, a feature detectable and thus learnable by the machine. After all, there is a physical change, and thus a difference in structure between papyrus with no ink and papyrus with ink; this is rather visible using an electron microscope (Parker et al. 2019, 5). Thus far, this has been the basic logic upon which we continue to refine and train our AI. It thinks in terms of ink and no ink features, not alphabets nor languages. Based on what it has learned, it predicts the presence of ink and amplifies its signal to be visible to the human eye **[figs 2a-b]**.

e-ISSN 2724-3923



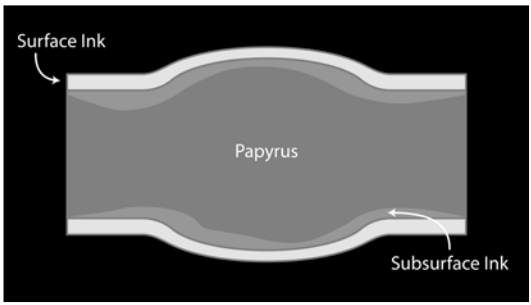


Figure 2a Morphology. A: papyrus with ink *vs* no ink is clear with an electronic microscope

Figure 2b Morphology. B: the feature, the signal, we are detecting is the ink both penetrating and resting on top of a papyrus fiber

The process starts with Volume Cartographer (VC), a custom software application developed at EduceLab for virtual unwrapping. Raw micro-CT data (sinograms) undergo reconstruction and that data is then rendered into a volume package that can be passed through VC. Put very simply, the VC pipeline allows for the efficient segmentation of volumetric image data (the slicing of the volume to isolate writing surfaces) and the subsequent texturing, flattening, and generating of 3D and even 2D images of those segments. Now, it is the texturing process that is critical for our AI. As the 3D mesh of a given segment is textured (the process of applying the visual details to a 3D model – the point clouds that represent the structure – to give it definition in terms of surface shape), a per-pixel map that stores all 3D positions is generated. For any segment, areas or points from this map are then selected and used to create sub-volumes that constitute the input for our 3D CNN. These sub-volumes, oriented toward the surface of the writing substrate, is where prediction will occur. This is where the so-called 'black box' of AI exists, the point at which something is purportedly seen or predicted based on prior training.

Understanding how learning takes place determines how transparent this black box will be.

The greatest challenge in applying AI to visualize carbon ink in Herculaneum papyri is a lack of training data. The most effective AI is the one with extensive reference libraries. The more data to reference and from which to learn, the greater confidence in its ability to predict. To prove the concept, we used a carbon phantom (a fabricated facsimile) scanned at 12 microns. Training labels were made by aligning and registering images containing the ground truth of ink/no ink to the x-ray images in which it is not visible; with both x-ray and conventional images, we thus know where the ink is, even if we cannot see it in the former. Multiple sub-volumes, each with their own label, were then used to successfully train a neural network. For actual fragments, creating training labels is essentially the same process. For evaluation, however, we have used a form of k-fold cross validation in early experiments to validate the concept, especially since we have limited training data. The writing surface is partitioned spatially into k-regions of interest. These regions are used for training, with one reserved for evaluation, i.e. one region is the input upon which the network applies what it has learned and predicts ink/no ink. Training runs on P.Herc.Paris Objet 59 demonstrate that this morphological approach is working. Nevertheless, one caveat must be pointed out: resolution. To detect this ink signal, that morphological pattern of ink covering and penetrating the substrate surface, a high resolution is required. Our current projection so far is that a resolution of 3-5 microns is needed; yet this could change over time as we learn more about the ink signal that we are detecting. The end results are not only images documenting the blank x-ray scan and the prediction of ink (thus a character), but also a photo-realistic rendition that offers a virtual facsimile of the manuscript as it would appear under natural light conditions to the human eye **[figs 3a-b]**.

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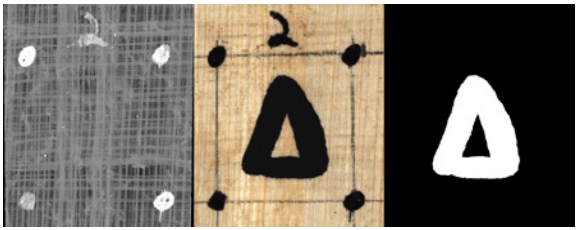

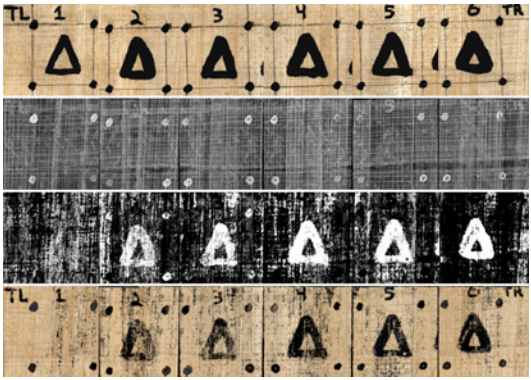

Figure 3a Carbon phantom. A: from left to right: the x-ray scan, the natural light view, the training label

Figure 3b Carbon phantom. B: from top to bottom: natural light, x-ray, prediction (i.e. reconstruction), the photo-realistic rendition

These ongoing experiments raise issues rarely, if at all, discussed. How do we edit this text? In recent scanning of Herculaneum papyri using X-ray phase-contrast tomography (XPCT), attempts have been made. In Mocella et al. (2015) cropped images of XPCT data (P.Herc. Paris. 1 fr. 101 and P.Herc.Paris. 4) were paired with basic transcriptions of the Greek text purportedly seen, as well as individually cropped images constituting an entire Greek alphabet (2015). In Bukreeva et al. (2016; 2017) we find the most extensive attempt to pair cropped images of XPCT data (P.Herc. 375 and 495) with both diplomatic and articulated transcriptions; the use of the typical editorial conventions in these transcriptions, such as the underdot and square brackets, indicate the application of papyrological method. Now, I have no interest here in debating the reliability of the ink allegedly seen in these publications. There are lingering issues, especially regarding resolution, and the reality that it may not be ink at all persists. Rather, I am interested in data that is missing in the presentation of this text. Let us hypothetically say that all the text published is, in fact, indicative of carbon ink. First, from where does this text come? For example, P.Herc.Paris 1 fr. 101 is actually a multi-layer fragment removed from an intact scroll. Where was its original location? Second, two lines are revealed from the hidden layer (Mocella et al. 2015). Which layer? Moreover, which line is first in

succession? There is no indication. In Bukreeva et al. (2017) an image of a layer virtually removed from P.Herc. 375 is provided. However, only a cropped, magnified image is later provided with annotation indicating possible lines of Greek text. As for the text edited and presented according to papyrological method, exiguous as it may be, it is actually from P.Herc. 495. Again, where is this text coming from? Finally, in Bukreeva et al. (2016) we find more cropped, close-up images from P.Herc. 375 and 495, albeit with better papyrological transcriptions. Whether P.Herc. 375 or 495, where is the text located in relation to the overall structure of the intact scrolls? The only indication is that the text comes from the inner part. Obviously, these are first attempts in the process to reveal the hidden ink. Be that as it may, for confidence and trust, we must be more precise.

With virtual unwrapping and AI prediction and enhancement, we cannot just pretend that we are looking at the usual 2D image, or even the actual fragment, and whatever text is or is not visible under natural light conditions. No, we cannot verify the text with our eyes at all. This is a moment in which metadata associated with the virtual unwrapping process and AI prediction becomes important. In the examples of published text mentioned above, virtual unwrapping and/or segmentation metadata is ignored. And while no AI was used in those experiments, in our work at EduceLab we plan on incorporating metadata in a JSON file during any application of AI, which will notably include a Git Hash that references the specific code used and thus responsible for ink prediction; this is a part of the on-going development of our AI work. This metadata is critical for scientific reproducibility. Normally this is just metadata stored on a server somewhere and (hopefully) accessible in some way. Yet due to the increasing role of virtual unwrapping in digital restoration and the on-going developments in the use of AI to virtually enhance text, some of this data should be moved into the workflow of the humanities scholars who will edit this born-virtual text. We are looking at a near future in which both multiple versions of AI (multiple versions of code) and multiple scans might be used to predict and to enhance text from one cultural heritage object over time. Furthermore, the segmentation process in virtual unwrapping must be tracked for understanding the location of the text and the virtual reconstruction of the physical object.

So, AI, segments, and sub-volumes. How does this affect the editing process? Intact scrolls from Herculaneum offer a good sandbox in which to approach that question. For any intact scroll, the degree of damage varies over the internal structure, potentially resulting in random rather than consistent areas that are initially strong candidates for virtual unwrapping. The odds are highly unlikely that we can start at the beginning of the work and slowly unroll to reveal the text. Moreover, while some characters may be successfully amplified and made visible on the first try, ambiguity due to damage and, of course, the

random noise of ink smudges, ink drops, crossed out letters, severely faded ink, tears, holes etc. will likely persist and drive further improvement of the AI over time. The more noise, the more training and improvement are needed. The AI will thus require an ever-evolving reference library as more training data is gathered to reduce noise that appears as we start to see accurately within in a Herculaneum scroll. Nevertheless, when our AI begins to detect, predict, and enhance ink, the scholarly community will want the publication of that text to start immediately, just as we saw above with the published XPCT data. Waiting until an entire scroll is virtually unrolled is not a welcome strategy at this point. Unfortunately, there is currently no indication of how long the full process of segmentation to completion, i.e. an entire intact scroll, will take; this is a massive optimization problem **[figs 4ab]**.

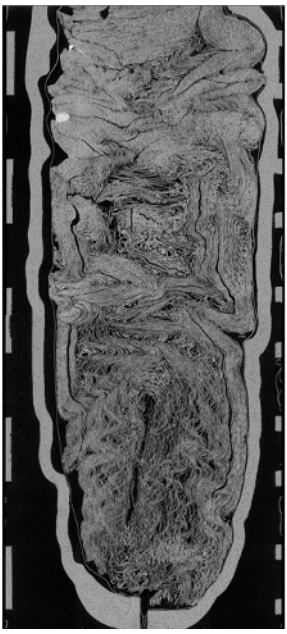

Figure 4a P.Herc.Paris 3. A: vertical Y axis

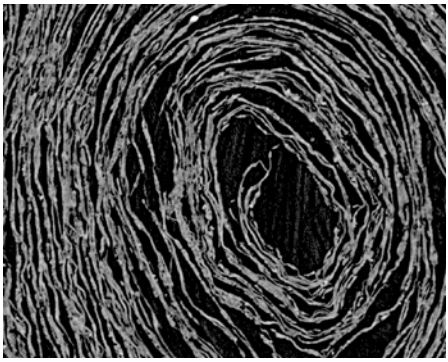

Figure 4b P.Herc.Paris 3. B: circumference at 7.91 microns

Based on the current state of virtual unwrapping and ink enhancement using AI, let us now explore a few theoretical scenarios in which we first present born-virtual text from an intact Herculaneum scroll in our edition models. A papyrologist that sits down to produce the *editio princeps* will need to document, at the very least, three attributes along with the expected metadata (e.g. publication/inventory number, measurements, date etc.). We need a segment ID, a volume ID, and even perhaps an AI ID **[fig. 5]**.

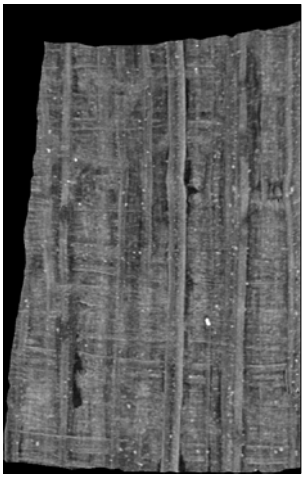

Figure 5 Segment of P.Herc.Paris 3

In figure 5 we see a segment of P.Herc.Paris 3 scanned at 7.91 microns. This data stems from scanning sessions at Diamond Light Facility, UK, in 2019. If we recall the general description of our AI process, multiple points across this segment will be selected to create sub-volumes that will be the input for the 3D CNN. Within these sub-volumes lies the ink signal that will be subsequently enhanced for both visibility and legibility. Moreover, these sub-volumes are so small (approximately 90 um × 90 um) that multiple sub-volumes are used in the reconstruction of just one Greek character. As we begin to see clearly successive lines of text based on multiple sub-volumes, perhaps it is best to follow the standards implemented by Obbink (1996, 99-103) and Janko (2000, 194-200) as we begin to edit that text. This method is characterized by the utilization of facing pages: 1) the diplomatic/articulated text, according to column structure, and a critical/testimonial apparatus on the left; 2) a modern layout of the text with a translation and notes on the right. Focusing on just the left facing portion, if we could now see text in this segment of P.Herc.Paris 3, we could possibly add our three attributes as follows:

P.Herc.Paris 3 V# SG#	Col.# AI# Greek Text
Testimonia	
Apparatus (palaeographical/critical)	

V# is the identifier for the volume scan which contains the ink signal. SG# is the identifier for the segment produced during virtual unwrapping. Lastly, the AI# is the unique identifier of the AI model

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or code used in prediction. Now, it is important to understand that this is just a theoretical approach at the moment. As work progresses, we might find ways to be more efficient and reduce the number of identifiers required in an edition. The AI#, for example, is a part of the metadata associated with the images (3D or 2D) produced. The exact identification of the AI model could just remain there. However, giving credit to the AI, or at least contemplating how we should do this at this very early stage, is worth considering. Overall, it is a mapping between text, segment, scan, AI, and the physical object that should be borne in mind **[fig. 6]**.

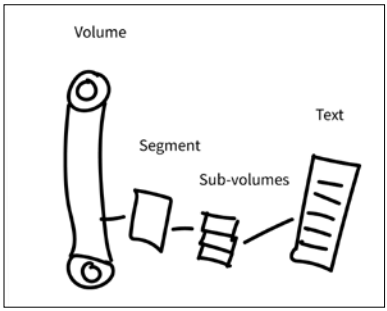

Figure 6 Mapping the volume, segment, and sub-volumes to the text

The general logic of the mapping in figure 6 should seem straightforward. However, it could (or will) get more complicated. In the above example we have a V# from P.Herc.Paris 3, a SG#, and text reconstructed from the sub-volumes by an AI#. The SG# from P.Herc.Paris 3 is a partial layer that is near the core of the intact scroll. The surface area is approximately 1 cm × 0.6 cm, and the scroll itself is approximately 6 cm in diameter and 18 cm in height. If we think about the dimensions of the papyrus sheets glued together to make the scroll, particularly the height, the segment is approximately 6 cm in height and thus a small portion of the scroll's, or a given papyrus sheet's, height. Clearly, we do not know the exact column height nor size of the upper and lower margins. Nevertheless, it is accurate to say that we only have a small portion of the text from one sheet. If for one column of Greek text we have multiple segments, as a hypothetical example, in the reconstruction of the born-virtual text, we will need to annotate accordingly. We would have text that points to more than one segment in our edited reconstruction.

P.Herc.Paris3 V#	Col.#, AI# (SG#) Text (lines 1-10)
Testimonia	
Apparatus (palaeographical/critical)	(SG#) Text (lines 11-20)

In order to know the correspondence between text and segments, marginal annotation can be employed; this kind of annotation is not unfamiliar in critical editions of works with a complex reconstruction based on both a mediaeval manuscript tradition and other witnesses (e.g. texts that provide quotations of text missing in the manuscript tradition). In the above example, we see that two different segments, containing twenty lines in sum, reconstruct one column. Now, while that is not too complicated, what happens when we have multiple scans, multiple segments unique to those scans, and multiple versions of AI used in the reconstruction of one column over time? Scans at different resolutions and further training to improve and to change the AI are also very likely to occur. Marginal annotation might indeed be necessary to convey how the text is reconstructed from these critical elements, e.g. (V#, SG#, AI#).

Too many segments? Too many volumes? Too many AIs? Exactly how many segments and volumes? Will every drop of ink appear perfectly clear? We do not know yet. Obviously, keeping the number of segments and volumes to a minimum would be ideal. Moreover, we want our AI to completely reveal every drop of ink with ease. Yet in the context of segmentation to completion some uncertainty remains. However, while a large number of volumes, segments, and AI versions seems cumbersome, this might not be a bad thing. That would indicate the possible existence of areas of persistent ambiguity. These areas might constitute points in the scroll where internal damage does not permit a clear virtual reconstruction by the AI, whether that is because noise persists (further training is required), or the ink signal itself has been irreparably damaged in some fashion. Even with AI, we could still have the ink traces with which all papyrologists are very familiar. Humanities scholars would thus continue to apply their skillsets to conjecture and to debate the reconstruction of a born-virtual text. Virtually extracting text embedded in cultural heritage artefacts is indeed exciting, especially in the case of Herculaneum papyri. Yet papyrologists might see the possibility of being replaced by an AI that is essentially recognizing and reconstructing Greek characters, even though it does not think in terms of the Greek language

or alphabet – yet.[3] Be that as it may, I envision a process where the human papyrologist is still very much in the loop. In terribly damaged cultural heritage objects, the human and the AI will work together to elucidate the text.

Now, one might still ask: why do we need to keep track of this metadata, let alone include it in our editions? We need to keep in mind that a sequence of segment IDs will not indicate the logical order of the work. If we virtually unrolled a well-known work, like a copy of Homer's *Iliad*, we would know our exact location based on the text itself. But for unknown works and works only known by title or random quotation this creates a slight problem in visualization. Without any visible data, such as stichometric counting (line counting) or a numbering of columns, the segment IDs are basically 'puzzle pieces' that we need to move around to reconstruct the proper order of the work as it is slowly revealed. One way to mitigate this issue is to expand or 'grow' a segment over time to extract large areas of continuous text. Still, this would not change the fact that we are likely to 'grow' multiple segments from different areas within a scroll. Note also how this even makes assigning columns an alphabetic or numerical sequence problematic. In the examples above, the Col.# is unique to a segment ID. Whether we call it Col. I or Col. A, that ordinal sequence pertains only to that segment ID, not to an alphabetic or numerical sequence of columns from the start to the end of a work. It is perhaps ironic that we are, in a way, creating virtual fragments (the segments) of a physically intact scroll in order to get to the text; invasively or non-invasively, we cannot seem to stop fragmenting Herculaneum papyri. At any rate, visually keeping track of the location of every segment within the physical object is critical **[fig. 7]**.

3 Along with colleagues at Middle Tennessee State University, the University of Tennessee at Knoxville, and the University of Minnesota Twin Cities, we have successfully trained a few machine learning models to classify Greek characters in images of papyrus fragments. This was uniquely done using crowdsourced transcription data from the Ancient Lives project (Williams et. al. 2014) as training data. Results to be published soon.

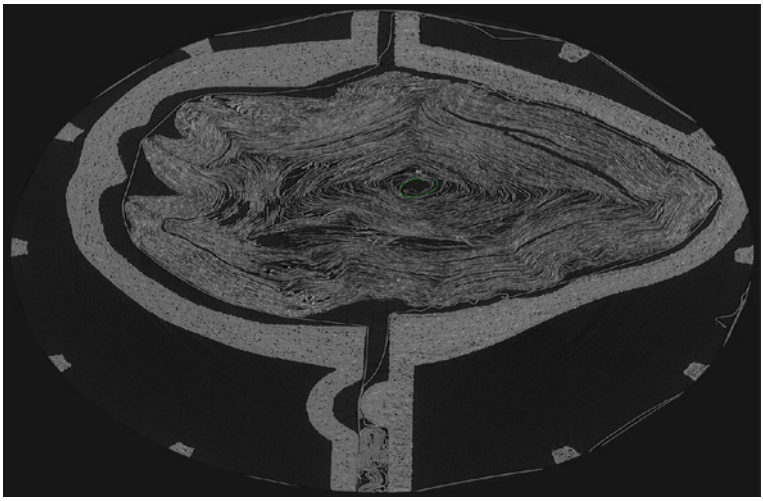

Figure 7 Location of the segment of P.Herc.Paris 3 in fig. 5

Although we have focused on the virtual extraction of text from intact scrolls thus far, the concepts discussed also apply to the opened Herculaneum fragments. P.Herc.Paris 1 fr. 101, which was a part of the study of Mocella et al. (2015), is a multi-layered fragment physically removed from an intact scroll. With the text purportedly seen in Mocella et al. (2015), again, we have two questions. Which layer? Which line of text comes first? Just as in our hypothetical examples above, we can be more precise. Let us take P.Herc.Paris Objet 59 **[figs 1a-b]**, an important subject in Seales' 2019 talk at the Getty, as another hypothetical example. This small fragment has a few layers with clear ink on the top and even some visible ink on the second layer.

Let us hypothetically peel that first layer off to reveal the second layer. Now, we can still use identifiers for the volume, segment (or in this case layer), and the AI. On the top layer, just below the ε, we can see what might be a ν in the second layer. Although two columns are distinct on the top layer, we cannot assume another intercolumnium in the second. So, in the example below, we simply present areas likely containing text and the possible ν, along with the volume ID, segment ID (or in this case we could call it a layer ID) and AI ID **[fig. 8]**.

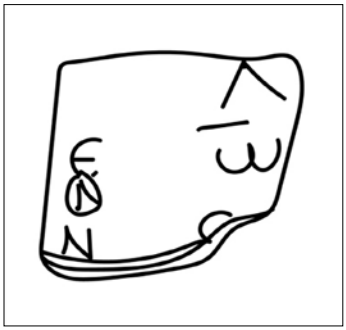

Figure 8 Visible ink in P.Herc. Paris Objet 59

P.Herc.Paris Objet 59		
Layer 1		V# SG# (Layer 2) AI#
Col. #	Col. #	
]	__λ	Greek Text
].ε	ω	ν
] ν	.	Greek Text

Even for Herculaneum fragments that are the result of human, physical intervention, nothing changes. These fragments too can benefit from virtually unwrapping and AI ink prediction and enhancement. Significant logistic challenges, nevertheless, remain for these fragments. For all those stored in *cornici* in Naples (the trays in which they are preserved), we cannot bring the synchrotron to them to acquire the desired resolution. And even if we could bring them to the synchrotron, is scanning even possible or safe due to the state of their conservation (in the *cornici*)? While that logistic issue remains a problem, we still have fragments like P.Herc.Paris Objet 59 and P.Herc.Paris 1 fr. 101 that can benefit from virtual unwrapping and AI ink prediction. In editing the born-virtual text from the hidden layers of opened Herculaneum fragments, we still need to account for the volumes, segments, and the AI involved.

Before moving to the final section of this paper, we should also briefly address the use of born-virtual text in the critical editions of Greek and Latin works, such as those found in the *Teubner* and *Oxford Classical Texts* series. Even now papyri published in *The Oxyrhynchus Papyri* series continue to confirm or reject emendations in critical editions, as well as offer new readings that are eventually printed in either the text itself or the critical apparatus. In collating manuscripts, the standard practice is to assign a papyrus a value in the *sigla*, which will then represent the papyrus in the critical apparatus. In Diggle's *OCT* edition of Euripides' *Medea*, for example, we find the following:

Π^2 P.Oxy. 1370 fr. 1: uu. 20-6, 57-63 v p.C.

We see the expected publication series, publication number, location data within the papyrus (fr. 1), location data within the work (verse numbers), and the date of the papyrus (5th century CE). Do we need to augment this? For specificity and clarity, yes. If hypothetically our segment of P.Herc.Paris 3 contained quotations of Euripides' *Medea* with variant or new readings, we should, at the very least, see the following:

$\Pi^{\#}$ P.Herc.Paris 3 V#, SG#, verse numbers, papyrus date

To have a simple and clear traceback, the volume and the segment IDs are required. Remember, we do not know how long the process of segmentation to completion will take. Accordingly, for one intact scroll, we could see a progression of their segments published over time; perhaps even their volumes too, if the object is scanned multiple times. And for the specific text incorporated into the critical apparatus or into the text of the critical edition itself, that volume and segment ID constitute precise location data for the born-virtual text. For papyrologists and philologists, this issue is not unlike the re-assigning and re-ordering of fragments in different editions over time, in which a system of mapping illustrates the change in fragment identifiers/publication numbers.

Now, if the above example satisfies the necessary requirements for the *sigla* of a critical edition, what about the critical apparatus? The current standard is to place the Greek lemma (text) followed by $\Pi^{\#}$, so that the reader knows that the text stems from a papyrus. But does that constitute transparency? After all, whether a fragment with multiple layers or an intact scroll, we cannot see the text in the physical object, nor can we see it in the x-ray image. The reading is there because of the AI. One could perhaps argue that the AI ID should also be included, since an artificial intelligence is responsible for the text. Perhaps we should give it credit, e.g. Greek lemma $\Pi^{\#}$ $AI^{\#}$. Furthermore, in the case an area of persistent ambiguity, if the AI only reveals ink traces, an editor will reconstruct according to established practices. We could, therefore, even find in a critical apparatus a listing of Greek lemma $\Pi^{\#}$ $AI^{\#}$ editor's name. Perhaps. Yet I will assume the continued use of a lemma followed only by $\Pi^{\#}$ will suffice for now.

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3 Challenges in Visualizing and Working with Born-Virtual Text

So far, we have reviewed the process of virtual unwrapping, AI ink prediction and enhancement, and how the resulting born-virtual text might be presented in editions that conform to the methodologies of Papyrology and Classics. The 2D space of print publication has been the tacit focus. What about digital editions? A careful reader will have noticed one issue percolating in the discussion above: the amount of image data inextricably tied to this born-virtual text. Furthermore, while we have suggested simple ways to introduce essential metadata into the critical editing workflow, there is so much more metadata associated with the generation of born-virtual text. The digital edition model might seem better suited in that context. But does this new kind of text deserve its own unique environment for editing and publication?

Digital papyrology has been around for some time now, and its history and current trajectory has been well documented by Reggiani (2017; 2018). For our purposes here, we will get straight to the point. Any text extracted from an intact scroll or from the hidden layers of Herculaneum fragments can be presented in a digital edition. The fundamental model is EpiDoc (TEI/XML) and the most critical resource is Papyri.info, which implements the EpiDoc standard for documentary papyri and allows for a robust search of the Greek text. For literary papyri, Papyri.info's recent Digital Corpus of Literary Papyri (DCLP) is now advancing digital editions for the kinds of text associated with Herculaneum (e.g. not documentary). Editions of Herculaneum fragments, in fact, already appear in the DCLP. And these texts and editions are indicative of the scholarly work that is dependent on a combination of the autopsy of the original fragment, the Oxford/Neapolitan Disegni (hand drawn facsimiles made mostly at the time of unrolling, or in some cases later), multispectral imaging conducted by Brigham Young University, and the user interface of Papyri.info, which allows for the creation of a digital edition for its platform. For bibliography and images, links are provided to Chartes (`chartes.it`), an online catalogue of Herculaneum papyri. Without a doubt, the virtually extracted text from Herculaneum papyri will appear in the expected Epidoc standard, or a modified version of it. However, as we have seen above, simply showing the born-virtual text within the parameters of standard papyrological conventions is not enough. Whether in print or in digital form, there are further data outputs and algorithmic metadata that should, if not must, accompany the text.

Let us start with the image data. At the end of the virtual unwrapping and ink prediction and enhancement process, we have multiple images. In 2D and 3D there are images of the whole object (intact scroll or fragment) and of the segments from which the sub-volumes are extracted. For the segments, the 2D images document the x-ray

scan (no visible ink), the ink prediction (visible characters), and the photo-realistic reconstruction (what the text would look like under natural light conditions). As noted in the second section, in the publication of any segment/s, a visualization documenting the location within the object is required for the 'bigger picture' view. So, for every line of text revealed, a reader of the edited text should be able to access the x-ray, the prediction, and the photo-realistic rendition images for that area of papyrus, as well as a visualization of its location within the scroll/fragment. Again, here is the refrain. We do not yet know how long segmentation to completion of an intact Herculaneum scroll will take. In addition, although keeping the number of volumes and segments to a minimum would be ideal, uncertainty also remains in that context. Building an edition of the born-virtual text from an entire, intact scroll will both take time and include an ongoing increase in associated image data **[fig. 9]**.

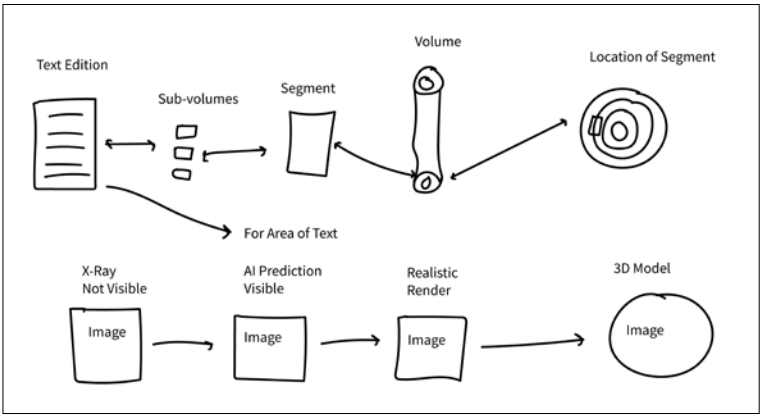

Figure 9 Relationships between data

Next, digital provenance is the only way to comprehend the full process involved in generating born-virtual text. For virtual unwrapping, this is a process of segmentation, texturing, flattening, and finally merging and visualization (2D and 3D images); as already noted, within this process, ink prediction and enhancement take place in the texturing phase. In Chapman, Parker, Parsons, Seales (2021), EduceLab presents its plan to use a METS container[4] to systematically document the digital provenance of any digital surrogates or digital twins generated in our lab; an important point to remember is that, for damaged cultural heritage objects, our digital versions are surrogates to

[4] Metadata Encoding Transmission Standard, `http://www.loc.gov/standards/mets/`.

