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Fusions

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A New Venture and a Commitment to Disciplinary Fusion in the Domain of Digital and Public Humanities

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1 Entering an Open Domain[1]

On 5 June 2019, Ca' Foscari University launched the Venice Centre for Digital and Public Humanities (VeDPH) in order to take a proactive role in the digital transformation of society and of the academic landscape. With the ambition of enhancing humanities research and opening up knowledge and practices to a wider public, scholars, artists and programmers have been attracted who are engaged in the application of computer science and emerging technologies in the humanities. Building on the competences and achievements already made at the Department of Humanities, which has been awarded with an excellence grant by the Italian Ministry of Education, Universities and Research (MIUR), a new team of expert scholars and specialists

1 This introduction paper was mutually agreed on by the authors, whereas F. Fischer wrote paragraph 1, D. Mantoan paragraphs 2 and 3, B. Tramelli paragraph 4.

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took on the task of establishing interdisciplinary collaborations and a wide range of training activities. In the course of the first year, a masters' study programme in the field of digital and public humanities has been set up, as well as a seminars series, a summer school, and a number of workshops and symposiums. Public events were delivered online under the conditions of the COVID-19 emergency, covering topics ranging from digital papyrology and palaeography to media archaeology and contemporary audio-visual art, from GIS to git, from code to the materiality of a global lockdown. A technical research infrastructure has been developed for facilitating both refactoring digital legacy resources and cutting-edge research. Social media has been explored for communicating and sharing information with scholars and the public. Strategic partnerships with cultural heritage institutions, learned associations and local communities have been created, and existing partnerships have been strengthened. The only missing element, it seemed, was an open access publication venue for genuine research articles at the crossroads of the humanities traditional core disciplines, and the methodologic advancement and technological innovation. Hence, the idea of making *magazén* soon took shape.

2 The Making of *magazén*'s Pilot Issue

A year ago, when we set forth to start *magazén*, we were indeed wondering whether the scholarly world needed another journal. The peculiar research niche we were planning to enter, the field of digital and public humanities, is still quite novel but over the last decade it has earned growing consideration inside the academia. Certainly, it cannot be said to be established yet, since some areas of prejudice derived from more traditional disciplines are hard to overcome. Doubts and suspicions often refer to methodological aspects and material boundaries, deemed excessively innovative or too elusive, hence at times they even hinder access to the main platforms of discussion (Kirschenbaum, Werner 2014) for researchers in digital and public humanities. We were pondering that perhaps a new journal explicitly devoted to this emerging field might be of some use, provided that it could become an open space for cutting-edge debates, as well as to define new categories or scientific vocabularies and recognise a varied range of resources and modes of research conduct (Drucker 2003). While this field is still struggling to find a truly theorised version of itself, it also needs to develop research models in an international context, such as to take account of different contexts and cultures around the scholarly world (De Groot 2018). Hence, at the VeDPH, we took up the challenge to create an interdisciplinary journal undergoing double blind peer review which we plan to publish

twice per year in printable version and in a web version, which are both available in open access. Being based at the Department of Humanities at Ca' Foscari University of Venice, our centre is founded upon an initiative of excellence that aims at stimulating an interdisciplinary methodological discourse. As a matter of fact, it is inscribed in our founding principles that we need to create a basis for the collaborative development of durable, reusable, shared resources for research and learning in the field of digital and public humanities. Furthermore, taking the term humanities in its entirety, we intend to be as inclusive as possible with regard to the disciplinary domains, ranging from textual scholarship, history and art history to cultural heritage studies and archaeology. Thus, the journal aspires to constitute an open platform for a wide range of disciplinary fields and methodological approaches sharing the scholarly potential of digital technology and public discourse. In our perspective, a novel journal would make sense only if it is devoted to a wide-open constituency.

Consequently, when we started to think of a name for this unlikely venture, we were looking for something that could hold together this urge towards openness and interdisciplinarity with the peculiar Venetian character of our centre. Curiously, our department is set apart from the main palace of Ca' Foscari, on the Grand Canal, and there is a narrow, almost secret passage connecting the two buildings. One has to cross the Campo Santa Margherita, a lively square at the heart of the university district, and then follow an intricate path between ancient houses: there lies the so-called *Calle del magazén*, a little alley that appears to lead to a dead end. And it is not the only *calle* – as the streets are called in Venice – that holds this particular name. There is another calle right behind the big State Archive at Frari's, the former huge Franciscan monastery where most of the documents from the various institutions of the millenary Venetian Republic were placed after Napoleon's conquest. Several others are to be found when randomly walking through the streets of Venice. At the beginning, the association with the English word *magazine* was reason enough to research further into the etymology of *magazén*, only to find out that it refers to the historical definition of public houses during the *Serenissima* (Tassini 1970, 364-5). Truly, *magazzino* in Italian still means warehouse, while the French version properly refers to shops, and the Venetian variant is not so different, since *magazéni* (in the plural form) were places of diverse human deeds and thriving that included information exchange, commercial bargains and pawn brokerage (Boerio 1971, 382). You would go to your favourite *magazén* to drink a glass of wine, to have a chit-chat, to close a business deal, to bargain your belongings for some money or, vice versa, to find things at a good price; and, yes, sometimes even for an hour or two of love. This little philological research bore good fruits, we had our name, one referring to a very Venetian place

of open exchange, a platform for diverse humanity where everybody was welcome and could mingle with other people. We are committed to make *magazén* such a place for digital and public humanists, today and in the future.

3 Looking for Fusions of a Broader Kind

In 2020, for our inaugural volume, we resolved to devote the two semestral issues to the intertwining landscape emerging from the recent development of digital and public humanities. For this reason, the international call for abstracts we launched in February simply bore the title 'Fusions', a straightforward term with no further frills, in order to leave the debate as open as possible. As a matter of fact, in the last two decades much effort was placed in defining separate disciplinary fields, in order to canonise and validate the use of digital methodologies or public approaches in the specific subsets of the humanities. Such is for instance the case of Digital Art History, which is still focused on the definition of its own research scope, while trying to legitimise the adoption of big data analysis for art historical knowledge (iconographic comparison, image matching, material analysis etc.) as well as establishing best practices in digital archiving systems specifically for the arts (Drucker 2013). A similar development may be traced in Digital Textual Scholarship where a variety of scholarly approaches created a wide range of standards for visual and critical representation and developed a vast array of digital methods and means for palaeographic, genetic, stylistic, linguistic and semantic analysis of texts and documents (Pierazzo 2015; Berti 2019). As far as archaeology is concerned, the extensive use of digital tools (GIS, spatial analysis, 3D modelling, network analysis, simulation, image analysis etc.) significantly expanded the understanding of the human past and unlocked new paths for archaeological enquiry and dissemination, such that all archaeologists today are 'digital' in their own right (Morgan, Eve 2012, 523; Costopoulos 2016). Eventually, the relationship between public and digital history recently occupied many scholars, since the process of digitisation of primary and secondary sources, in particular for historians, called out traditional approaches and methods of research, analysis, communication, and dissemination (Cohen, Rosenzweig 2005). However, evidence suggests that digital and public challenges facing individual disciplines are actually common to the entire field of the humanities, thus favouring a cross-disciplinary approach rather than thematic isolation. Indeed, the impact of digitisation and public involvement offered a unique opportunity to the humanities: a window for experimentation with merged methodologies, blended sharing practices, joined representation modes, interpenetrated material research (Cauvin 2016; Leon

2017). In this process, new actors, factors and agents that are about to consolidate today's landscape in the digital and public humanities emerged; however, standards and best practices that apply to the entire field still need to be developed.

Following this strain of thoughts, for the first volume of *magazén*, we were adamant to examine the concept of 'fusions' as the very backbone of recent developments in the realm of digital and public humanities. After all, the term serves well to embrace every possible kind of merger, interrelation, joint, blend, interpenetration, interdependency, cross-contamination that affected or still informs the processes, approaches, and practices of research in this wider field. Hence, we invited scholars to submit contributions that span from theoretical debates to methodological reflections, as well as the examination of particular case studies. The research scope should cover the widest possible chronology and typology of topics without any distinction of methodological approach, provided that it is convincingly presented and suitable to address the concept of 'fusions' in the digital and public humanities. We were particularly eager to find experimental research or works making use of media and code, with special attention to articles dealing with best practices or committed to an open source policy. Specifically, we intended to urge prospective authors to engage with an open concept of 'fusions', though at the same time clarifying how they would position themselves across a set of transversal domains that we believe need to be addressed with due awareness, in order to establish digital and public humanities as a coherent field inside academia. These dimensions refer to: 1) the kind of materials (e.g. monuments, documents, works of art, born digital artefacts); 2) the media of representation (e.g. image data, textual data, audio-visual data, 3D data); 3) the applied methods (modelling, epistemology, collection, processing, visualisation, analysis, hermeneutics); 4) the modes of sharing (publication, participation, communication, preservation, afterlife); and 5) actors, factors and agents of the chosen field (society, institutions, communities, technology, environment, discourse). This task could not be accomplished by the authors solely, as they needed the members of our editorial board to accompany them on this path, while from our side we also had to identify reviewers capable of appreciating cutting-edge research in an open domain. Despite our first call for abstracts and the subsequent peer review process happening in the midst of the worldwide emergency situation, we were astounded by the considerable participation and warm reception that this issue of *magazén* earned from scholars all over the globe. Apparently, a new journal in this domain was indeed desirable and the chosen topic just hit the nail on the (scholarly) head.

4 Five Takes on an Ever-merging Field

Considering fusions as an open concept and as the place to start the journal's discussion on the different dimensions of digital and public humanities summarised above, we were particularly pleased with the selection of this issue's contributions, which provide us with different and yet connected interpretations and reflections on the topic.

The first article written jointly by Dennis Del Favero, Ursula Frohne and Susanne Thurow presents the authors' research on interactive immersive aesthetics conducted by the iCinema Research Centre at the University of New South Wales in Sydney, which seeks to re-conceptualise access and engagement with cultural datasets via digital platforms, with the ultimate aim of enabling new forms of experience, exploration and insight. The analysis of the Centre's milestones across the past two decades opens up a methodological discussion on the fusion of technological and artistic frameworks that guide the development of its digital methodologies.

The second contribution by Franco Niccolucci discusses the widespread use of digital applications in archaeology, questioning the critical use of Big Data. Starting from the issue of the 'data deluge' already raised in 1999, the author critically analyses different approaches on how to manage the increasing amount of information available online, suggesting the need to re-think the digital approach using a 'data-centric methodology', a fusion of artificial and human intelligence in order for researchers to be able not only to interpret but to re-use the data collected during their archaeological investigations.

Stoyan Sgourev, in the third article, starts from the traditional definition of 'fusion' in physics – a process during which part of the content of two atoms is lost, though a qualitatively new entity is created – to engage the reader in a challenging discussion on the benefits of interdisciplinary exchange, and on the need to overcome the aversion (in all fields) to external influence and in opening up. He argues that technological and methodological developments are facilitating a more malleable state of disciplines, and he presents as an example his data on the students of Antoine Bourdelle, ultimately pointing out that much is to be gained by the interaction of computer algorithms, sociological methods and historical data, which can be of great help to address (and solve) substantive questions in the history of art.

The last two contributions in the issue offer two intriguing and innovative case studies on specific topics, respectively on early modern Italian music and Byzantine sigillography.

In their article, Angela Fiore and Sara Belotti give us preferential access to the world of 17th century Modena, presenting musical manuscripts, historical maps and archival sources as engaging primary sources whose comparative study is particularly apt to get an

insight on the different relationships between the spaces of 'knowledge production' in the early modern Italian city. They present the *in fieri* project *Este Soundscape*, based on the construction of a digital platform for the research and dissemination of the cultural and documentary heritage, which involved the *fondi musicale e cartografico* of the Biblioteca Estense Universitaria. The platform will serve as the basis for the reconstruction and exploration of the historical soundscape of early modern Modena and will give a new interdisciplinary perspective on the field of early modern studies.

In the final contribution of this first issue, three authors, Alessio Sopracasa, Martina Filosa and Simona Stoyanova present SigiDoc, the new-born encoding standard for Byzantine seals, as the first attempt for this intrinsically interdisciplinary discipline to benefit from the Digital Humanities. The paper illustrates the digital genealogy of SigiDoc in the broader context of TEI and its relationship with open source initiatives and tools such as EpiDoc and EFES (EpiDoc Front-End Services). This provides the readers with a clear and meaningful example of how the creation of a new interoperable encoding standard can lead to the enhancement of an entire discipline, allowing for the exploration of exciting materials and new insights into the historical, administrative, economic, socio-political, prosopographic and iconographic aspects of the Byzantine empire and beyond.

5 A Big Community and Sincere Acknowledgments

Presenting different methodological approaches and materials, the contributions collected in this first inaugural issue of *magazén* give us a glimpse of the heterogeneous and evolving scene of Digital Humanities and of its scholarly community. More articles on this subject will be included in the second issue of 2020 to further fuel this interdisciplinary debate. We hope that this journal will become a starting point for discussions on the interconnected methodological aspects, in between innovation and tradition, of this ever-changing field. Just like a Venetian *magazén*, this journal is a virtual place of exchange and knowledge sharing, an open platform of discussion where researchers and experts in the field can share their work, stimulate novel research paths and create new connections.