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be used in lieu of an object that can no longer be physically handled (with the exception of conservation). In the first instance, the 3D compilation of P.Herc. 118, housed in the Bodleian Library of the University of Oxford, is presented as a test case (Chapman et al. 2021). The 3D compilations of all 12 *pezzi* (fragments) are created using 3D photogrammetry, digitized versions of analog photos, multispectral and hyperspectral images, and digitized versions of the Disegni. Through complex processes such as segmentation, image stitching, and image registration, the resulting 3D model is an unprecedented digital entity in which multiple, and formally separate, datasets are now accessible in one 'place'. Chapman et al. demonstrate how a METS container, which can incorporate multiple schemata like Dublin Core and MIX to track administrative, technical, and descriptive metadata, offers an efficient means to document an entire digital provenance chain, from image acquisition, whether starting with x-ray scanning or photogrammetry, to the final 3D and 2D images that can include AI predicted and enhanced text. Essentially an XML wrapper, METS provides a familiar and easy to use human and machine-readable format. More importantly, EduceLab intends to repurpose the behavior section (behaviorSec) of a METS container to document, to describe, and ultimately to visualize complex algorithmic processes (7-10). Stop for a moment and think about viewing a 3D model of an opened Herculaneum fragment, like P.Herc. 118, to which archival analog photos, multispectral images, and hyperspectral images have been registered, so that you can easily view any of those images at will in one 3D space. But at the same time, there is also a way for you not only to visualize the image registration pipeline used, and thus ensure comprehension of all the fixed and moving parts (the 3D mesh and the unique 2D images registered to it), but also to recreate that digital object. Utilizing the METS behavior section, Chapman et al. lay out how EduceLab envisions implementing graph visualizations and hands-on scientific reproducibility to reveal how algorithmic processes like registration, segmentation, and stitching work 'under the hood'. As an initial example, Seth Parker has released the Structured Metadata Engine and Graph Objects Library,[5] a C++ library for visualizing dataflow pipelines. For one digital surrogate, whether it is a digital object in 3D and/or 2D created through the process of photogrammetry, scanning sessions at a synchrotron facility, or any available x-ray imaging equipment, the combination of a canonical METS document plus the visualizations of dataflow pipelines represents not only an unprecedented account of the metadata involved, but also a significant advance in accessibility and transparency in digital provenance.

5 SMEAGOL, `https://gitlab.com/educelab/smeagol`; `https://zenodo.org/record/4298710#.YADk9MVKimE`.

To ensure trust in the generation of born-virtual text, much more is needed than the typical editorial conventions applied in both current print and digital formats. Put simply, the text itself is not enough. To present it alone is nearly useless, in fact, since it is text that cannot be verified by the human eye. In the case of Herculaneum, presentation of the text with the usual papyrological editorial conventions and new conventions (like those suggested in the second section above) must be inextricably linked to the variety of image and metadata generated in the process of revealing that text. Ideally, we should be able to see and to work with these relationships in one place. And thus, one might see how the 2D space of print publication might not be the best medium. A digital edition format, which allows 3D functionality, is far better suited to see the relationships between edited text, the 3D and 2D image data revealing its location in the object and the reality of ink prediction, and the data visualizations representing the dataflow pipelines involved. This is scientific reproducibility and transparency at the level of working with the published text and at the level of accessing the image data and metadata itself – preferably in live time.

Is there a current application, web or desktop based, to facilitate these kinds of user interactions between born-virtual text, the image data, and both the metadata and the graph visualizations of it, let alone a digital environment for creating a digital edition with that data and the additional editorial conventions required? No. In his account of digital papyrology, Reggiani goes through many in great detail, and he highlights a very important agenda in the creation of digital edition platforms for papyri and similarly fragmented texts: integrating the existing print/bibliographical resources (2017, 146-59). In Vindolanda Tablets Online, Codex Sinaiticus, Derveni Papyrus Online, and, but certainly not least, Papyri.info, we see digital texts accompanied by digital translations, essential descriptive metadata of the fragment, bibliographical sources, addenda and corrigenda, and reference sections and/or commentary. In the context of visual integration between digital text and image, in Anagnosis and Codex Sinaiticus, in particular, visual alignment between a word in the digital text and the location of its sequence of characters in the image of the manuscript is provided (151-9; Reggiani 2018, 63-74). Devoted entirely to Herculaneum papyri, the Anagnosis UI can facilitate the ongoing process of editing the opened carbonized scrolls, as it allows one immediately to anchor a transcription to the image of the carbonized surface, in which contrast between black carbon ink and black papyrus substrate is often wanting. Indeed, these platforms have been a great success and are indispensable to the academic community. But now we are facing something new. We are entering a new phase in which text embedded or hidden in cultural heritage objects can be extracted through complex algorithmic processes and

artificial intelligence. Furthermore, we have also noted that the AIs used to predict and enhance ink will also likely be used to enhance the legibility of visible but damaged ink in the typical papyrus fragments we find in collections around the world. Where do we go to work with this data? How do we work with this data?

To even begin to visualize these connections, one would need multiple and disconnected applications, such as Papyri.info, Adobe Photoshop, Mac Preview, and Meshlab for 3D object files. Yet even with them, none of these applications were designed to facilitate these connections in a manageable space designed with the workflows of editors and researchers in mind. Now, while the creation of new tools and platforms can often receive pushback – why not concentrate efforts on improving existing tools? – the process of virtual unwrapping and the subsequent production of born-virtual text is a massive step forward in the digital restoration of damaged cultural heritage objects. And even though we often omit cultural heritage objects that are not damaged in this discussion, these methods, for example, can be used for the digital preservation of centuries old codices that just should not be opened anymore; we are literally breaking their spines. With this type of leap forward, a combination of improving existing tools and building new ones, which can be integrated, is required.

What is the answer? What is the path forward? Without providing one definitive answer at this time, let us say that we fundamentally know how to approach the question. There are a few existing tools that point in the right direction. For visualizing, annotating, and interacting with 3D models, IIIF, the 3D Heritage Online Presenter (3DHOP), and the Smithsonian Voyager are notable. 3DHOP allows one to create interactive 3D models, at high resolutions, that can be embedded in a standard web page.[6] The Smithsonian Voyager[7] is a unique authoring tool that allows users to create visual presentations or 'stories' using 3D models. One can position them freely, export 2D versions, inspect the 3D mesh, and annotate the 3D object with 'articles' or content to add critical context to the visualization. For the cultural heritage community, these tools are very effective in creating content or virtual exhibitions for both academic and general audiences. The standards set forth by IIIF[8] allow one to set up a data server that accepts IIIF API calls and to utilize predefined viewers that let you access data from multiple, disparate servers. For the editing and presentation of the born-virtual text, in the context of Greek and Latin Papyrology, Papyri.info and especially its DCLP are foundational tools with proven methodologies for presenting digi-

6 https://www.3dhop.net/index.php.

7 https://smithsonian.github.io/dpo-voyager/introduction/.

8 https://iiif.io/.

tal editions. However, the requirements for producing born-digital, critical editions of literary and sub-literary papyri are still wanting. From the ability to visualize the variety of marginalia (notably symbols) present in literary and sub-literary papyri and the more custom methods of annotation, such as the combining asterisk and bold font unique to Herculaneum papyri editions (to mark editorial correction of the Disegni and the placement of sovrapposti/sottoposti respectively), to the visualization needs of the critical, testimonial, and palaeographical apparatuses, much more development is needed. Proteus is a project designed to fill in these gaps (Williams et al. 2015). The project began at the University of Oxford in 2015 and successfully built a stable editor for creating born-digital, critical editions that included all the desired attributes: diplomatic and articulated text, palaeographical, critical, and testimonial apparatuses, a translation, and critical notes. Moreover, Proteus' editor allows a user to create these components without any hardcoding of the XML. As one types, the XML and HTML are generated in live time. And, of course, this editor is a part of a larger web application for presenting these editions online in a similar fashion to Papyri.info. Unfortunately, due to funding the project's development timeline has slowed down considerably. Be that as it may, as of January 2021 Proteus has been upgraded from Python 2.7 to 3 and is now undergoing preparation for a small beta test. In the end, we can thus see the components we need across existing applications.

In thinking about the virtual unwrapping of Herculaneum papyri and the virtual extraction of the text hidden inside, the ideal tool for editing and interacting with the born-virtual text and the amount of image data and metadata that accompanies its creation is likely to be combination of what we see in 3DHOP, Smithsonian Voyager, Papyri.info, and Proteus. The papyrologist needs an editor that allows them to create a critical edition that meets the requirements of literary and sub-literary papyri. Yet they also need, within that same editorial interface, the ability to pair annotated (especially for text location purposes) 2D and 3D image data, AI ink prediction metadata, and digital provenance metadata with the edited born-virtual text itself. And for the readers of published born-virtual text, they too will need a UI that allows them to interact with and understand in a meaningful way the relationship between the text, image data, and metadata. Without this functionality, at both the level of editing and publishing editions for subsequent research, we will only pretend to understand the text before us.

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4 Conclusion

Scholarly editing with AI. It probably does not seem very exciting at the moment. As we have seen in this paper, the topics of concern have been metadata, images, and the editorial conventions used in Greek and Latin Papyrology and Classics. Be that as it may, at this fundamental stage in the application of AI to reveal and to enhance text in manuscripts, it is the perfect time to initiate conversations about how we edit text produced by AI before the process becomes, perhaps, even more complex. The basic conventions proposed here, for carbon ink text embedded in Herculaneum papyri, are by no means definitive solutions. They are simply ideas meant to encourage thinking and further discussion on the topic. And while digital editions seem to be more appropriate, the 2D space of print could also still be used. What is clear is that we cannot treat text extracted from Herculaneum papyri by AI and through virtual unwrapping in the same fashion as the legible, and even illegible, ink in manuscripts and papyrus fragments that preserve a natural contrast between text and substrate surface – even if spectral bands are required to see that contrast. To do so, we will only pretend to understand the nature of the text before us, and upon which we are making scholarly arguments in research. To ensure trust in the born-virtual text before us, we need to understand its virtual birth. We need to understand the data, i.e. the structured data describing and visualizing the entire process from start to finish. As for AI, identifying it and bringing it into our editions may or may not be necessary at this time. It is probably not the type of AI about which our science fiction induced imaginations think and dream. It is an intelligence that makes predictions. But we cannot talk to it. We cannot interact with it. Still, it represents the very beginning of the kinds of digital minds of which Bostrom speaks (Bostrom, Shulman 2020). We must, then, begin to think about how we represent AI, as a critical assistant, if not full partner, in our work.

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Quality Assessment of Digital Elevation Models in a Treeless High-Mountainous Landscape
A Case Study from Mount Aragats, Armenia

Pavol Hnila
Freie Universität Berlin, Deutschland

Julia Elicker
Albert-Ludwigs-Universität Freiburg, Deutschland

Abstract Global Digital Elevation Models (DEMs) are widely employed in geoarchaeology. Usually, their adequacy for particular landscapes is not tested. We assessed 30m-resolution-DEMs (ASTER, SRTM, ALOS, EU-DEM, NASADEM, NEXTMap) with local precision datasets. Our results reveal considerable differences (ASTER unsuitable for the region, NEXTMap and EU-DEM fit most closely to our reference model). This outcome does not necessarily apply to all similar regions. It rather stresses the need for a check of DEMs' quality in any given study area, and it encourages the use of detailed topographic visualisations of DEMs in absence of suitable reference data.

Keywords 30m resolution DEMs. Comparison. Evaluation. RMSE. Spatial analysis. GIS. Landscape archaeology.

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1 Introduction[1]

Digital elevation models (DEMs) as approximate virtual representations of terrain have a wide range of applications in archaeology – for visualizations, spatial analysis, predictive modelling etc. (cf. Conolly, Lake 2006; Gillings, Hacıgüzeller, Lock 2020; Siart, Forbriger, Bubenzer 2018 for an overview). Given different understandings of 'terrain', terminological distinctions are called for. Currently, DEM is one of three terms used to describe representations of terrain surfaces through sets of heights. The other two terms, with which DEM occasionally is confused and should therefore be delimited from, are a Digital Surface Model (DSM) and a Digital Terrain Model (DTM). While DSM generally designates surfaces that include trees, buildings, and other above-ground objects, the distinction between DTM and DEM is not universally agreed on. DTM and DEM are sometimes used as synonyms designating bare ground surface devoid of natural or human-made above-ground objects. Other times, DTM is the general term for all elevation models and DEM reserved for bare ground surface, or vice versa (Zhou 2017 as opposed to Hirt 2014). In the past, a number of global models were named and distributed as DEMs, although they correspond to DSMs in the terminology prevailing today. For the purposes of this study, we use the DEM term in its general sense – as any digital terrain model with elevation information. In our study area, the treeless and unbuilt character of the landscape means that the terrain has, in most cases, only a single surface which corresponds to the ground level.

In recent years, the increased availability of drones and the advances in multi-image photogrammetry have simplified the creation of detailed DEMs. Elevation models based on low-altitude aerial imagery are thus rapidly becoming a standard practice for smaller sites. For large sites and for regional surveys the DEMs based on LIDAR-data (Light detection and ranging) would be optimal, yet until this data becomes widely available, DEMs obtained with satellite remote sensing methods continue to be the preferred choice. Their continental or global coverage and their availability at (mostly) no cost outweigh the disadvantage of their lower resolution. Indeed, for some applications on

1 We thank Prof. Dr. Alessandra Gilibert and Ca' Foscari University of Venice for purchasing the NEXTMap dataset used in this study. We are also grateful to our colleagues from Yerevan – Dr. Arsen Bobokhyan for helping to organize the fieldwork, Dr. Smbat Davtyan for information about topographic measurements and Dr. Shahen Shahinyan for providing us with detailed information about his GPS measurements and the Armenian quasi-geoid. Furthermore, Prof. Dr. Alessandra Gilibert, Michael Rummel, M.A., Stefan Biernath, Ausgr.-Ing. M.Sc., and two anonymous reviewers read the manuscript and provided comments that helped to improve it, which we greatly appreciate. We also extend our thanks to Emma Castle, B.A., for generously proofreading and correcting the final version.

regional scale the lower resolution is not even a disadvantage, but rather a desirable necessity. Moreover, the generation of DEMs from satellite data is a dynamic field and in recent years high-resolution datasets with 10m, 5m and even 1m resolution became commercially available for selected areas.[2] It can be reasonably expected that in the near future high-precision satellite-derived DEM datasets will reach global coverage and gradually also become available for academic research.

All the current advantages have led us to consider global or continental DEMs for our studies in the Armenian high mountains. Additionally, the treeless character of the studied terrain, which effectively eliminates the danger of vegetation bias, and the relief, which is not particularly rough, represent a setting well within the satellite remote sensing capabilities. We were therefore all the more surprised when the first study, conducted by our colleague Norbert Anselm from the Freie Universität in Berlin (Anselm 2012), contradicted our expectations and raised a serious issue about the appropriateness of satellite-derived DEMs for the Armenian mountains.

Using the ASTER dataset, Anselm calculated viewsheds of prehistoric stone steles distributed in groups over the subalpine landscapes on the Mount Aragats and on the Gegham mountains in Armenia. The size of his study areas varied, the largest among them comprised approximately 460 km^2. Though his obtained results of intergroup visibility were encouraging, the intragroup visibility of individual steles did not match the observations from the field. In the best-documented example, six steles studied at the site of *Karmir Sar* are 130 to 580 m distant from each other and, when erected, are expected to have been all intervisible. The computer-based analysis of their viewshed, instead of simply confirming the overall intervisibility of the steles, concluded that out of 30 possible visibility links only three had an uninterrupted line of sight, the remaining 27 combinations were classified as invisible (Anselm 2012, fig. 5.1). These contradictions casted doubts on the plausibility of the entire analysis. After double-checking all input data, the suspicion fell on the accuracy of the chosen DEM. Though it was evident from the beginning that the vertical precision of ASTER is not particularly high, its accuracy in terms of surface rendering was expected to be sufficient for reaching consistent results in a viewshed analysis.[3]

Intrigued by this discrepancy between the empirical observation and the results of computer-based analysis, we decided to follow up on the accuracy issue from Anselm's study. We were determined to reach two

2 https://store.intermap.com/.

3 ASTER was used for similar viewshed analyses in various landscapes before and afterwards, e.g. Bongers, Arkush, Harrower 2012; Lambers, Sauerbier 2007; Triplett 2016; Dungan et al. 2018; Marsh, Schreiber 2015.

objectives. First, to understand why ASTER failed to provide convincing results. Second, to find out whether other available DEMs based on satellite remote sensing data did represent the local topography more appropriately. It became imperative to assess the quality of available DEMs and their suitability for our study area, before any other geoarchaeological analysis and prediction modelling could be conducted.

2 Study Area and the Datasets

In general, our area of interest for geographical analysis covers the south slope of Mount Aragats in Armenia **[fig. 1]** and comprises more than 580 km^2. For the comparative testing scope of this paper, we have focused exclusively on a limited ca. 1.5 km^2 study area around the archaeological site *Karmir Sar* (also known as Tirinkatar), whose centroid is located at 40.42053° N, 44.14880° E (WGS 84 Datum). The median altitude value of the study area is 2850 m a.s.l. Its topography is characterized by a slightly concave high mountain meadow with two small water streams and several small ponds, all placed on a wider mountain ridge **[fig. 2]**. The area belongs to the subalpine vegetation zone, is covered by grass and devoid of any trees or shrubs. Two deep lateral valleys delimit it on the east and on the west. A steep, rocky uphill slope delimits it on the north, and a gradual downhill slope on the south.

This study area at a super-local scale was chosen as a sample for comparisons with DEMs derived from satellite data, because here we had high-detail geodetic data at our disposal. They were of two kinds: a set of 17 ground control points, and a detailed contour plan. Both are used as our reference for assessing the quality of six widely available satellite-derived DEMs with 30 m resolution (abbreviated here as ALOS, ASTER, EU-DEM, NEXTMap, NASADEM, SRTM). Our attempts to include two remaining global DEMs with 30 m resolution were not successful. All model derivations of the TanDEM-X mission,[4] which was operated by the German Aerospace Center, are subject to German legislative regulations, according to which the tiles covering Armenia are treated as sensitive information and are not publicly available. For the second model, Elevation 30 (also known as Reference 30) based on SPOT-5 satellite data, we did not receive sample data before the deadline for the submission of this paper.[5]

4 TanDEM-X distributed for academic purposes by German aerospace center with a small administrative fee (`https://tandemx-science.dlr.de/`), WorldDEM 30 distributed commercially by Airbus Intelligence (`www.intelligence-airbusds.com/geostore`), GLO-30 distributed at no charge by the Copernicus programme of the European Union (`www.copernicus.eu`).

5 The dataset is available commercially with a minimum order area of 500 km^2 on `https://www.intelligence-airbusds.com/geostore/`.

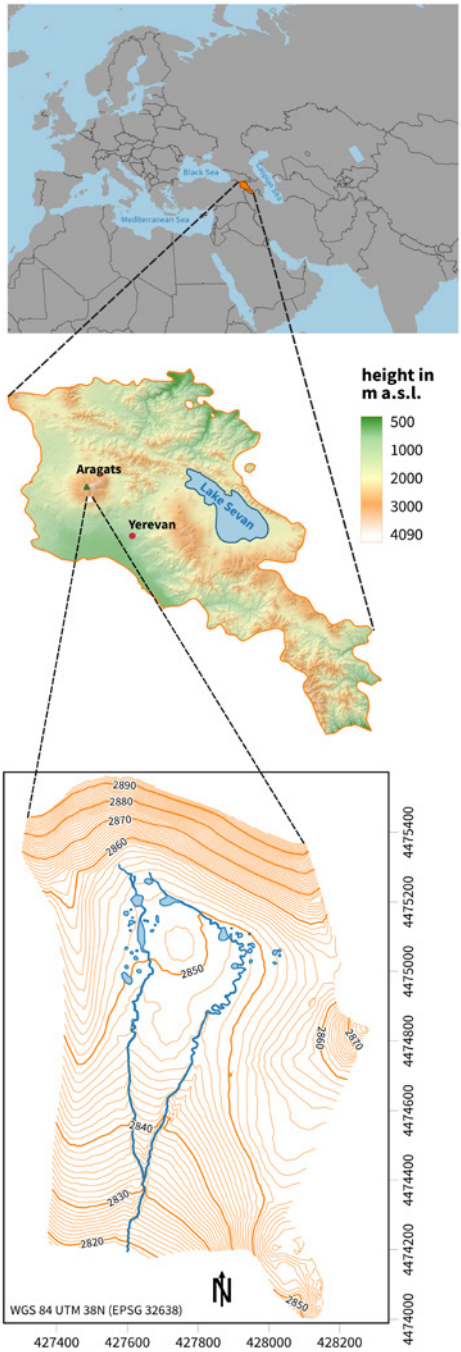

Figure 1 Location of the study area Karmir Sar on Mount Aragats, Armenia. Map: J. Elicker; data: Natural Earth, Alos DEM

Figure 2 Karmir Sar. View of the central and lower part of the study area from the northwest. Photo: M. Rummel

2.1 Ground Control Points (GCP)

The excavation project on *Karmir Sar* uses 17 fixed points that are dispersed at different elevations over the site **[fig. 3]**. All points were measured in 2018 by Dr. Shahen Shahiniyan with a Leica GS10/15 GNSS rover receiver in static mode (30 minutes per point), combined with a Leica AR10/GR10 used as a reference station. Thanks to post-processing with base data (RINEX), the coordinates in WGS84/UTM 38N reference system were obtained with accuracy to the millimeter. The elevation values were converted from the ellipsoidal WGS84 height to the Baltic 1977 orthometric height using a proprietary quasi-geoid of Armenia (a previous version of this quasi-geoid is described in Margaryan 2014, the update by Shahinyan 2017 used in our case was not yet published). For purposes of this study, we rounded the elevation values to two decimal places.

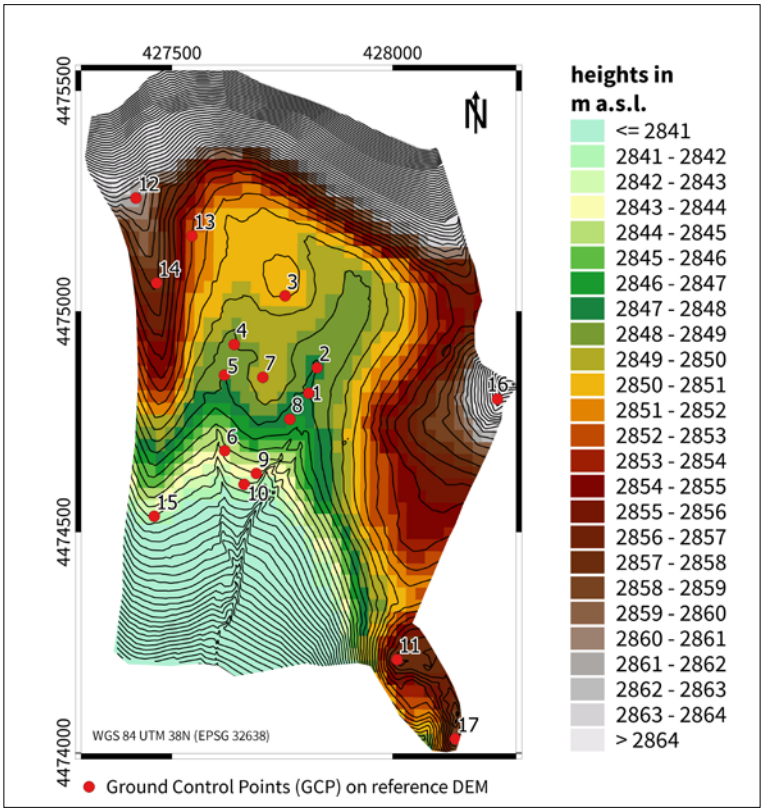

Figure 3 Position of high-definition ground control points at the study area. Map: J. Elicker

2.2 Reference DEM (RefDEM)

Previous research has demonstrated that a DEM derived from elevation contours of local topographic maps can be used as a reliable mean to reduce errors of global DEMs (Szypuła 2019). Our reference DEM, designated as RefDEM throughout this study, is derived from the contour plan of the archaeological site *Karmir Sar*. The contour plan, produced by geodesist Smbat Davtyan from Yerevan, has an interval of one meter between individual contour lines and covers an irregularly shaped area of circa 1.1 km^2. Davtyan generated the contours in AutoCAD® software[6] with standard settings of the *create contour lines* algorithm from 1735 points measured with a laser total

6 AutoCAD® 2007 Autodesk, Inc., `https://www.autodesk.com/`.

station in 2012. Thanks to the presence of a geodetic triangulation point on site, it was possible to align the entire plan with the Armenian state grid. At the time of the plan's completion in 2012, the coordinates were reported in the Gauss-Krüger Zone 8 coordinate system instead of Universal Transverse Mercator coordinate system used in Armenia today. The contour plan was originally georeferenced within the Pulkovo 1942 datum/Gauss-Krüger Zone 8 coordinate reference system (now deprecated) in order to obtain an overlap with local topographical maps of the entire Aragats area.

For the purposes of this study, the georeferenced vector contour plan was transformed into our RefDEM with a 25 m resolution. The conversion was conducted with the GRASS implement *v.to.rast.attribute*[7] within the QGIS program[8] (factor 25 set as raster size for adapting to the other DEMs in the best way possible). In this way, no data could be generated between the contour lines, so they were subsequently interpolated by the GRASS function *r.surf.contour,*[9] which converted the previous patchy raster into a continuous DEM.

2.3 ALOS

The full name of this freely available DEM is *ALOS Global Digital Surface Model (DSM) 'ALOS World 3D-30m'*, abbreviated in *AW3D30*.[10] For our calculations, we have used its version 3.1 released in April 2020. ALOS is an acronym standing for Advanced Land Observing Satellite, nicknamed 'Daichi' and operated from 2006 to 2011 by the Japan Aerospace Exploration Agency. The ALOS elevation dataset was produced primarily from the processed stereo pairs of the PRISM (Panchromatic Remote-sensing Instrument for Stereo Mapping) optical instrument onboard the satellite (Tadono et al. 2016, 157-9). The spatial resolution of the originally developed 3D dataset is approximately 5 m, but the freely distributed DEM was reduced to a spatial resolution of approximately 30 m. In our study area, when

7 © 2003-2021 GRASS Development Team, GRASS GIS 7.6.2dev Reference Manual (Authors: Original code: Michael Shapiro, U.S. Army Construction Engineering Research Laboratory, GRASS 6.0 updates: Radim Blazek, ITC-irst, Trento, Italy, Stream directions: Jaro Hofierka and Helena Mitasova, GRASS 6.3 code cleanup and label support: Brad Douglas), `https://grass.osgeo.org/grass78/manuals/v.to.rast.html`.

8 All basic calculations and visualizations have been conducted within the program QGIS and its implemented functions, with the latest version at the given time: 2.18, 3.0 and 3.16 (`QGIS.org`, 2021. QGIS Geographic Information System. QGIS Association. `http://www.qgis.org`).

9 © 2003-2021 GRASS Development Team, GRASS GIS 7.6.2dev Reference Manual (Author: Chuck Ehlschlaeger, U.S. Army Construction Engineering Research Laboratory), `https://grass.osgeo.org/grass78/manuals/r.surf.contour.html`.

10 `https://doi.org/10.5069/G94M92HB`.

using the projected WGS84/UTM38N coordinate reference system, one cell along the longitude corresponds to 21.2 m, along the latitude to 27.6 m.

The mask file (MSK extension) provided as a component of the ALOS dataset is a useful tool to retrace the origin of elevation values for each individual cell. It attests that the vast majority of cells in our study area was produced by the PRISM sensor of the ALOS satellite itself and their elevation was classified as valid (not distorted by snow or clouds). The few void cells concentrated on the slope in the northwest part of the study area were filled by using the SRTM1 V003 DEM **[fig. 4]**. The elevations in ALOS were converted from the ellipsoidal height, using the EGM96 geoid model (JAXA EORC 2020, 2).

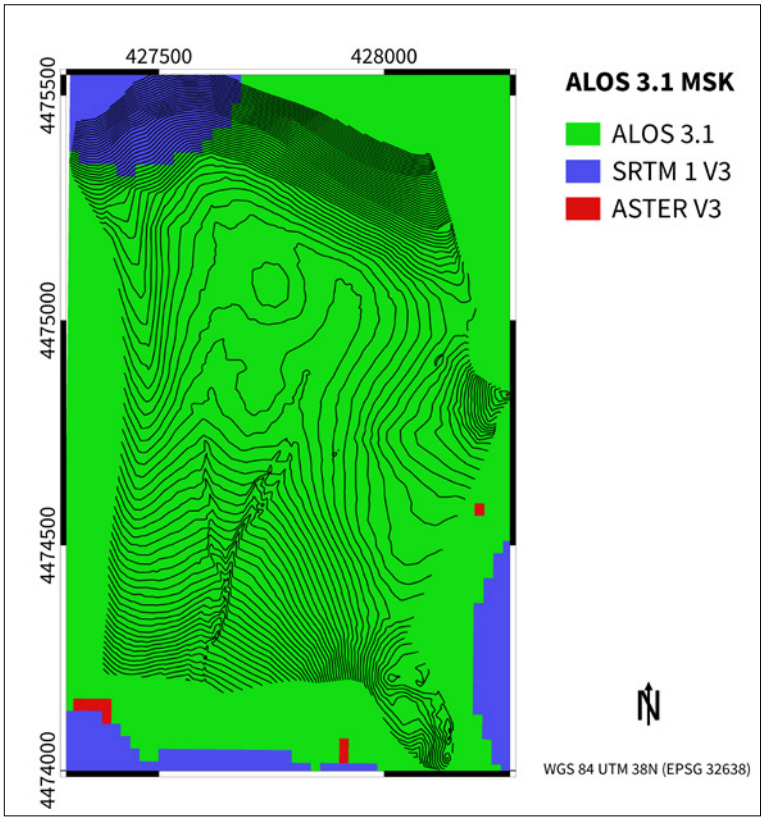

Figure 4 Void filled areas within the ALOS World 3D 3.1 version. Map: J. Elicker

2.4 ASTER

ASTER stands for Advanced Spaceborne Thermal Emission and Reflection Radiometer and it was released jointly by The Ministry of Economy, Trade, and Industry (METI) of Japan and the United States' National Aeronautics and Space Administration (NASA).[11] For our calculations we have used the Global Digital Elevation Model Version 3 (ASTER GDEM V3) released in August 2019. The original dataset was created photogrammetrically from a compilation of cloud-free ASTER stereopairs (DeWitt, Warner, Conley 2015, 182). ASTER GDEM V3 preferably used alternative DEMs to fill any voids before attempting to close them by an interpolation (Abrams, Crippen, Fujisada 2020, 5).

To identify the source of any given elevation cell value, the ASTER GDEM V3 dataset includes a numerical raster file (NUM extension). Its content indicates the number and the origin of scenes (stereo pairs) used to calculate the individual elevation values (Abrams et al. 2020, 7-8, table 3). In terms of internal assessment of quality, between ten to fifteen scenes are deemed sufficient; beyond that number the elevation error diminishes only marginally (Gesch et al. 2016, 145-6, fig. 5). According to the NUM file, our study area does not contain any voids filled with alternative DEMs; all cells were produced with stacking of 18 up to 30 ASTER GDEM V3 scenes and accordingly they not only fulfill, but also exceed the internal quality standards.

2.5 EU-DEM

The EU-DEM combines the advantages of both data acquisition techniques used for satellite remote sensing – the optical stereoscopy and radar interferometry.[12] It is a blend of SRTM1 V003 and ASTER GDEM data, fused together by a weighted averaging approach and improved through Russian topographic maps, a hydrology dataset, proprietary high-precision elevation data and removal of artefacts (Bashfield, Keim 2011). It should be noted that its source data does not share the same level of detail – while the resolution of ASTER GDEM is 30 m, the SRTM3 dataset only has a resolution of ca. 90 m; the more precise SRTM1 dataset with 30m resolution was not freely available at the time for areas outside the United States of America. EU-DEM is provided with 25 m resolution, yet it is not specified in its documentation whether this improvement was achieved by simply upsampling the original lower-resolution datasets, or by enhanc-

11 https://doi.org/10.5067/ASTER/ASTGTM.003.

12 http://land.copernicus.eu/pan-european/satellite-derived-products/eu-dem/eu-dem-v1.1/view.

ing them through proprietary high-precision data. For our analysis we have used the EU-DEM V1.1 version, released in 2016.

2.6 NEXTMap

The full name of this model, produced by the Intermap company, is *NEXTMap World 30 DSM*. Analogically to the EU-DEM, this model too is a fusion of other freely available datasets, specifically SRTM3 v2.1, ASTER GDEM v2.0, GTOPO30 (for polar areas). All datasets were void-filled, merged by a proprietary Intermap algorithm and their elevations were corrected with high-resolution LIDAR data from NASA's Ice, Cloud and Land Elevation Satellite (Intermap 2013). The NEXTMap World 30DSM was marketed by Intermap as the "best-available surface elevation data with a 30-meter ground sampling distance" with a reliable and consistent global coverage (Intermap 2018). We have purchased the dataset for our area of interest in 2018, but in the meantime it was replaced by its successor with a higher, 10 m resolution.[13] Though no versioning information has accompanied our dataset, we assume that it was NEXTMap World 30 DSM v2.0 released in 2013.[14]

2.7 SRTM

In contrast to the ASTER and ALOS DEMs, which are based on optical stereoscopy, the SRTM (Shuttle Radar Topography Mission) DEM is based on the radar interferometry technique. The main advantage of the radar interferometry is that its data quality does not depend on light conditions. The interferometric synthetic aperture radar (InSAR) used by the mission has operated day and night, irrespective of the cloud cover (Rabus et al. 2003, 242). In fact, though the SRTM data covers nearly 80% of the earth's land surface, they were collected within just 11 days – between 11th and 22nd February 2000 by the Endeavour shuttle (Farr, Kobrick 2000; Farr et al. 2007). For our analysis we have used SRTM1 Version 3 (also known as void-Filled SRTM Plus, SRTM NASA V3 or SRTMGL1 V003), which has a resolution of 1 arc-second (ca. 30 m) and had all of the previous voids filled.[15] It was released in 2013 (NASA JPL 2013). The ancillary NUM

13 `https://store.intermap.com`.

14 Only two versions are publicized in the archive of Intermap press releases at `https://www.intermap.com/pressreleases` – the first version released in June 2012, the second in August 2013.

15 `https://doi.org/10.5066/F7PR7TFT`.

file provided with this SRTM dataset attests that our study area had no voids filled with data from other sources. All its elevation values were classified as coming from either two or three SRTM swaths (for field coding cf. SRTM User Guide 2015).

2.8 NASADEM

NASADEM is a modernized version of the SRTM data. It was created by reprocessing the original raw SRTM signal data with improved algorithms, and by filling the voids with data from alternative sources (Buckley et al. 2020, 1, 5). For our analysis we have used the *NASADEM Merged DEM Global 1 arc second Version 1* dataset, released in February 2020.[16] Its resolution in our area is ca. 30 m. The ancillary NUM file provided with the NASADEM dataset attests that our study area had no voids filled with data from alternative sources. Its elevation values were classified as coming from SRTM radar swaths – the majority of cells from three swaths, with very few coming from just two swaths (for coding see Buckley et al. 2020, table 2).

3 Assessment Methodology

We have used three approaches to assess the quality of tested DEMs for geoarchaeological applications: a statistical comparison with ground control points, a statistical comparison with a reference DEM, and a visual assessment of the DEMs' spatial structure (for a critical review of available assessment methods see Polidori, El Hage 2020). In this section we present the methods, the results are discussed in § 4.

3.1 Statistical Comparison with Ground Control Points

A common method of evaluating the quality of a DEM is to use a set of ground control points (GCP) measured precisely, and to compare their elevations with values at corresponding locations on the DEMs. By calculating the Root Mean Square Error (RMSE) of these values it is possible to statistically express the elevation discrepancies in meters between any tested model and the reference dataset. Comparing all tested models, the one with the lowermost RMSE value will have the least difference to the reference dataset and should thus be the one with the best vertical accuracy.

16 https://doi.org/10.5067/MEaSUREs/NASADEM/NASADEM_HGT.001.

RMSE became a standard for determining the accuracy of maps (Ghilani 2017, 28) and it was frequently used by previous evaluations of DEMs (cf. e.g. Saran et al. 2010, 110; Nsanziyera et al. 2018). The advantage of the RMSE method is that, on one hand, the minus and plus errors will not neutralize themselves, but will all get treated equally. On the other hand, the outliers will have a substantial effect on the result because their weight will be exponentiated by the square function. The latter characteristic is a convenient method to differentiate between the quality of DEMs, where even a single substantial outlier can cause serious difficulties during various landscape analyses.

For our comparison, we have used the points described in § 2.1 as the reference dataset and computed the RMSE values (in meters) of all tested DEMs with the following equation:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} \left(DEM_i - GCP_i\right)^2}{n}}$$

where i is the ground control point number, n is the total number of ground control points (in our case 17), GCP_i is the elevation of the ground control point, DEM_i is the elevation value of the cell corresponding to the position of the ground control point in the given DEM.

3.2 Statistical Comparison with the Reference DEM

While a statistical assessment with RMSE and GCPs offers a quick and precise glimpse on the vertical accuracy of DEMs, it is limited to a few cells that overlap with the position of GCPs, which can be misleading. One or few outliers can be concentrated on a limited area, on certain features, or on certain landscape types. The spatial distribution of errors thus plays an important role in recognizing error patterns and accordingly, whenever possible, it is meaningful to enhance the assessment of DEMs' quality over their entire area. This can be achieved through comparisons with a reference DEM, which is usually less precise than ground control points, yet it offers the added benefit of being able to compare elevation cell values of the entire models.

In order to enable comparisons between the tested DEMs and the RefDEM, all available datasets needed to be adapted to matching parameters. We achieved this in two steps: in the first step, the RefDEM with a 25 m resolution was generated from the vector contour plan of the *Karmir Sar* site (see § 2.2) and in the second step, all raster im-

ages from the tested DEMs have been adjusted to the same size – to grant their correct overlay and correspondence of their cells. This was conducted within the *raster calculator* inside QGIS, where each model could be clipped to the exact same size as the RefDEM (rows: 47; columns: 57), resulting in matching position and size of all cells.[17]

After adapting all datasets to matching parameters, the resulting clipped rasters were used to calculate the difference of height values of each cell with the *raster calculator*: values of each individually tested DEM were subtracted from values of the RefDEM. The outcome is either negative (RefDEM value is lower) or positive (RefDEM value is higher). For better visualization, each cell was then classified by means of a specific color – depending on the absolute difference in height. The height differences were divided up into one-meter steps, ranging between 9 and -9 m.

In addition, for the purpose of statistical evaluation, the values (height difference in meters) of each model´s cells have been extracted. This was achieved by creating sample points in the center of each cell with the *raster pixels to points* algorithm in QGIS. In order to avoid comparing distorted data from raster cells within the fringe range of the RefDEM, the outer sample points were deleted within a 'buffer zone' and not taken into consideration.[18] Subsequently, the height difference values of each model´s cells have been extracted by the *point sampling tool* from the centered vector points (n=1569). These values were summarized within Excel and afterwards processed with JMP software[19] to determine summary statistics (median, mean, minimum, maximum). Finally, the results were visualized as histograms to provide a closer examination of the value distribution.

17 Previous attempts to cut the models based on a polygon showed an imperfect overlay of raster cells. This can be attributed to differing projections of the underlying raw data, resulting in slight distortion of raster cells.

18 A polygon surrounding the vector contour lines was created with the implemented tool *concave hull (k-nearest neighbor)*.

19 Version JMP Statistics Pro 15 (SAS).

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3.3 Visual Assessment of the Spatial Structure

For some applications, a surface consistency and a reliable rendering of terrain forms are more important than an absolute vertical accuracy, as long as an elevation offset is evenly distributed and not random. These characteristics are referred to as a "shape and topologic quality" (Polidori, El Hage 2020, 3) or also known as a "relative" or "geomorphological" accuracy (Szypuła 2019, 850). In order to assess them, the previous two statistic evaluations should thus be enhanced by a visual assessment of the spatial structure. An additional advantage of visual assessment is that it can also be done on each DEM intrinsically, without the need for external supplementary data. This is especially important for new field projects, where a convenient high-resolution reference dataset for comparisons rarely exists.

One of the easiest ways to gain a first impression of surface regularity, and even of the elevation difference regarding various models, is to make a cross-section. In our case, a cross section going from northwest to southeast was created for each model with the *terrain profile* tool of QGIS. After extracting the values (57 equally distributed points) along this selected line, they were visualized as line graphs within JMP Statistics. However, this approach only gives a first impression of the variation in terrain gradation for the selected models and, significantly, only in a restricted area.

A more comprehensive way to assess the spatial structure is to meaningfully visualize all elevation values. To ensure direct, cross-model visual comparison of elevation values and their distribution, all raster images need to be shown with standardized settings. For this purpose, the minimum and maximum values in the color style were adjusted to match the range of values at the location of *Karmir Sar* – with a minimum of 2840 m and a maximum of 2865 m a.s.l., following an elevation gain of one-meter steps. Simultaneously, the contour lines that served as a base for producing our RefDEM were put on top of each raster image to visualize the respective accordance in terrain gradation.

An additional approach regarding the assessment of elevation values distribution and surface regularity was to depict the models as shaded reliefs.[20] Using this option, the quality of the data's steadiness and possible errors by depicting or not depicting certain landscape features become even more distinguishable.

20 Implemented *hillshade* tool in QGIS (GDAL) with standard settings and a chosen z-factor of 0.00003.

4 Results and Discussion

All three assessment methods revealed considerable differences in the quality of the tested DEMs. However, it is interesting to note that the deployed assessment methods did not produce identical quality rankings, so a final combined assessment became necessary. We first present the results individually for each method, before proceeding to the combined assessment.

4.1 DEM Quality Assessment Based on Comparison with Ground Control Points

All tested DEMs, including the RefDEM generated from the contour plan, were compared with the GCP dataset using the methodology described in § 3.1 (for the description of datasets see §§ 2.1-2.8). The following Root Mean Square Errors (RMSE) have been calculated:

Table 1 RMSE values of all tested DEMs when compared with the ground control points dataset (GCP)

GCP no.	A GCP	B RefDEM	C ALOS	D ASTER	E EU-DEM	F NASADEM	G NEXTMap	H SRTM	RefDEM $(A-B)^2$	ALOS $(A-C)^2$	ASTER $(A-D)^2$	EU-DEM $(A-E)^2$	NASADEM $(A-F)^2$	NEXTMap $(A-G)^2$	SRTM $(A-H)^2$
1	2848.06	2848.00	2851	2857	2847.81	2850	2849.04	2851	0.00	8.64	79.92	0.06	3.76	0.96	8.64
2	2848.40	2848.00	2851	2853	2847.34	2849	2849.00	2850	0.16	6.76	21.16	1.11	0.36	0.36	2.56
3	2851.30	2851.00	2854	2856	2851.06	2852	2852.00	2856	0.09	7.29	22.09	0.06	0.49	0.49	22.09
4	2849.07	2849.00	2852	2853	2851.06	2850	2851.26	2851	0.01	8.58	15.43	3.94	0.86	4.79	3.72
5	2848.18	2848.33	2851	2848	2850.66	2851	2852.02	2851	0.02	7.95	0.03	6.13	7.95	14.75	7.95
6	2844.55	2844.00	2847	2848	2847.03	2847	2846.06	2846	0.30	6.00	11.90	6.15	6.00	2.28	2.10
7	2849.87	2849.19	2853	2858	2850.09	2854	2851.42	2856	0.46	9.80	66.10	0.05	17.06	2.40	37.58
8	2847.86	2847.00	2850	2852	2849.08	2848	2848.13	2849	0.74	4.58	17.14	1.48	0.02	0.07	1.30
9	2844.19	2844.00	2847	2851	2846.46	2846	2846.04	2847	0.04	7.90	46.38	5.16	3.28	3.42	7.90
10	2842.63	2843.00	2846	2849	2845.19	2844	2843.62	2845	0.14	11.36	40.58	6.56	1.88	0.98	5.62
11	2858.10	2856.00	2859	2862	2851.30	2857	2854.31	2858	4.41	0.81	15.21	46.25	1.21	14.36	0.01
12	2862.35	2861.50	2865	2870	2865.43	2862	2862.95	2864	0.72	7.02	58.52	9.47	0.12	0.36	2.72
13	2853.30	2853.00	2856	2866	2856.17	2858	2856.54	2857	0.09	7.29	161.29	8.23	22.09	10.50	13.69
14	2858.40	2858.00	2862	2861	2855.27	2859	2857.25	2860	0.16	12.96	6.76	9.81	0.36	1.32	2.56
15	2841.91	2842.00	2844	2842	2842.10	2841	2841.61	2842	0.01	4.37	0.01	0.03	0.83	0.09	0.01
16	2871.04	2871.00	2869	2871	2859.98	2871	2869.04	2872	0.00	4.16	0.00	122.29	0.00	4.00	0.92
17	2859.36	2859.00	2861	2863	2848.27	2854	2852.23	2856	0.13	2.69	13.25	123.07	28.73	50.84	11.29
Root Mean Square Error $\left(\sqrt{\frac{\sum_{i=1}^{n}(DEM_i - GCP_i)^2}{n}}\right)$ **in meters**									0.66	2.64	5.82	4.54	2.36	2.57	2.77

The comparison of the RMSE values demonstrates that our RefDEM has the lowest deviation from the high-precision GCP dataset. The deviation value of 0.66 m is a very good result, considering the creation of the RefDEM from a base contour plan with one-meter equi-

distance.[21] It is a statistical confirmation of the fact that the RefDEM, which was produced from the most detailed dataset, comes closest to the high-precision control points and is accordingly the best suitable base for comparisons requiring entire surfaces.[22]

The second-best result in terms of absolute vertical accuracy when compared with the GCP is held by the NASADEM dataset: 2.36 m. The RMSE values of ALOS, SRTM and NEXTMap came very close to each other; they range between 2.57 and 2.77 m. Considerably worse are the results for EU-DEM and ASTER, with values of 4.54 and 5.82 m, respectively. While the ASTER error is due to a number of randomly dispersed deviations in magnitude of 5 to 7 m and a single deviation in magnitude of almost 13 m, the substantial error of EU-DEM is caused by three points with 7 to 11 m deviation (GCPs no. 11, 16, 17), all of them close to the eastern limits of the contour plan. It looks as if the terrain modelled by EU-DEM near the three points was already sloping down towards the valley, though all the points are in reality located on the ridge. We suspect that this reflects either an intrinsic algorithm-based deformation of EU-DEM or a horizontal shift caused by the EU-DEMs projection.

4.2 DEM Quality Assessment Based on Statistical Comparison with the Reference DEM

Since its reliability and precision was confirmed by an assessment based on ground control points, the RefDEM can be considered a suitable base for visual and statistical comparisons with other DEMs where entire surfaces are required. For evaluating the whole extent of the study area, the deviation of height values from the RefDEM was calculated for each cell of every tested DEM raster (following the methodology described in § 3.2). The results were visualized in two ways: as a comparison of difference-rasters showing the spatial distribution of deviations **[fig. 5]**, and as a histogram comparison of height differences in relation to cell count **[fig. 6]**. Both visualization types are interrelated and need to be mutually examined.

21 If it was not for a single outlier – the Ground Control Point no. 11 and its liminal position on the edge of a steep slope between two raster cells – the RMSE value would have been 0.50 m or better. This outlier is owed to the raster-creating algorithm that interpolated a medium value in the chosen 25 m cell size in a challenging terrain. Nonetheless, it is in the sense of the RMSE method to stress such deviations.

22 Since the GCP dataset is based on distinct and independent measuring methodology, the comparison with the RefDEM is legitimate and avoids circular reasoning.

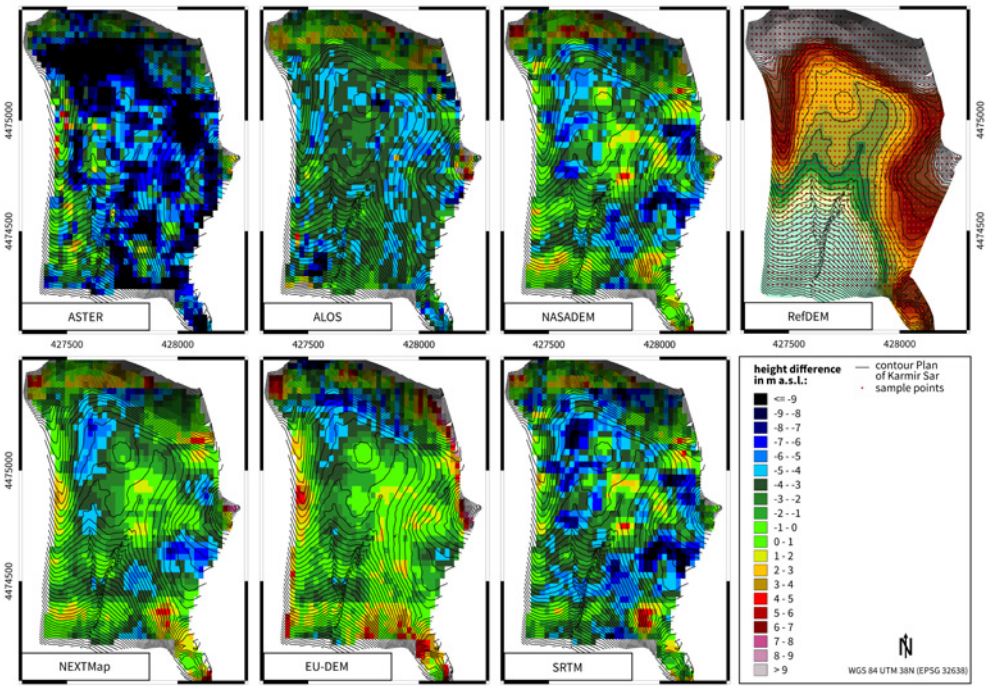

Figure 5 Distribution of differences in elevation between DEMs and the reference DEM with marked sample points within the cell centers. Map: J. Elicker

In general, both visualizations of height differences show that the majority of significant discrepancies lies within the negative range.[23] This means the models in question depict higher elevation data than the original terrain. In particular, the spatial visualization of deviations allows several insights concerning the magnitudes of error and distribution of error clusters. The ASTER data evidently shows the largest area covered by highest deviations of -8 to <-9 m. In this range, the NASADEM and SRTM values differ more occasionally within smaller areas, which are irregularly distributed. The variation of these models rather lies within a lower range from -7 to -4 m. In both cases, significant leaps in value are noticeable. However, the NASADEM shows more spots ranging between 0 and -2 m of height difference than the SRTM data. The ALOS model depicts rel-

23 It must be noted again that the areas outside the contour lines were ignored for they have no correctly interpolated values and consequently cannot reflect a reliable value in difference.

atively widespread values between -1 to -4 m, while only limited areas show differences of -4 to -6 m or higher. The NEXTMap model as well as the EU-DEM show widespread variations to a lesser extent (mainly -2 to 2 m). Most of the higher difference values are still situated within a moderate scale and, in addition, more clustered in certain areas. Especially within the higher located areas in the north or east one can still find extreme variation up to -9 m, though they only appear in single spots.

The second visualization enhances the first one by summarizing the statistical evaluation of height differences **[fig. 6]**. The histograms show the number of cells on the y-axis while depicting the difference of height in meters on the x-axis for each DEM. This way, one can perceive how many cells are situated within a certain range or increment of height difference (total number of included cells according to the marked sample points in fig. 5: N = 1569). Summary statistics such as minimum, maximum, mean and median are depicted on the right. Ideally, a DEM of favorable quality would be expected to show a low ranging spectrum, where the min. and max. values lie as close around 0 m of height difference as possible. Given a wider range, at least a clustering of values around 0 m would be expected, leaving only occasional cells within higher increments (negative or positive) so they can be determined as outliers. In both cases, the mean and median value should be close to 0 m and not differ significantly from each other.

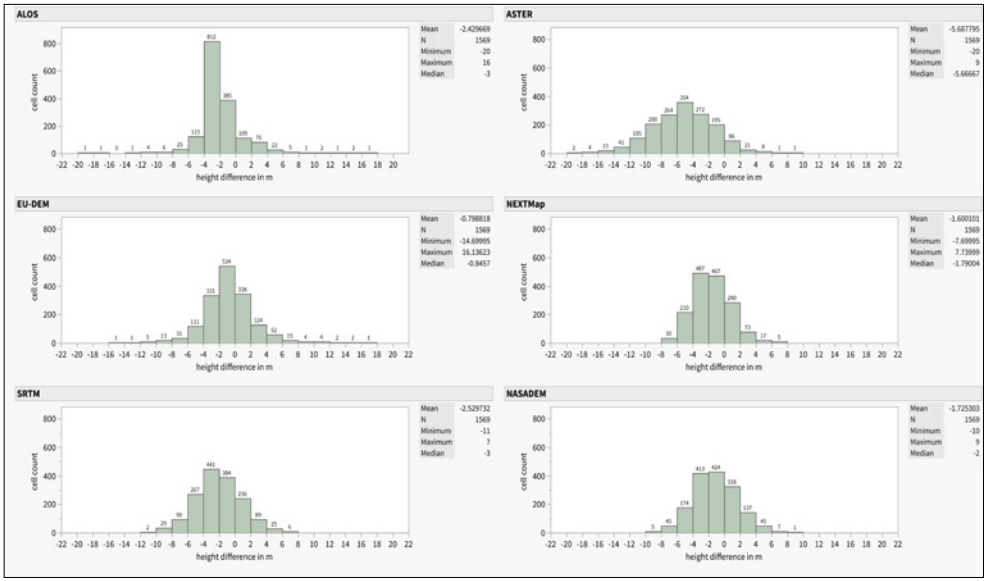

Figure 6 Distribution of differences in elevation according to cell count. Chart: J. Elicker

The ASTER data shows the most even distribution resulting in a flattened 'curve' with a vaguely distinguishable peak. The median and mean (-5.66 m and -5.68 m) are almost similar in value, but are also the ones furthest away from the ideal 0 m. The values' range is slightly less scattered (min. -20 m; max. 9 m) than others, but the number of cells for each increment are more evenly distributed across the spectrum. Therefore, higher differences e.g. between -10 to -12 m still comprise about 105 cells.

The deviation range of the ALOS model (min. -20 m; max. 16 m) must be considered as extremely high. However, most values (812) have height differences ranging between -2 and -4 m, leaving a remarkable gap to neighboring increments. Higher increments (-6 to -20 m and 4 to 18 m) entail only a small share of cells in total. Those can be classified as outliers and do not heavily influence the overall impression of this model. The median (-3 m) and mean (-2.4 m) differ slightly, which is not ideal but an acceptable result, also regarding the values themselves.

While the mean (-1.7 m) and median (-2 m) of the NASADEM are slightly smaller and closer to each other compared to the ones of ALOS, a difference regarding the range is evident (min. -10 m; max. 9 m). Compared to its predecessor SRTM, a slight improvement is visible regarding both the range (min. -11 m; max. 7 m) as well as median (-3 m) and mean (-2.5 m). In both cases, the number of cells is rather clustered without many outliers, resulting in a less significant peak and, consequently, a higher and more evenly distributed share of cells within the increments. Nevertheless, the well rated range of NASADEM is only exceeded by NEXTMap (min. -7.7 m; max. 7.7 m), which reaches the best result in this regard. Also, in terms of median (-1.8 m) and mean (-1.6 m), the model comes out considerably well.

With a rather moderate range (min. -14.7 m; max. 16.1 m), the EUDEM shows the best results regarding median (-0.85 m) and mean (-0.8 m). Even so, the highest increments in height difference only include minimal numbers of cells in total and can be classified as outliers. Therefore, the significant number is situated between -6 to 6 m and, including median and mean, this model shows the most favorable statistics.

4.3 Visual Assessment of DEMs' Quality

For visual comparisons focusing mainly on terrain gradation, we used a visualization with multi-color elevation rendering and a hillshade visualization. In addition to these two separated comparisons between the RefDEM and the tested models, a cross section was used to depict the differences of all models simultaneously within a selected area (see § 3.3 for more details). Although all tested models were compared to the RefDEM, these three visualization methods convey

important autonomous insights into model quality and would allow some primary assessment even without a reference dataset.

4.3.1 Visualization of Terrain Profiles with a Cross-Section

The cross section follows a northwest to southeast running line **[fig. 7]**. Its position was chosen with the aim of cutting through areas with the highest topographic variability. Thanks to this visualization, all tested DEMs can be compared in a single figure.

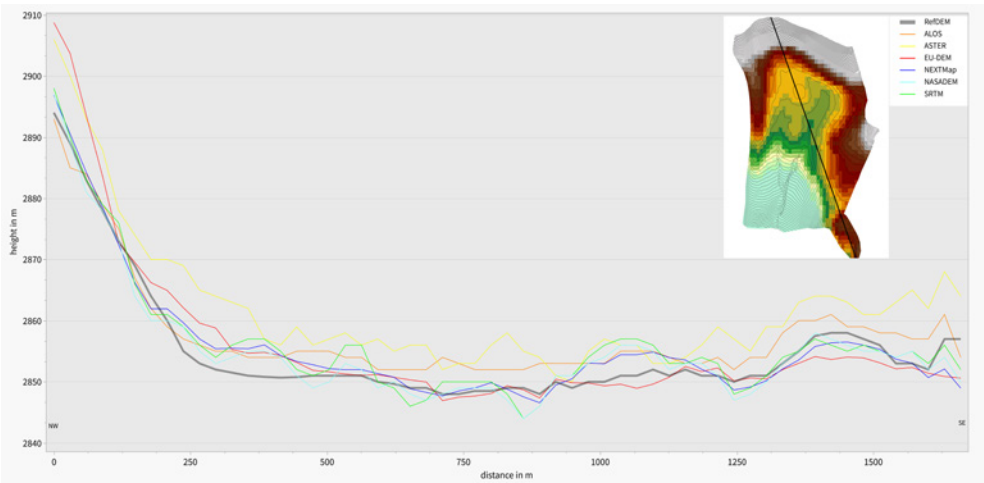

Figure 7 Differences of terrain gradation between the DEMs from a cross section going northwest to southeast. Chart: J. Elicker

In this cross-section the volatile and inconsistent character of NASADEM, SRTM and ASTER is evident, though the former two at least range in the vicinity of the RefDEM´s height level. For the most part, ASTER depicts by far the highest values throughout its whole course. At the same time, all other models show a little more steadiness. While the northwestern region (between 0 and 125 m in distance) is very closely resembled by ALOS, NEXTMap, NASADEM and SRTM, a significant difference of more than 10 m for the two remaining models is evident. Apart from this particular spot, EU-DEM generally follows the original landscape with differences of more than 5 m in certain areas. However, ALOS follows the original course most closely, but with a consistent gap of a few meters. Within the already above-mentioned plain area (between 250 to 625 m distance) the data suggests – besides complete irregularity in cases of ASTER, NASADEM and SRTM – higher elevations from 5 up to 15 m for all models.

4.3.2 Visualization of the Terrain with Multi-Color Elevation Rendering in Discrete 1-Meter Steps

Regarding the spatial visualization with multi-color elevation rendering in discrete 1-meter steps, some differences between the open data models are already obvious at first sight **[fig. 8]**. Especially the ASTER dataset seems to contain an extremely irregular and volatile distribution of values. No natural gradation whatsoever is recognizable, and a correlation with the RefDEM is scarcely apparent, with the exceptions of the higher regions within the north as well as the eastern peak. Nonetheless, values higher than 2861 m are extensively widespread, which does not correspond to reality. The NASADEM is of only slightly better quality in this regard and shows only small differences compared to SRTM. For both models, the values of the cells follow a smoother gradation, though they still contain some evident leaps. Nevertheless, the models only match the RefDEM in limited areas and those values themselves are mostly much higher than the original landscape. This is especially evident by looking at the plain in the middle of the northern half (originally at a height between 2850 - 2851 m a.s.l.) and, again, the eastern peak.