With regard to the journal setup and this pilot volume, in the end we would like to attribute exact responsibilities – for better and worse – and make various necessary acknowledgments. Franz Fischer is General Editor and Diego Mantoan is Associate Editor of *magazén*, while the latter and Barbara Tramelli curated the present volume. Eventually, we must express our most sincere thanks to the many scholars involved in this venture, first and foremost to Giovannella Cresci and Paolo Eleuteri who led the way on this Excellence In-

itiative at the Department of Humanities of Ca' Foscari and allowed us to experiment freely in the field of digital and public humanities. We are further grateful to the members of our advisory board for the international prestige and precious suggestions they provided at the kickstart of this journal. Many thanks go to the editorial board members, who actively participated in the entire process flow with their disciplinary expertise and allowed a careful selection of abstracts, the subsequent directions to the chosen authors and finally the support to peer reviewers. We would like to name all of them, in alphabetical order, given that this volume would not have been possible without the concurrency of their knowledge and connections: Federico Boschetti, Elisa Corró, Stefano Dall'Aglio, Holger Essler, Tiziana Mancinelli, Paolo Monella, and Deborah Paci. We must also highlight the fundamental work done by our reviewers, who are among the most reputable scholars worldwide. There were so many reviewers to ensure the double-blind peer review process, with two scholars for each paper, that we would like to thank them all for their efforts and time. Last but not least, we would like to thank our publisher, Edizioni Ca' Foscari directed by Massimiliano Vianello, for the constant support and useful advice, as well as for planning a special HTML-version of this journal that will be ready in 2021. These acknowledgements are of course extended also to the coming issue of this inaugural volume, which will devote another five papers to the topic of 'fusions'.

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Immersive Intelligent Aesthetics as Conduit for Digital and Public Humanities Research

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Abstract The article outlines conceptual frameworks and experimental studies developed at the University of New South Wales, surveying a selection of creative arts industry research projects. These deliver fully immersive interactive visualisation systems that enable new forms of embodied engagement with artistic, cultural and performance datasets, deploying Artificial Intelligence to analyse and augment user navigation for improving data identification, access and processing. Sketching the developmental trajectory of intelligent aesthetics across these projects, the paper closes with a critical consideration of effects and implications of human-machine co-agency in this new context of cultural reflection.

Keywords Artificial Intelligence. Collaborative Design. Collection Management. Digital Museology. Immersive Visualisation. Interactive Aesthetics. User-led Experiences.

Summary 1 Introduction. – 2 The iCinema Research Centre. – 2.1 The Advanced Visualisation & Interaction Environment (AVIE). – 2.2 Foundational Interactive Immersive Visualisation Projects. – 2.3 Elaboration SPACE of SPACE Intelligent SPACE Aesthetic SPACE Frameworks. – 3 Conclusion.

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1 Introduction

Digital and public humanities research methodologies have generated robust capabilities for deep artistic and cultural engagement in the Digital Age. By leveraging the scale and speed of digital platforms, new pathways have been generated to explore cultural heritage, discourse formation and creative practice. As these technologies themselves have facilitated new forms of being and doing across societies, their deployment for exploring the human condition, and its manifold ecologies, provides suitable means to reflect transformations in a highly malleable medium. Digital platforms and their interfaces can be configured to cater to multiple dimensions of human perception, simultaneously activating multiple senses so users can comprehensively generate knowledge in highly contextualised ways. Flexible data assembly and dynamic analysis afford capability to amplify the potential for knowledge creation, allowing exploration of both the datasets themselves as well as their usage over time. This integration of artefact and engagement data supplies compelling avenues especially for creative arts and humanities research as it streamlines access to heterogeneous information and enables coherent curation and processing. A key challenge is the translation of material artefacts and practices, which have long since dominated historical documentation and memorialisation, into the virtual domain. While 3D-rendered virtual twins and supplementary digitally native material are powerful tools that enable addressing this challenge, the underpinning aesthetics of implementation play a crucial role in achieving engaging and productive representations in virtual space.

For the past two decades, the iCinema Research Centre at the University of New South Wales (UNSW) in Sydney (Australia) has been home to dedicated research into interactive immersive aesthetics, seeking to reconceptualise access and engagement with cultural datasets via digital platforms to enable new forms of experience, exploration and insight. Experimenting with cinematic-scale motion-tracked environments networked to desktop and mobile applications, the research has focused on leveraging intuitive interface design and interactive capabilities to translate visual, textual and auditory data into expansive 3D multimedia assemblages that embody new perspectives on cultural, industrial and pedagogical data (Langdon 2014, 75-6). Collaborating across disciplines with a wide range of researchers and industry partners, the fusion of artistic and technological approaches has over the years progressively yielded solutions that enable ever more sophisticated simulations and animations of complex real-world scenarios at one-to-one scale. Through cross-platform functionalities, these can be simultaneously engaged with by multiple users. In step with contemporary philosophical currents that highlight agency as the result of a transactional web maintained by inter-

related entities (Latour 2017a, 58; Barad 2007, 123) and technological advances in the field of computational knowledge representation and reasoning (e.g. Schwering, Lakemeyer, Pagnucco 2017), new research at iCinema has been exploring the integration of immersive visualisation and Artificial Intelligence (AI) programming to leverage the Centre's existing capabilities for unlocking the benefits of latest advances for creative arts and humanities research. Doing so promises to deliver a step change for both creative practice as well as academic reflection since it aims to couple the speed and scale of computational processing with the subtlety and agility of human creativity in the production, curation and analysis of cultural artefacts.

The article surveys a selection of milestones of iCinema's research across the past two decades, outlining the technological and conceptual frameworks that guide the development of its digital methodologies. With this broader research context mapped, the paper critically reviews the adaptation of iCinema's established approaches across three current industry research projects. These projects, ranging from museological to performing arts application, each develop artificially intelligent aesthetics for augmenting user engagement and insight. They deliver interactive collaborative full-body immersive visualisation platforms that enable new forms of embodied engagement with cultural datasets, while also intelligently analysing user navigation to improve identification, access and processing of relevant data. Having sketched the developmental trajectory of intelligent aesthetics across these projects, the paper closes with a critical consideration of effects and implications of human-machine co-agency in this new context of cultural expression and reflection.

2 The iCinema Research Centre

In 2002, research artists Dennis Del Favero and Jeffrey Shaw, along with design researcher Neil Brown, co-founded the iCinema Research Centre as UNSW's first interdisciplinary cross-faculty research centre (Leggett 2003, 76), initially spanning the Faculties of Art and Engineering, and from 2009 the Faculties of Arts & Social Sciences and Science, as well as the National Institute of Dramatic Art (NIDA) – Australia's major performing arts training institutes. This structure has guaranteed access to and creative exchange with key research centres, groups and facilities across the university, such as with, for example, the Autonomous Systems and Knowledge Representation Groups, the EPICentre VR-facility and the National Facility for Human Robotic Interactions. Drawing on the available interdisciplinary expertise and regularly recruiting new partners from within academia as well as industry, the centre has grown into one of Australia's most successful research hubs focused on arts-led vis-

ualisation, having garnered funding and commissions in excess of AUD $40M from a range of national as well as international sources. Realised projects have thereby spanned the arts, as well as the broadcast, construction, environment, heritage and museum sectors. They have been presented at first-tier outlets, such as ArtLAB ÉPFL (Switzerland), Avignon Festival (France), EMPAC (USA), Melbourne Museum (Australia), Shenyang Research Institute (China), Smithsonian Institution (USA), STRP Festival (Netherlands) and ZKM | Centre for Art & Media (Germany).

2.1 The Advanced Visualisation & Interaction Environment (AVIE)

At the heart of iCinema's experimental creative-arts-led research lies the *Advanced Visualisation & Interaction Environment* (AVIE), a bespoke mobile 360° 3D interactive cinematic-scale environment developed by Del Favero and Shaw.[1] It affords groups of up to 30 users the capability to manipulate dynamic 3D datascapes in real time. Its 4.5 metre-high cylindrical screen with stereoscopic visualisation affords a full-body immersive experience that foregrounds the corporeal experience of physical space while retaining social interaction with other users in the environment – contrary to head-mounted-display solutions that cut off users from social interaction by enveloping their visual sense at the expense of kinaesthetic engagement (Thurow 2017, 246). In opposition to conventional desktop computer screens that only provide a small window into a virtual space that remains largely cordoned off from the user's embodied experience, the virtual world here dominates the user's sensory apparatus. Its aesthetic experience aims to establish a continuity between the user and representational space, reorganising perception so that the distance between subject and object becomes highly condensed. *AVIE* fully immerses users through multi-viewpoint projection and spatialised sound in the informational space by enveloping peripheral vision and auditory system. Its carefully calibrated motion capture and tracking system allows exploration not just via voice and tablet but also through gestural and kinaesthetic input. The entire body is thus activated as an interface, facilitating an intimate and intuitive engagement with data across the entire circumference of the projection space which opens up a range of dimensions for holistic enquiry and insight. For example, stage designers may collaboratively review and adapt a simulated set design for a theatre play at one-to-one scale or a group of students may embark on a virtual field trip to ancient

1 With funding supplied by the Australian Research Council through the grants DP0345547, DP0556659 and LE0453517.

temple ruins in Vijayanagar (India), each garnering comprehensive information through the digital experience that would be inaccessible through a small-screen or an analogue engagement. The interactive functions of the environment additionally provide users with a range of capabilities to deepen their exploration of the displayed data, for example, rotating, zooming in and out as well as collating datasets – actions that significantly augment and provide an edge over conventional information processing by allowing new narratives to emerge from the data (Brown, Barker, Del Favero 2011, 214).

The AVIE environment has been commercialised to 15 partners across Australia, Europe, the US and Asia, enhancing scope for networked research collaboration. To cater to stakeholder needs arising from various disciplines, budgets and objectives, it has been adapted into a range of complementary platforms that supplement iCinema's infrastructural assets. For example, *AVIE_SC* and *iDOME* are mobile 160° and 180° versions, respectively, of *AVIE*, with reduced circumferences that accommodate up to five simultaneous users. Their size, configuration and lower prize-point make them ideal for temporary location at end-user sites, readily extending audience and user groups beyond the circle of immediate collaboration partners. The systems' focus on kinaesthetic audio-visual engagement streamlines its technical architecture, keeping its mobile deployment feasible. Tactile and olfactory engagement lies outside of *AVIE*'s current scope, yet for the purposes of its applications thus far this has been a negligible limitation. Similarly, floor and ceiling projection are aspects that could heighten *AVIE*'s immersive experience – as seen in the popular works of Japanese collective *teamLAB* –, yet which have so far not proven cost-benefit efficient to warrant investment. Instead in 2017, UNSW set up the Expanded Perception & Interaction Centre (EPICentre), a novel ultra-high-resolution VR visualisation facility, whose fixed-location 340° 120M pixel *EPICylinder* environment set new benchmarks in clarity, brightness and contrast for interactive computer-automated visualisation environments (so called 'CAVEs') (Paterson, Simpson-Williams, Cordner 2020, 166). While its tiled display, comprising 56 separate LCD screens, slightly detracts from the immersive effect especially in video-reliant creative arts applications, its strength for analysis of scientific data has been extensively exhausted in various bioinformatics, anatomy and neuroimaging projects (167).

2.2 Foundational Interactive Immersive Visualisation Projects

All projects developed within iCinema's research context have been conceptualised through a lens that prioritises creative arts methodologies, harnessing the productivity that arises from the reformulation of basic aesthetic parameters of received disciplinary approaches. For example, in the early 2000s when museological displays largely followed non-interactive, small-screen standards strongly privileging the visual sense, Shaw and Del Favero assembled a collaborative team (including digital museology pioneer Sarah Kenderdine, interactive art curator Peter Weibel and AI expert Maurice Pagnucco) to explore the capabilities of 3D animation, 360° video and multi-sensory interpellation for deeply engaging museum audiences in heritage settings that bespeak their ongoing dynamic evolution. For the ARC-funded *PLACE Hampi* project (2006-10; LP0669163), they designed a highly responsive experience that overlaid cinematography of Vijayanagar's ancient temple ruins with animated computer graphic scenarios re-enacting key scenes of mythological Hindu texts. Triggered by user gaze and movement in the AVIE space, the animation progresses along alternate pathways, entangling users and characters in basic co-evolutionary narratives. These are enabled through symbolic logic and high-level cognitive programming, which endows digital characters with a limited set of pre-programmed goals – such as seeking to protect or to socialise (Kenderdine 2007, 68). These form the basis on which they are able to enact a limited behavioural vocabulary in response to user positioning, escalating chains of interaction. Through responsive coupling of sounds, picked up from within the AVIE space to subtle visualisation changes, the overall responsive impression for visitors is additionally reinforced. By complementing kinaesthetic visual and auditory immersion with projected textual information that affords insight into Hampi's layered sociocultural, historical and political dimensions, the *PLACE Hampi* project supplied an early proof-of-concept for advanced museological applications that target the entire human sensorimotor apparatus for data exploration (58). Conceptually, this research drew on Bruno Latour's spatial and Maurice Merleau-Ponty's phenomenological theories that conceive of the body as closely entangled with the objects of the world, formulating any meaning making as contingent on dynamic emplacement and sensory engagement (62-3). These theories were deployed to provide a point of articulation for the Hindu concept of *darshan*, i.e. engaging with a deity through sensory impressions, within the *PLACE Hampi* experience (67). Deploying immersive interactive aesthetics allows translating these concepts into an exploration of new museology approaches that seek to reinstitute the body as an integrated vehicle for information processing. It recognises cultural artefacts as dynamically evolving sites of encoun-

ter that speak of past significance as well as of present and future imaginations (69).