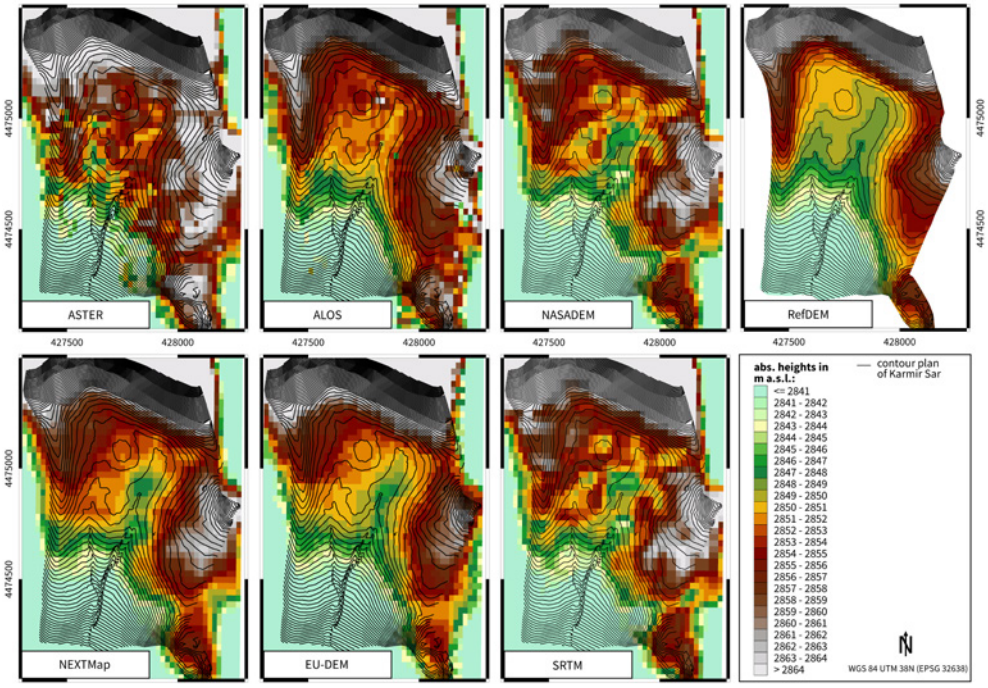

Figure 8 Spatial visualization of surface regularity for the different DEMs in Karmir Sar. Map: J. Elicker

Within the ALOS model, different topographic features are discernible e.g., the two north-south depressions are indicated, and irregularities as well as volatile transitions are shown only occasionally. The terrain is fairly coherent, particularly within the lower regions. Nevertheless, the whole area generally seems to be depicted as higher than the RefDEM suggests the original terrain to be.

By far the best quality of all compared open data models is shown by the EU-DEM. The terrain gradation is both clearly visible and smooth, without any sudden or extreme leaps. Topographic features are distinct and match the contour lines of the RefDEM more closely. Even the eastern depression is clearly indicated in its entire length. Only few differences remain in comparison to the natural terrain. For instance, the plain is less discernible and the western depression reaching from north to south is less pronounced than it should be.

The charged model NEXTMap World 30 is quite similar to the EU-DEM, e.g. it also appears to misrepresent the plain and the western depression. Only a few differences in quality between these two models can be pointed out. Especially, the accordance with the original terrain is exceeded by the EU-DEM in some areas (like the eastern depression). The general terrain gradation is comparable to the EU-DEM, but with slightly higher values in total. Even though the quality of both models seems to be comparably high, a small apparent difference to the RefDEM, and therefore to the original terrain, remains.

4.3.3 Visualization of the Models as Shaded Reliefs

Differences in terrain gradation become likewise visible when looking at the visualization of the models as shaded reliefs **[fig. 9]**. This hillshade view offers a more detailed impression regarding gradation and continuity of the data. The volatile and unsteady character of the ASTER, NASADEM and SRTM data stands out, while the remaining ones occasionally show landscape features, which do not – or at least not to the depicted extent – exist in reality: e.g. the distinctive mound in the middle of the northern area (ALOS), or the extended spaciousness of the easternmost peak (EU-DEM and NEXTMap). Nevertheless, apart from the RefDEM, ALOS as well as EU-DEM show the closest resemblance by depicting a generally flat and smoothly undulating landscape. In this regard, the NEXTMap model depicts a more irregular terrain than the previous visualization suggested. EU-DEM shows some jittery effects that might be caused by algorithm smoothing or reprojection issues.

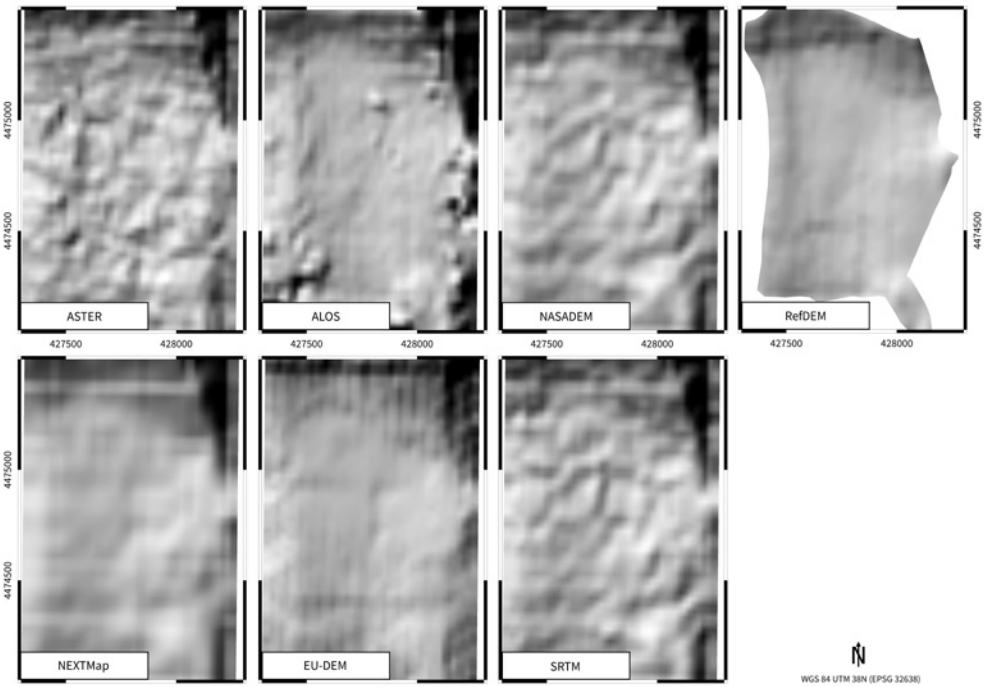

Figure 9 DEMs depicted as shaded reliefs as an additional approach to examine surface continuity and point out irregularities. Map: J. Elicker

4.4 Combined Assessment

As already indicated in the introduction to this section, and corroborated in its previous subsections, the various assessment methods led to some differences in rankings. The assessment with GCP placed NASADEM as the most accurate, followed by NEXTMap and ALOS. According to the assessment with RefDEM the first place belongs to EU-DEM, followed by NEXTMap and NASADEM. Finally, the visual assessments revealed the following sequence: EU-DEM first, NEXTMap second, and ALOS third. What all rankings have in common is the last position achieved by the ASTER model.

But which ranking is then most useful and which model can be recommended as the best? Evidently, each assessment method has its advantages and limitations. The advantage of the assessment with GCP lies in its high precision, yet it is limited by a reduced comparison area. The assessment with a reference DEM uses complete areas for comparisons, yet it has lower precision and is not sufficient for detecting surface flaws. The visual assessment does detect sur-

face flaws, yet it does not quantify them. So, in order to understand which DEMs do best represent a landscape, it is useful to combine the advantages of all assessment methods. At the end, the result also depends on the intended use of the models.

In consequence, the ASTER, NASADEM, and to a much lesser degree also ALOS, demonstrate modelled surfaces that are uneven, distorted and contain artifacts. This overrides some statistically good results and limits the use of these models for geoarchaeological purposes. In case of viewshed analyses, the randomness and the magnitude of such irregularities effectively hinders the use of affected DEMs as a reliable source. A similar conclusion applies for hydrological applications, unless intended in a low resolution. Regarding the NASADEM and SRTM, which are based on the same data, the more recent NASADEM indeed obtained better results in every assessment method for our study area. It is to be expected that NASADEM is going to replace SRTM in the near future.

For our studies on the open treeless subalpine landscape of Mount Aragats, the combined assessment reveals that among all tested DEMs the most suitable ones are the EU-DEM and NEXTMap. They are both very similar in quality, and were produced with nearly identical methodology, involving the proprietary algorithms of the Intergraph company (also by EU-DEM, cf. Bashfield, Keim 2011). Both EU-DEM and NEXTMap 30 DSM are largely free of artifacts and are consequently more reliable and consistent, probably as a result of smoothing algorithms, fusing with a lower resolution SRTM3 dataset (90 m), and the removal of spikes. NEXTMap has markedly better mean elevation precision, while EU-DEM is slightly better in modelling the terrain shapes. The main advantage of NEXTMap is its global coverage, while the main advantage of EU-DEM is its availability at no cost.

4.5 Interpretations and Limitations

Our study area in high mountains is topographically very static, so the temporal aspect of data collection does not play a crucial role. However, there are two relevant, seasonally recurring patterns to consider as exceptions. First, every winter season the study area is covered by several meters of snow, so any data acquired remotely in this period can be expected to be systematically higher than the actual terrain. Second, seasonal pastoralists traditionally visit the study area during the summer months, and they build their large tents in the middle of it. Depending on the time of the data collection, there could theoretically be differences of up to three or four meters in the limited central area of the site where the tents temporarily stood.

The first recurring pattern could explain the thoroughly higher elevations in case of SRTM as well as NASADEM, and to a certain de-

gree also EU-DEM and NEXTMap. All four models are based on (or incorporate) data from the SRTM mission, which was collected in February 2000, when our high-altitude study area was in the peak of the winter season and must have been covered by several meters of snow. To a certain degree, the presence of snow might be responsible for the higher elevations of ALOS and ASTER, too. Though both latter models were produced by stacking of image pairs acquired over several years, their elevations resulted from averaging all values, presumably including the extreme winter ones. Snow surfaces are notoriously difficult to model with optical photogrammetry due to point alignment issues on homogeneous backgrounds.

Concerning the second recurring pattern, we examined the option that some of the irregularities in ASTER and ALOS might have been caused by seasonal pastoralist activities. However, we concluded that this is not necessarily the case, as the irregularities in the models do not concentrate exclusively on the central area, which is being recurrently used by the pastoralists. The irregularities thus must have been caused by other conditions.

What might these conditions have been? Irregularities in form of spikes are typical for models based on optical stereoscopy and are likely caused by point mismatches in the image pairs; they occur locally as jumps between two adjacent pixels (Honickel 1999; Karkee, Steward, Aziz 2008, 294). A number of similar errors like 'bumps', 'pits', 'mole-runs', other geometric artifacts, and grainy anomalies ('noise') have been reported for previous versions of ASTER, especially for areas with insufficient image coverage, persistent clouds or suspected abundant snow cover (ASTER GDEM Validation Team 2009, 22-6; 2011, 18). Yet, irregular artifacts evidently persist even in the newest, third ASTER version and in spite of sufficient imagery coverage (see §§ 2.4 and 4.3). We can only speculate about the reasons – insufficient light conditions, differences between periods with and without snow cover, reflection from the water surface of the small ponds, and missing contrast in times with snow cover are among the most likely options.

Radar interferometry avoids some of the errors typical for optical stereoscopy (cloud errors, snow and water reflection errors, insufficient light contrast), yet this technique is susceptible to other errors, some of which also produce geometric artefacts or voids (failings under high terrain steepness or rapid change in surface roughness, specular reflection errors of water areas, deserts and other surfaces that reflect too little microwave energy, radar shadows, radar correlation and phase-unwrapping errors).[24] This seems to be confirmed in our case, where the visualizations of SRTM and NASADEM also displayed various artifacts.

24 Rodríguez, Morris, Belz 2006; Karkee, Steward, Aziz 2008, 294; Yang, Meng, Zhang 2011.

At last, an additional option to explain the generally higher elevations of all DEMs based on satellite remote sensing methods in our study area should be discussed. It is a possible systematic offset caused by using different geoids for transformation between the ellipsoidal and the orthometric heights. Our ground control points were transformed using the proprietary high-precision quasi-geoid of Armenia, which yields values nearly identical to the heights used in local topographic maps and to our RefDEM. The satellite models, on the other hand, were transformed with either EGM96 (Earth gravitational model from 1996 used for ALOS, ASTER, NEXTMap, NASADEM, SRTM) or EGG08 (European gravimetric geoid/quasi-geoid from 2008 used for EU-DEM). A quick test for a trigonometric geodetic point in Tirinkatar (= our GCP no. 17 with an ellipsoidal height = 2883.939 m) revealed that its height recorded in the Armenian cadaster office is 2859.20 m, in topographic maps it is 2859.10 m;[25] transformed with the quasi-geoid of Armenia it is 2859.36 m, while transformed with EGM96 it is 2861.03.[26] We could not find out the exact transformation value with EGG08, but a transformation with similar EGM2008 (Earth Gravitational Model from 2008, recommended for areas outside continental Europe) yielded an elevation value of 2860.02 m.[27] This implies that if all elevation datasets were transformed to the same vertical reference system, the observed difference between the height values of our tested DEMs and the RefDEM could be lowered by up to 2 m, thus making most datasets derived from satellite data comparable to the RefDEM in terms of absolute elevations (see table 1). We did not execute these transformations because we were interested in assessing the quality of DEMs in the form in which they are distributed. However, if the expected improvement in accuracy were confirmed, it would be a remarkable result, partly improving the impression that the vertical accuracy of the freely available global DEMs is their grave limitation (Schumann, Bates 2018).

5 Conclusions

Regarding the first objective formulated in the introduction section – to understand why ASTER failed to provide convincing results in the first landscape study (Anselm 2012) – we have reached the following conclusion. The visual assessment provided evidence that

25 Soviet military map K-38-125-V in 1:50 000 scale from 1974.

26 Calculated online at `https://geographiclib.sourceforge.io/cgi-bin/GeoidEval`.

27 Recommendation from INSPIRE 2013: VI, 75. The value calculated online at `https://geographiclib.sourceforge.io/cgi-bin/GeoidEval`.

ASTER's modelled surface of our study area is covered by abrupt and random spikes between neighboring cells of up to 10 m in magnitude. We identify these spikes as the cause of misleading results encountered during the visibility analysis of prehistoric stone steles in *Karmir Sar*. Any higher spike occurring between two steles, or even a lower spike positioned close to the observer or the observed point, inevitably interrupts the computed line of sight and the visibility analysis returns a negative result. Since the spikes do not exist in the real world, they distort the digital elevation model and falsify analyses based on it.

Regarding our second objective – to find out whether other available DEMs based on satellite remote sensing data did represent the local topography more appropriately – we report a positive result. According to all our assessment classifications, the ASTER DEM finished with the worst scores in our study area and all other tested DEMs did better, some of them considerably. The best result in terms of vertical accuracy was assessed by the NASADEM (RMSE of 2.36 m against 5.82 m in case of ASTER), yet NASADEM also suffers, though to a smaller extent than ASTER, from random spikes. When considering the surface regularity and accuracy, the best results were obtained for EU-DEM and NEXTMap, whose surfaces were algorithmically smoothed and, as a consequence, are more reliable.[28]

To conclude, we would like to express a warning and a recommendation. A warning against the uncritical use of our (and any other) results for choosing the best available DEM, even in study areas with supposedly comparable landscape and vegetation characteristics. Instead, we strongly recommend assessing the suitability of available DEMs for every study area separately, with an assessment strategy calibrated for the needs of the intended analysis. This may sound self-evident, but it is rarely done for archaeological projects. In the absence of precise reference datasets against which the DEMs could be checked, we recommend choosing a small area (1-2 km^2), zooming in to distinctly visualize all of its pixels and then visually assessing whether it corresponds with the expectations (see § 3.3). Preferably, it should be an area that can be compared to one's own empirical experience, or – if the evaluator has no prior first-hand knowledge of the landscape – some area known to be largely even or flat.

28 E.g., the visibility analysis of the steles leads in case of using NEXTMap to 18, in case of EU-DEM to 24, in case of refDEM to 26 positive results out of 30 possible combinations (in contrast to 3 positive results in case of ASTER, cf. Introduction).

Abbreviation list

ALOS	ALOS World 3D 30 m 3.1
a.s.l.	above sea level
ASTER	ASTER GDEM V3
DEM	Digital Elevation Model
DSM	Digital Surface Model
DTM	Digital Terrain Model
EU-DEM	EU-DEM V 1.1
EGM96	Earth Gravitational Model
GCP	Ground Control Points
LIDAR	Light Detection and Ranging
MSK	mask file extension for ALOS
NASADEM	NASA Merged DEM Global 1 arc second Version 1
NEXTMap	NEXTMap World 30 DSM
RefDEM	Reference DEM derived from high precision points for *Karmir Sar*
RINEX	Receiver Independent Exchange Format
RMSE	Root Mean Square Error
SRTM	Shuttle Radar Topography Mission 1 V003
WGS	World Geodetic System

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Publishing Complexity in the Digital Humanities

Christian Wachter
Georg-August-Universität Göttingen, Deutschland

Abstract When we talk about characteristics of Digital Humanities (DH), digital publishing certainly is a prominent domain to mention. Open access papers and books, blogging, collaborative writing, and digital editions have become deeply rooted in the DH, reflecting a self-confident culture of Open Science. The rational constitution of our writings, however, has received far less attention: How can we design digital publications that mirror epistemological implications of DH methods and the composition of our arguments and narratives better than current publishing formats? In this paper, I argue that the DH need formats that exceed traditional texts and their rather linear design. Digital publishing that provides (meta) data or remarks on applied methods as mere supplements would not be enough, too. Those elements are integral parts of a scholarly demonstration and they should be presented as such. They must be visible as constituents of our sense-making. We need media that depict the complex nature of data-driven research. Interlinked and multimodal digital publishing seems to lead in the right direction. I elaborate on this matter from a theoretical point of view by building on research on hypertext. I will also point to first successful attempts of implementation. Refining these approaches promises to facilitate the presentation of intricate sense-making in the DH.

Keywords Digital publishing. Hypertext. Visualization. Multimodality. Structure of arguments and narratives.

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> The problem with creating sequential documents is this: any sequence cuts connections, just as any grouping omits items. The cutting of connections is the loss of information.
> The problem is worsened with publication. Usually, a document submitted for publication has content edited out. Information is lost, content is lost, connections are lost, often forever.
> Before hypertext, these problems were intrinsic to writing and publication.
>
> (Nelson 2002, 24)

> Design is making sense of things.
>
> (Krippendorff 2006, xiii)

1 Introduction: The Challenge of Communicating Complex Findings

In the Humanities, scholars frequently apply diverse and often interdisciplinary methods while examining a broad range of objects and contexts. They do so to cope with the complex character of a multifaceted research topic. Along the way, they must thoroughly reduce complexity. The latter is a well-known challenge to research and writing a publication alike. Despite this accustomed enterprise, a particularly complex research project can lead to a feeling of limitation when findings are to be expressed in a text. The problem here is the sequential structure of traditional text itself. It conflicts with the author's intention of laying out the intricacy of research. Complexity would get too much reduced. New formats of publishing emerge in reaction.

William G. Thomas III and Edward L. Ayers give us an early example. Their Digital History project *The Differences Slavery Made* (1993) deals with the significance of slavery for two selected counties, one on each side of the front line during the American Civil War. The two historians mainly seek to unravel the intertwined political and social structures of Franklin County (Pennsylvania) and Augusta County (Virginia). This goal led to an online publication with an interlinked design, including collections of digitized source texts and GIS maps. Ayers and Thomas reason about their publication format:

> Our principal goal was to fuse the electronic article's form with its argument, to use the medium as effectively as possible to make the presentation of our work and its navigation express and fulfill our argument. As a result, this piece of electronic scholarship operates on several levels to connect form and analysis. (Thomas, Ayers 2003, 1299-300)

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This "applied experiment in digital scholarship" (Thomas, Ayers *The Differences Slavery Made*, Key = TI1)[1] attempts to use "a language of exposition that works by branching and layers and connections rather than operating on one plane of exposition" (Key = TI3). In other words, the two authors go for a visible disentanglement of an intricate historical phenomenon in order to make this very intricacy comprehensible.

The Differences Slavery Made is but one example. Since its establishment in 1993, DH research and publishing have highly evolved and diversified (Blanke, Pierazzo, Stokes 2014). We now have a broad range of tools to create e-books, enhanced publications or rich internet publications, as Breure, Hoogerwerf and van Horik (2014) classify different types of digital publishing formats.

Nonetheless, the DH have scantly reflected on these new formats as opportunities to mirror and "fulfill" (as Thomas and Ayers put it) scholarly argumentation and narrative. Only few scholars reason about further enhancements, about potentials and limits of digital knowledge representation. Other subjects dominate the discourse about digital publishing. For instance, we hear a lot about Open Access as a fulfilment of Open Science. Other points of interest are data publication, standards for object representation, or semantic web features in machine-readable publications and editions. Furthermore, the DH community addresses weblogs as a means of open and social publishing. Finally, multimedia and transmedia traits play a big role, such as embedded video clips, images, links to other online resources etc. In this context, elements other than the 'actual' written demonstration are mostly seen as useful "supplements" (Breure, Hoogerwerf, van Horik 2014). Media-rich publications then mimic the sequential text flow along fixed sections and chapters, as Leen Breure, Breure and van Horik (2014) have pointed out, but they do not "connect form and analysis" in the sense of Thomas and Ayers. This is even more true for e-books (Drucker 2009, 165-74).

One might ask, why should we reflect on this subject on a general level, beyond individual approaches like *The Differences Slavery Made*? After all, Thomas and Ayers went for a new publication format specifically suited for their own purposes. There is always a particular research design to be considered. Unique, too, are the argumentative and narrative structures that authors plan to play out. Any publishing design must respect this specific setting – form follows function.

Quite common practices of DH research and demonstration indicate that a broader consideration is indeed required: Scholars regularly release their data and meta data and must refer to them in their

1 Thomas and Ayers published their article as an XML-based website. Each page has a 'key' as an identifier.

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publications. They often assemble complex relations between information chunks when interpreting the contextual use of linguistically analyzed terms. Additionally, they refer to collocation results to support their interpretations. They relate those findings to topic models, further elucidating computational techniques and other applied methods. Data visualization has become a prominent part of DH projects, too. Scholars frequently point to a visualization and its parts in their remarks. By doing so, they give multiple references crossing two different media forms. We might add manifold other practices of complex relation building and transmedia discourse that are typical for the DH. As a subsuming headline, however, we can note: Scholars connect plenty (meta) data, seek to represent it in comprehensible ways, and derive conclusions from these procedures. The entire process must be laid out transparently in the final publication. Here we do not have a mere 'documentation' of used material, applied methods, and derived results. In fact, scholars represent these elements as constituents of their *sense-making*. It does not seem too keen to claim that there is something intrinsic to most of DH research that corresponds with interlinked, media-rich publishing.

Therefore, general reflections on this matter are justified. Theory of digital publishing in the DH comes into play. Theoretical perspectives can provide orientation for at least two contexts: Firstly, they can function as a backdrop for new projects that strive to implement a fitting publication format. Secondly, theory can inform basic research on digital publishing, in order to guide the development of flexible publishing tools.

In this sense, I would like to offer an approach based on hypertext theory. 'Hypertext' is a conceptual term for a digital medium that corresponds with the sketched understanding of digital publishing. In fact, the invention, theorization, and development of hypertext have mainly been motivated by the quest for such new publishing formats. As a medium of non-linear linking of information chunks ('nodes'), it has been an object of interest for a long time and by many disciplines. This trend reached a boom in the 1980's to the 1990's and has declined ever since.

In the following sections, I would like to argue that this depreciation happened for the wrong reasons. Hypertext and its theory still have a lot to offer when it comes to concepts of complexity publishing. This potential has stayed concealed until now. I will show that hypertext was over-hyped, as the hype primarily rested upon utopian visions for the digital medium. 'The end of the book' or the fulfilment of post-structuralism are only two narratives to be mentioned. These bloated expectations led to disappointment and dragged down the interest in hypertext. Furthermore, most of the research has focused on network-like hypertext, meaning that nodes are interlinked as a web. Readers may open up 'pathways' through this web on their own.

In contrast, I will favor a multi-linear design, hypertext that branches in pathways right from the start. This means a reduction of the medium's potential of linking information in any direction, but it is a gainful reduction. For authors normally strife to demonstrate those meaningful relations *they* consider essential. They play out *their* sense-making, consisting of *their* arguments and *their* narratives. All this structuring work leads to *specific* constellations that are complex but rarely follow the logics of a network. In addition, I will address visualized hypertext. A reader gains more insights into the author's complex sense-making if she sees a visualization of the inherent connections and paths. Coherence itself becomes depicted, visible at one glimpse. This adds a powerful quality to hypertextual publishing formats.

I will start with a brief characterization of hypertext. For a better understanding, I will also sketch major motivations that led to the intense engagement with this digital medium and its theory as well as reasons for the dwindling engagement. My paper is no place for extensive remarks, but the short demonstration is necessary to understand my plea to revive hypertext theory for 'publishing complexity'.

2 Hypertext: An Extended Form of Writing

'Hypertext' describes a very broad concept. Its nodes might consist of text, video clips, images or any other media product that is cohesively closed. They are connected by hyperlinks ('edges'). Ted Nelson (1965) coined the term, building on earlier concepts, particularly by Vannevar Bush and Douglas Engelbart. Nelson's main idea was to understand text freed from its traditional linear composition. He thinks of hypertext as "the extended, generalized form of writing" (Nelson 1993, 0/3)[2] and states: "Well, by 'hypertext' I mean non-sequential writing – text that branches and allows choices to the reader, best read at an interactive display" (0/2). This generic conception still counts as a minimalistic definition, although later hypertext research has conceptualized a lot more features. In practice, hypertexts may look very dissimilarly. The above-mentioned media formats of the nodes might be different. The overall hyperlink structure might form varying patterns, too. Technological implementation also is not predefined. All in all, 'hypertext' can refer to many things that share only the minimalist definition of a modular and interlinking digital medium.

2 Nelson resets the paging in every chapter of his book. The pagination therefore consists of a number for the chapter and one for the page. Accordingly, the indication above refers to chapter 0, page 3.

magazén
2, 1, 2021, 103-118
e-ISSN 2724-3923

2.1 Overrated or Overinterpreted? The Rise and Demise of Hypertext Research

Due to this open concept and the notion of 'overcoming' structural limitations of printed text, different disciplines and various approaches turned to hypertext. Besides computer science and media studies, literary studies became a prominent domain for hypertext research. In all these areas visionary hopes and apotheotic praises arose. For instance, Nelson himself saw an educational revolution on the horizon. He imagined every piece of literature united by "a system of interconnected writings" (Nelson 1993, 2/9). Anyone could explore it online. His famous project *Xanadu* is dedicated to this vision of a "docuverse" (2/53) that would render every library in the world obsolete. Furthermore, poststructuralists like George P. Landow (1992) imagined publishing that would dissolve the concept of finished works. Hypertext would allow for a processual, 'rhizomatic' writing. No one could identify a clear authorship anymore. For poststructuralists, the "death of the author" (Barthes 1977) or at least the end of her authority over the reader seemed near. Others have seen hypertext as a collaborative medium. Members of a writing project would be able to produce their own nodes, connect them to the contributions of others, and in consequence build a many-voiced work. Moreover, hypertext was regarded as a universal paradigm for postmodern societies. In this view, the existence of fixed and stable identities (of societies, social groups, or individuals) was abandoned. Identities would have to be formed contextually. This way of thinking found its counterpart in the flexible design of hypertext networks that a reader could browse freely, thus manufacturing own constellations of information (Krameritsch 2009, 419-25). Beyond that, does not the World Wide Web or our highly interconnected communication practices in the digital age reflect the logics of hypertext networks? The WWW is based on the Hypertext Transfer Protocol (HTTP) and the Hypertext Markup Language (HTML), after all. Here, the reference to the medium is not just metaphorical but a technological one.

This roundup already illustrates how hypertext was considered no less than 'the next big thing' by many proponents. In the boom era of the 1980's and 90's, revolutionary visions and high hopes were projected into it. This explains the theoretical drive that accompanied the medium from the very beginning. However, hypertext has not revolutionized scholarly publishing. There are two major reasons for this failure:

Firstly, practical reasons stood in the way. Hypertext editing was no easy business due to lack of intuitive tools. At the same time, scholars were (and still are) trained to fashion traditional texts. The customs and competencies necessary to produce texts greatly differ from the skills needed to link information chunks – hypertext production

e-ISSN 2724-3923

can be wearisome. Another practical reason for the small use goes back to reputation criteria in academia. Until today, most scholars want to see their papers in prestigious journals and their books published by well-known publishers. That promises quality assurance, visibility, and in the end reputation. Reputation is a crucial currency in academic discourses. In this context, traditional publishing still benefits from powerful – historically grown – incentive structures.

Secondly, interest in hypertext itself declined because of disappointment in hypertext theory. Few visions and promises turned out to be true. As they revealed themselves as mere "media philosophical utopias" (Winko 2005, 137; Author's transl.), believe in hypertext research ceased in the new millennium. The label has, subsequently, widely vanished in modern academia. The annual *ACM* conference *HT: Hypertext and Hypermedia* and some other institutions keep up the term. Nowadays, though, we hear more about 'network media', 'interactive literature', 'interactive narrative' or more generic: linking formats of electronic/digital publishing.

2.2 Reason for Revision: Representing Arguments and Narratives

Albeit this development, it is important to note that unfulfilled social, educational or poststructuralist promises do not necessarily diminish other potentials that hypertext does offer. Shifting our view towards argumentation, the logic connections inherent to it, and to structuring narratives, we still can learn a lot from hypertext theory. Representing these connections and structures is a key goal in every academic publishing, after all.

It becomes pertinent in this respect that hyperlinks can function as "meaningful links" (Nentwich 2003, 267-9) if they show a projection to the other end of the link. Propositional relations between the linked nodes become apparent to the reader. She follows along a series of nodes and edges and thereby may absorb "multithreaded stories composed of many intersecting plots" (Murray 1997, 86). The possibilities for exploitation of this mechanism are numerous, including the creation of diverse patterns of hypertext stories (Bernstein, 1998). I do not intend to elaborate on these patterns or a typology here, because I am more interested in two other aspects: On the one hand authors structure narratives that may contain any complex kind of interconnections, byways, marginalia etc. On the other hand, they represent these coherent yet complex narratives by the very structure of nodes and edges. In contrast to traditional texts, hypertexts do not rely on descriptions (i.e. metalingual references) of complex coherence to make it comprehensible. A reader of a traditional text must 'decode' the linear demonstration as a representation of non-

e-ISSN 2724-3923

linear, complex interconnections. A Hypertext already 'shows' this complex structure by its modular appearance and functionality. Here we find an epistemic quality because a hypertext mirrors how the author has composed a narrative with all its propositional ties. The 'architecture' of narratives becomes apparent to the reader.

This is also true for arguments that authors embed into their narratives. Arguments have a logic structure, meaning that authors introduce premises, derive intermediate and final conclusions. This syntactic process runs by the application of logic operations. In this context, Anne Britt et al. (1994) invented the term "global argument model". It says that one must interpret and correlate diverse documents to understand a research topic. This would result in a

> mental representation in which each document contributes to the issue by providing either a factual background, an opinionated interpretation, or the evidence to support or to confirm these interpretations. (74)

The ensemble of potentially available documents, "their contribution to the issue, and their relationships among them define the global level of an argument model" (74-5). Here, Britt et al. focus on hypertext as a tool to study and reason about history. Hypertext would grant access to historical topics, addressing arrangements of entire documents. If we switch this perspective from unlocking a topic to building-up a topic the same systematics apply. Scholars regularly build and represent their own global argument models with the same intricate structures of logic connections. Additionally, not only entire documents contribute to their argumentations but also single information or data points. These basic principles of argument-building are not exclusive for history, of course. They are at work in all the humanities.

To sum up, hypertext theory shows us that hypertexts may represent narrative and argument structures with their entire complexity. This has traditionally been seen as a network-like representation. Most of the theory has addressed literary hypertext, foremost hyperfiction (Rettberg 2016). Academic publishing has been much less a focus, and contributions specifically to DH publishing are scarce. This is surprising in my view, since DH scholars regularly make complex references to (meta)data, visualizations, applied methods etc. DH seem to form an area of research that is particularly predisposed to hypertextual publishing formats.

e-ISSN 2724-3923

3 Beyond Traditional Hypertext: Multi-linear, Multimodal Publishing

So, why do we not infuse our conceptions of digital publishing with strands of hypertext research? Is there not a greater momentum to advance traditional publishing policies and reputation regimes than in the last decades? Does it not seem conclusive for DH scholars to publish works that fulfil the idea of a network of information chunks?

We might embrace this idea by shedding further light on the conditions of data-driven research and publishing: There usually is a multitude of interrelations between data points in a collection. Those interrelations are defined semantically, but they may also remain implicit if the connections have not (yet) been defined. Beyond that, scholars relate data points to each other in their discursive demonstrations. Scholars build up interrelations by interpretation. A common goal in DH publishing is to provide access to both data collection and academic dealing with data. A network-like display of all the intrinsic and explicit connections may count as a value of its own because it communicates: 'There are a lot of data relations that are (more or less) meaningful. We may select some of them for a closer look, depending on the context of interest. We could apply further research questions to them'. That would be a system theoretic perspective that understands hypertext as a sort of database or knowledge base.

The network becomes even more complex if we add information on applied methods. When DH scholars interpret data, they must illustrate procedures of data retrieval and analysis. Which tool was used for text mining? What was the tag set for manual annotations? Which reference corpus made automatic analyses possible? Answers to methodical questions like these are crucial to elucidate research findings and their interpretation. In some way scholars must give such commentary in their publications.

Following these short remarks on some basic characteristics of DH research, network-like hypertext does indeed seem to support central publishing needs. However, this impression neglects that scholars typically put their interpretative demonstrations into the foreground when writing a publication. Scholars weave (meta) data and methodological remarks into their overall explanation. The explanation may rely on the totality of intricate interrelations, but in the end scholars do not simply document this totality – they primarily carve out those relations that are most relevant to their unique research perspective. This does not mean that the demonstration would follow one linear, even teleologic line, in the end. It may branch when scholars refer to many data points and make various methodological remarks. Scholars may offer divergent, yet equally valued, interpretations of data. They may also refer to entangled fields of research, utilizing cross references, forking elaborations, and so on. Demon-

e-ISSN 2724-3923

strations like these are indeed intricate and non-linear, but they do represent *specific* argumentations, narratives, and descriptions. They have a directed structure because they are coherent products of the scholar's sense-making. The network that connects nodes in *all kinds* of direction is no fitting model here.

3.1 Multiple Hypertext Paths: Complexity Must be Structured

The notion of 'trails' or 'paths' leading through a hypertext helps us in this context. The metaphor goes back right to Bush (1945). He originally thought of the cells of the brain that would connect pieces of information by association, forming a "web of trails" (106). Technology might at least partially mimic this web, so his idea. Bush focused on challenges in storing and accessing information – he worked on knowledge management and information retrieval, not on publishing designs. Anyway, the idea of paths has remained prominent in hypertext theory. In later research this feature was largely attributed to the reader: She must find her own pathways through a hypertext network. Authors create webs and readers create paths, so the understanding. Except for hyperfiction proponents, only a minority has thought of creating hypertext in a multi-linear design ab initio. Such a conception has even been considered half-baked, actually "weaker" than the network (Krameritsch 2007, 134).

I would like to flip this verdict. If scholars want to give a complex, yet coherently structured demonstration, multi-linear hypertext is not a mere compromise. On the contrary, it is the very fulfilment of the scholars' communicative intention to convey *her* arguments and *her* narratives to the reader. Multi-linear hypertexts seem to set up what Murray has described as "intersecting plots". Admittedly, one might very well think of a network-like hypertext that highlights multi-linear paths. A hybrid implementation like this would confront readers with paths as the dominating trait of the user interface. They would still be able to navigate along own paths. This conception promises to be very powerful, because it leads to the representation of the whole information/data base with all semantic constellations, on the one hand. On the other hand, it clearly represents those connections that the author has in mind as the primary content of her publication.

This kind of publication design already tackles two problems that critics have prominently attributed to hypertext: Firstly, 'lost in hyperspace' describes the phenomenon of orientation loss when a reader is confronted with too many opportunities for her navigation. The sense of coherence perishes. Secondly, reading a hypertext should not require too many cognitive resources. A reader can have trouble in deciding which node makes sense to next jump to. She might

be even overwhelmed if the interface design does not signalize what narrative waits behind a specific selection of nodes and edges. She must step back and make up her mind of the record of already consumed contents. Only then she can decide which node she should navigate next to, or she just performs trial and error. This cannot be done constantly without fatigue. The phenomenon goes by the name 'cognitive overhead'. 'Lost in hyperspace' and 'cognitive overhead' are classical objections to hypertext literature. Since the boom era of hypertext, they have led to an intense occupation with better usability and interface design (Shneiderman, Kearsley 1989; Nielsen 1990; 1991). The two phenomena have basically been addressed towards network-like hypertexts. They apply to multi-linear hypertext to a much minor extend, because it already reduces complexity on a representational level. Hypertext paths are devices of reader guidance.

3.2 How It can be Done: Forms of Implementation

What may multi-linear hypertext publishing in the DH look like? While the primary goal of my paper is to carve out advantages of hypertextual publishing from a theoretical point of view, practical solutions remain to be addressed. I would like to do this by pointing at some interesting attempts, beyond Thomas' and Ayers' early example. Not all of these modern initiatives are clearly multi-linear but they can serve as a basis for further considerations. In any case, they demonstrate how media-rich and non-linear publishing meets central requirements of DH research.

International publishing companies have created own formats. Elsevier's digital *Article of the Future* (Cope, Phillips 2014), for instance, augments traditional linear text by interactive elements. The interface has a main panel that presents a typical academic paper. It can include interactive elements, too, such as digital maps or diagrams. Additional side panels show further material like a representation of data, digitized resources, visualizations, or side remarks to the paper. The panels allow for cross linking, so a reader may navigate between them. She may also scroll down them individually. This design allows for zooming into the details that an author refers to in the article. At the same time, these details are visibly attached to the main presentation which makes them more than a supplement. The *Article of the Future* is developed for the sciences, but the format appeals to other data-driven domains of research, too.

The Luxembourg Centre for Contemporary and Digital History (C^2DH) and De Gruyter publishing group have created another promising format, the *Journal of Digital History*. It applies a multi-layered approach (University of Luxembourg, De Gruyter 2021): a 'narration layer' facilitates transmedia storytelling. A 'hermeneutic layer' ex-

e-ISSN 2724-3923

plores methodological implications of the use of digital tools and data. Finally, a 'data layer' grants access to data and code by means of a professional infrastructure. This publishing format addresses the needs of data-driven research in a profound way. Scholars can fuse their coherent arguments and narratives with detailed accounts on methodological issues. They may directly include the data they have investigated. Therefore, readers absorb research results presented in their broader contexts. The publishing format connects central constituents of research and lays it out transparently.

The two presented publishing formats enhance traditional text by integrating interactive elements. The scholarly demonstration resembles a traditional text, but it provides branches to further material. Multiple strands of demonstration, therefore, complement the main course of exposition. *Scalar* is another initiative in that sense. It takes the notion of multi-linear publishing even more serious. The tool is developed by *The Alliance for Networking Visual Culture* and aims at open, media-rich online publishing. On the one hand, *Scalar* publications mimic traditional codex-books. Chapters align in a linear order and readers can access them via a menu. One the other hand, the tool allows for breaches through this hierarchic structure by a 'path' feature: An author may select and thematically group any page, whenever she wants to give (additional) demonstrations that are transverse to the chapters. Pages function as hypertextual nodes here. The multi-linear paths are prominently represented by special menus, so readers can easily select them and follow along. Paths may intersect and readers can jump over. The showcase on *Scalar*'s website documents numerous ways of exploiting this feature.[3] DH publishing can very much benefit from such a publication design. A nodal page may represent a section of the scholar's overall narrative. It may also contain data representations, visualizations, or methodological information. The author may link these chunks to multiple other parts of her overall discourse, wherever it seems fitting. She may also curate paths that gather all the relevant information on specific domains of research. A path on 'applied methods of topic modeling', for example, could bind together all relevant pages that otherwise scatter in other strands of the publication. Paths may also provide differing perspectives on the same set of analytic data. If scholars use *Scalar* in this way, they create a multi-linear hypertext that weaves nodes into a complex, yet coherent demonstration. The branching publication format lets readers explore the intricate connections but keeps the scholar's vision of sense-making in the foreground. Since *Scalar* is open-source and allows for flexible customization, design possibilities are numerous.

3 https://scalar.me/anvc/scalar/showcase/.

Another interesting property of *Scalar* is a set of visualizations that depict the publication's contents. Different visualization formats – graphs, trees, radial, or grid visualizations – provide an overview of the contents. These are all the pages, all the paths, media contents, tags, or individual object categories. If a reader clicks on any representation of an instance, descriptions appear, connecting lines become visible, and the user may jump to the represented node. In the DH visualizations play a huge role. There has been a lively discussion about the topic in recent years, and the community has developed ever more sophisticated techniques (Drucker 2014; Manovich 2020). Visualizations provide an overview over large amounts of data, patterns of (cor)relations and other features, facilitating access to the complexity of digital research objects. However, visualization of data is something else than visualization of an authors' discourse. Why do we not use visualizations for the depiction of our complex sense-making, too? Why do we not create multimodal publications in that sense? Multi-linear arguments and narratives have complex architectures that often are neither easy to express nor to follow. If we depicted the structure of logic and narrative conjunctions between the nodes of a publication, as *Scalar* offers this possibility, we could add quality to our demonstrations. Showing complexity and reducing complexity go hand in hand. David J. Staley (2014, 156) uses the term "meta-narrative" to emphasize that a visualization can communicate the coherent composition of an academic demonstration. Pure text cannot provide 'the bigger picture' with the same degree of explicitness.

Hypertext research also informs about this combination of modalities (textual and visual). So-called *spatial hypertexts* (see Bernstein 2011) present a visual map of nodes and edges. The map dominates the user interface and nodes are represented in different sizes, distances to each other, with or without linking lines between them, and feature other design characteristics. These properties indicate semantic qualities, such as the weight of a node for the overall demonstration or its isolation from other information chunks. When selected, the contents of a node come into the foreground (in a new window, a pop-up box, or any other kind of appearance). The total design is therefore multimodal and the user experience clearly contrasts hypertexts without any visualization (document-centered hypertexts). Spatial hypertext concepts and editing tools are promising antetypes for multimodal publishing formats because "[r]epresentation of argumentative structure in spatial hypertext has been a conspicuous goal", as Bernstein (2011, 108) states. Admittedly, spatial hypertext has primarily served as a tool for individual note taking and management of ideas. Academic publishing is an entirely different domain. Nevertheless, research on spatial hypertext provides informative conceptions of structuring and representing information

e-ISSN 2724-3923

visually, in order to convey a "meta-narrative" about complex academic sense-making.

4 Summary and Outlook: Towards Multi-Linear and Multi-Modal Publishing

The DH are an area of complex sense-making. Data-driven research deals with interdisciplinary methods and extensive data analyses. Scholars must refer to intricate interrelations between all these constituents of research in their publications. This task often proves to be difficult, as complexity is not easily represented by a written text. Non-linear digital publishing seems to answer to the DH better than traditional publication formats. Surprisingly, this has not yielded a broader reflection on the issue. While it is a well-known exercise to create multimodal and linked representations of digital objects, DH scholars normally express their complex arguments and narratives in a rather linear fashion. They may supplement their publications with other media formats, but the 'actual' demonstration remains a traditional text.

Hypertext theory is a powerful backdrop for conceptions of innovative digital publishing. A hypertext organizes arguments and narratives in a non-linear way, representing their intricate architecture. This potential has remained widely overlooked until now because hypertext research has focused on other issues. Additionally, the digital medium was burdened by illusionary expectations what led to disappointment and, in consequence, a dwindling interest. Hypertext research has also largely narrowed its perspective on network-like hypertext. As I have illustrated, the underrated multi-linear hypertext has yet more to offer. An author can represent those specific arguments and narratives *she* intends to convey. The multi-linear format nevertheless allows for complex demonstrations.

Only a few initiatives have created publishing formats in that sense. They are innovative sources of inspiration and build the ground for further conceptions. The examples I have presented in this paper tackle essential demands of DH publishing, making them interesting role models. Especially *Scalar*'s path feature is a powerful means to represent the lines of arguments and narrative that an author wants to communicate. Other formats dedicate special panels or layers to digital data and methodological remarks. They are no supplement but integrate central elements of data-driven research into the publication.

Visualizing the multi-linear structure of a publication is another promising potential for the DH. A reader may grasp 'the bigger picture' of intricate arguments and narratives. Thus, she gains a better access to the overall demonstration. Research on spatial hypertext

e-ISSN 2724-3923

may advance further development of such techniques, as it offers a lot of conceptual thought on visual "meta-narrative", as Staley calls it. For instance, *Scalar*'s visualizations offer an overview in this respect, but one must specifically select them from a menu. If they had more weight in the default user interface the "meta-narrative" would be emphasized. *Scalar*'s visualizations are labeled with little information, too. One must choose and explore nodes with attention. A more extensive labeling might lead to a more expressive combination of textual and pictorial features.

These ideas may yield new design challenges and problems on their own. Furthermore, the developers of *Scalar* might not have the same publishing contexts in mind that I have stressed. However, *Scalar* and similar tools can still serve as a source of inspiration. They demonstrate means of implementation for hypertextual publishing. They give clues for potential improvement, and they indicate that multi-linear and multimodal formats satisfy essential demands of 'publishing complexity' in the DH.

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The Use of Serious Games as an Educational and Dissemination Tool for Archaeological Heritage
Potential and Challenges for the Future

Samanta Mariotti
Università di Siena, Italia

Abstract In the last decades, digital technologies have pervaded every aspect of the production of archaeological knowledge and they have been massively used to communicate the past. This contribution analyses the potential and benefits of serious games as they appear a promising tool for engaging the users in active learning of cultural contents, for attracting new audiences and promoting knowledge and awareness around archaeological heritage. Moreover, the need for multidisciplinary collaborations between archaeologists and developers and the necessity of assessment studies on learning levels to implement their effectiveness will be highlighted.

Keywords Archaeology. Digital technologies. Game-based learning. Edutainment. Serious games. Heritage enhancement. Public engagement.

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1 Introduction

In recent decades, digital technologies have pervaded every aspect of the production of archaeological knowledge, from data collection to their analysis and interpretation, to interaction with the public (Hugget 2019; Morgan 2019). Archaeologists have been experimenting with digital data for a long time. The main reason for this "curiosity" is the nature of the cognitive process related to the discipline: the stratigraphic excavation method, in fact, requires the destruction of stratigraphy, hence the importance of tracking the information obtained to recover and interpret any data even after a long time. Moreover, the archaeological record is often difficult to read and to explain to a non-specialist. Digital technologies have been helping archaeologists to fill the communication gap between the traces of the past and their potential audiences, a necessity that has gained more and more importance through the years. University courses on digital technologies, 3D modelling, or computer simulation – to name just a few – which until a few years ago were considered niche, are gradually included in a growing number of undergraduate and postgraduate archaeology curricula. At the same time, as 3D and interactive technologies are becoming ever more affordable, a proliferation of digital tools, ranging from virtual and augmented reality applications and interactive displays to mobile apps, have been made available for the communication of the past in museums and via the internet (Hageneuer, Schmidt 2020).

At the same time, over the last few years, the use of new technologies has grown exponentially, permeating every aspect of everybody's lives. It has consequently also affected the way different communities around the world experience heritage. People are increasingly encountering sites and monuments and learning about the past through digital media, in the form of virtual reconstructions, digital representation of artefacts, online videos, and so on (Bonacchi 2017). This is particularly the case for younger generations, whose first experience of cultural heritage is often through a digital surrogate that shapes their understanding and perception (Shapiro 2018). The expansion of Web 2.0, the increasing use of smartphones, and the demand for almost constant access to the Internet also mean that social interaction with other visitors or staff at heritage sites, as well as face-to-face discussions about heritage, are increasingly transferred to the digital space. Digital media in all its different forms, such as the multitude of social networking tools that Web 2.0 encompasses (including blogs, podcasts, RSS feeds, YouTube, Facebook, Instagram, Twitch etc.), the mobile apps designed for individual use, virtual reality, digital collections, and interactive kiosk applications in exhibitions, all have been offering new possibilities for heritage organizations to interact with their public (Boom et al.

2020). Moreover, the increasing convenience of 3D and interactive technologies has led to a proliferation of digital tools (VR, AR, mobile applications), used to communicate the past. Heritage institutions have been experimenting with these tools for quite some time as part of their efforts at greater democratization, opening up to diverse communities and inviting different viewpoints and interpretations of their sites and collections. But have these hopes actually materialized in practice? As Economou (2015, 224) argues, heritage digitization programs are creating digital resources which constitute the building blocks of research, learning, management, cultural tourism, and the general understanding and appreciation of heritage. These digital resources are often used to create interpretative and "edutainment" applications related to heritage. However, it is not the tools or the digital assets themselves which are causing concerns, but rather the use that these are being put to. Who is producing them and towards what means? In what way are these being used and by whom? Are they actually effective and engaging? Other scholars (Mortara et al. 2014) have raised the same questions. They argued that although they may be helpful to allow the general public to appreciate "remote" (in space and time) cultural content through an immersive experience, these applications still lack a powerful mechanism to engage the large public into an active state of lasting commitment and learning where spectators are motivated to create their own knowledge rather than to receive information passively.[1] Conversely, such engagement is evident in computer games providing amusing and compelling experiences, which keep the player focused for long-lasting sessions. For this reason, games with educational purposes – namely serious games (Dörner et al. 2016) – have become more and more popular and they are starting to get recognition even from academics and cultural institutions[2] of those countries – the Italian case will be analysed more in detail – where the focus on university-based courseware in the historical and archaeological domain has remained quite entrenched.

Supporting the player to achieve learning targets through a playful experience is the objective and main feature of a serious game. Thus, the design process of a serious game differs from the one of a

1 Many authors (see Champion 2017, 26 and reported references) also argue that AR and VR have several use limitations: they can require extra and special devices (3D glasses, specific system features), and the user is typically restricted to certain types of online browsers, operating systems, and platforms. Moreover, they contain too much data for many people to download, and walkthrough, especially on portable devices (smartphones and tablets).

2 For a recent analysis on the changing practices of cultural institutions which are increasingly involved in the production of serious games, considering them as strategic digital marketing tools to promote cultural heritage, see Bonacini, Giaccone 2021.

common e-learning application since an intrinsic balance between learning and gaming should be found. Indeed, the learning content in a serious game has a predominant role in the game-play, but the game interactions and mechanics should not simply be a playful layer added atop a digital learning tool.

This paper aims at presenting serious games as a promising tool for promoting and engagingly learning cultural contents, attracting new audiences and encouraging knowledge and awareness on archaeological heritage. The potential benefits of this tool will be analyzed and the role of archaeologists in the process of creating archaeological serious games will be stressed. The aim is to underline the need for a digital content that goes beyond the mere digitalization of the existent and its simple presentation in a different form (just more eye-catching) that adds nothing. The challenge for the future is the exploitation of tools that can promote the creation of awareness, lasting engagement, and critical knowledge starting from a specific and scientifically validated cultural content (Watrall 2002); that's why this paper is specifically addressed to archaeologists interested in the use of original means to make the past relevant for the present: archaeological expertise shall be a crucial asset in this area and it can determine a whole bunch of professional possibilities over the coming years. Besides, this intent is consistent with the most recent and significant European conventions and documents concerning cultural heritage sustainable development (Council of Europe 2005, Council of the European Union 2014) and with the deepest intent connected with the widespread of digital and sustainability aspects in Public Archaeology projects (Bollwerk 2015; Gould 2018).

2 Digital Games as Educational and Engaging Tools

Gamification is defined as "the use of game design elements in non-game contexts" (Deterding et al. 2011, 10). Another definition describes it as "the process of game-thinking and game mechanics to engage users and solve problems" (Zichermann, Cunningham 2011, XIV). There are many other aligned terms of gamification, such as productivity games, surveillance entertainment, playful design, behavioral games, game layer, and applied gaming; however, gamification is the term that is widely accepted in related literature (Bozkurt, Durak 2018). Though it was first used for marketing purposes, it has been used in relation to many issues – the pervasiveness and ubiquity of computer and video games in everyday life; the need to arouse and maintain students' interest in learning – to involve users and encourage them to achieve more ambitious goals, following rules and having fun. The basic purpose of using gamification is to increase users' motivation to provide more effective, efficient, engaging, endur-

ing and entertaining experiences. In other words, the main goal of gamification is to keep the users, that is to say, players, *in* the game.

The process of modern education takes place in the rapid growth in volume of new information, which is so rapidly becoming obsolete that students have no time to acquire the necessary useful knowledge but gained quickly loses their relevance. Rapidly developing technologies facilitate new leisure activities, and time for obtaining information becomes smaller for everyone. Also, the cognitive process is not required to take place in the formal (and often boring) environment and can turn into wholesome entertainment, with the acquisition of knowledge at the same time. Edutainment is a feature of technological implementation of modern forms of entertainment in traditional lectures, lessons, classes, workshops and masterclasses. Without television programs, desktop, computer and video games, movies, music, web sites, multimedia software is already impossible to imagine modern training and communication. Classes and activities held in the format of the technology edutainment can be conducted in cafes, parks, museums, offices, wherever you can obtain information on any informative topic in a relaxed atmosphere. Currently, in education, there is a transition to more interactive, engaging, and experiential learning methods in which also emotions play a fundamental part. According to Buckingham and Scanlon (2005), edutainment is "a hybrid genre that relies heavily on visual material, on narrative or game-like formats computer games-education-implications for game developers and more informal, less didactic styles of address". Edutainment is the act of learning heavily through any of various media such as television programs, video games, films, music, multimedia, websites and computer software. Moreover, the importance of instrument-mediated activity through the use of edutainment environments is consistent with the learning theories derived from Piaget (1962) works focused on cognitive development.

The use of games and video games as learning tools, known as game-based learning, is not a recent innovation, but it has been gaining prominence in recent decades.[3] Game-based learning has assumed greater interest since the beginning of the century with the Internet and the World Wide Web and, more recently, with the paradigm of Web 2.0 and social networks. Video games are popular among younger generations, designated by some as "digital natives" (Prensky 2001). For them, all these technologies always existed and are used as something that was always part of their lives. Moreover, all the researchers tell us that kids learn things through play: they learn to interact with each other, to follow rules, the executive func-

3 An extensive bibliography and some of the most significant contributions are discussed and summarised in Sailer et al. 2017.

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tions and problem-solving skills. Video games are successful because they seem to address today's approaches to challenges and are consistent with the needs of our time (Shapiro 2018; Mariotti, Marotta 2020; Singh 2021).

According to the last reports shared by the Entertainment Software Association, 2020 was a record-breaking year for the US industry, with total video game sales exceeding $57 billion. Over 214 million adults in the United States play video games, and three-quarters of all Americans have at least one gamer in their household (Entertainment Software Association 2020). Things are not very different if we focus on Europe: the size of the European video gaming industry reached € 21.6 billion in 2020 (Interactive Software Federation of Europe 2020). According to the most recent report (Italian Interactive Digital Entertainment Association 2020), Italian trends mirror these growth forecasts: in 2020 the industry turnover (including physical and digital hardware and software) was € 2.179 billion with an exceptional growth of 21.9% compared to 2019. Another very interesting fact revealed by the report is related to the profile of Italian gamers: 16.7 million people played video games in 2020, meaning 38% of the Italian population between 6 and 64 years. From a gender perspective, a quite similar proportion of men (56%) and women (44%) is also attested. The age groups of 15-24 and 45-64 are the most represented, followed by the range 25-34. In general, we can observe that the diffusion of video games is quite uniform and another very interesting data comes from the 6-14 range with an average of 10% of the total (considering both boys and girls as the difference between them is almost inconsistent). It appears quite obvious that, also due to the COVID-19 pandemic, 2020 marked a record in the use of digital content. A very recent survey (Creative Keys 2020) shows that, during the lockdown, video games were amongst the tools cultural institutions used to engage with their public. According to the survey, people who played serious games linked to a cultural institution stated that: they have the perception of having learnt something (78%), they enjoyed that time (85.8%), they were encouraged to try other digital games with cultural content (81.1%), and more than half of them (54.4%) confirmed their willingness to visit those sites or museums in the future.

3 Gamifying the Past: an Italian Perspective

In this global context, another interesting piece of data emerges: in fact, a brief perusal of video games' content also reveals themes that often incorporate archaeological content, sometimes highly accurate, other times (most frequently) not so much (Christensen, Machado 2010). As Watrall (2002) argues, archaeological content has been of-

ten used as a triggering subject but archaeologically inspired interactive entertainment titles are often an outlet for some of the worst kinds of pseudo-archaeological ideas (e.g. *Tomb Raider* series).

In the last decades, with the increasingly widespread use of advanced personal device technology such as smartphones and tablets and thanks to broadband internet access, the number of multimedia products developed within the archaeological community has certainly increased. However, the focus on peer-to-peer communication and university-based courseware has remained quite entrenched until recently. Archaeologists rarely ever considered exclusively targeting their interactive media towards the commercial market. As a result, the increasing public desire for sensational representations of the human past has been largely fulfilled by commercial interactive media producers who rarely have anywhere near the level of expertise necessary to produce titles that conform to the high content standards archaeologists desire and archaeology deserves. While, in a global perspective, serious games, edutainment, and gamification have been well-known concepts and many museums have been using digital playful activities for a long time, an increasing emphasis on these aspects is quite evident in the last years, especially in Italy where a certain resistance among the academics was still strong, with more and more archaeologists who have finally put their preconceptions aside and started considering video games as a useful tool for their objectives (Mariotti 2020a). The recent development of institutionalized public archaeology programs in Italy has had the potential not only to face the interactive entertainment industry's increasing encroachment into archaeology, but also to change the sentiments that many Italian archaeologists hold toward interactive entertainment. It is not a coincidence that video games are a growing concern in global academic research in the archaeological field and present a considerable attraction for archaeologists who wish to present their research in a media format that can incorporate multiple perspectives, alternative narratives, and 3D representation to audiences that may not be engaged with other forms of academic literature or media regarding archaeology.[4]

In the last years, serious games in the archaeological heritage domain in Italy have received more and more attention, gaining the interest of museum institutions, academics, and local administrations. They appear in a wide variety of forms spanning from trivia, puzzles and mini-games (e.g. *Time Tales – The Etruscans*, a serious game for children designed by two archaeologists (Mariotti, Marotta 2020) in collaboration with a serious games company, Entertainment Game

4 Some of the most significant contributions in the field are Champion 2011; Mol et al. 2017; Reinhard 2018; Politopoulos et al. 2019; Hageneuer 2020; Pescarin 2020.