Shaw and Kenderdine developed these capabilities further in the subsequent *Pure Land* project (2012-16) that brought to life the murals of Cave 220 of the Buddhist Mogao Grottoes at Dunhuang (China). Using high-resolution photography and laser-scanned models enhanced through composited animation, pictorial recolouring, digital enlargement and a complex sound design, they created a virtual one-to-one-scale facsimile of the 1378-year-old images of the Medicine Buddha. Entering *AVIE*, visitors are able to closely investigate colourful reconstructions of the Cave's images and sculptures, taking in the aesthetic, narrative and spiritual dimensions of these vulnerable cultural artefacts. Conceptually, the project refined the premises of *PLACE Hampi*, seeking to imbue the rendition of this historic site with an 'aliveness' that exploits the capability of digital platforms to augment visitor experience via new functionalities that are inaccessible in the physical domain. Examples are a magnifying function that allows selecting panel sections – even of those near the cave's ceiling – and enlarging them by a factor of up to 10; a retouching tool that re-enlivens the colour palette of the paintings, overlaying century-old faded designs with their original pigments that had been reconstructed at the collaborating Dunhuang Academy; and animations of paintings via superimposed cinematic sequences that performatively extend the activities depicted on the cave's walls. These elements contribute to generating a heightened sense of presence in the virtual cave, enabling a reconfigured relation to historical artefacts as giving rise to a cosmos of epistemological and hermeneutic practice. *Pure Land* was praised for its innovation of conceptual, technological and operational paradigms in the field of digital preservation, cultural heritage interpretation and embodied museography – especially in light of the solutions it offered for engaging visitors with delicate physical artefacts, such as the original cave structure, which prohibit extensive public display (Kennicott quoted in Greuter, Kenderdine, Shaw 2016, 82).

The keys to functional immersive interactive visualisation projects are database architectures and programming that allow flexible access to and dynamic assembly of datasets. This vouchsafes that animations can be correlated with user interaction, so that the imagery responds in conclusive and consistent ways to a given user input. While users of works like *PLACE Hampi* and *Pure Land* might not be fully aware of such 'backend' engineering, other iCinema applications have specifically foregrounded database navigation and interlinking of assets, calling attention to this 'underbelly' of information processing and its aesthetic effect on scopic regimes. For example, the *mARChive* project, delivers a 360° museological data browser for industry partner Museums Victoria (2014-16; LP100100466), which

affords users the means to view, browse, select, compare and analyse over 30,000 assets from nineteen collections, experimentally applying a re-compositional narrative framework. Layered according to thematic fields and stratified by chronology, digitised assets can be displayed within *AVIE*'s full circumference, collectable via tablet so that users may access and analyse them beyond the visualisation environment at their convenience. Standard solutions at the time had been constrained through comparably flat interfaces, inability to handle large amounts of heterogeneous data and paucity in their consistent assembly due to application of narrow analytical systems. Conceptually, *mARChive* explored the questions raised by co-Investigator Lev Manovich in his work on info-aesthetics, investigating how the super-human scale of our present-day information structures may be translated to the scale of human perception and cognition (Manovich, forthcoming). This project successfully addressed Museums Victoria's challenge of interrogating, managing and curating from its vast distributed collections while also providing sustained public access to those parts of collections not on current display. This represents a widespread concern of many institutional agents in the field, such as of ZKM (Germany), which commissioned iCinema to adapt the *mARChive* solution to cater to the needs of its extensive media arts collection.

The methodologies for effectively assembling and curating video content in *AVIE*'s full-body immersive space have been supplied through sustained exploration as part of iCinema's flagship *T_Visionarium* project (2003-05; DP0345547). This study investigated the potential of interactive narrative as an aesthetic framework for reassembling televisual information within a cinematic space. It provided a user with the means to simultaneously display, browse, curate and recombine 20,000 video clips of free-to-air Australian television into new storylines. To enable this, the data was processed and tagged in line with a set of categories, such as dominant colour scheme, mood, gender of actors, activity, etc. The programming design incorporates low-level AI algorithms that analyse input and data in real time, supporting a user's search by proffering 125 potentially relevant clips in their immediate field of vision while displaying an additional 125 oppositional datasets at a 180° angle. This allows users to field the database in effective ways, with each collection of assets resulting in a dynamic interactive response by the AI system that seeks to forecast evolving user interest through aggregating new data in light of preceding user choices. While the AI system's response at times digresses into high-level pattern recognition that is no longer intelligible to human users, the project prototyped an intriguing human-machine dialogue that probes the limits of reciprocal understanding. Doing so, *T_Visionarium* reformulates the televisual experience into the cinematic space by stripping it of its con-

ventional aesthetic, conceptual and semantic parameters. It dissolves them into a novel immersive spatial experience of inhabiting an all-encompassing mediascape that explicates the televisual dispositive by revealing and engaging users with its underlying formal properties, casting them as active producers rather than passive consumers (Bennet 2008, 39).

A similar deconstructive lens was applied to the genre of cinematic narration in the *Scenario* project (2011-15; DP0556659), which explores the concept of co-evolutionary narrative through the interaction of human users and AI-enabled autonomous characters. Rather than enacting pre-scripted sequences in response to a defined trigger as in *PLACE Hampi*, these characters are furnished with basic sensing and interpretive capabilities. This allows them to respond to dynamic user movement in the *AVIE* space and to escalate interaction through a carefully calibrated decision-making range stored on a knowledge database. For example, they can either prompt users to collaborate or actively antagonise their actions (Scheer 2011, 29). Rather than exposing viewers to a string of pre-sampled cinematic events, the filmic narrative in *Scenario* is contingent on active intervention by users and their reckoning with the characters' behaviours. Semantic determinacy and formal closure, as hallmarks of cinematic storytelling, are hence impeded in favour of an emergent interplay of multiple agencies who each contribute to morphing the direction and outcome of the cinematic narrative. Rather than unfolding a preconceived meaning defined by the director, interaction generates semantic structures, constantly in flux with unpredictable outcomes. As such, *Scenario* translates the basic tenets of postmodern interactive art into the cinematic genre (Colebrook 2014, 142), shifting the focus from auctorial exposition to dynamic process as the key site for cinematic meaning making. Meaning hence is no longer something to be unfolded but an ephemeral malleable product that emerges from transactions between multiple agents. The exploration of such ambient agential networks was refined in the *Intra Space* project – a collaboration with Academy of Fine Arts, Vienna, funded by the Austrian Science Fund (2016-17; AR299-G21). It applied to human-machine interaction the concept of 'agential realism' as developed by theoretical physicist Karen Barad, which stipulates that entities constitute each other and maintain their identities only through processes of interaction (Barad 2007, 123). The project team, including Del Favero and architect Wolfgang Tschapeller, honed the interactive coupling of user and digital character to investigate the potential of advanced AI programming for dynamic spatial exploration. Equipping the digital character with both its own distinct behaviours as well as the capability to sense, mimic and splice a user's physical behaviour into its choreographic sequences, the project delivered valuable methodologies that support the exploration of reciprocal stimulus

and response transactions. This helps pave the way for new forms of creative encounters with technology that let users experience themselves as part of a wider network of agencies, finetuning their awareness of ecological embeddedness that is crucial for developing sustainable ways of being and acting in the world (Del Favero, Thurow, Frohne, forthcoming).

2.3 Elaboration SPACE of SPACE Intelligent SPACE Aesthetic SPACE Frameworks

The latest generation of research at iCinema focuses on upscaling the intelligent capabilities of digital agents and leveraging these for reformulating basic processes in creative arts as well as museological practice. With the long-term objective to unlock new creative and institutional potential with the help of AI, this research focuses on integrating human and machinic capabilities in such a way that technology may augment and extend human creativity. The aim hereby is to institute 'parallel autonomy' for digital systems rather than to strive toward a 'serial autonomy' that would replace human agents in a digitised process (D'Inverno, McCormack 2015, 2440). In flanking and supporting human agency with digital systems, the experience takes on a distributed quality, honing collaborative and explorative skills by extending the means available for research, production and reflection. Working from the premise that technological advances condition certain ways of practice and vice versa (Delanda 1994, 264), iCinema's current research investigates the foundational concepts that inform a given practice, taking stock of standard methodologies and analysing how these have enabled progress yet, also specifying how they may inhibit further advances in a field. Currently, the Centre administers three large-scale research projects under the direction of Del Favero that seek to deliver tailored solutions for the museological and performing arts sectors, leveraging AI-methodologies for upscaling collection management, curation as well as design and rehearsal practice.

The *netARCHIVE* project (2019-22; LP180100126) is undertaken in collaboration with the Sydney-based Museum of Applied Arts & Sciences (MAAS), addressing the challenge of providing compelling user-led digital approaches that enable coherent exploration and management of dispersed collections and their environs. Institutionally, MAAS encompasses three venues located in different parts of Greater Sydney, each holding distinct collections that extend to particular subject areas and geographic locales. To achieve their experiential and curatorial integration, *netARChive* investigates an embodied, distributed storytelling framework that is underpinned by an artificially intelligent database. It is constituted through a cluster of net-

worked platforms, including the *AVIE*, a mobile application and a website portal to be run on desktop computers. From each of these platforms, users are able to access and interrogate MAAS' database. Yet, rather than accessing it through their conventional *EMu* interface, user searches are funnelled through a customised application programming interface (API) that provides additional AI-supported capabilities. On the one hand, the application works as a real-time recommender system, proffering data from the collection that concurs with a user's query. It dynamically refines its search outcomes as the user continues to select and save their preferred digitised collection items to a personal account. On the other hand, the system logs each user interaction, processing the bundles of assets generated by visitors as new data on their preferences which is fed into the *EMu* database.

For example, a visitor to MAAS' Powerhouse Museum will be able to enter the *AVIE* and encounter a one-to-one scale panoramic projection of an animated urban scene in Sydney's Central Business District anno 1850. Being accosted by a range of digital characters, the visitor may choose to engage through gesture and voice with a merchant who sells astronomical instruments. Adopting this character through the app run on their personal mobile device, the user will experience the museum's physical exhibition with this digital character as a personal guide and interpreter. As users point their device at an artefact, the app will activate augmented content, revealing aural histories, collection links, maps, multimedia content, 3D animations and a web browser. The user will be able to virtually collect and store artefacts on their mobile device, with the system analysing their choices according to emerging fields of interests. Having dynamically mapped these preferences, the system will generate personalised recommendations for further exploration, suggesting both sites in the immediate vicinity of the museum as well as items of interests on display at MAAS' other venues. To deepen engagement with these knowledge pathways, users may utilise the desktop application to extend their searches into dedicated fora and external partner websites, offering enhanced browsing and social networking functionalities.

The hypothesis is that, when provided with such a framework, users will be empowered to experience heterogeneous artefacts and data in lucid ways and to compose them as an expanding network of distributed yet semantically connected episodes. Doing so will enable to release the concept of museum experience from a solely curator-directed event playing out in a restricted physical space, to advance instead a concept in which visitors and AI systems are involved in co-creating meaning by actively shaping the experience and contributing behind the scenes to data management and elaboration (Macalik, Fraser, McKinley 2015, 2). This will furnish MAAS with greater

clarity on their visitors' interests, enabling them to closely cater to their various visitor demographics as well as to enhance their curatorial pipelines through AI-assisted database management.