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Apps Ltd.), to engage in interactive exhibitions/visit (e.g. *Inventum* (2018), a 3D application in AR to enhance the Archaeological Park of Venosa, Potenza) to mobile applications for museums or touristic sites visits motivated by some reward/engagement mechanism (e.g. *Mi Rasna*, developed by Entertainment Game Apps Ltd. and dedicated to the Etruscan civilization (Amoroso 2020); *Mediterranean* developed by the same society as part of an European project dedicated to the Phoenician civilization; *Father and Son* (Solima 2018) created by Tuo Museo for the Archaeological Museum of Naples; *Beyond Our Lives* an adventure game by Tuo Museo to promote the main ancient Etruscan cities in Tuscany), to simulations of past events (e.g. *Difendiamo le Mura* based on the siege of the city of Paestum by Alexander Molossus and until recently available inside the local archaeological museum) to adventures set in faithful reconstructions and/or digital counterparts of real sites (e.g. *A Night in The Forum* (Ferdani et al. 2020; Pescarin et al. 2020), a 3D video game for PlayStation VR created by VRTRON in collaboration with Italian CNR and set in the Forum of Augustus, one of the Imperial fora of Rome; an ongoing 3D project (Mariotti 2020b) dedicated to the Park and Archaeological Open Air Museum of Poggibonsi, Siena and to the medieval phases of the site discovered by archaeologists.

Generally speaking, a proliferation of video games projects connected with heritage sites, museums and institutions can be observed in the last few years. This encouraging figure, however, must be evaluated carefully: the risk is that fostering the creation of a serious game is reduced to the trend of the moment and that to an increasing number of projects does not correspond an equally high level of quality and relevance. Quality standards in terms of content, game design and objectives should be always respected and assessed wisely.

4 Serious Games & Archaeology: Potential and Benefits

While, in the last decades, we have witnessed the introduction of serious games to support cultural heritage purposes, such as historical teaching and learning, or to enhance archaeological sites and museum visits, the increasing emphasis on and eye for the opportunity of this in the last years – especially in Italy – is beyond any doubt. The main reason is that this tool has the potential to be very adaptive and to allow a wide range of possibilities. These benefits can be classified into three different groups (with many spaces of interaction): education, public outreach and audience engagement, and touristic development.

4.1 Education and Learning

The popularity of video games, especially among younger people, makes them an ideal medium for educational purposes. Serious games can provide player engagement by creating a fun experience for users while also supporting them to achieve learning objectives. That is why games can also aid in familiarizing young people and adults with specific cultural heritage topics, such as ancient history or archaeology, and significantly increase their interest levels and engagement (Mortara et al. 2014). Supporting the player to achieve learning targets through a fun experience is the objective and main feature of a serious game. The fun aspect of a serious game provides engagement and can be determined by several factors like storyboard, graphics, usability, collaboration/competition mechanisms, and interaction devices (Mariotti, Marotta 2020). The learning aspect implements a pedagogical approach, by structuring the educational content and organizing its presentation (Capdevila Ibáñez et al. 2011). An appealing and meaningful environment, a compelling narrative, and a suited and intuitive interaction paradigm are the three main elements to create engagement. Moreover, serious games for cultural heritage seem particularly suited for the affective domain. Empathy with a game character and plot may be very helpful to understand historical events, different ancient cultures, other people's feelings, problems, and behaviors, on the one hand, and the beauty and value of the past, architecture, art, and heritage, on the other one. This persuasive approach should be combined with the rigour of the scientific method, which is a balance not easy to achieve, not only in games. As pointed out by Mortara et al. (2014), adventure games are particularly suited to implement the "learning by doing" approach (Dewey 1938), which is related to the constructivism theory, where the player learns by constructing knowledge while doing a meaningful activity. In this approach to education, the learner does not passively receive information – as in a simple explanation, a panel or a virtual reconstruction although accompanied by a description – but rather actively constructs new knowledge by finding information in the game, understanding it, and then applying the new knowledge to fulfil tasks (Boyan, Sherry 2011). As underlined in Froschauer (2012), players remember more the knowledge related to task completion than information directly provided by the game, not to mention that simply responding to direct instructions would not be fun at all.

Moreover, serious games allow a personalized approach to learning: except for games located in exhibitions or designed as mobile applications for augmented visits, all the other games can be consumed at home or school, or both; a game can even be played partially at school, in small groups and with the support of the teacher, and partially at home for example as a tool to review the acquired knowledge.

4.2 Public Engagement

In a 2017 article discussing whether archaeologists and games could mix, Erik Champion (2017) concluded saying:

> My solution is to suggest that rather than concentrate on the technology, archaeologists should focus on the expected audience. What do we want to show with digital technology, for what purpose, for which audience, and how will we know when we have succeeded? (27)

I think he pointed out a key issue regarding this discussion: different professionalism and different competences are essential for a good result. Archaeologists have their area of expertise regarding historical and archaeological content, narrative, storytelling; on the other hand, the technological aspects should be determined by other professionals whose knowledge about the game industry better fits the requests. But this also means that since we, as archaeologists, are entering a completely new way of communicating, we have at least to understand the 'new rules' of video game form. One of the main risks is to be too didactic since we are used to telling historical events and explain processes. In a video game, this would be totally wrong. In this case, you have to create the system to show the player, do not tell them. They have to be put in a situation in which they have to use the acquired knowledge to go on in the game: these are the keys to children's engagement (Haddad 2016) and they work for adults too, as suggested by the already cited "learning by doing" approach.

Moreover, public engagement and the communication of archaeological data have been on the top list of the major concern in Italian archaeology debate in the last decade (Volpe 2020) and the natural development of multiple strategies exploiting different mediums was a natural consequence of this new experimental attitude in which technology has been playing a central role. While archaeological content has always evoked a certain interest and fascination, archaeological sites or museum have often been perceived by the general public as places for experts and professionals. Archaeologists have finally learned that a different approach, less patronizing and truly more informative and inclusive, makes people enjoy the content more easily and experience the visit in a more friendly way; in doing so, they will feel engaged, free to appreciate the past and also have fun.

Video games, in particular, are a form of new media, whose novel affordances facilitate active participation and agency through player interaction with both content and digital systems, thus providing the player with the ability to direct or alter the course and outcome of the game as it progresses. The thrill of discovery and exploration combined with the opportunity to relive the past is something that

appeals both on an instinctive and emotional level. Video games have played into this desire in several ways. First of all, because they allow players to immerse themselves in the experience: in the case of a serious game set in the past, the authenticity of the space (whether stylized or not) and of the narrative is fundamental. 'Experience' is a keyword when people discuss using game-based learning. Games engage people psychologically – they can be very emotional experiences – and they also engage people physiologically. What is going on beyond the peripheries of the TV screen or computer monitor ceases to register to the user. His/her heart rate increases, the hair on the back of the neck stands up and s/he may well end up laughing out loud at (or furiously cursing at) a virtual character who is actually nothing more than a collection of pixels and programming code. Games are very good at using drama, storyline, humour and characters to create a compelling experience which, from a training point of view, develops memory hooks and means that learners not only remember *what* happened but also *why* it happened.

In an archaeological serious game project, archaeological expertise becomes essential and it can be easily translated both in set dressing and in information conveyed through boxes, dialogues, meaningful objects etc. (Anderson et al. 2010). To encourage an actively involved player, free to explore and to interact, the creation of a 'safe' setting in which errors, mistakes, wrong moves are allowed and have no 'real' consequences is necessary. This 'safe virtual space' is also supported by the 'avatar' or in general by the possibility to play through someone else (a character) and with an interface screen that provides the player with the 'right distance' between what is real and what is not. Moreover, games, more than any other medium, have the advantage of establishing a direct relationship with the player: the game and the story only evolve if he/she makes a move and this occurrence makes players feel like they are the protagonist of the story. In this way, cognitive and emotional responses for vigorous historical engagement can be created: apart from the stimulation of reflection, people have the opportunity to explore past events and information and to perceive history in an all-encompassing way.

Focusing back on Champion's suggestion, I too believe that knowing the audience we are addressing is fundamental, as it is crucial in every practice of communication. However, I would say that, for an archaeologist, the main focus of the creative process of a serious game should be the content. One could argue that the more creators master the content, the more they will be able to translate it into a comprehensible language for the target public. As I said, it's not always so easy. This represents a crucial moment in the creative process because it requires working with professional game designers and developers: by creating together, we all found ourselves constantly pushing up against the boundaries of our disciplines and by

doing so, we, as archaeologists, have the opportunity to critically reflect on our own perspective and to experiment a completely new way of communicating our research by adapting our language to the video game medium as well as the audience (Copplestone 2017).

4.3 Touristic Outcomes

Towards the end of 2009, Ubisoft released the second chapter of its series *Assassin's Creed*. One of the settings of the game was Monteriggioni, a small medieval Tuscan village near Siena. Economic results regarding the tourism sector from the first half of 2010 (from January 1st to June 30th) pointed out an increase of 7.24% in arrivals and 16.28% in overnight stays in town compared to the same period in 2009 (Capone 2011). Six years later, in summer 2016, the municipal administration of Monteriggioni launched a survey asking 500 tourists to fill out a questionnaire. Among the questions, there was one that concerned the knowledge of *Assassin's Creed II*. The result was that 11.4% of people answered that they knew Monteriggioni thanks to the video game.

According to recent studies, as in the case of films or books, video games should be considered as a driver of tourism (Dubois, Gibbs 2018; Sajid 2018). A very recent survey of 827 Italian gamers carried out by the project Italian Videogame Program (2019) confirmed that the majority of them (79.9%) are willing to visit a place they got to know through a video game and that 47,9% already have done so.

First of all, this potential breaks the cliché according to which video games have a very negative influence on players (especially the youngest) because they would induce them to isolation and disconnect from reality. Secondly, this possibility deserves to be carefully considered and exploited for many good reasons: to enhance the knowledge and the value of cultural heritage in general, to address public engagement and audience development, and to promote archaeological sites, parks, museums. The development of public archaeology as a field of study and the significant European conventions and documents released in the new millennium (Council of Europe 2005; Council of the European Union 2014) contributed to placing laypeople and sustainable development through the promotion of cultural heritage at the centre of the archaeological discourse. The commitment to public participation is of pivotal importance for archaeology, given the need to clearly demonstrate the extent of its economic and socio-cultural impacts. Once again, archaeological serious games can be a strategic asset for achieving these objects. Games, in fact, are increasingly being played online (on the browser) and/or on mobile devices. The latter ones, in particular, have a great potential to engage museum visitors. Mobile applications typically feature

images, bar-codes, and QR codes and exploit GPS position (e.g. the already cited *Inventum* and *Mi Rasna*). One popular type of feature in this perspective is 'location-gaming': the mechanic is that players go to places, do fast, simple tasks (like typing something into their phone, or simply confirming their presence by pressing a button in the app), and win a reward (either virtual points as in *Mi Rasna*, or the possibility to unlock new areas or options as in *Father and Son*, or even something tangible). The opportunity given by this mechanism motivates players on one hand and concretely involves cultural spaces on the other. This also allows museums, cultural institutions, and even local administrations to make themselves known, develop a network of multiple connections, and share common benefits deriving from this growth.

The 'visiting time expansion' is another very interesting key point and it is probably the litmus test for the effectiveness of the serious game project because it allows us to evaluate what links the virtual scenario offered by serious games and the real space they represent or refer to in their interconnection. Let us consider, for instance, an archaeological site: tourists may visit it and then go back home. If we are lucky and it happens that they are particularly interested in the historical context and/or amongst those who grow a particular fascination with the remains, they may be interested in coming back for a second visit or in developing their own research and curiosity afterwards. This is unfortunately a very rare occurrence. A serious game offers the opportunity to expand visitors' time *on* the site and it can provide further information about it (potentially much more than any guide can do during a generic visit – just think for example of the *Assassin's Creed Discovery Tours* (Porter 2018) – and providing more fun than a book for the majority of people). Moreover, it gives players the chance to choose when to access that information: in some cases, it can be done before the visit, in others after, but nothing prevents them to do it even during the visit. Serious games can be adjusted and conceived to offer a tailored experience and to overcome time and space limitations, especially given that the great challenge of our time is to move from a mass-oriented approach towards a personalized experience (Mortara et al. 2014). However, the benefits of serious games applied to archaeological heritage are not limited to a post-visit moment. As we have seen, they can actually be extremely convenient to engage a larger and more diversified audience and by doing so, to attract the public and bring people physically to specific places. In this sense, and by linking the touristic benefits to the educational ones, teachers can also use serious games to prepare the visit to a specific site or museum and, in particular circumstances, they can also be used as a temporary substitute for the visit (e.g. in case of bad weather referring to open-air archaeological sites or under any other inconvenience).

5 Future Challenges: Assessing Archaeological Serious Games

While several serious games have been developed in the last years, and despite the consensus that they have as a tool for instruction, still the literature stresses a lack of significant, extensive user tests: their effectiveness in terms of learning outcomes is still understudied mainly due to the complexity involved in assessing intangible measures (Bellotti et al. 2013). A systematic approach – based on established principles and guidelines – is necessary to enhance the design of serious games, and many studies lack a rigorous assessment. An important aspect of assessing serious games, like other educational tools, is the user performance assessment. This is an important area of exploration because serious games are intended to evaluate the learning progress as well as the outcomes. This also emphasizes the importance of providing appropriate feedback to the player. Moreover, performance assessment enables adaptability and personalization to meet individual needs in various aspects, such as learning styles, information provision rates, feedback, and so forth. Despite the globally growing interest in digital game-based learning and the significant efforts in researching and evaluating serious games, considerable weaknesses remain, including a lack of comprehensive frameworks for comparative evaluation: it is possible to evaluate a single title, problems come when you have to deal with more than one since it is very difficult to assess all the characteristics and the relative level of learning they allow for. While some game-based learning models have been developed in the literature (Mayer et al. 2014), they do not specifically tackle the evaluation of the learning impact produced in the learner by playing (serious) games. Despite many methodologies that have been elaborated in the last years (Catalano, Luccini, Mortara 2014), this remains nowadays one of the most important challenges researchers have to deal with.

This applies all the more to Italy where serious games are now slowly starting to be recognized as effective tools applied to cultural heritage enhancement. Further research is necessary to investigate in greater detail the real effectiveness of the various types of serious games, to define a methodology based on metrics and evaluation tools (Bellotti, Berta, De Gloria 2010), even more so those with archaeological content.

Since the purpose of a serious game is twofold: to be fun and entertaining, and to be educational, therefore, assessment of a serious game must consider both aspects of fun/enjoyment and educational impact.

Standardized assessment methods often take less time and are easier to conduct, and their results are readily interpretable. The easiest way in this sense is appropriate questionnaires administered

before and after the experience. However, in the case of an archaeological serious game, the intent is often much more complex than the mere learning aspect. Serious games have proven to potentially be an independent instrument, capable to bring information, lasting engagement, knowledge, and curiosity to a very diversified public. So, how to assess these further aspects? Recent studies have explored how play-based assessment can provide more detailed and reliable evaluation and emerging interests reflect the needs for an alternative or supplemental assessment tool to overcome limitations in the standardized approach. Play-based, or in-game, assessment (which can also be personalised in case of different users) can provide more detailed and reliable information, and the emerging interest in this field reflects the need for alternative and/or supplemental assessment tools to overcome limitations in the standard approaches (Bellotti et al. 2013).

I strongly suggest that, in the case of an archaeological serious game, all the aspects discussed before (the recognised benefits) must be taken into consideration and carefully assessed since they can be considered the learning outcomes linked to knowledge acquisition and skills development. Learning is a complex construct difficult to measure since it deals with personal behavior and emotions, and as Brockmyer et al. (2009) suggest, indirect measures of learning must be applied to assess the levels of engagement of players. These indirect measures in the archaeological field must take several other data into account as Koutsabasis (2017) suggests: from touristic numbers to scholastic results, and visitors' retention referable to the development of serious games project connected to a site or a museum, just to name a few. When it comes to the benefits of cultural heritage, as archaeologists, we know that this account cannot be calculated in terms of cash, but on a much larger scale, in reason of the productive assets generated by the activities that revolve around this particular type of resource and, I would add, in terms of public engagement: the most important economic calculation is the one that measures the wealth produced in terms that I would define 'intangible' and longer-term. We must, in fact, calculate the lower expenditure generated over time by that which we can define it as 'active social protection', that is, a cultural and participatory growth, which leads to responsible social behavior respectful of monuments, of landscape and environment. It goes without saying that by cross-referencing these – apparently – different data, a more detailed and defined assessment can be provided and the real benefits generated by an archaeological serious game can be estimated.

6 Conclusions

Serious games are an acknowledged tool for several purposes and amongst this range of possibilities, they can meet archaeological aims and so, represent an extraordinary medium for archaeological heritage dissemination and enhancement. First of all, they are a potential for public outreach and education, because they can strongly motivate learners and create awareness about a topic. They can also provide immersive environments where a large variety of users can practice knowledge and skills, and finally, they can be used as an asset to promote tourism and sustainable cultural heritage development. The design of a serious game, by its nature, requires the iterative collaboration of various experts with specific competencies and skills: educators, art directors, game designers, scriptwriters, software developers, graphic and sound designers. Additionally, a serious game in the archaeological heritage field cannot ignore the domain experts who select the educational contents and provide scientific validity and reliability. This teamwork aims at preventing the project from being just a game with an extra layer of pedagogical and pseudo-archaeological content. There needs to be a new breed of archaeologists who take an active participatory role, as consultants, developers, and writers. This is an ethical responsibility but also a very stimulating possibility for archaeologists who are interested in exploring new ways to engage the public, share their research and promote archaeological sites and knowledge: actually, this kind of new interdisciplinary professional profiles can take up the challenge and, through serious games, create a brand new set of opportunities for professionals and cultural and archaeological heritage (Mariotti 2020a).

However, for serious games to be considered a viable educational tool, they must provide some means of testing and progress tracking. As Kevin Corti of PIXELearning stated (Michael, Chen 2005). Again, archaeologists must take care of this issue in collaboration with other professionals. This will increase efficiency in designing games and authoring contents, which is a key requirement for the serious game industry. By doing so, archaeologists can also get the chance to explore how and why creating and communicating through serious games might provide powerful new ways to think about, do, and present the past.

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VaSto: un'edizione digitale interdisciplinare

Dario Brancato
Concordia University Montreal, Canada

Milena Corbellini
Alma Mater Studiorum Università di Bologna, Italia

Paola Italia
Alma Mater Studiorum Università di Bologna, Italia

Valentina Pasqual
Alma Mater Studiorum Università di Bologna, Italia

Roberta Priore
Alma Mater Studiorum Università di Bologna, Italia

Abstract The paper focuses on a case of interdisciplinary digital edition, developed in collaborative mode, whose ecdotic and interpretative innovations are analyzed. The edition – produced as part of the *VaSto* project – is dedicated to Benedetto Varchi's *Storia fiorentina*, which traces the events that took place in Florence between 1527 and 1538, commissioned by the Duke of Florence Cosimo I de' Medici in 1546, left unfinished and published only in 1721 in a version censored by Cosimo's circle. Due to the wealth of data on Florentine life at the time, it is considered a valuable source for scholars, historians and art historians, but the original version is still unpublished.

Keywords Digital scholarly editing. Authorial philology. Censorship. Benedetto Varchi. Renaissance history. Italian Renaissance literature.

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1 Un progetto digitale interdisciplinare

Il progetto qui presentato riguarda l'edizione digitale della *Storia fiorentina* di Benedetto Varchi, realizzata nell'ambito del progetto *VaSto*, promosso da Università di Bologna, Concordia University di Montreal e Cassa di Risparmio in Bologna (CarisBo), nell'ambito della ricerca, coordinata da Dario Brancato: *The Italian Art of Political Correctness: Patronage, Censorship, and Authorship in Florentine Renaissance Historiography (1548-1574)*.[1] Per il numero di istituzioni coinvolte e la loro diversa natura si tratta di un progetto interdisciplinare, che mette a sistema la collaborazione già esistente tra Università di Bologna e Concordia University, con il gruppo di ricerca del /DH.arc (Digital Humanities Advanced Research Centre)[2] e CarisBo per l'utilizzo delle tecnologie digitali in ambito didattico. L'edizione, di cui qui si presenta il prototipo realizzato sul *Proemio* della *Storia fiorentina* di Varchi, verrà realizzata mediante una serie di laboratori digitali che saranno attivati presso il Dipartimento di Filologia classica e Italianistica dell'Università di Bologna nell'a.a. 2021-22.

L'argomento è di grande interesse, perché riguarda non solo la *Storia fiorentina*, opera commissionata da Cosimo I, scritta da Varchi, ma pubblicata solo nel 1721, prima tappa di questa indagine testuale e storiografica, ma anche le altre due storie commissionate da Cosimo I e scritte a Firenze nel ventennio fra la fine degli anni '50 e '70 del Cinquecento: la *Historia della guerra di Siena* del piacentino Lodovico Domenichi[3] e la *Istoria de' suoi tempi* di Giovan Battista Adriani.[4] Trattasi di casi in cui committenza e autorialità si mostrano in forme diverse, e per questo più interessanti da indagare con il sussidio di un'edizione digitale: nel caso di Varchi, per l'intreccio, come si vedrà, tra volontà d'autore e revisione di committenza, per il Domenichi, nello studio di un manoscritto ancora inedito, in cui vanno inda-

Nell'ambito di una più generale collaborazione tra gli autori, i paragrafi del seguente articolo sono stati scritti rispettivamente da: Paola Italia (§§ 1 e 3); Dario Brancato (§ 2); Roberta Priore e Valentina Pasqual (§ 4); Roberta Priore (§ 5); Valentina Pasqual e Milena Corbellini (§ 6); Milena Corbellini (§ 7).

1 Social Science and Humanities Research Council of Canada, Insight Grant 2020-2023, file number 435-2020-0421.

2 `https://centri.unibo.it/dharc`.

3 Storia a cui il poligrafo, divenuto celebre come revisore editoriale della tipografia veneziana dei Giolito, si dedica dalla fine degli anni Cinquanta e che si trova tuttora manoscritta presso il cod. II.III.128 della Biblioteca Nazionale Centrale di Firenze (Piscini 1991; Bramanti 2001; Bramanti 2015, 24-33).

4 Storico ufficiale dei Medici, incaricato da Cosimo nel 1564, poco prima della morte del Varchi, di continuare la sua opera storiografica con la storia del proprio principato, pubblicata postuma e censurata, nel 1583, a cura del figlio Marcello, dopo la morte avvenuta nel 1579 (cf. Miccoli 1960; Albonico 1994, 1098-101; Fasano Guarini 2009, 91-9; Garavelli 2008).

gate le forme di scrittura e di reazione ad essa da parte della corte medicea, per Adriani con un caso di *authorship* che mette in gioco la volontà dell'autore, quella del committente (l'*entourage* mediceo) e le correzioni del revisore (il figlio Marcello). Il modello individuato per Varchi permetterà di rappresentare anche gli altri due testi storici, che presentano problemi tipologicamente meno complessi.

In tutti questi casi, la dimensione diacronica, garantita dall'edizione digitale, permette di studiare: 1. la genesi del testo, 2. la sua stabilizzazione, secondo la volontà dell'autore, 3. l'evoluzione relativa alle correzioni di 'revisione' e quella conseguente alle volontà del committente. Il prototipo elaborato, tuttavia, ha consentito di progettare ulteriori sviluppi dell'edizione digitale in un vero e proprio *knowledge site* (Tomasi 2016), che offre una concreta ambientazione digitale (mappe, *timeline*, link esterni) a luoghi, fatti, protagonisti, della Firenze rinascimentale dal 1527 al 1538, di cui questo testo offre uno straordinario e dettagliato racconto.

La dimensione didattica del progetto porta, da ultimo, a sperimentare un modello di edizione collaborativa sostenibile, a sviluppare nei partecipanti competenze digitali che sensibilizzino allo studio diacronico dei testi e alla necessità di farsi garanti della loro autorevolezza e affidabilità, mostrandone concretamente i meccanismi di censura e manipolazione e sviluppando nuove interpretazioni sulle ragioni di tali operazioni.

2 La *Storia Fiorentina* di Benedetto Varchi

La figura di Benedetto Varchi (1503-1565) fu al centro di una rete di relazioni intellettuali con i principali attori della cultura del Cinquecento fiorentino e non solo, e con cui ancora oggi è necessario confrontarsi, nel bene e nel male, per comprendere le trasformazioni politiche e culturali nella Firenze nei decenni centrali del secolo. Criticato lungo la maggior parte del XX secolo, Varchi ha suscitato nell'ultimo quarto di secolo un rinnovato interesse di studi che abbracciano i vari campi del sapere in cui egli si cimentò, dalla poesia latina e volgare alla filosofia, intesa *lato sensu* fino a comprendere discipline oggi separate, come la teoria artistica e, appunto, la storiografia.[5] Alla storia, però, Varchi fu introdotto non per sua scelta, ma per ordine di Cosimo de' Medici: il duca di Firenze, infatti, non era rimasto indifferente al prestigio accumulato da Messer Benedetto fra il 1539 e il 1541 a Padova (dove fu uno degli animatori dell'Accademia degli Infiammati), e volle sfruttarlo mettendo il letterato al

5 Per una panoramica aggiornata su Benedetto Varchi, si rimanda ad Andreoni 2020, con relativa bibliografia.

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centro di un progetto di promozione della lingua e della cultura fiorentina. Nel giro di pochi anni, a Varchi, fuoruscito dalle simpatie repubblicane, fu dunque consentito di rientrare in patria (1543), di essere eletto console dell'Accademia Fiorentina (1545), il principale centro di propulsione culturale controllato dal duca, e infine, fra il 1546 e il 1547 di ricevere il delicato compito di scrivere una storia che, continuando idealmente quella del Machiavelli, si concentrasse sul tumultuoso passaggio di Firenze dall'ultima Repubblica al principato (1527-1532).[6]

L'incarico non fu privo di polemiche: come si è scritto sopra, Varchi si era fino ad allora distinto per le sue doti di accademico e di poeta e per di più, al contrario di altri storici come Machiavelli o Guicciardini, non era stato fra i protagonisti degli eventi da lui narrati;[7] tuttavia ebbe modo di supplire a queste carenze raccogliendo un'immensa mole di dati grazie all'accesso libero all'archivio della Segreteria Vecchia (dove si custodivano tutti i documenti della Repubblica Fiorentina), ai mai interrotti contatti con gli esponenti di spicco del fuoruscitismo repubblicano (fra tutti Giovan Battista Busini e Jacopo Nardi), e a un'eccezionale biblioteca personale, che contava, fra l'altro, numerose opere storiche manoscritte (Bramanti [2002] 2017, 172-86; Brancato 2017, 47-8). Benché il suo lavoro fosse spesso interrotto da nuove e incessanti richieste del duca, Varchi si dedicò fino alla fine dei suoi giorni alla *Storia*: per volere di Cosimo – è bene specificarlo – essa oltrepassò il limite cronologico del 1 maggio 1532 che l'autore aveva fissato all'inizio del suo progetto e narrato nei primi dodici libri, comprendendo gli eventi fino al 1537-38, e avrebbe con tutta probabilità incluso anche la Guerra di Siena (1554-1555; Bramanti [2002] 2017, 191) se non fosse sopraggiunta la morte improvvisa. In tale occasione, tutti i materiali della *Storia* furono recuperati dal duca e riuscirono a salvarsi in gran parte alla distruzione e a conservarsi fino ad oggi (Brancato, Lo Re 2015). Cosimo, però, volle dare forma compiuta all'opera, in preparazione di un'edizione che però non vide la luce in quei tempi (Brancato 2020, 27-30), ma dovette aspettare fino al 1721 per essere pubblicata (Albonico 1994, 1085-6; Brancato, Lo Re 2015, 223-5).

6 Come si è accennato sopra, la *Storia fiorentina* uscì a stampa solo nel 1721 (Varchi 1721), ma negli anni successivi furono allestite altre tre edizioni: la prima pubblicata a Leida nel 1723 (Varchi 1723) e le altre, basate sul testo di Varchi 1721, rispettivamente a cura di Lelio Arbib (Varchi 1837-41, la cui seconda edizione, Varchi 1843-44, è ancora oggi il testo di riferimento) e Gaetano Milanesi (Varchi 1857-58).

7 Era questa l'accusa principale mossa al Varchi dai suoi detrattori contemporanei, dalla quale egli si schermì nel Proemio alla *Storia*: «[Io] non mi ritrovai in quel teatro come strione, nondimeno come spettatore v'intervenni; e suole molte volte accadere che più veggano e meglio giudichino d'alcuna o commedia o tragedia coloro i quali a vederla rappresentare intervengono, che quegli stessi non fanno, i quali a rappresentarla si trovano» (Varchi 1843-44, 1: 46).

Come già accennato sopra, attraverso Baccio Baldini, medico, bibliotecario e segretario ducale, la *Storia* fu sottoposta a una serie di operazioni editoriali al termine del quale il testo fu purgato dei dettagli politico-religiosi più scomodi, sfrondato degli elementi che appesantivano la narrazione e ricopiato nel manoscritto oggi conservato alla Biblioteca Palatina di Parma e segnato Palatino 342 (= Pr3; Brancato 2015; Brancato, Lo Re 2015, 215-7). Il testo stabilito dall'*entourage* mediceo fu vulgato in oltre cento testimoni manoscritti e a stampa (Brancato, Lo Re 2015, 217).

La fortuita sopravvivenza dei materiali varchiani, dagli spogli all'edizione manoscritta postuma di Baldini e Cosimo, dunque, ci consente di documentare – per ampie porzioni anche nei minimi dettagli – lo sviluppo dell'opera, che pertanto rappresenta un eccezionale caso filologico, il quale, sebbene sia stato studiato nell'impianto generale, rimane ancora poco esplorato nella dimensione microtestuale (Brancato 2018).

Il primo censimento dei testimoni della *Storia fiorentina* si deve a Simone Albonico, curatore dell'antologia degli *Storici e politici fiorentini del Cinquecento*: nella nota filologica, lo studioso ha anche individuato i materiali di sicura provenienza varchiana.

Diamo qui di seguito un elenco di tutti i testimoni d'autore contenenti redazioni della Storia e dei principali collettori di avantesti (Albonico 1994, 1074-6; Bramanti [2002] 2017, 191-5).