A similar objective drives iCinema's *memorySCAPE* project (2019-22; LP180100080), which investigates the application of an intelligent database narrative framework to develop the commemoration of war, working with the Australian War Memorial (AWM) in Canberra to integrate their steadily growing heterogeneous collection of artefacts and documents pertaining to the Afghanistan conflict. Since a large portion of this collection represents digitally native material in various formats, the AWM's challenge resides in processing these for a compelling visitor experience that integrates with physical artefacts while operating within the restricted protocols governing military commemoration. To address this challenge, the project team is currently working on a solution that enables memorial audiences and staff, assisted by an AI database, to compose museological experiences by interlinking and contextualising diverse data across a range of interactive digital platforms. This will deliver a new intelligent form of commemorative database and display, transforming the way in which the experiences and recollections of personnel can be interactively captured, organised and explored. This will allow more effectively addressing the social nature of memorialisation and the multi-dimensional quality of defence personnel experiences than currently practised (Phillips, Reyes 2011, 14). While adopting a similar cross-platform approach as in *netARChive*, the key AI deliverable for this project is to achieve a coherent translation of a large amount of heterogeneous, mostly unscripted and unprocessed data into compelling narrative episodes that users may assemble into informative storylines. For example, the AWM's audio-visual archive of accounts by Afghanistan veterans currently comprises 20,000 hours of uncatalogued data that in its present state and volume provides little curatorial value to AWM staff, let alone their visitors. The project team leverages natural language processing algorithms to automatically transcribe this data, comprehensively auto-tagging the personnel accounts with narrative-based keywords. This will enable the digital agent to identify and play back selected veteran accounts in response to conversational user queries about certain facets of the Afghanistan war experience. Hence, the digital agent here significantly improves accessibility and intelligibility of the data, opening it up for analysis and engagement that would otherwise devour a substantial amount of the AWM's time and resources. Parallel autonomy here articulates as a complementary interactive relationship between human user and digital agent that draws on their respective strengths in quantitative and qualitative information processing. Same as in *netARChive*, the digital agent programming will enable to identify, analyse and dynamically respond to user queries,

supporting or challenging their assumptions with a selection of related data that provides expanded perspectives on the content in question. The digital agent hence becomes a conduit for deepening the engagement with an exhibition. It provides avenues for reaching beyond the physical limitations of artefacts and their on-site discursive framing by inviting the user onto unanticipated informational trajectories. These may reveal unexpected relational patterns among the AWM's data that can shape new perspectives on experiences of deployment and warfare, their history as well as their impact on communities in Australia and abroad.

These AI capabilities also find application in iCinema's current performing arts-based applications, which seek to enhance design and rehearsal practices via full-body immersion. The *iDesign* project (2018-21; LP170100471) thereby targets a reconceptualisation of set design aesthetics. It does so by supplying an interactive digital framework that embodies the entire modelling pipeline, eliminating the costly need for alternating between digital and physical platforms in the creative process. Conventionally, set designers create scaled set models using a mix of analogue tools and desktop applications. Once drafted, the scale model provides the blueprint for a physical trial-extrusion on stage. In this so-called 'Bauprobe', the functionalities and aesthetic properties of a proposed design are evaluated and subsequently adjusted (Brejzek, Wallen 2018, 20). Due to growing resource constraints and sustainability concerns in the performing arts sector, alterations at this stage in the production process tend to focus on improving a design's operation rather than radically revising its foundational aesthetics. By immersing designers in *AVIE*'s one-to-one scale visualisation space, *iDesign* affords the means to collaboratively prototype set models from the outset at life size on a virtually twinned theatre stage. Its full-body immersion enables a sense of inhabitable space from the beginning, allowing an impromptu evaluation and critical iteration of design ideas without the obligation to commit costly resources to a physical Bauprobe. With a customisable industry-tailored asset library as well as free-drawing and sophisticated lighting capabilities, the platform enables designers to introduce significant efficiencies into their workflow that open up scope for expanded creative exploration. The platform's AI functionalities thereby support practice in three ways: firstly, the system monitors a design's effect on audience sightlines, calculating optimal dimensions and placement of assets on stage to improve the viewer experience while keeping negative impact on aesthetic quality at a minimum. Secondly, it tracks occupational health and safety compliance, evaluating a design's potential hazards and suggesting a range of feasible adjustments. Thirdly, on the grounds of its steadily growing design archive, the AI is being trained to creatively collaborate with the user, for example by identifying a designer's intentions and rec-

ommending solutions to problems on the grounds of previously realised designs. This form of parallel autonomy for the AI agent is carefully integrated into the modelling process so as to not disrupt the creative flow of ideas or unduly overdetermine experimentation. Responding to desiderata identified through industry focus groups, the AI system can be fore- or backgrounded in the application interface, ensuring that it will analyse input throughout, yet only offering suggestions to the creative team when prompted.

Other research at iCinema currently adapts and extends the AI capabilities developed thus far in its research context, applying them to support the entire performing arts production design process. It develops an intelligent cyber-physical spatial aesthetic that affords the means to virtually ideate, compose, integrate and test the entire palette of design components flowing into a stage production within an interactive 3D modelling environment. This represents a significant step change for performing arts rehearsal design as the current standard relies on partitioned design pipelines that draw on a range of individual digital tools. While the latter have introduced significant efficiencies especially into the creative ideation phase – proving powerful in refining emergent design ideas –, communicating these ideas across the creative team and testing their feasibility vis-à-vis other components is currently still markedly constrained. This is due to the lack of a platform that is capable of visualising and flexibly adapting the interaction of all activity streams, such as set, costume, lighting and multimedia design. Thus far, comprehensive testing, evaluation and refinement is only undertaken in costly physical stage rehearsals that require gathering the entire team of directors, designers, choreographers, cast, musicians and technicians in the theatre space, which during this time is unavailable to other performers. Consequently, rehearsal periods tend to be timed meticulously, condensed into very short periods of time that place contradictory demands of efficiency and creative affluence on the team to communicate and fuse their separate visions into a coherent whole. The new iCinema platform will address this limitation by developing a fully immersive shared rehearsal environment that facilitates collaborative decision making by distributed creative teams. Using a dynamic cross-platform visualisation pipeline (comprising *AVIE*, *HTC Vive*, tablets and desktop computers that will be networked using the *HEVS* software; Bourke, Bednarz 2019, 65), the creative team will be able to upload their specific design components into a shared modelling space where they can virtually validate ideas before testing their interaction on a physical stage. Component data may extend to costume and choreographic sketches, musical scores, set models and stage plans, indicative lighting states, mechanical tracking notes, performance cues, screen content, robotic props, stage configurations and truss plans. The modelling system will allow real-time team composition,

assembly and manipulation of components – both in orthographic (i.e. diagrammatic) as well as stereoscopic (i.e. 3D) view. Each interaction on the platform will be recorded, enabling playback and archiving of component operation, both individually and in combination, in time with the musical score, to afford exhaustive testing capabilities. The AI deliverables for this platform once again target the streamlining and optimisation of testing and iterative refinement. Its AI data analysis, documentation and recommendation system tracks user action on the platform, monitoring the impact of component integration on line-of-sight angles as well as flagging potential collisions or obstructions resulting from component dynamics. At any time, creatives may prompt the system to generate alternative solutions to their current vision, with capability to 'accept and integrate' or 'reject and return' to their original design. Leveraging the agility and computing power of the AI system in this way will allow the team to swiftly revert their focus back to aesthetic conceptualisation and refinement rather than getting caught up in lengthy assessments and calculations. The system will hence support creative flow, collaborating with users on solving integration issues as well as supplying expanded resources for further ideation that may impact future aesthetic direction. Accordingly, the AI system will supply both the framework for interaction as well as act as a proactive partner throughout the design process, configuring it as an evolving matrix of co-determining material, human and technological dynamics (Latour 2017b, 174).

3 Conclusion

The research conducted at the iCinema Centre has addressed many challenges that have constrained advancements in creative arts and museological design. Its most recent focus on AI probes the current frontiers of collaborative human-machine paradigms, seeking to carry across latest advances in the field of Computer Science into the digital and public humanities to exploit their capabilities for supporting new cultural insight and expression. Dominant practical challenges that circumscribe this work and its translation into broader domains relate to data availability, interaction modalities, pipeline integration and aesthetic innovation. In order to deliver workable digital solutions to industry partners' requirements, a representative amount of data has to be available and of sufficient quality so as to furnish the AI system with an informational foundation to draw on. This means that, for example, a museum has to first implement a digitisation strategy and provide a data collection that can be streamlined through computation and tagging. Such preliminary steps can become a costly endeavour and need to be resolved prior to commencing any research activity. As digitisation has entered the list of

priorities of many institutional agents, the quality and cohesiveness of the records created can be decisive for delivering compelling experiences. A higher degree of completeness and homogeneity within a database enables more streamlined discovery and informative interlinking of assets that result in dynamic human-machine transactions. How these exchanges are best conducted, i.e. which interface will suit users the most, will thereby depend on the kind and length of activity they seek to perform and what form of experience will result in novel insight. For example, while gestural input within *AVIE* during set design ideation can powerfully support the development of ideas, allowing embodied exploration of inhabitable space, carrying this input modality across the entire refinement phase would prove physically too strenuous and would potentially disrupt the creative flow when adjusting intricate details of a design sketch. Consequently, a combination of input modalities can enhance the usability of a platform, flexibly adapting to the needs of a user. A new platform's user-friendliness is key also because it needs to as effortlessly as possible integrate with existing institutional pipelines to ensure uptake by staff and visitors. If an interface design proves unintuitive and too complex, it will not successfully compete with established systems as users will likely revert back to proven and familiar solutions once the 'gadget novelty effect' wears off. Providing compatibility with software suites that are firmly established on the market and ensuring seamless platform exchanges can help, making the costly investment that accompanies any new digital ecology a worthwhile consideration within long-term strategic institutional planning. An important consideration for implementing such strategies is that the digital experience needs to add genuine value to an institution's engagement, addressing an experiential dimension that the physical alone cannot supply.

iCinema's research explores how such add-on can be generated by abandoning the conventional approach of simply providing a digital 3D twin of a physical artefact that can be explored on a desktop screen. Instead, it reconceptualises the aesthetics that underpin the display of data as well as the status of the digital system as an agent in its own right. Imbuing the digital system with autonomous decision-making capability and enlisting this to support human exploration and reflection of cultural datasets configure it as a shared practice, centralising collaboration and joint agency at its heart. Instead of re-inscribing modernist conceptions of the human subject as central to meaning-making activities, this recalibration articulates agency as a rhizomatic structure that intertwines human and non-human entities in dynamic collaboration. It accounts not just for the human gaze onto the world but introduces machinic reasoning into the epistemological process that complements and expands the user's schemes. iCinema's research is thus indebted to theories that

incepted a non-human turn in the humanities, conceiving of users as part of a wider network comprising organic and synthetic agencies (e.g. Barad, Delanda, Latour). This body of thought pushes us to re-define our place in and our relation to the world, providing us with the tools to investigate what forms 'knowledge' and 'understanding' in the Digital Age may take. Fusing human and machinic agencies in research that is conceptualised through a humanities-driven lens provides an ideal conduit for such exploration, given its concern for the ways in which we perceive, process and understand information.

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From Digital Archaeology to Data-Centric Archaeological Research

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Abstract Since the end of the 20th century the widespread use of digital applications in archaeology has legitimized their inclusion in the archaeological toolbox. Together with archaeological sciences, databases, GIS and other computer-based methods are nowadays present in every respectable archaeological investigation. This makes archaeology a peculiar discipline, where the scientific method combines with the historical one to produce new knowledge. However, the large availability of archaeological data creates the risk of a data deluge and may suggest using online information just to collect previous interpretations rather than to re-use the data supporting them. A 'Grand Challenges' list compiled some years ago includes important research questions that undergird contemporary issues and require an appropriate digital methodology to be addressed. The present paper discusses the benefits, or better the absolute need, of a data-centric methodology to address large-scale research. It argues that an acritical use of the so-called 'Big Data' approach may be questionable. It suggests how the combination of artificial intelligence with human intelligence is the key to progress into the understanding of phenomena of paramount societal importance for researchers and for the public at large.

Keywords Archaeological data. Data-centric research. Semantics. Archaeological ontologies. Big data.

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1 Introduction

In a paper published about 20 years ago (Gardin 1999, 63), Jean-Claude Gardin stated that:

> un des problèmes majeurs de notre temps en matière d'information scientifique est le déséquilibre qui s'est instauré entre la quantité croissante des travaux publiés à l'intention des chercheurs que nous sommes, dans quelque domaine que ce soit, et le temps à peu près inchangé que nous pouvons consacrer à les lire.[1]

As Gardin mentions in the same article, a similar statement had been made almost 10 years before, in 1991, by Sir Anthony Kenny, then President of the British Academy, who declared that he could not hope to read more than a very small part of the articles published in the UK and the USA relevant for his reportedly *narrow field of interest*. In sum, the question of 'information deluge', i.e. the overwhelming quantity of data pertaining to the same subject is not new, and, according to Gardin, the development of information technology did not appear to have solved it in those early years:

> les nouvelles technologies de l'information ne répondent pas pleinement à la crise présente de l'information scientifique. (66)[2]

A few years ago, Keith Kintigh and several other US archaeologists, authors of a 2014 paper (Kintigh et al. 2014, 19) on the Grand Challenges for Archaeology, stated that:

> both the modelling and the synthetic research will require far more comprehensive online access to thoroughly documented primary research data and to unpublished reports and other documents detailing the contextual information essential for the comparative analyses.

In conclusion, the amount of information available online is exponentially increasing due to the improved availability of storage and to policies fostering openness of research results. This is a significant achievement, but without a solution, available information risks to become unmanageable because, as Gardin stated, the time available

1 "One of the major current problems concerning scientific information is the existing imbalance between the increasing quantity of works published by researchers like us, in whatever domain, and the almost unchanged time that we can spend on reading them" (this translation and the following ones are by the Author).

2 "New information technologies do not *fully* answer to the present crisis of scientific information" (Author's italics).

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for reading has remained the same notwithstanding such increase.

Policies concerning Open Access, such as the FAIR (Findable-Accessible-Interoperable-Reusable) data principles (Wilkinson 2016, 2019) will help little in the retrieval of archaeological information unless accompanied by implementation guidelines and supported by effective software tools and services. The FAIR principles concern generic research data, and it is relatively easy to document scientific datasets with appropriate metadata in order to be able to fulfil such principles.[3]

On the contrary, for archaeological datasets, plain compliance with the FAIR principles is a significant step forward, but not enough to address the issues described above. This is due to the complex nature of archaeological datasets, where the scientific method combines with the historical one to produce new knowledge and the contribution of many different disciplines including physics, chemistry, materials science and biology adds to direct observation and to digital services like databases, GIS (Geographical Information Systems) and more. The issues discussed in the present paper concern, in particular, unpublished archaeological reports (the so-called 'grey literature'), which are the most difficult to manage, more than publications, for which there exist well-organised digital libraries. In what follows, reference to archaeological text documentation should be intended to include both.

In the present paper, potential advancements to survive to the archaeological data deluge are discussed. The first part will address data accessibility and interoperability, together with what might be called 'first level' findability. To implement full re-usability that requires 'advanced findability', more sophisticated technology is required. A discussion of available methods and tools to achieve it is presented in the second part of this article, including some caveats about potentially misleading shortcuts.

2 Gardin's Logicism

Before proceeding, Jean-Claude Gardin must be cited again. He must be credited for proposing 'Logicism' (Gardin 1980) in the last quarter of the twentieth century, an innovative approach on how IT can support archaeological research. The logicist proposal was criticised arguing that it proposed to simulate archaeological reasoning, with what appeared to critics as a lack of interest in the content.

3 Henceforth, when one of the four terms forming the FAIR acronym is mentioned with reference to the principles, it will be capitalized: e.g. 'Find' refers to the first of the FAIR principles while 'find' just means discover, retrieve, as usual.

Even in France, the logicist approach did not become a blockbuster and did not achieve a widespread acceptance, besides an attempt to use multimedia for the purpose (Gardin, Roux 2004).

Logicism had little fortune outside of France also because it did not belong to the Anglo-centric theoretical and methodological discussion. In Italy, besides the pioneering journal *Archeologia e Calcolatori*, computer applications at the time were not appreciated in the archaeological circles, with the notable exception of a handful of far-sighted distinguished scholars. The few researchers interested in such applications were more attracted by English and American models such as those, for example, presented at the annual CAA (Computer Applications and Quantitative Methods in Archaeology) international conferences (D'Andrea, Niccolucci 2000). Thus, also in Italy this methodology did not attract many supporters and had no application.

Regardless of any theoretical evaluation of logicism, a major obstacle to its diffusion consisted also in the need to adopt a novel system for the documentation, risking that all the accumulated results might become incompatible with it. But, on this regard, a French team has recently used a logicist approach to document the excavations in the church of Rigny with interesting results (Buard et al. 2019; Marlet et al. 2019; Zadora-Rio et al. 2020). This methodology provides interoperability with other systems by using for its concepts and its inference chain (the reasoning) the standard ontology used in Cultural Heritage with the appropriate archaeological extensions, described in the next sections. This could make the logicist approach interoperable with the archaeological documentation standards, keeping the richness of documentation it provides and overcoming the objection of being an 'alien' in a world of databases, archaeological GIS and systems based on semantics. This work is currently progressing, as shown in a very recent methodological paper (Nuninger et al. 2020).

3 Data Availability and Access

Back to Kintigh's statement mentioned above, several initiatives started collecting and making available online archaeological documentation. The most important initiatives to store, preserve and make archaeological data available online are ADS (Archaeological Data Service) (Richards 1997, 2017) in Europe, led by Julian D. Richards at the University of York. ADS is a UK repository for digital archaeological records existing since 1996, storing a large number of unpublished reports. In the USA, tDAR (the Digital Archaeological Record) aims at a similar target (Kintigh 2006; McManamon, Kintigh, Brin 2010). tDAR is led by Keith W. Kintigh at Arizona State University. There are also many specialised databases such as, among others,

ROAD (ROCEEH Out of Africa Database) created by the ROCEEH[4] (The Role of Culture in Early Expansions of Humans) project led by the University of Tubingen and funded by the Heidelberg Akademie der Wissenshaften (Heidelberg Academy of Sciences), dedicated to palaeoanthropological and palaeoenvironmental data; and Open Context,[5] a US initiative publishing research data at a fee.

Since 2013, the ARIADNE (Archaeological Research Infrastructure for Archaeological Data Networking in Europe) project is an EU-funded integrating activity to aggregate archaeological datasets in Europe (Niccolucci, Richards 2013; Meghini et al. 2017; Aloia et al. 2017; Niccolucci 2018). It has created and manages a registry of about 2,000,000 archaeological datasets, searchable according to facets such as time, place and object type. The ARIADNE extension, ARIADNEplus (Richards, Niccolucci 2019; Niccolucci, Richards 2019), also an EU-funded project, recently started an ambitious plan to extend its coverage both geographically and thematically, using state-of-the-art digital technology to support searching and finding. ARIADNEplus is fully compliant with the FAIR data and Open Science principles.

Both ARIADNE and ARIADNEplus work as aggregators. They collect metadata from organisations managing a data repository such as ADS or other institutions in Europe that institutionally store archaeological datasets, like INRAP (Institut National de Recherches Archéologiques Préventives) in France; KNAW-DANS (Data Archiving and Networked Services of the Koninklijke Nederlandse Academie van Wetenschappen) in the Netherlands; and many more. Actually, ARIADNEplus has widened its horizon, including among its providers the already mentioned tDAR in the USA; the Argentinian network of archaeological research centres created under the auspices of CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas); IAA (Israel Antiquities Authority); and Nara (Nara National Research Institute for Cultural Properties) in Japan. At present, 41 partners are involved, coming from 22 EU and EFTA (European Free Trade Area) countries, and from UK, USA, Argentina, Israel, and Japan outside Europe. A continuously increasing number of associate partners is joining the initiative, extending the ARIADNE coverage in practice to all of Europe and beyond.

The process of aggregation consists in the collection of dataset metadata from the data providers, their conversion to a common standard and the inclusion in the catalogue. The original datasets are kept and maintained by the owners.

ARIADNE organises such metadata into a catalogue presently containing about 2,000,000 items, which can be accessed and searched

4 https://www.hadw-bw.de/en/research/research-center/roceeh/home.

5 https://opencontext.org/.

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via the project portal.[6] Search parameters may be defined according to keyword, time, place and data type. The search produces a list of datasets fulfilling such parameters, each one with a short description based on the related metadata stored in the catalogue. Each list item is linked to the original dataset stored at the dataset owner, which can be directly accessed by the user according to the access rules established by the data owner. The catalogue is being continuously updated and new items are added as soon as they become available.

Creating the ARIADNE catalogue has required the setup of common controlled multilingual vocabularies based on Getty's AAT (Art and Architecture Thesaurus, Getty s.d.) and the creation of cross-references for named periods, which are location-dependent, as it is well-known that Iron Age, for instance, covers a different time-span in France, England and Ireland.

From the FAIR perspective, ARIADNE is a one-stop access point to archaeological repositories which includes a find functionality. Interoperability is provided by the use of a common ontology, called AO-Cat (ARIADNE Object Catalogue), which is a subset of the current standard ontology for the domain, CIDOC CRM (Conceptual Reference Model of the Comité International pour la Documentation – International Committee for Documentation of ICOM, the International Council of Museums), usually referred to simply as 'the CRM' (Doerr 2003a; Doerr, Kritsotaki, Boutsika 2011; Doerr, Smith-Ore, Stead 2007). In ARIADNEplus, all contributors' metadata schemas are mapped to > AO-CAT- using tools provided by ARIADNEplus.

As regards re-use, a number of services to re-process the data are being made available to users. They will be operational in a VRE (Virtual Research Environment), i.e. a virtual space within the ARIADNEplus infrastructure where data can be stored, processed and analysed by users. An aspect still under investigation is data reliability, a key factor for re-use. ARIADNE and ARIADNEplus have so far addressed this issue by accepting only data from highly-reputed institutions: but extending data aggregation to new repositories will require investigating how to evaluate the trustworthiness of the data and of their producer.

4 The Semantic ARIADNE Infrastructure

As already mentioned, datasets in ARIADNE are organised according to a general ontology, AO-Cat, a subset of the CRM ontology. AO-Cat includes a limited number of classes that are common to any dataset. AO-Cat is fully documented on the ARIADNE web site.

6 https://portal.ariadne-infrastructure.eu.

The general nature of the AO-Cat structure is determined by the extreme diversity of archaeological datasets. As regards formats, there are texts (usually PDF), images, maps, drawings, tables (e.g. Excel ones) and databases created with different DBMS (Data Base Management Systems). Also their content is extremely diverse: there are excavation reports, sites and monuments descriptions, lists of finds, results of scientific analyses and more. ARIADNE has listed 14 groupings of such subdomains, ranging from a-DNA (ancient DNA) Analyses to Standing Structures. For each sub-domain, an Application Profile is envisaged, i.e. a specification of the AO-Cat ontology. For example, the Application Profile for analytical investigations includes specific classes to better describe the data, such as, among others, Analysis, which describes the kind of analysis used in the investigation, and Sample, which describes the sample being analysed. All the classes and properties used in the ARIADNE Application Profiles are taken from the overall CRM ontology or from one of its extensions[7] such as CRMarcheo, the CRM extension for archaeological excavations; CRMsci, the CRM extension for scientific investigations in general; and CRMdig, the CRM extension for digital objects and activities.

The use of Application Profiles will allow a LOD (Linked Open Data) approach. But it also shows that there is a tension between the factuality implied by the CRM and the semantic representation of abstract concepts and inference processes (Doerr, Kritsotaki, Boutsika 2011; Lippi, Torroni 2016) used in the archaeological discourse. Argumentation and inference appear to be the current frontier of any data-centric archaeological semantic methodology, together with documenting quality, uncertainty and imprecision.

5 Beyond the Aggregation of Archaeological Datasets

Aggregating archaeological datasets from sparse repositories as done in ARIADNE or tDAR is a significant step forward to use and re-use archaeological data. Before they were created, a researcher needed to access many different repositories, some of which did not even provide a search engine. Google search gave no support because it produced too many hits and was unable to go beyond the surface of repositories, without reaching and indexing the datasets they contained.

Nevertheless, further progress is still desirable.

All integrating initiatives rely on metadata that are usually not rich enough to satisfy Kintigh's conditions mentioned above. Kintigh

7 All the CRM documentation is available on the web site: `http://www.cidoc-crm.org/`.

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(2015) shows with an example that knowledge extraction from archaeological texts requires not just recognition of nested relationships but also substantial reasoning to properly assess the information, as well as the ability to analyse texts written in languages different from English: an improvement in the semantics is mandatory. Text mining techniques have been applied to archaeological data in various ways to enrich the metadata originally provided with the records (Richards, Tudhope, Vlachidis 2015; Felicetti et al. 2018), and there are promising efforts to identify nested connections and argumentation built on them (Meghini, Bartalesi, Metilli 2017; Meghini et al. 2018).

An additional complication derives from the intrinsic uncertainty that accompanies all archaeological data. Studies on how to identify and address the fuzziness of archaeological knowledge were initiated almost 20 years ago[8] starting from burial databases and lithics typology, and progressively extending to concepts such as time, place, archaeological site and archaeological 'culture' (Niccolucci, Hermon 2015; Niccolucci, Hermon 2017; Hermon, Niccolucci 2017). Archaeological reasoning and argumentation are likely affected by such fuzziness in an even greater way. Also theoretical considerations as those introduced by Niccolucci, Hermon and Doerr (2015) must be taken into account.

6 Technology: A Quick Overview of the State of the Art and the Need for Innovation

6.1 Semantics

The debate on archaeological argumentation, in the broader domain of archaeological theory, has seen many contributions in the last two centuries, with a peak in the late 20th century. While we will not enter in such discussion, it is clear that the first step to re-use and build on data is documenting argumentation with a neutral approach, keeping into account that the semantic structure of reasoning differs according to the theoretical school authors belong to. Assessment must be left to the user, supported by appropriate documentation. The CRM does not consider such aspects, it deals with actual information stored by researchers, museums, libraries and archives. Thus, it needs to be extended to take account also of how such data were produced, collected, analysed and synthesised. Hints in this direction may come from current studies on narratives, so far semantical-

8 See Niccolucci, D'Andrea, Crescioli 2001; Hermon, Niccolucci 2002; Niccolucci, Hermon 2003; Hermon, Niccolucci 2003; Niccolucci, Hermon 2010.

ly analysed from a literary perspective.[9] Since archaeological reports tell a story about the past, an analysis of narration may give significant insights. Archaeology as a discipline has its reasoning structure that needs to be interpreted and formalised into a model allowing the description of archaeological statements ('interpretation') in formal terms. 'Narrative' modelling has not been applied in archaeology so far. In parallel with such semantic backbone, tools to analyse stored data are equally required.