FL2 = Firenze, Biblioteca Medicea Laurenziana, Mediceo Palatino 168. Contiene avantesti e frammenti autografi dall'XI libro;
FL5 = Firenze, Biblioteca Medicea Laurenziana, Tempi 4. Contiene avantesti e frammenti autografi dall'XI libro;
FN7 = Firenze, Biblioteca Nazionale Centrale, II.I.176. Contiene, in versione autografa, la Dedicatoria, il Proemio e i libri I-IV; sono inoltre presenti (mani di vari copisti del Varchi) il libro IX e un frammento del X;
FN8 = Firenze, Biblioteca Nazionale Centrale, II.II.137. Contiene vari avantesti;
FN9 = Firenze, Biblioteca Nazionale Centrale, II.II.138. Contiene avantesti e frammenti (in varie redazioni) della Dedicatoria, del Proemio, dei libri I-IV e IX-XVI, in massima parte autografi; nel frammento del libro XIII si trovano le tracce degli interventi editoriali di Baldini;
FN10 = Firenze, Biblioteca Nazionale Centrale, II.II.139. Contiene: a) Dedicatoria e Proemio, b) frammenti dai libri II e III, c) il libro IX, d) un frammento dell'XI e i libri XV e XVI (mani di copisti con correzioni autografe); nella sezione d) si riscontrano alcuni interventi di Baldini;
FN20 = Firenze, Biblioteca Nazionale Centrale, II.III.102. Contiene avantesti;

FN21 = Firenze, Biblioteca Nazionale Centrale, II.III.103. Contiene avantesti;
RC4 = Roma, Biblioteca dell'Accademia Nazionale dei Lincei e Corsiniana, Cors. 1352 (44.G.8-9). Contiene la copia in pulito di Dedicatoria, Proemio e libri I-X; i libri XI e XII, sono autografi, ma coincidono con la redazione autoriale più avanzata di Varchi; su tutto il codice sono presenti i segni delle correzioni di Baldini.

Non bisogna dimenticare che le carte superstiti della *Storia* sono la testimonianza di un immenso cantiere rimasto ancora aperto dopo la morte del Varchi: allo stato attuale delle ricerche non è ancora chiaro quale fosse, vivente l'autore, lo statuto dei libri successivi al dodicesimo, oggi numerati da XIII a XVI, se fossero cioè stati licenziati o rimanessero ancora da rivedere e correggere. In secondo luogo, i diversi codici compositi con i materiali originali a noi pervenuti sono il risultato di un assemblaggio postumo, avvenuto nel XVII secolo, dei vari fascicoli sciolti e non organizzati e che rappresentano diversi movimenti del testo.[8] Inoltre, bisognerà distinguere fra redazioni vere e proprie e avantesti: le une, anch'esse da considerare in una prospettiva dinamica di testo in evoluzione, contengono già una narrazione organica dei singoli eventi, sebbene ancora fluida nel suo insieme; gli avantesti, invece, cioè l'insieme di appunti, riassunti e spogli di scritti storici e documenti (originali e in copia) che servirono a Varchi per l'allestimento del suo lavoro, per quanto utili allo studio delle fonti del Varchi e del suo modo di raccogliere i dati, non rientrano nello scopo del presente articolo, se non per documentare il lavoro preparatorio dello storico.

L'evoluzione del testo può essere documentata passo per passo per molti libri: in generale, frammenti o redazioni antiche (anche plurime) della Dedicatoria, del Proemio e dei libri I-IV e IX-XVI si trovano in FN9, FL2 e FL5. Dedicatoria, Proemio e i primi quattro libri si conservano, autografi e in redazione stabile, in FN7 (una redazione anteriore dei libri II-III, indistinti, si trova in FN10); per i libri V-VIII sopravvive la sola copia in pulito di RC4; per il libro IX disponiamo, oltre agli sbozzi di FN9, una redazione intermedia in FN10, poi ridotta e trascritta in duplice copia in FN7 e RC4. I libri X-XII completi sono contenuti in RC4; del libro XIII ci sono giunti solamente due brevissimi frammenti, entrambi in FN9, il secondo dei quali comprende, in redazione diversa, anche alcuni fatti poi trattati più distesamente nel libro XIV. Infine, la copia in pulito (ma non ancora finalizzata)

8 Ciò trasse in inganno i curatori antichi e moderni dell'opera: Francesco Settimanni, cui si deve l'*editio princeps* del 1721, contaminò la lezione d'autore con quella censurata da Cosimo e Baldini, e in ciò fu seguito da Lelio Arbib, nell'edizione ancora oggi citata; ancora peggio fece Gaetano Milanesi, il quale contaminò ulteriormente tali lezioni con antiche redazioni della *Storia* (Albonico 1994, 1086-7). La sola edizione che riproduce più o meno fedelmente la *vulgata* censurata è quella pubblicata in Varchi (1723).

dei libri XV e XVI si trova in FN10. Il codice Corsiniano RC4 è dunque il testimone in cui si trovano i primi dodici libri allo stadio autoriale più avanzato e sui quali intervenne materialmente Baldini. La mano del segretario di Cosimo, però, si nota anche nelle parti non incluse in RC4: nelle carte superstiti dell'inizio del XIII libro (FN9, cc. 369*r*-373*r*, corrispondente a circa un quinto del libro) e nella copia in pulito dei libri XV e dell'inizio del XVI.

L''edizione' voluta da Cosimo e realizzata dal Baldini si trova in Pr3, che, come si è affermato sopra, contiene la *Storia* in sedici libri ed è probabilmente il manoscritto di dedica fatto allestire dopo la morte dell'autore mettendo assieme la lezione *post censuram* oggi conservata fra le carte del Varchi: RC4 (Dedica, Proemio, libri I-XII), FN9 (prima parte del libro XIII) e FN10 (libri XV-XVI). Ciò si può verificare anche da un raffronto superficiale fra i materiali d'autore e il codice Palatino Parmense, nel quale sono sistematicamente omesse le parti segnate per l'espunzione in RC4, FN9 e FN10. Tuttavia non ci sono pervenute redazioni autografe o idiografe per una lunga porzione di testo, corrispondente a gran parte del libro XIII e a tutto il XIV (Varchi 1843-44, 3: 3-247), e pertanto, dovendo fare affidamento solo su Pr3, rimane difficile determinare esattamente quale operazione editoriale fosse stata effettuata su questi libri, né è del tutto chiaro per quale motivo Baldini si risolvesse a includerli nel testo finale.[9]

Non è però peregrino affermare che RC4 costituisca il primo stadio compiuto dell'opera, e la parte dell'opera sicuramente licenziata dall'autore. Il testo base di questo codice è vergato da quattro mani, segnalate da Varchi in un appunto e verificate da riscontri paleografici: le prime tre sono quelle di amici e allievi di Messer Benedetto, Lelio Bonsi (Dedicatoria, Proemio, libri I-IX), Piero della Stufa (inizio del libro X) e Alessandro Del Serra (seguito del libro X, alcuni passi del libro XI); la quarta è quella dell'autore (libro XI-XII). Sul testo base intervengono quindi, in ordine cronologico: a) i copisti per correggere eventuali errori meccanici; b) l'autore, a più riprese, per apportare correzioni o modifiche al testo; c) le mani dei censori, Baldini in massima parte, per segnare le parti destinate alla censura, correggere errori fattuali o aggiungere informazioni supplementari, scrivere frasi di raccordo fra i vari pezzi cassati e fornire informazioni metatestuali. I brani da cassare sono in genere segnalati o con un tratto di penna verticale lungo il bordo del testo o tramite sottolineatura.

Per evidenziare quanto sia produttiva l'operazione di studio delle varianti, varrà dunque la pena di fornire due esempi, entrambi dal Proemio, dei tipi b) e c) di questi interventi.

Il primo esempio (RC4, c. 8*v*) **[fig. 1]** chiarisce i vari ripensamenti di Varchi nel fissare al 1 maggio 1532 il *terminus ad quem* per la sua

9 Una discussione dettagliata del problema si trova in Brancato 2018.

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narrazione: nel sintagma «primo giorno di Maggio» Varchi depenna «primo» e «di Maggio» sostituendoli nell'interlinea superiore con «ventisettesimo» e «d'Aprile». Successivamente, l'autore cambia idea, depennando «ventisettesimo d'Aprile» e aggiungendo nell'interlinea inferiore «primo», ulteriormente depennato a favore di «27». Infine, per paura di rendere illeggibile il testo, preferisce ripristinare la lezione originaria «primo giorno di Maggio» riportandola sul margine destro della carta dopo aver cassato «giorno».

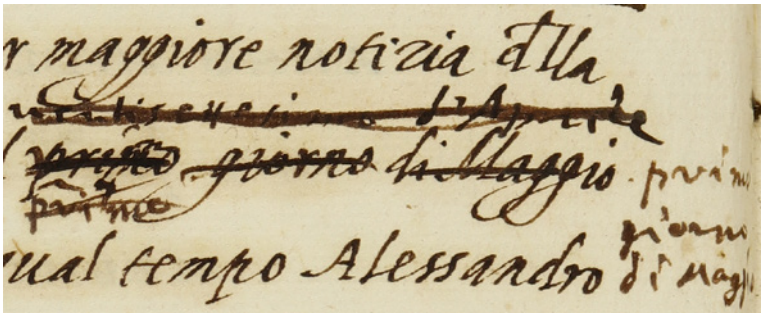

Figura 1 RC4, c. 8*v*, mano di Lelio Bonsi con correzioni autografe

Gli interventi posteriori alla morte dell'autore si possono invece comprendere meglio nel secondo esempio (RC4, cc. 10*v*-11*r*) **[fig. 2]**: qui, infatti, si trova l'avvio di un lungo brano di quattro carte destinato alla cassatura. Il testo prima della 'rassettatura' recita:

> Conciosia che, oltra le altre cose, non ritrovandosi nella Segreteria alcuni libri publici, ne i quali erano le cose dello stato e della guerra più segrete e più importanti notate, percioché furono, secondo che coloro dicevano a cui la cura d'essi toccava, a papa Clemente, il quale instantissimamente gli chiedea, dopo l'assedio in diligenza mandati subito, fui costretto non pure a leggere, ma notare e intavolare per l'ordine dell'alfabeto, e poco meno che trascrivere, non solo molti libri dei signori Dieci di libertà e pace, e molti delle Riformagioni […]; ma volgere eziandio e rivolgere non pochi zibaldoni (che così gli chiamano) e parte scartabelli e scartafacci.

Baldini segna le cc. 10*v*-12*r* prima con una linea verticale lungo il bordo esterno del testo; poi, a c. 10*v*, sottolinea la porzione da «oltra le altre cose» a «libri publici, ne i»; quindi delimita meglio le parti da eliminare, depennando «le» e «alcuni», inserendo dopo quest'ultima un segno a forma di angolo retto, che in genere indica l'inizio o la fine del testo da espungere (si veda, per esempio, «percioché furono» o «e intavolare») e sottolineando «fui costretto»; infine scrive le

parti di raccordo sul margine sinistro «al vedere tutti», «volsi» e il passo che comincia con «molte scritture e publiche e private». Tuttavia, un'altra mano, dal tratto più sottile, apporta ulteriori ritocchi a quelli di Baldini: l'articolo «i» dopo «tutti», «ancora» dopo «volsi» e il segno di richiamo dove innestare la correzione più lunga di Baldini. Il passo 'rassettato', quindi, riduce quasi quattro carte di testo a poco più di una frase (in corsivo i raccordi aggiunti dai censori):

> Conciosia che, oltra *al vedere tutti i* libri publici, ne i quali erano le cose dello stato e della guerra più segrete e più importanti notate, *volsi ancora* non pure leggere, ma notare *molte scritture e publiche e private dalle quali io credetti potere in maniera alcuna ritrovare la verità delle cose seguite in quei tempi che io doveva scrivere.*

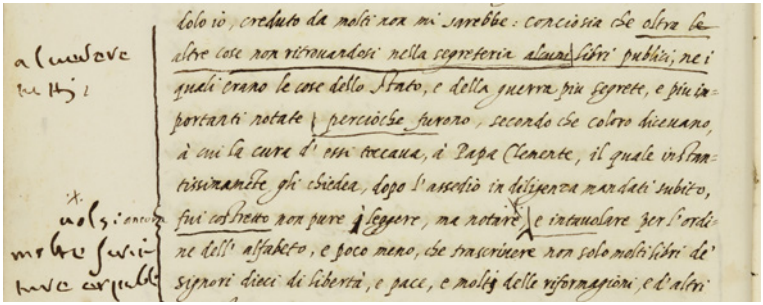

Figura 2 RC4, c. 10*v*, correzioni di Baldini e di mano sconosciuta

3 Ecdotica delle edizioni digitali a testimone unico con varianti d'autore: il caso Varchi

Il caso delle edizioni a testimone unico è uno dei più diffusi nel panorama delle edizioni digitali. Nonostante i cataloghi tutt'oggi a disposizione – quello curato da Greta Franzini,[10] e quello di Patrick Sahle[11] – non diano la possibilità di interrogare le banche in relazione alla tipologia di edizione, da una valutazione quantitativa effettuata su entrambi i cataloghi più della metà delle edizioni digitali è costituita da edizioni a testimone unico, e nella maggioranza dei casi si tratta di edizioni diplomatiche, ovvero edizioni in cui il testo ha una stretta interdipendenza con il documento rappresentato. Questa spinta, che potremmo definire 'bédieriana', dipende da alcuni elementi peculiari all'ecosistema digitale: 1. la possibilità di una corrispon-

10 https://dig-ed-cat.acdh.oeaw.ac.at/.

11 https://v3.digitale-edition.de/.

denza biunivoca tra documento e testo; 2. Il «prestigio storico» del documento rispetto alla ricostruzione ideale del testo; 3. La valorizzazione del documento, offerta dalla tecnologia digitale, dalla magnificazione al trattamento post-produzione dell'immagine (Italia 2020, 52-56). Paradossalmente, proprio nel momento in cui il testo si smaterializza, assistiamo a una centralità del documento, a una sua valorizzazione, in ragione della sua originalità, del maggiore contenuto di verità offerta dal documento rispetto al testo.

La diffusione delle edizioni a testimone unico, con prevalenza di edizioni diplomatiche, ha portato alla individuazione di una tipologia di edizioni, definite «edizioni documentarie» (Pierazzo 2014; Pierazzo, Mancinelli 2019), che sono proprie della filologia digitale, e che, nella filologia 'analogica' (ovvero la filologia il cui fine è una edizione a stampa) sono considerate edizioni diplomatiche o semidiplomatiche. Si veda la definizione offerta dal *Parvum Lexicon Stemmatologicum*:

> A documentary edition is an edition based on a single manuscript, often the supposedly best manuscript, the *codex optimus*, but in some cases also a manuscript of particular literary or linguistic value. In the latter case, the codex optimus will usually have been edited, so making a new documentary edition is a way of supplementing the editions of the work in question.[12]

La disponibilità di 'spazio testuale' garantita dall'ambiente digitale, infatti, non è di per sé un impedimento alla realizzazione di edizioni critiche, anzi, può affiancare alle edizioni critiche la riproduzione diplomatica dei singoli testimoni su cui l'edizione critica si basa (Fischer 2019; Monella 2019). Se, infatti, l'edizione digitale presenta una edizione critica, la possibilità di visualizzare anche tutti i singoli testimoni non costituisce un disconoscimento o una *diminutio* dell'edizione stessa, ma, anzi, un suo completamento: la possibilità di potere seguire, direttamente a contatto con il documento, il percorso che ha portato alla costituzione del testo, alla realizzazione dell'edizione critica.

In questa prospettiva, diversamente dalla filologia 'analogica', nella filologia digitale edizione critica ed edizione diplomatica non vengono più contrapposte come due soluzioni antitetiche e reciprocamente escludenti, ma, al contrario, come due edizioni complementari: da un lato l'edizione diplomatica di un testimone dà la possibilità di confrontarlo analiticamente con il documento corrispondente, dall'altro l'edizione critica adempie al compito che il filologo si deve sempre prefiggere: quello della *constitutio textus*, e delle scelte rispetto ai luoghi varianti. Viene in tal modo superata la prospettiva per cui l'ecosistema digitale provoca un'abolizione delle edizioni critiche, inte-

12 https://wiki.helsinki.fi/display/stemmatology/Edition%2C+documentary.

grata invece dalla possibilità di presentare tutti i testimoni della tradizione. Nella dicotomia pasqualiana (Pasquali [1934] 2003): 'storia della tradizione' e 'critica del testo', l'ecosistema digitale dà la possibilità di rappresentare analiticamente e singolarmente la storia della tradizione (con la riproduzione dei singoli testimoni), ma adempie anche al compito principe della filologia: esercitare nella forma più conveniente possibile la critica del testo.

La tradizione testuale della *Storia fiorentina* costituisce un caso esemplare, recando un testimone unico, parte autografo e parte apografo con correzioni autografe (documentato in quattro sedi diverse), del quale, grazie all'edizione digitale, sarà possibile dare diverse forme di edizione, complementari fra loro:

1. **Edizione diplomatica** (semi-diplomatica), che conservi tutte le peculiarità del testo originario, compresa la *mise en page*, gli *addenda*, le correzioni genetiche ed evolutive del testo (cassature, riscritture, inserzioni interlineari e allineari) e che si limiti a distinguere le *u* dalle *v* e a sciogliere le abbreviazioni, segnalandole con il carattere *corsivo* (es.: Mons*ignor*) **[fig. 3]**.

Figura 3 Edizione diplomatica della *Storia Fiorentina* di Benedetto Varchi, c. 8*v*

2. **Edizione critica**, che costituisca il testo in modo da garantirne la *piena leggibilità* (attraverso interventi sulla punteggiatura, la razionalizzazione di maiuscole/minuscole, la scrizione unita/separata, la modernizzazione delle grafie latineggianti, a esclusione della *h* etimologica, la conservazione dei numeri cardinali, delle date in lettere, la correzione dei numeri romani in arabi, come si vedrà dettagliatamente nel par. 4) e ne faccia percepire la *diacronia interna*, attraverso una differenziazione cromatica, relativamente alle correzioni genetiche (apografe), le correzioni evolutive (autografe), e le correzioni apportate da altra mano, identificata da Dario Brancato, come si è visto, in quel-

la del revisore di Cosimo I: Baccio Baldini (testo contrassegnato da diversa marcatura cromatica, un fondino azzurro) **[fig. 4]**.

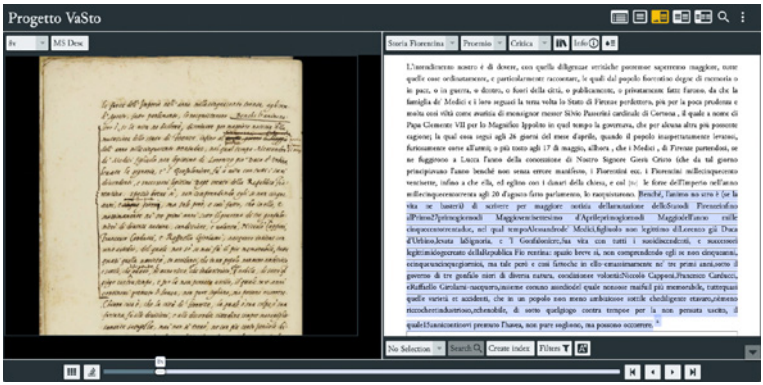

Figura 4 Edizione critica della *Storia Fiorentina* di Benedetto Varchi, c. 8*v*

Come mostrano gli esempi riportati, il caso della *Storia fiorentina* consente di dare una soluzione ecdotica a un caso di filologia d'autore particolarmente complesso. Il testimone, infatti, reca quattro tipi di correzioni:

1. Correzioni genetiche di mano del copista: Lelio Bonsi
2. Correzioni evolutive di mano di Benedetto Varchi
3. Correzioni evolutive di mano di Baccio Baldini (censure)
4. Correzioni evolutive di mano non identificata.

Mentre le correzioni del primo tipo e del secondo tipo portano alla costituzione del testo secondo l'ultima volontà dell'autore, le correzioni del terzo e del quarto tipo portano al testo secondo la volontà del committente, Cosimo I, messa in opera dal revisore Baccio Baldini.

Per un'edizione cartacea, l'editore critico avrebbe dovuto scegliere quale lezione stabilire a testo, privilegiando:

1. Ultima volontà dell'autore (testo comprensivo delle correzioni 1 e 2)
   Con due fasce di apparato: genetico (correzioni 1 e 2) ed evolutivo (correzioni 3 e 4)

oppure

2. Ultima volontà del revisore (testo della *vulgata*, comprensivo delle correzioni 3 e 4)
   Con una sola fascia di apparato tutta genetica (comprensiva delle correzioni 1, 2, 3, 4).

L'edizione critica digitale, invece, permette di superare anche la dicotomia tra l'esigenza di rappresentare l'ultima volontà dell'autore e quella di documentare il testo così come è stato conosciuto nella *vulgata* voluta da Cosimo (e diffusosi poi, come si è visto, nelle edizioni a stampa a partire da quella del 1721), poiché nell'edizione critica digitale la marcatura (illustrata dettagliatamente nel par. 4), permette di rappresentare entrambe le edizioni e dà al lettore la possibilità di seguire, testo a fronte, la *trascrizione diplomatica* del documento **[fig. 3]**, oppure di leggere distesamente il *testo critico*, con le sue evoluzioni interne, relativamente alle correzioni tardive d'autore, e agli interventi censori **[fig. 4]**.

I vantaggi sono evidenti: il lettore non è costretto a rinunciare allo studio analitico, dal punto di vista paleografico, linguistico, stilistico del documento (edizione diplomatica), per una lettura distesa del testo (edizione critica), e può seguirne contemporaneamente le variazioni interne, distinguendo le varie stratigrafie correttorie, e studiandole separatamente grazie alla intuitività data dal colore, che sostituisce, nella rappresentazione, le sigle di identificazione dell'edizione cartacea (che sono tuttavia presentate nella *Guida alla lettura*).

La marcatura di nomi di persona, luoghi e date (illustrati analiticamente nel par. 4), aggiunge l'*annotazione* necessaria per inserire in un contesto storico gli elementi testuali, fatto tanto più urgente per un testo storiografico, e per un'analisi approfondita delle varianti d'autore e di quelle apportate dal revisore, spesso correlate a situazioni, personaggi, vicende che richiedevano una particolare illustrazione, oppure che vengono direttamente censurate. La presenza di strumenti di contestualizzazione storico-geografica: 1. *Timeline*, 2. Mappe geografiche, 3. Richiamo a opere d'arte citate (illustrate analiticamente nel par. 6), completano il testo, fornendo al lettore, a richiesta, tutte le informazioni che in un'edizione cartacea non potrebbero essere presenti contemporaneamente.

L'edizione digitale così realizzata risolve vari problemi ecdotici, mostrando l'interazione proficua di edizione diplomatica, edizione critica, edizione genetica ed edizione annotata, e presentano il testo in un *knowledge site* che ne contestualizza la storia e i contenuti.

4 Per uno standard di codifica e visualizzazione per la filologia d'autore

La costruzione dell'edizione digitale è partita dalle carte 8*r*-13*r* di RC4, il manoscritto finora «inedito e inutilizzato» (Brancato, Lo Re 2015, 202). Le carte costituiscono il Proemio della *Storia fiorentina*, ovvero il caso di studio scelto per mettere a sistema le modalità di codifica e rappresentazione che sono state poi applicate all'intero testo.

La complessità delle edizioni digitali deriva dalla «complessità combinata della storia testuale di un'opera e dei possibili approcci critici da un lato e delle possibili modalità di realizzazione in ambiente elettronico dall'altro» (Meschini 2013, 28). La codifica si colloca come anello centrale, tra le questioni filologiche che il testo pone e la sua visualizzazione, formalizzando il linguaggio naturale e rendendo il testo *machine readable*. È per questo motivo che la codifica richiede «un lungo lavoro di *pre-editing*, preparazione del testo» (Busa 1997). Tale preparazione ha tenuto conto dei requisiti richiesti dall'edizione scientifica, formalizzati dalla marcatura: visualizzazione del facsimile del manoscritto; edizione diplomatica con particolare interesse alla stratigrafia del testo; comparazione del testo stabilito dal curatore prima e dopo la censura di Baldini; valorizzazione di entità descritte nel testo (persone, luoghi, date).

Nonostante un vivace dibattito attorno alle diverse possibilità di codifica alternative, come lo *standoff markup* che si contrappone alla linearità della marcatura in TEI,[13] lo schema di codifica che è stato utilizzato è basato sul linguaggio XML/TEI,[14] in quanto a largo uso, standardizzato, interoperabile, e che può essere implementato nel tempo.

Trattare i testi con la marcatura XML/TEI, infatti, significa anche riconoscere che

> standards need to be adopted if we are to push digital editions in a social direction or integrate their resources. Without guidelines such as TEI, exchange and repurposing of data will not be possible and electronic editions will be used as standalone objects with their own set of characteristics, objectives and requirements. (Franzini et al. 2016, 176)

13 Secondo la proposta di Desmond Schmidt (2012, 131) lo *standoff markup* risolve alcune criticità oggettive legate all'*overlapping* di categorie di marcatura diverse, specialmente la variazione testuale (Italia 2020, 142-3).

14 Si fa riferimento qui alla versione 4.1.0 delle Guidelines TEI P5, `https://www.tei-c.org/release/doc/tei-p5-doc/en/html/index.html`.

Se XML/TEI può essere a tutt'oggi considerato lo standard per la marcatura di testi, non si può dire lo stesso per quanto riguarda uno standard per la visualizzazione delle edizioni digitali.

Durante la fase di modellizzazione dell'interfaccia dell'edizione e considerando le naturali limitazioni di progetto (tempo, *budget*, etc.), è stata presa in esame la possibilità di implementare una *Graphic User Interface* (GUI) in grado di ospitare le peculiarità dell'edizione oppure riutilizzare un *tool* di visualizzazione già esistente. Nel primo caso è possibile personalizzare il design dell'edizione digitale a seconda delle necessità dell'editore; mentre il riuso di un *tool* esistente garantisce robustezza grazie ad una attività di *testing* già attuata, accessibilità e usabilità della GUI e la possibilità di presentare un lavoro completo in tempo breve. Rosselli Del Turco (2017, 227) sostiene che nello stato dell'arte vi è una forte mancanza di *tool* abbastanza generici per visualizzare, manipolare ed analizzare le edizioni digitali in un ambiente globale. A questo si aggiunge il panorama frammentato della visualizzazione delle edizioni digitali online, risultato della mancanza di standard e di un approccio collaborativo.

Un'edizione digitale deve rendere le scelte del filologo fruibili da parte del lettore specialista, in contesti di ricerca e accademici, ma anche da parte del lettore comune, grazie alla intuitività delle scelte ecdotiche favorite dall'ecosistema digitale (come, per esempio, l'uso di marcatori cromatici, la visualizzazione della stratigrafia e la possibilità di mettere sempre la variante nel contesto invariante). A questo scopo la realizzazione di un'interfaccia attrattiva non è garanzia di 'usabilità' dell'edizione, fondamentale invece rimane la necessità di metodi di visualizzazione condivisi.

In questo contesto, EVT 2[15] si è candidato come perfetto strumento di visualizzazione dell'edizione digitale, in quanto risulta abbastanza generico, robusto, nonostante la complessità del sistema, e facile da usare: si tratta di uno strumento aggiornato,[16] *open-source* e flessibile.

Nonostante ciò, nella costruzione dell'edizione secondo tale modello, è stato necessario riadattare EVT 2 alle esigenze della filologia d'autore. I limiti del *software* sono emersi maggiormente per la realizzazione dell'edizione critica monotestimoniale, in quanto – al fine di rappresentare a testo l'ultima volontà dell'autore – è stato necessario un riuso 'creativo' delle possibilità offerte da EVT 2, che consente di rappresentare e confrontare il testo di diversi testimoni; nel caso della *Storia fiorentina*, invece, ci troviamo davanti a un manoscritto unico, sul quale si depositano diverse volontà, ovvero l'ultima volon-

15 `http://evt.labcd.unipi.it/`.

16 Si noti che EVT è costantemente aggiornato e seguito dal team di sviluppo coordinato da Roberto Rosselli Del Turco.

tà dell'autore e le revisioni ad opera di Baccio Baldini, volute da Cosimo I. Per conformarci alle necessità dell'interfaccia, si è operata, così, una distinzione tra le due 'volontà' che, per esigenze di marcatura e rappresentazione, abbiamo definito come due diversi 'testimoni' (*witnesses*), e cioè RC4 (il manoscritto corrispondente all'ultima volontà dell'autore) e RC4c (lo stesso manoscritto, comprendente le correzioni censorie di Baldini). RC4c risulta così un testimone fittizio da un punto di vista fisico, perché è lo stesso manoscritto RC4, ma reale da un punto di vista concettuale, perché è costituito dall'ultima lezione (censurata) di RC4 che è molto diversa dall'ultima lezione (d'autore) dello stesso testimone.

Per l'edizione della *Storia fiorentina* di Varchi sono stati quindi adottati *standard* di codifica che garantivano interoperabilità (XML/TEI), usabilità e visualizzazione (EVT) e sostenibilità. Quest'ultima, in particolare, tra le esigenze messe in luce da Shillingsburg (2017, 133) per un'edizione digitale ideale, viene garantita grazie al centro di ricerca DH.arc, che ne assicura la gestione e 'manutenzione' nel tempo.

5 La codifica come anello centrale del workflow: il Proemio

Il testo del Proemio della *Storia fiorentina* è stato codificato in due macro-elementi: <teiHeader> e <text>. Il primo è il contenitore dei metadati relativi alla pubblicazione, la descrizione del testo base, i criteri di edizione, la dichiarazione dei testimoni utilizzati. È qui che vengono definiti, attraverso un identificatore unico, gli elementi che verranno poi richiamati nel <text>.

La marcatura ha seguito le esigenze ecdotiche individuate dall'editore. La *homepage* dell'edizione prevede le riproduzioni del manoscritto e il testo in edizione semi-diplomatica, che replica le caratteristiche strutturali del manoscritto: la *mise en page*, la divisione per pagine (*tag* <pb>) e le righe (<lb/>), mentre le abbreviazioni sono state sciolte e le *u* sono state distinte dalle *v*.