Such a new ontology will also need to take into account the representation of uncertainty due to the fuzziness of archaeological statements (Niccolucci, Hermon 2017). The application of fuzzy logic in archaeology is motivated by the need to consider the intrinsic imprecision of archaeological concepts. Fuzziness involves time, space and basic concepts such as type, site and culture. It arises when analysing argumentation and the trustworthiness of conclusions. In semantics, fuzziness is introduced with the concept of 'fuzzy ontology' (Cross 2018; Cross, Chen 2018; Di Noia et al. 2019), used in various domains, from medicine (Parry 2004) to news articles (Chang-Shing, Zhi-Wei, Lin-Kai 2005), but not yet applied to the archaeological discourse.

6.2 Machine Learning, Text Mining and Pattern Recognition

Machine learning has been used in the creation/adaptation of tools to search archaeological datasets and to enrich their metadata.

As regards **Text Mining using NLP** (Natural Language Processing), successful examples of initial application in archaeology[10] have demonstrated that they strongly depend on the underlying semantic structure and on multilingual vocabularies. Machine learning is promising great opportunities, especially in identifying arguments and content beyond, or across, different styles, languages, contexts and purpose.

Another field where computer may support archaeological synthesis is **Pattern Recognition** in 2D images. Here the step forward requires going beyond the mere appearance and graphical resemblance, looking instead for stylistic similarity as defined by archaeologists (Bolettieri et al. 2015; Amato, Falchi, Vadicamo 2016). Another topic with a great potential is **3D Shape Recognition**, i.e. the classification of artefacts based on their shape. There is a large number of studies on this subject, those more relevant for archaeology are probably the ones by Tal (2014), Canul Ku et al. (2018) and

9 Ciotti 2016; Meghini, Bartalesi, Metilli 2017; Meghini et al. 2018; Bartalesi, Meghini, Metilli 2017; Bartalesi et al. 2019.

10 Richards, Tudhope, Vlachidis 2015; Felicetti et al. 2018; Esuli, Moreo, Sebastiani 2019.

Hermon et al. (2018), and the research carried out in the EU-funded project GRAVITATE[11] coordinated in 2015-2018 by Michela Spagnolo of CNR (Consiglio Nazionale delle Ricerche) as well as in the ARCHAIDE[12] EU-funded project.

6.3 Virtual Research Environments

A **VRE** (Virtual Research Environment) is a computer framework that virtually mimics a research laboratory, making available in the same virtual space the data and the tools to process them, by individuals or by teams collaboratively working on the same topic (Jeffery et al. 2017). An example of such environment for archaeological research is the one called D4Science (Candela et al. 2014) at ISTI (Istituto di Scienze e Tecnologie dell'Informazione) of CNR in Pisa, Italy. This VRE is being activated for the ARIADNEplus project and will host the services provided by the project to process archaeological data, like the storage of interim results and the reference to their background data, annotation and workflow organisation, text mining, and more.

6.4 Addressing Archaeological Grand Challenges

In conclusion, there are several technologies that may help in managing the archaeological data deluge by organising, synthesising and interpreting them, but they still need an overall methodological organisation to define a data-driven approach to the archaeological research methodology. This is an indispensable step, resulting from the awareness that addressing archaeological Grand Challenges – as defined by Kintigh et al. 2014 – needs to synthesise a huge amount of fragmented information resulting from the convergence of investigations based on many diverse sources and methodologies, such as field campaigns, stylistic analyses, scientific analyses, historical sources and anthropological approaches. As reported in the above-mentioned paper, this concept of archaeological Grand Challenges came after a survey asking the members of the European Association of Archaeologists and the Society of American Archaeologists to indicate the archaeological problems of broad scientific and social interest that could drive cutting-edge research in archaeology for the next decade and beyond. The most compelling and important scientific questions in archaeological research, the Grand Challenges, were then identi-

11 A list of related publications is available here: `http://gravitate-project.eu/?q=content/articles`.

12 `http://www.archaide.eu/`.

fied, elaborating on the answers received and eventually compiling a list of 25 of them. Each one has global significance, requires decisive support from data and involves multidisciplinary collaboration to be solved. The list includes questions about community dynamics, transformation of societies, human-environment interactions and movement and mobility of people, including migrations.

At present, the availability of a wide online access seems reasonably at hand; detailing the contextual information may instead still require substantial research work.

As already mentioned, Kintigh (2015) also shows with an example how misleading a naive approach based on simple word search could be.

Besides the ability to analyse texts written in different languages, a radical change in the semantic approach is therefore mandatory to discover data relevant for re-use which may be buried under several information layers, as they were considered of minor importance for the original research question. Kintigh concludes (2015, 97) that the tools currently available do not support a deep analysis of texts – as published papers or grey literature – which remain one of the most important sources of knowledge:

> Enormous quantities of archaeological information and knowledge are embedded in often-lengthy reports and journal articles […] A number of factors conspire to frustrate synthetic research. They include the problems of discovery and access to archaeological data, the difficulty of integrating data from diverse sources, and the problem of extracting usable data, information, and knowledge from text. [It is necessary] to translate knowledge written in natural language into a state-of-the-art knowledge representation language [that] can be queried by machine reasoning based on formalized basic principles of archaeology. (2015, 97)

Raw scientific data are no less difficult to integrate. For example, Sr isotope analysis is widely used when studying migrations, to identify foreigners – potential immigrants – buried in cemeteries. However, such data might need to be combined with studies on pottery or metalwork, to discover a stop-over of these migrants before they reached their final destination. Viking settlers in Britain may have originated in Denmark or Norway, but it appears from their dress accessories that many made a stopover in Carolingian France or Ireland before reaching England. Migration is frequently a complex phenomenon, not a question of single start- and end-points. Migrations are a good example of how an archaeological Grand Challenge from the above-mentioned list needs a powerful support from data.

In conclusion, data-driven archaeology is not a job for 'parachuted' technologists – here the data science and knowledge organisa-

tion experts – who pop up at some point in time and teach archaeologist how they should organise their methods and way of thinking. It is neither a do-it-yourself machinery, as this would possibly turn into *the blind leading the blinds* of biblical memory (Matt. 15:14). Instead, a *bicycle for two* approach[13] is required: data science for archaeology must be tailored according to the nature of the discipline, the use researchers need to make of them, and how the archaeological discourse is structured.

7 Archaeological Big Data

Archaeological data are increasingly available in digital format but, according to Hugget (2015, 2019), they are messy and complicated by their partial, fragmentary, interpretative nature. Hence, sometimes existing data may not be re-used and incorporated in archaeological interpretation just because they are not identified as relevant or because they are disregarded in the flood of available information. Applications of information technology and proper data organisation endeavour to reduce this risk. The large amount of available data has suggested to address the question in a 'Big Data' framework. As it is well known, the so called 'Big Data' approach collects, stores and analyses very large sets of data, too large to be processed with the usual data processing software. However, the term 'Big Data' applies to archaeological data with a different nuance than it usually has, and their intrinsic diversity may lead to unforeseen results, as argued by Hugget. Studies have demonstrated that inconsistent results may be produced by applying deep learning and AI (Artificial Intelligence) techniques in an irreflexive way (Woodall et al. 2014; Succi, Coveney 2019), replacing causation with correlation, thinking that the numbers speak for themselves and that research can advance even without coherent models or unified theories.[14] In these papers it is also argued that the impact of poor-quality data can increase rather than reduce, as dataset size increases.

In archaeology, 'big' refers more to variety and diversity than to quantity. Archaeology does not create an immense – but conceptually shallow – ocean of data, continuously and rapidly increasing in number, as for example the data used for behaviour analytics on the

13 This definition was originally used by Pollard and Bray for archaeological sciences (2007).

14 This sentence is the Author's synthesis of the conclusions made in Succi's and Coveney's paper (2019).

web or those created by the Internet-of-Things.[15] Such big data can indeed be addressed using powerful computing power and relying on a pretty simple knowledge organisation system. On the contrary, archaeology requires the definition of a complex semantic organisation able to capture and organise the inner meaning of statements, arguments and interpretation. Therefore, data science must adapt to the specific needs of the discipline and focus on refined semantics rather than on large-scale processing only.

There is another common pitfall: the belief that if tools work properly when applied individually, they do the same when used in cascade. It is actually the opposite. A fictitious example will clarify this statement.

Let us assume we have an excellent OCR (Optical Character Recognition) system able to recognise characters from written texts, even handwritten or poorly printed ones, in our case for example inscriptions or historical accounts. Such a system has a success rate of 90%, i.e. it understands correctly 9 characters over 10 and puts them in sequence to form words. Also, let us have a very good text mining system. It can extract, among others, monument descriptions from texts, based on controlled dictionaries, ontologies, and all the required semantic paraphernalia. Only 10% of its extractions turns to be wrong, i.e. it also has a success rate of 90%. Finally, let us assume that a large catalogue of shapes is available, so that the shape of objects like capitals, columns, architraves, pediments and so on are available in the many possible aspects they may have, so that searching e.g. for "column with a Corinthian capital and a noticeable entasis" produces the right picture. Due to some possible ambiguity in the search description, the result is not always as expected, but the system gives the right result in 90% of the cases.

Now, let us create a pipeline formed by the three tools in sequence, so that the outcome of the first one feeds into the second one and this produces a result that is processed by the third one: namely, one inputs the text of some ancient source into such pipeline and gets the picture of the object as the outcome. A naïve attitude would expect that 90% of the results produced by this assemblage are good, but it is not so: error multiplies, so the expected quality of the final result is only $0.9 \times 0.9 \times 0.9 = 0.729$ or 72.9%, i.e. about 30% of the outcomes may be wrong. In other words, the more complicated a process is, and the more passages are involved, the less reliable is the result, unless intermediate results are assessed and cleaned at every step: but this is something our fully automatic mechanism was designed to avoid.

15 This term usually indicates the automatic creation of data by sensors connected to the Internet.

In conclusion, there is still a long way to go before Big Data techniques, very fashionable today, may apply straightforwardly in archaeological research. This consideration does not imply refusal of such advanced tools, but just critical consideration and the avoidance of an overoptimistic and irreflexive acceptance, based on an acritical approach to technology.

8 Conclusions and Further Work

Although much has been done in the twenty years since Gardin's statement mentioned in the introduction, there is still work to do to achieve an operational data-centric approach in the archaeological research methodology. Accumulating, storing and making openly available archaeological data is a great progress compared to not so many years ago. It saves results for the future, avoids ignoring previous work or re-doing it, and creates an eco-environment of collaborative research. However, without further work it risks making the data deluge more suffocating. If the goal is well summarised by the FAIR principles mentioned above, this cute acronym still hides many unresolved issues.

Access to existing data must be as open as possible while remaining as closed as (strictly) necessary. In archaeology, this is achieved for data coming from research, where openness can be easily enforced by leveraging on funding as most funding agencies do nowadays, requiring the publication of results with open access. The same must be required also from those resulting from administrative activities such as emergency excavations. Once personal and security information is protected, such data must be disclosed to the research community. Intellectual property limitations must not apply to administrative acts, as the reports resulting from emergency excavations, or in general after a reasonable and short embargo period from archaeological discoveries, as it happened in the past by researchers and officers keeping finds hidden for years as they were 'under study'.

Finding data is reasonably suitable with the search system implemented so far, but it needs a substantial improvement as regards the inner connections and argumentation and an in-depth analysis of reports as discussed above. Otherwise, searches will report too many results to be manageable. In other cases, they will still ignore valuable data filtered away by poor metadata, not rich enough to enable the discovery of deeply hidden information as in Kintigh's example mentioned above. Searching must be able to explore the connection of concepts and not just their presence.

Interoperability is probably the FAIR principle where results are most advanced. Possible different perspectives and a vibrant debate do not challenge the global consensus on a shared ontology, with a

handful of exceptions – over which we will draw a veil – diverting from the mainstream and renouncing to global interoperability for vested interests, not worth consideration.

Finally, **Re-use** still requires much work. Quality assessment is a primary concern and a machine-actionable chain of trust is required. While for the other principles the roadmap is clear, for this one exploration is still necessary.

Last but not least, global awareness in the research community is an achievement to be heartily acknowledged. The EAA is undertaking an initiative on these issues and a joint European and US research team has recently proposed an initiative to foster and investigate archaeological data FAIRness. Unfortunately, academic reward for basic work supporting these aspects is still lacking, and for progressing in the career a monograph on some obscure ceramics is still preferred to any global instrument supporting FAIRness as the publication of a digital corpus or the creation of a virtual reference collection.

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A Session of Disciplinary 'Fusion' Exploring the Interaction of Time and Space in Modern Art

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Abstract Often met with suspicion, practices of 'fusion' between neighbouring disciplines simultaneously build on and reinforce complementarities between them. I argue that the key advantage of identifying and exploring such complementarities is the opportunity for improved understanding of the interaction of time and space in the history of art – i.e. how temporal tendencies unfold across geographical space. New digital sources of information on artistic careers, museum and personal collections or important sales make it possible to chart the mobility of people, artworks and concepts across time and space. A combination of computer algorithms, sociological methods and historical data provide opportunities to address substantive questions in the history of art, to identify patterns and resolve controversies. As an example of synergies in data collection and analysis between sociological and historical research, I analyse data on the students of Antoine Bourdelle. Results expose the interaction between centrality and two types of marginality, based on gender and the country of origin, and that between mobility of artists and the fragmentation of the field, as key factors in the acceleration of innovation at that time.

Keywords Time. Space. Methods. Mobility. Bourdelle. Gender. Modern art.

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1 Introduction

The debate between neighbouring disciplines can prove in equal measure intriguing and infuriating. Exposure to different methods and paradigms opens up new ways of thinking and seeing, but may also serve to emphasise invisible lines of division that undermine cross-disciplinary explorations. An indelible memory of mine is the awkwardness that enveloped me at an art history conference, when the panel discussion suddenly stopped, and forty pairs of eyes turned in my direction upon the question: "and what does THE Sociologist think"? The Sociologist had all the markings of an exotic animal on the red list of threatened species. If well-intentioned, the audience struggled to recognise as pertinent my efforts to discuss patterns over time and to extrapolate on the basis of individual cases.

That pertinence transpired more easily at another art history conference, dedicated to Gustav Vigeland, where I presented a report on the students of Antoine Bourdelle. Vigeland and Bourdelle have important aesthetic differences, but are also related, as both had studied with Rodin, before they developed an idiosyncratic style. Similarities and differences in career trajectories can be informative when analysed over time, helping to understand the reasons for the emergence of clusters in particular times and places, or why clusters tend to disintegrate and move somewhere else. Individual styles aggregate into such clusters, but are also a product of these clusters, reflecting complex trajectories of mobility that structure processes of competition, reproduction and differentiation in art. The positive response of the audience to my insistence on the centrality of mobility in Modern art and pertinence of quantitative methods encouraged a more systematic overview of the questions that animate the first issue of this journal – mechanisms of Fusion in the study of art history.

The classic definition in physics posits that a process of fusion occurs when two light atoms bond together (or fuse) to make a heavier one. The total mass of the new atom is less than that of the two that formed it. In order for the nuclei of two atoms to overcome the aversion to one another, high temperatures are required to rend the matter more malleable. In the process of fusion, some of the content of the two atoms is lost, but a qualitatively new entity is created. The metaphor of 'fusion' is appropriate to the context of interdisciplinary exchange, as there is naturally aversion to external influence and fear that, in opening up, something of the unique disciplinary tradition is inevitably lost. The premise of this paper is that more is to be gained. I argue that technological and methodological developments are contributing to a more malleable state of disciplines, favourable to mechanisms of 'fusion' between theoretical orientations, methods of inquiry and research agendas.

In contrast to our predecessors, we are increasingly capable of accessing massive digital data sets that can be analysed computationally to identify patterns and underlying associations, uncover career trajectories and cycles of innovation in the domain of art. Technologies are rarely unequivocal in their impact; they create new divisions, while helping to overcome established ones, such as those between uniqueness and generalizability or between case-based and variable-based methods in social science. If the application of Artificial Intelligence to Big Data can allow to recognise, for example, patterns in the diffusion of styles across countries or periods, it also requires application of contextual knowledge to make sense of the emerging patterns that do not lend themselves easily to interpretation. Practices of 'fusion' simultaneously build on and reinforce complementarities between disciplines, such as those featuring algorithms from computer science, sociological methods and historical data.

The key advantage of identifying and exploring such complementarities is the opportunity to achieve an improved understanding of the role of *time* and *space* in the history of art. A fundamental assumption in sociological scholarship is that the meaning of an action is comprehensible only when situated in social time and space – defined temporally, within sequences of events, and structurally, as a component in a relational configuration of actors (Abbott 1995). Scholarly accounts bring together structure and temporality by analysing relations between individual actions across time and space.

As a full-fledged social actor (Abbott 2016), time encompasses the complex ways in which historical events overlap with and succeed one another. To comprehend the dynamics of a field, we need to account for the changing rate of manifestation of its key characteristics, such as, for example, the number of resident artists or the multiplicity of styles in a specific location. Adopting a dynamic perspective means attributing a primordial role to mobility in the constitution of the artistic field and in the origination of novelty (Urry 2000; Abbott 2016). Attention in this perspective is directed to the mobilities of people, objects and images, and the consequences of these complex interdependencies for developments in the artistic field (Urry 2000, 2007; Joyeux-Prunel 2017).

Interrogations of space in social science are motivated by the basic understanding that space is not a simple container of topographical coordinates, but is constituted socially (Durkheim 1915) through interrelations, which are always under construction (Massey 2005). For Simmel (1997) space is indispensable for understanding social life. Human action produces meaningful space, such as in the spatial clustering of social relations or of artistic exchanges, which then reflects back on human action. To conceive of space relationally is to acknowledge the complexity of the interplay between individual actions and social structure (Fuller, Löw 2017). Scholarly accounts in this tradi-

tion tend to explore the ways in which individual developments, such as stylistic changes or career moves, are shaped by structural factors, such as the 'density' of artists or the level of competition between them (see Kaufman 2004). A different tradition analyses the geography of social space – the emergence of a core-periphery structure in artistic fields and the principles regulating the constitution of these fields and mobility between them (Bourdieu 1993; Collins 1998).[1]

In the next pages I demonstrate how the availability of new types of data and the possibilities provided by new quantitative methods can contribute to addressing a range of substantive questions in the history of art. I discuss these contributions as related to considerations of time and space, and use as an illustration of the proposed approach the analysis of data on the students of Antoine Bourdelle.

2 Time

There are multiple ways in which the influence of time on artistic developments can be modelled and studied. The utility of a temporal approach is most obvious when capturing the impact of rare events in the history of art, which exercise disproportionately large impact. That this impact is often spread over decades or centuries makes it necessary to adopt a different time frame to the one typically used in art history. Consider the development and then diffusion of oil painting techniques in the 15th and early 16th centuries. The introduction of oil paint was an innovation with far-reaching consequences, reorganising the process of picture making and redefining the social status of the artist. It was not a sudden discovery, but developed over a period of hundred years through the work of artists trying to adapt to changing styles and techniques (Meyer 1969).

It is surprising that such a crucial development has not received more attention in art history, which may be due to the relative obscurity to which technical issues are relegated in scholarship that is dominated by aesthetic matters (Meyer 1969).[2] Scholarly accounts explain the adoption and use of oil paint by individual artists, but this is only partly helpful in understanding the 'agentic' properties of oil paint (Gell 1998) – how oil paint triggered a wave of technical and stylistic innovations in the 16th century. As Flemish art became increasingly popular, the oil-based techniques diffused gradually throughout Europe. They were first adopted in the Southern

1 The core-periphery model has its own tradition in art history, especially in medieval and early modern history (e.g. Castelnuovo, Ginzburg 1979).

2 However, there is a current of recent research on technical matters, both in art history (e.g. Dupré, Göttler 2017) and sociology (e.g. Sgourev 2020).

regions of the Italian peninsula, before reaching Venice around 1475 where the techniques were refined, and then diffused widely (Steinberg, Wylie 1990).

Oil paint created a powerful internal ('endogenous') dynamic of influence, differentiating between adopters and non-adopters. To understand this dynamic and tease out the intricate interplay between technological and cultural factors (e.g. Leonardi, Barley 2008) requires the aggregation of diverse data sources and mapping out of the trajectory of diffusion over time, as oil paint moved across countries and artists. An analysis of the rate of diffusion and adoption would enable us to better comprehend the extent to which oil paint impacted the productivity of artists and their proclivity for technical and stylistic innovation. The evidence in this regard remains largely anecdotal in nature (e.g. Steinberg, Wylie 1990; Sgourev 2020).

These observations pertain as well to another notable material development – the invention in 1841 of hermetically sealed, collapsible tin tubes for oil paint, offering unparalleled possibilities to record directly the fleeting effects of light and atmosphere by venturing outside the studio. The tin tubes contributed to changing the painter's habits, allowing to better preserve colours and facilitating the practice of outdoor painting (Tinterow, Loyrette 1994). The scholarly challenge is to position this development in a socio-historical perspective, understanding the ways in which a material factor served as a trigger for the congealment of a new artistic identity and as a 'focus' for the organization of artists with a shared identity of avant-garde craftsmen (Callen 2000, 2015).

A similar challenge is presented by one of the most famous 'exogenous' shocks in the history of art – Japan's involuntary and abrupt opening to trade with European countries in 1859, and the wide circulation in Europe of Japanese prints. The influence of these prints on the rise of Modern art is uncontested (e.g. Ives 1974), but the magnitude and nature of the influence leave much room for debate (Plaud-Dilhuit 2014). Was that influence predominantly direct in nature, as when Western artists borrowed elements or visual solutions from Japanese authors, or was it rather indirect, shifting attention to novel subjects or confirming emerging beliefs about the purpose of art, thus reinforcing the rejection of the precepts of academic art (Napier 2007)? To understand the nature and magnitude of the effect of an exogenous shock requires targeted comparisons of artists before and after the shock, between adopters and non-adopters or early and late adopters. It may be helpful to map out the networks of painters, writers, critics and collectors congregating at *Café Guerbois* around 1865, as social networks constituted a key agent of propagation of cultural influences. Other possibilities include investigating the sequences of adoption of Japanese visual elements by artists, the frequency with which visual elements appear in paintings over time or the aver-

age duration of presence of oriental elements in the oeuvre of artists.

New research methods and data sources can bolster our capacity to differentiate between the roles of cultural, material and relational factors in the evolution of complex historical processes, such as Impressionism or Modern art. Similarly, they might help to tell apart endogenous and exogenous explanations with more precision. Consider the fundamental observation by Gary Tinterow:

> Art history, particularly at the end of the 19th century, is the history of artists. While untold forces – economic, social, political and literary, doubtlessly influence the creation of any work of art, the most salient confrontations are those between an artist and the work of another artist. It is then that the one is challenged into activity by the other. (1987, 11)

This statement is notable for challenging the premises of much of historical and sociological scholarship, which tend to present Impressionism and the erosion of the Academic system as a function of cultural, political or economic developments (e.g. White H., White C. 1965), giving relatively short shrift to the endogenous social dynamic that Tinterow describes.

Endogenous behavioural models are receiving increasing attention in sociological research in the last two decades. The analytical focus in this perspective is on the internal workings of cultural processes (for an overview, see Kaufman 2004), investigating change independently of exogenous (i.e. relational, technological or material) factors. Studies attribute a key role to naturally evolving subdivisions that serve to differentiate between 'us' and 'them' (Lieberson 2000; Abbott 2001). For example, one such subdivision appeared in the second part of the 19th century, differentiating between those who identified with a craft tradition, employed 'material' techniques in outdoor sessions, and pursued sales outside the Salon system, and those who endorsed Academic conventions and exhibited 'polished' paintings at the Salons (Joyeux-Prunel 2015). As Tinterow suggests, underlying much of artistic life was an internal process, guided by simple behavioural rules of differentiation and contrast.

This process is also fundamental in the work of Michael Baxandall (1985, 1988), who conceives of the artistic field as a billiards table, featuring complex positional games. Each time an artist is influenced by another artist (s)he changes the configuration of the balls on the table, rewriting the history of art a little. Artists face a multitude of options from which they can choose their references, and the choice of references affects the type of problems they seek to address and the ways in which they address them (Baxandall 1985). By adding or removing references, artists modify their agenda and the priority attributed to conceptual and technical issues. Their reference

set, on its turn, shapes what artists view as relevant and important. The 'repositioning' of references in this manner facilitates (or precludes) the ability to see new things or to see old things in a new light.

This elegant model of endogenous influence presents acute challenges to any efforts to test it empirically. However, the increasing availability of digital data sources is making this task easier, as new information sources are enabling us to identify networks of references (whom an artist is paying attention to), the trajectories of influence (whom an artist is influencing) and sequences of mobility of artists in space and time. Analyses of these networks, trajectories and sequences facilitate the analysis of the mechanisms described by Tinterow (1987) and Baxandall (1985), allowing us to map out and study movements and historical periods by aggregating information from a multitude of case studies.

A particularly promising recent development is sequence analysis, capturing the sequences of personal and professional experiences over time and their impact on creative outcomes (e.g. Simonton 1997). These models assume interdependence between early choices/outcomes and later ones in one's career. The sequences are of two types – temporal sequences of unique events and sequences of events that repeat over time (Abbott 1995). Career trajectories feature elements that are common and unique; the analytical objective is to accurately reconstitute the combination of uniqueness and similarity that defines a trajectory. There are recognisable patterns to the way people pursue careers over time, but there is also an important distinction between a person's sequence of experiences, and the subjective sense that (s)he makes of those experiences (Anand, Peiperl, Arthur 2002).