Nell'*header* del documento.xml è stata descritta la presenza di quattro diverse mani nel testo (vedi *supra*, par. 3), secondo la seguente marcatura:

```
<handDesc>
  <handNote scribe="Bonsi" xml:id="A1">Mano di Lelio Bonsi,
  testo base su RC4;</handNote>
  <handNote scribe="Varchi" xml:id="A2">Mano di Benedetto
  Varchi, revisioni;</handNote>
  <handNote scribe="Baldini" xml:id="A3"> Mano di
  Baccio Baldini, interventi di correzioni e
  aggiunte</handNote>
  <handNote scribe="N.I." xml:id="A4">Altra mano non
  identificata</handNote>
</handDesc>
```

Il testo è esemplato, come si è detto, dal copista del Varchi, Lelio Bonsi (penna che è stata denominata A1), e rivisto dallo stesso autore (penna denominata A2). La mano di Baccio Baldini è responsabile della 'rassettatura', voluta da Cosimo I (penna denominata A3), mentre gli ultimi ritocchi, pressoché ininfluenti sul piano della censura, sono di responsabilità di un anonimo revisore (penna denominata A4). Nell'*header* del file XML, all'interno di <MsDesc>, sono state definite le tre penne presenti, così che all'interno del body si può individuare e, poi, in fase di visualizzazione, distinguere attraverso colori differenti la stratigrafia dell'opera: @hand è, infatti, usato come attributo delle aggiunte (<add>) e cassature (<del>) rispetto al testo base, vergato da quella che abbiamo definito la mano A1. Inoltre, grazie all'attributo @place aggiunto al *tag* <add>, si definisce e quindi si rappresenta la posizione delle aggiunte all'interno del manoscritto.

La rappresentazione delle differenti mani solleva una questione, centrale in filologia, circa le diverse volontà presenti sul manoscritto e riguarda quale testo si debba restituire al lettore. Il testo critico stabilito da Dario Brancato restituisce l'ultima volontà dell'autore, dunque il testo di RC4 al netto delle revisioni di Baccio Baldini, con la possibilità però di confrontare il testo secondo la volontà dei curatori (Brancato, Lo Re 2015, 218). Si è operata quindi una distinzione, come si è detto, tra le due 'volontà' definite come due 'testimoni' (*witnesses*) differenti nell'*header*, RC4 e RC4c:

```
<listWit>
  <listWit xml:id="rec1_wits" ana="#rec1" resp="#D.B.">
    <head>Author Version</head>
    <witness xml:id="RC4">
     <msDesc>
       <msIdentifier>
         <settlement>Roma</settlement>
         <repository>Accademia    Nazionale    dei    Lincei    e
       Corsiniana</repository>
         <idno>Cors. 1352 (44.G.8-9) (=RC4)</idno>
       </msIdentifier>
       <msContents>
         <msItems>
          <locus from="8r" to="13r">8r - 13r</locus>
          <title type="work" subtype="prose">Proemio</title>
         </msItems>
       </msContents>
       <physDesc>
         <handDesc>
          <handNote  scribe="Bonsi"  xml:id="A1">Mano  di  Lelio
          Bonsi, testo base su RC4;</handNote>
          <handNote scribe="Varchi" xml:id="A2">Mano di Benedetto
          Varchi, revisioni;</handNote>
         </handDesc>
       </physDesc>
     </msDesc>
    </witness>
    <witness xml:id="RC4c">
     <msDesc>
       <msIdentifier>
         <settlement>Roma</settlement>
         <repository>Accademia    Nazionale    dei    Lincei    e
       Corsiniana</repository>
         <idno>Cors. 1352 (44.G.8-9) (=RC4, censured)</idno>
       </msIdentifier>
       <msContents>
         <msItems>
          <locus from="8r" to="13r">8r - 13r</locus>
          <title type="work" subtype="prose">Proemio</title>
          <incipit/>
          <explicit/>
         </msItems>
       </msContents>
       <physDesc>
         <handDesc>
          <handNote  scribe="Baldini"  xml:id="A3">Mano  di  Baccio
          Baldini,      interventi      di      correzioni      e
          aggiunte;</handNote>
          <handNote  scribe="N.I."  xml:id="A4">Altra  mano  non
          identificata;</handNote>
         </handDesc>
       </physDesc>
     </msDesc>
    </witness>
</listWit>
```

RC4 rappresenta dunque l'ultima volontà dell'autore con le penne A1 e A2, mentre RC4c è quella che può essere definita come 'copia censurata', cioè il 'testimone' che contiene le penne A3 e A4. In questo modo è possibile non solo individuare quei luoghi dove il revisore è intervenuto sul testo di RC4, ma anche di confrontare i due 'testimoni'.

Seguendo tale riuso delle possibilità dateci dallo standard TEI e, poi, dalla visualizzazione, si sono confrontate le due versioni del testo, aprendo un vero e proprio *tag* di apparato secondo il *parallel segmentation method*, dove la lezione corrispondente all'ultima volontà dell'autore, che l'editore ha scelto di mettere a testo, è marcata con <lem> e la lezione di RC4c (la copia censurata) viene restituita nel *tag* <rdg>.

Nel testo dell'edizione critica, che si propone come una 'edizione per il lettore', si è provveduto inoltre a normalizzare l'uso della punteggiatura, delle maiuscole e minuscole, della scrizione unita e separata, a eliminare le grafie latineggianti (con l'eccezione dell'*h* etimologica), a conservare i numeri cardinali e le date in lettere (trasformando al contrario quelli in cifre romane in arabe o a traslitterare nel caso di magistrature fiorentine, es. *i Dieci*). Tutte le normalizzazioni, nell'edizione diplomatica restano fedeli al manoscritto, questa differenza è resa nella marcatura attraverso il *tag* <choice> che consente di sottolineare la differenza tra quanto si visualizza nell'edizione diplomatica (<orig>) e la scelta che l'editore opera per il testo critico (<reg>).

Rimane, però, un altro livello di codifica che attraversa trasversalmente l'edizione diplomatica e la critica e che mette in luce gli elementi più rilevanti all'interno del testo, quali date (<date> con attributo @when), persone (<persName>) e luoghi (<placeName>): la marcatura di questi elementi permette di fornire un commento o un rimando ad informazioni esplicative collegate al testo. Tale marcatura non solo permette di generare un indice di tali elementi (*named entities*), ma ne individua anche le occorrenze all'interno del testo. Per quanto riguarda la marcatura delle 'persone', essa viene definita nell'*header* e richiamata poi nel *body*: di ognuno viene fornito un identificativo unico, VIAF (Virtual International Authority File), e un link diretto al lemma corrispondente nella versione digitale del *Dizionario Biografico degli italiani*.

I diversi livelli dell'edizione consentono, dunque, non solo di valorizzare il testo nella sua trasformazione, di metterne in evidenza la stratigrafia e insieme l'evoluzione, ma anche di estrarre dati relativi ai contenuti dell'opera; un'opera, nel nostro caso, estremamente ricca di informazioni non solo letterarie che, attraverso la marcatura, con la sua traduzione in «segni» (Busa 1997), in linguaggio leggibile dalla macchina, si rivela sempre più parlante anche per il lettore.

6 L'infrastruttura

Quando il progetto *VaSto* è nato, EVT presentava una versione EVT 1 (Rosselli Del Turco et al. 2014-15), che poneva la sua attenzione verso le edizioni diplomatiche, e una versione EVT 2 beta 1 (Rosselli Del Turco et al. 2019), che si prefiggeva l'obiettivo di rappresentare le edizioni critiche. EVT 2 beta 1 aveva anche il vantaggio di visualizzare un gran numero di *features* in edizione diplomatica, critica ed interpretativa. Ad esempio, era possibile accedere a diverse rappresentazioni del testo (testo e immagine, solo testo, comparazione del testo dei diversi testimoni, etc.), e interagire con esso in modi piuttosto eterogenei, a seconda delle proprie necessità.

Le nostre esigenze rappresentative (sia di visualizzazione che di codifica del testo) sono state dunque declinate sulle richieste espressive di EVT 2 beta 1, a cui si è aggiunta l'esperienza acquisita nell'esplorare i demo realizzati e messi a disposizione degli utenti con l'interfaccia stessa.[17] L'edizione digitale *VaSto* è stata poi portata a termine utilizzando EVT 2 beta 2, versione di cui è annunciato il rilascio entro il 2021, e che è stata fornita anticipatamente dagli sviluppatori EVT.[18]

Quest'ultima versione, rispetto ad EVT 2 beta 1, ha risolto alcuni *bug* e ha permesso, di conseguenza, un'esperienza più completa e soddisfacente. Ad esempio, consente di esaminare il manoscritto ingrandendo l'immagine a piacimento (funzione molto utile perché consente uno studio più dettagliato del testo, implementata in EVT 1, ma non presente nella versione EVT 2 beta 1); permette inoltre di navigare tra le pagine utilizzando dei selettori alla base delle pagine stesse (un sistema molto comodo e intuitivo, già presente in EVT 1) e visualizza automaticamente i manoscritti in una sezione apposita dedicata, in cui è possibile anche aggiungere descrizioni del manoscritto.

La visualizzazione delle entità nominate nel testo risulta già completamente implementata in EVT 2. In questo caso, quindi, non è stato necessario apportare alcuna personalizzazione dell'interfaccia. Nell'edizione è possibile selezionare le *named entities* nel menù in basso a sinistra e visualizzarle direttamente nel corpo del testo **[fig. 5]**. Per ogni persona o luogo evidenziati sono presenti alcune informazioni aggiuntive esplicitate in fase di marcatura e altre occorrenze della stessa entità. Inoltre, dalla prima voce del menù in alto a destra, è possibile selezionare la funzionalità «Paratesto e Indici», contenente le informazioni sul progetto e l'indice dei contenuti delle entità marcate (nel nostro caso persone e luoghi descritti nel testo) **[figg. 5-6]**.

17 `http://evt.labcd.unipi.it/`.

18 Ringraziamo per il costante sostegno e i preziosi suggerimenti il Prof. Roberto Rosselli Del Turco e la Dott.ssa Chiara Martignano.

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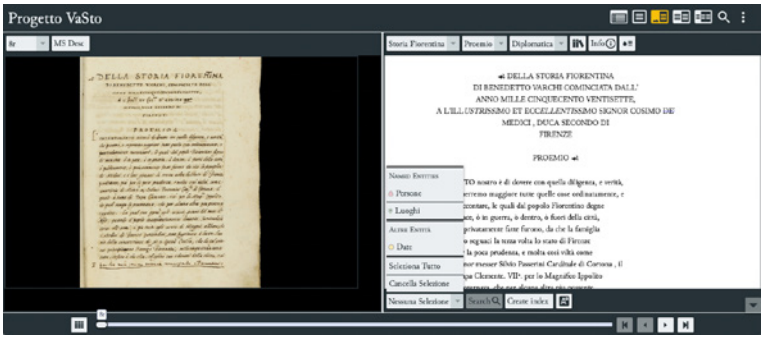

Figura 5 Visualizzazione Testo-Immagine del Proemio della *Storia Fiorentina* in edizione diplomatica con *named entities* (persone, luoghi e date) selezionate ed evidenziate nel corpo del testo

Figura 6 Visualizzazione della selezione di un'entità esemplificativa di persona (Francesco Carducci) selezionata dal menù di «Paratesto» e «Indici»

Nell'edizione diplomatica si vuole visualizzare insieme la stratigrafia del testo e l'impaginazione del manoscritto. Ne consegue che questi due requisiti rappresentativi richiedono una particolare visualizzazione, che attualmente EVT 2 non offre. Questi requisiti di visualizzazione sono dunque stati adattati specificatamente per l'edizione digitale *VaSto*. Tramite semplici modifiche al file di configurazione, che consente di attivare o disattivare varie funzioni dell'interfaccia, è infatti possibile accedere ad alti livelli di personalizzazione. La sua natura modulare, che si basa primariamente sulla possibilità di modificare e personalizzare in modo semplice i file al suo interno, lo rende malleabile e adattivo, permettendo di lavorare su più livelli di rappresentazione: sia contenutistica, attraverso il file.xml, che, sebbene in minima parte, di design grafico, attraverso il foglio di stile.

Al momento, l'impaginazione del testo a fronte dell'immagine nell'edizione diplomatica in EVT 2 non fornisce alcuno strumento per visualizzare aggiunte e cassature avvenute nei margini del *folio*. Sono stati dunque aggiunti dei riquadri a lato, che mantengono i colori della stratigrafia quando necessario.

Come mostra la figura 7, la stratigrafia del testo è stata segnalata con colori diversi rispetto alle diverse mani operanti; di conseguenza, le cassature si visualizzano con il testo barrato, mentre le aggiunte in base alla posizione all'interno del manoscritto (*supra lineam*, *marginalia* ecc.) **[fig. 7]**. Si veda, ad esempio, la prima aggiunta al margine del folio 10*v* in fig. 3 ad opera del revisore che ha cassa-

to una parte consistente del testo (in figura barrato in verde) e inserisce «Laonde per supplire» come elemento di raccordo con la frase successiva. Quest'ultimo inoltre presenta una variante immediata ad opera dello stesso Baldini (*Et* > *Laonde*).

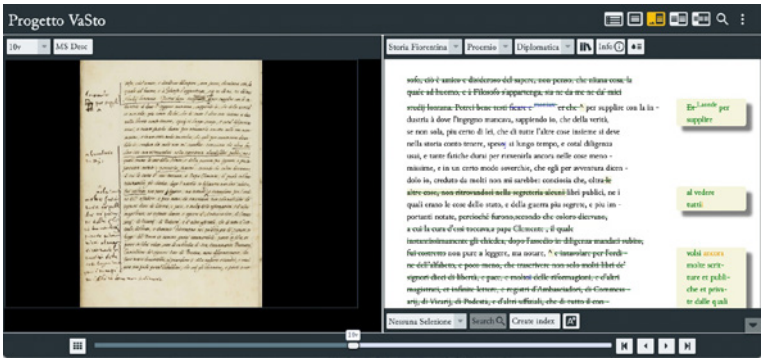

Figura 7 Visualizzazione Testo-Immagine del Proemio della *Storia Fiorentina* in edizione diplomatica, con cassature e aggiunte nel corpo del testo e nel testo a margine

EVT 2 fornisce come ultima voce del menu nel riquadro di testo (selezionato in giallo nella figura 8) la legenda dei colori dell'edizione critica. Ad essa, al fine di rappresentare la resa grafica della sedimentazione stratigrafica, è stata aggiunta la sezione «Legenda dei colori in Edizione Diplomatica» **[fig. 8]**.

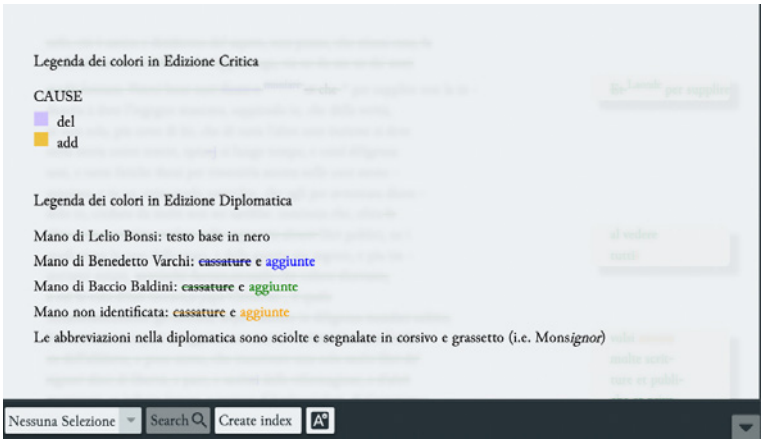

Figura 8 Visualizzazione della legenda dei colori di edizione diplomatica e critica dell'Edizione *VaSto*

Nello stesso menu, inoltre, la voce «Lista dei testimoni» (selezionata-nella figura 8) descrive dettagliatamente le versioni e i testimoni, nel nostro caso le due versioni del testimone RC4 (RC4 e RC4c) **[fig. 9]**.

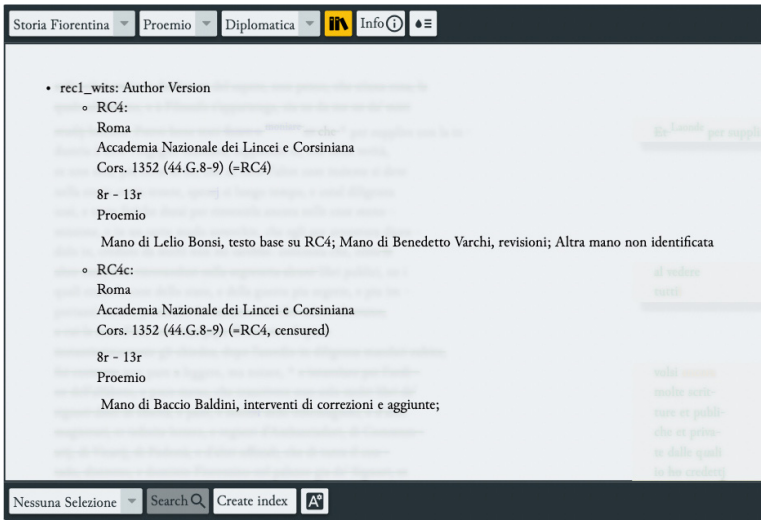

Figura 9 Visualizzazione della legenda dei testimoni presentati nell'edizione critica dell'edizione VaSto

EVT 2, come già accennato, permette varie visualizzazioni del testo: quella di solo «Testo», attraverso la quale si può visionare la trascrizione nella versione critica o diplomatica; quella «Testo e Manoscritto»; la visualizzazione denominata «Collazione» che è stata ideata proprio per il raffronto dei testimoni **[figg. 10-11]**; quella di «Recensione Multipla», che si presta alla comparazione delle varie versioni; e, infine, la visione «Testo a Testo», nata per confrontare l'edizione diplomatica con quella critica.

Utilizzando la visualizzazione «Collazione» è possibile esaminare i due testimoni e vederne sottolineate le differenze, averne informazioni aggiuntive e visualizzare la codifica XML direttamente nell'interfaccia: è possibile cliccare sul testo evidenziato e posizionare le due testimonianze allo stesso livello, in modo tale da avere un confronto parallelo del testo, oppure accedere al contenuto presente nella tendina che si apre sotto il testo selezionato **[fig. 12]**.

Figure 10-11 Visualizzazione della collazione nell'edizione critica dell'edizione *VaSto*

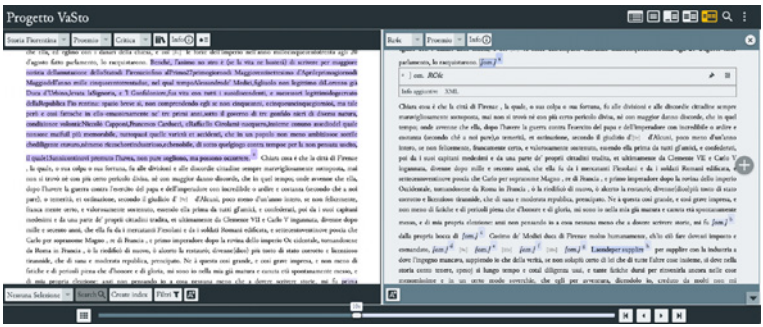

Figura 12 Visualizzazione dei testimoni a confronto nell'edizione critica dell'edizione *VaSto*

7 *VaSto* come knowledge site

Dalla homepage del sito *VaSto*, inoltre, è possibile visualizzare informazioni contestuali al progetto come:

- l'introduzione al progetto digitale, disponibile nella sezione del sito *Il Progetto* > *Introduzione*> *L'Edizione Digitale* > *Introduzione al Progetto* VaSto;[19]
- una breve biografia di Benedetto Varchi, a cura di Dario Brancato, che si trova in *Il Progetto* > *Introduzione* > *L'Edizione Digitale* > *L'autore*.
- la descrizione del prototipo e del progetto, e i criteri editoriali scelti per ciascuna delle edizioni rappresentate (*Il Progetto* > *Introduzione* > *L'Edizione digitale VaSto* / *Il prototipo (pilot version)*);
- i riferimenti storici relativi al caso filologico, che sono descritti in *La storia del testo* e *I principali Manoscritti* (*Il Progetto* > *Introduzione* > *Cenni storici*);
- una Bibliografia Essenziale (*Il Progetto* > *Introduzione* > *Cenni storici* > *Bibliografia Essenziale*);
- la documentazione formale dell'edizione in *Documentazione* > *Funzionalità*, oltre al collegamento diretto al *repository* di Github (*Documentazione* > *Github*), dove si possono trovare tutte le informazioni sul progetto (come, ad esempio, le *guidelines* dei *tag* utilizzati in XML/TEI e il codice sorgente dell'edizione digitale).

Per quanto riguarda il futuro sviluppo del progetto, l'intenzione è quella di implementare ulteriormente la piattaforma su molteplici fronti: sia sul piano testuale, integrando gradualmente tutti i libri della *Storia Fiorentina*;[20] sia sul piano funzionale. Infatti, la piattaforma *VaSto*, oltre a offrire l'edizione scientifica e quindi *full-documented* della *Storia Fiorentina* del Varchi, mira a supportare ed arricchire con varie informazioni e funzionalità interattive il semplice testo, in modo tale da contestualizzarlo più efficacemente. In particolare, si è pensato di soffermarsi su specifici livelli di conoscenza: tempo, spazio e personaggi.

L'idea è appunto quella di inserire diverse visualizzazioni per ogni livello, che diano, quindi, la possibilità di avere una fruizione diversamente contestualizzata dei dati che le *named entities* (luoghi, date e personaggi) ci forniscono; nello specifico una mappa per lo spazio, una *timeline* per il tempo e una collezione per i personaggi. La map-

19 `https://dharc-org.github.io/progetto-vasto/Progetto.html`.

20 La trascrizione semidiplomatica di RC4 è attualmente in corso, a cura di Giacomo Ventura.

pa, infatti, rappresenta lo strumento adatto a identificare i luoghi di Firenze che vengono nominati nel testo, mentre la *timeline* fornisce all'utente una raffigurazione grafica delle date più importanti. Infine, una collezione di oggetti presenta e descrive in modo ideale i manoscritti e i personaggi nominati nel testo, in modo tale da offrirne al lettore una raffigurazione e contestualizzazione meno superficiale.

Queste integrazioni sono già in fase di sviluppo o alla loro prima versione rilasciata nella sezione «Strumenti di Visualizzazione». Il primo *tool* sviluppato e già presente nell'edizione *VaSto* presenta una visualizzazione avanzata e interattiva delle immagini del manoscritto, elaborate tramite IIIF:[21] è possibile manipolare l'*Uniform Resource Identifier* (URI)[22] delle risorse secondo i dettami della documentazione IIIF[23] e ottenere un'immagine, o un dettaglio di essa, nitida e leggibile.

Una *timeline* delle date più importanti, selezionate dal testo del Proemio e integrate con altre di eventi storici importanti e correlate, è stata creata utilizzando il sistema Timeline Js[24] sviluppato dal Knight Lab della Northwestern University.[25] La peculiarità di questo *tool* consiste nella capacità di visualizzare le date singolarmente, associandovi file multimediali (immagini, video, etc.) e descrizioni testuali, il che fornisce all'utente la possibilità di spaziare in diversi ambiti e contestualizzare ulteriormente la *Storia Fiorentina* in un periodo storico definito.

La mappa **[fig. 13]**, ancora in fase sperimentale,[26] è stata invece realizzata facendo uso della libreria *open-source* Javascript Leaflet.[27]

Essa rappresenta tutti i luoghi identificati di Firenze menzionati nel testo, distinguendoli in sei categorie o *layers* (chiese, castelli, ponti, porte, piazze/località e posizioni ricostruite), che possono essere disattivate o attivate nella Legenda. I *markers* sono stati accuratamente personalizzati[28] per rappresentare le diverse categorie tramite simboli e colori (rosso per luoghi ancora esistenti, viola per ricostruiti). Clic-

21 Progetto sostenuto e realizzato dalla IIIF Communty e dal IIIF consortium (`https://iiif.io/community/consortium`), disponibile al link: `https://iiif.io/`.

22 L'utente può definire misure, rotazione, regione e qualità dell'immagine desiderata, agendo direttamente sull'URI della risorsa, seguendo le indicazioni fornite a questo link: `https://iiif.io/api/image/3.0/#4-image-requests`.

23 `https://iiif.io/api/image/3.0/#4-image-requests`.

24 `https://timeline.knightlab.com/`.

25 `https://knightlab.northwestern.edu/`.

26 `https://milenacorbellini.github.io/VaStoMap/`.

27 `https://leafletjs.com/`. Leaflet è stato originariamente sviluppato da Vladimir Agafonkin. Il layout della mappa è stato invece preso da MapTiler (`https://www.maptiler.com/`).

28 La personalizzazione è stata realizzata tramite Leaflet.awesome-markers plugin (`https://github.com/lvoogdt/Leaflet.awesome-markers`).

cando sui singoli *markers* si apre una finestra che porta informazioni aggiuntive: un'immagine del luogo, un collegamento a DBpedia, WikiMedia o VIAF, e uno alle pagine in cui viene menzionato il luogo. Allo stesso modo dall'edizione EVT della *Storia Fiorentina*, accedendo ai luoghi dalla lista delle *named entities*, è possibile raggiungere la mappa se il luogo selezionato è stato identificato e rappresentato in essa.

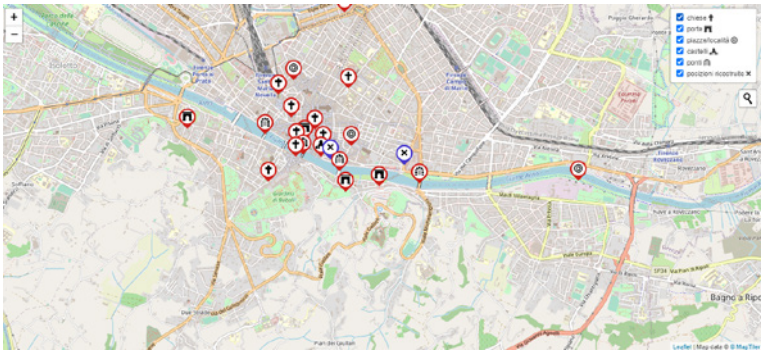

Figura 13 Mappa di Firenze in *VaSto*

L'ultima integrazione al momento disponibile è una collezione di elementi legati al Proemio della *Storia Fiorentina*, denominata *VaSto-Collection* e implementata con `omeka.net`:[29] si tratta di una raccolta che conta al suo interno tre sotto-collezioni («Manoscritti», «Personaggi storici» e «Ritratti dei personaggi storici») derivanti dal contenuto del Proemio, di cui ogni elemento viene presentato usando lo standard Dublin Core.[30] La collezione «Manoscritti» comprende nuovamente tutte le immagini del Proemio da RC4, ma stavolta catalogate secondo un preciso intento descrittivo e non meramente di visualizzazione come in IIIF. Le altre due collezioni sono, invece, strettamente connesse tra loro, dal momento che entrambe rappresentano i personaggi nominati nel Proemio: una presenta le schede biografiche che li descrivono come individui, dando informazioni come data di nascita e di morte, attraverso Dublin Core **[fig. 14]**; l'altra, quando possibile reperirli, contiene i ritratti dei personaggi descrivendo l'oggetto fisico – un dipinto ad esempio – come entità a sé stante, rivelando informazioni come, ad esempio, creatore, divulgatore, dimensioni, formato originale e molte altre **[fig. 15]**; gli elementi affini vengono poi connessi tramite *tag*, in modo tale da poterli esami-

29 `https://archivevasto.omeka.net`. Omeka è un progetto della *Corporation of Digital Scolarship* (`https://digitalscholar.org/`).

30 `https://dublincore.org/`.

nare come realtà correlate **[fig. 16]**. Inoltre, la sezione «Manoscritti» rimanda nuovamente alla visualizzazione IIIF di ogni immagine in modo tale da chiudere quello che potremmo definire un 'circolo virtuoso' che permette di esplorare a fondo l'edizione.

Figure 14-15 Dettaglio della scheda biografica di un personaggio storico (Alessandro de' Medici) tramite Dublin Core in *VaStoCollection*

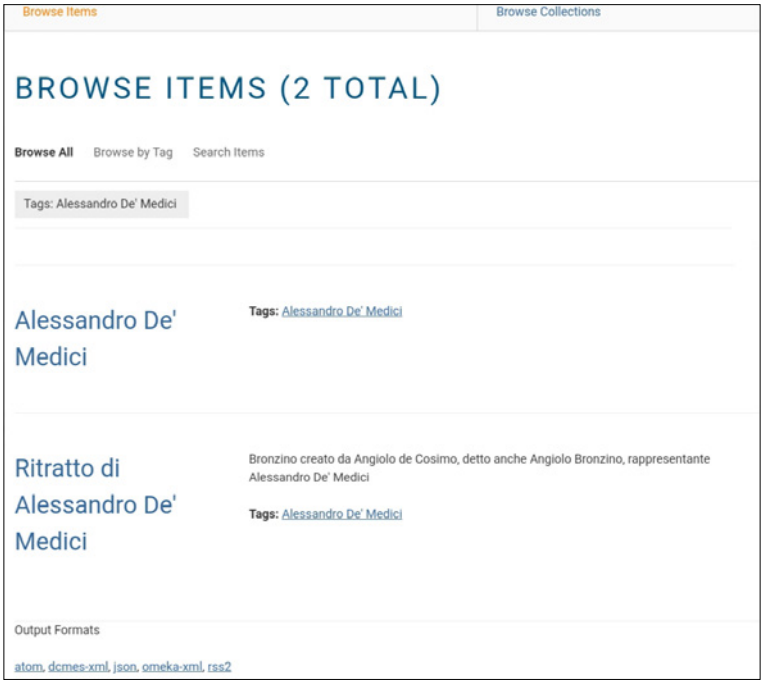

Figura 16 Esempio di connessione tramite tag in *VastoCollection*

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