Through algorithmic procedure, sequence analysis investigates the similarity among a set of trajectories by rearranging them into clusters of "sequential equivalence" (Han, Moen 1999). One can then categorize observed sequences to see whether certain sequences result in creative outcomes. A broad range of sequences can be examined, such as those of artists changing their style, techniques or affiliation with a movement or a gallery. We can use the method to study whether diverse stylistic trajectories pose an advantage or disadvantage for artists in terms of visibility and success. Are artists with erratic career histories more creative in their pursuits or at what career stage is one most likely to pursue original pathways? By analysing the sequence of works of an artist we can establish the point in a career when stylistic experiments are most probable or valuable. Through this approach, we can adumbrate trajectories of stylistic innovation and examine how these change across historical periods.

These methods complement traditional methods in art history by combining the specificity of historiography with the scientific abstraction of quantitative methods (Abbott 1995). A good example are recent efforts to align narratives with sequences. Traditional contex-

tual methods can be a source of narrative constructs, derived from personal letters and archival documents, which are then used to corroborate and interrogate specific career sequences. Matching sequences with narratives in such a manner provides insights into the construction of artistic identities (Waltham-Smith 2015). Identities guide and simultaneously reflect trajectories of personal and professional experiences – this duality is a key characteristic of the sequence approach in social science (Formilan, Ferrian, Cattani 2020).

Modelling the multifarious impact of time on social and individual outcomes is one of the key challenges in social science (Abbott 2001). The combination of new digital sources containing ample information on artistic biographies and careers, museum and personal collections, and historical sales, make it increasingly possible to chart trajectories of movement of people, artworks and even concepts across time and space. Time is an essential ingredient in the constitution of space – dynamic processes of all kind sculpt the social structure of artistic fields.

3 Space

The social structure of a field is typically defined in terms of relations and of the density of relations within the boundaries of the field (e.g. Bourdieu 1993, Collins 1998). Artists can thus be identified as belonging to the core or the periphery of a field based on their position in networks of social relations.

A 'core-periphery' social structure is characterised by a hub of dense relationships at the core and by layers of dispersed relationships on the periphery. The core is the domain of 'star artists', with many relationships to other prominent artists, while the periphery is the habitat of the *hoi polloi*, with few relationships of this kind (Collins 1998). The core of the social structure provides better opportunities to access and combine external knowledge and ideas (e.g. Collins 1998; Burt 2004). However, those on the periphery have greater latitude to develop ideas or styles that challenge the status quo. Weaker embeddedness in the dominant culture enables these artists to cross boundaries and import ideas from external domains (Hargadon and Sutton 1997). The density of relations in a field or its fragmentation matter in this process. For example, the fragmentation of a field into clusters reduces social pressure for conformity (Friedkin 1998), increases competition and motivates individual pursuit of difference.

These concepts are useful in understanding how the creative process is influenced by social factors, such as the structure or change rate in a field (e.g. Teodoridis, Bikard, Vakili 2019). Given that artistic activity is principally composed of processes of imitation and differentiation (Tarde 1903), we can assume the existence of social thresh-

olds at which imitation turns to differentiation (Kaufman 2004). Established styles and paradigms within a field aggregate to a point where innovation becomes increasingly pursued by those seeking to differentiate themselves from competitors or predecessors. In this logic, competition spurs the individual desire for differentiation, which creates preconditions for stylistic schism – for artists to identify with opposing paradigms (Abbott 2001).

As an illustration, consider how the intensifying competition spurred innovation in early 20th century Paris. The number of artists at the Salon des Indépendants rose from 150 to approximately 1,000 between 1896 and 1910 (Bidou 1910). According to the critic Pierre Tournier (1910), the total number of exhibits at all salons in Paris in 1910 was 15,000, while Vauxcelles (1911) estimated that number at 17,000 in 1911. Census data indicate that the number of French describing themselves as artists increased from 22,500 to 35,500 between 1872 and 1906 (Charle 1990, 237). One of the key consequences of the intensifying competition and market saturation was the fragmentation of the art market, which facilitated the emergence of cliques of radical artists on the margins of the city, thereby accelerating the innovation rate (Sgourev 2013).

The availability of reliable estimates of the number of artists residing in a particular location or the number of artworks produced, can be used to establish the degree of competitive pressure and its change over time. This is a key motivation behind research initiatives, such as the *Artlas* project,[3] looking to create digital maps of galleries in late 19th century Paris using archival data. The analysis of these data can provide valuable insights into contested topics. Thus, Joyeux-Prunel (2015) asserts that the market demand for Impressionist art before the late 1880s was insufficient to justify interpretation of the style as responding to market demand (e.g. White H., White C. 1965). She contends that the rising prices of Impressionist art in the mid-1880s were primarily due to the unexpectedly successful entry of the US market by Durand-Ruel. This illustrates how archival data and its digital representation can be employed to shed new light on familiar historical developments.

Archival data can also be used to reconstitute the configuration of social relations underlying a movement or a field. The assumption in network scholarship is that ideas originate in exchanges and flow through relations (Collins 1998). The analytical focus is on how change in the social structure facilitates creative outcomes (e.g. Burt 2004; Sgourev 2013). Networks encompass not only relations between people, but also among people, objects and ideas (Latour 1999). Creative acts thus emanate from networks of cultural and material ele-

3 Additional information is available at `https://artlas.huma-num.fr/en/`.

ments (Godart, Seong, Phillips 2020).

New data sources and analytical methods can provide valuable insights into spatial aspects of the emergence of new configurations of cultural and material elements. A good illustration of how digital data and quantitative methods can illuminate questions of theoretical importance is the work of Elgammal and Saleh (2015). These authors developed a method to classify images by the visual concepts (*classemes*) they contain. These include objects, such as a house or a church, simple features, such as colour and texture, or complex features, such as walking or turning. This approach allows the development of an algorithm to analyse a picture by producing a list of classemes that define it. This list is then used to compare any picture against others, identifying paintings that are highly original compared to others. In this manner, art history is analysed as a network of interlinked paintings. The method identifies degrees of originality by establishing links between paintings over time, allowing to establish when certain patterns appear for the first time and how they will be elaborated in the future.

Applying this algorithm to 62,000 digital reproductions of paintings from the Wikiart dataset results in a 'time map' of innovation in art. The originality scores for the period 1850 to 1950 (see Elgammal, Saleh 2015, 14) attest that originality rises in the 1860s and 1870s, decreases in the next three decades, before exploding in the second decade of the 20th century. The authors identify the watershed year as 1912, when originality scores undergo a sudden increase, remaining consistently high thereafter. The originality of Picasso is confirmed, but what is particularly remarkable is that in the period after 1912, it is not Picasso, but Mondrian and Malevitch that display the highest scores. This provides evidence that the most radical artistic experiments in the wake of Cubism occurred not in Paris, but in more peripheral locations. A similar pattern emerges in the years following the rise of Impressionism, when the highest originality score is obtained not by a painter based in Paris, but by the *Scream* by Munch.

The patterns identified in this study are corroborated by recent work by art historians. Joyeux-Prunel (2015, 501) compiled a list of important international exhibitions of Modern art over the period 1910-1914. Her data confirm the shifting centre of gravity in art away from France and the identification of 1912 as a watershed year in Modern art. The alignment between results obtained with different methods reveals the potential synergies in employing mixed research methods in addressing historical questions. Creating maps featuring thousands of painters can lead to better understanding of the social structure of the field, the competitive pressure for differentiation at any particular time and the trajectories whereby ideas travelled across countries, schools and artists. These methods allow to address the fundamental question of the forms of intersection of time and space – how temporal trends unfold across geographical space.

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As an example, Sgourev (forthcoming) interprets results from Elgammal and Saleh's analysis (2015) as evidence for a process of 'radicalization', whereby ideas originating from the core escalate on the periphery. A condition facilitating radicalization is the simultaneously increasing and decreasing social distance between the core and periphery, observed when the growing prominence of the core accelerates mobility and encourages the diffusion of ideas to the periphery.[4] This process contributes to the appearance of locations in the social structure that are exposed to ideas from the core, but are relieved of the pressure for conformity at the core. As these locations are marked by the collision of opposing cultural forces (Park 1928), they are conducive to idiosyncratic pursuits and the refusal of compromise. They tend to appear either at the periphery of central areas or at peripheral locations connected to the centre. The next section provides an account of one such location, using digital data and simple statistical methods to examine the intersection of time and space in Modern art, and to illustrate the usefulness of applying techniques of disciplinary 'fusion' in the study of art history.

4 Bourdelle's Workshop

The renowned French sculptor Antoine Bourdelle (1861-1929) attended the School of Fine Arts in Paris and worked in the studio of Alexandre Falguière. He entered the studio of Auguste Rodin in 1893 and maintained affiliation with it until 1908. He had a successful career as a sculptor, receiving notable commissions in France and abroad. But attention here is on his teaching activities, as he was recognised as one of the most important educators of the Modern age, championing the increasing autonomy of fine art from academic conventions.

His teaching style was unorthodox at the time, encouraging students' creativity and freedom, avoiding assertions of strict principles, and allowing students to pick and choose elements that may be useful in articulating an idiosyncratic style. In contrast to Academic teaching, he worked with his students in partnership, turning his studio into a place for aspiring artists to learn and practice. The sociological importance of his teaching practice was in serving as a medium for the diffusion of Modernist ideas and techniques to students from all over the world. His unorthodox teaching style attracted a different kind of student from that at the Academy. It reflected and rein-

4 There is considerable research in art history documenting the increasing salience of artistic mobility in the late 19th century and its contribution to the effervescent experimental scene in the first decades of the 20th century (e.g. Waller, Carter 2015; Baetens, Lyna 2019).

forced ongoing processes of differentiation and opposition in the cultural texture of early 20th century European art.

To better understand the nature of these processes and explore the underlying interplay of time and space, I use digital data collected by art historians on the students that attended one (or more) of his places of teaching: the studio at Rue du Maine (from 1890), the Institute Rodin (1900), the Academy of the Grande Chaumière (between 1909 et 1929), and the School of Design of the Gobelin factory (between 1920 and 1926). The data were compiled from several archives, from salon catalogues to artist dictionaries, online sources and personal exchanges with scholars and descendants of students.[5]

The data provide basic information (name, country of origin) on 455 students of Bourdelle. The country of origin data was almost complete and a few missing records were imputed based on the name. Gender was inferred from the name; in a few cases gender could not be ascertained and was coded as missing. Two indicators were created for personal communication with Bourdelle – whether a student sent him a letter or received one from him.

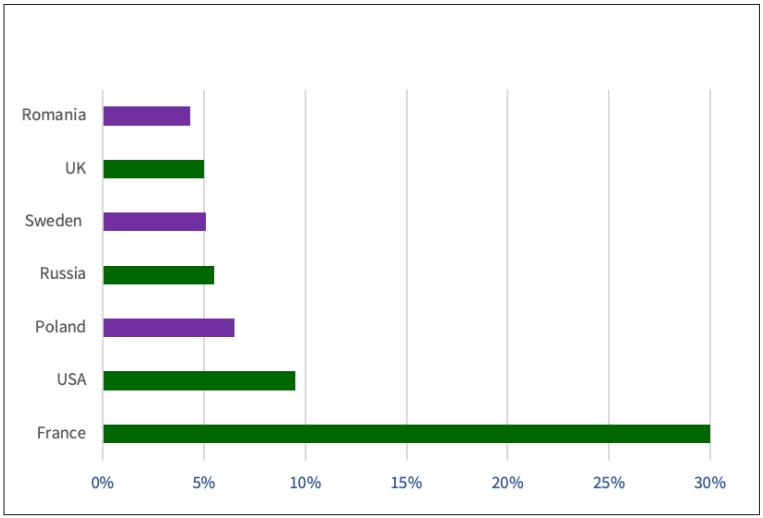

Figure 1 Composition of the student body of Bourdelle's workshop (by country of origin)

5 Detailed description of the sources (and the data themselves) can be obtained at: http://www.bourdelle.paris.fr/fr/antoine-bourdelle/repertoire-des-eleves-de-bourdelle.

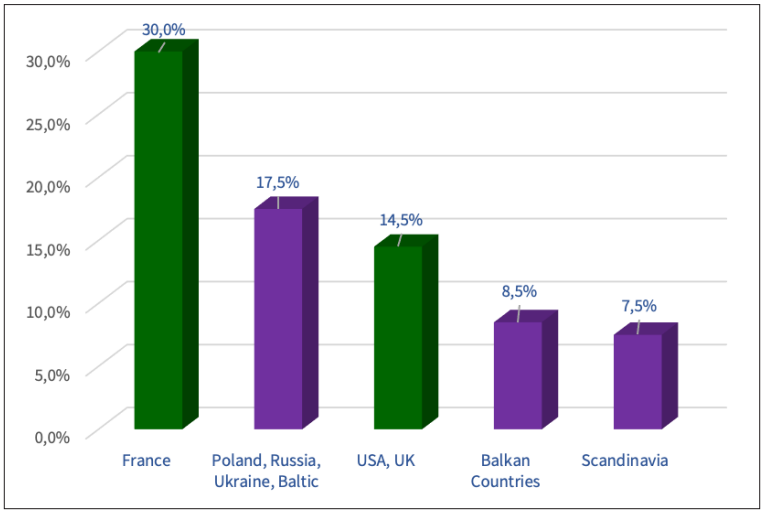

Figure 2 Composition of the student body of Bourdelle's workshop (by region of origin)

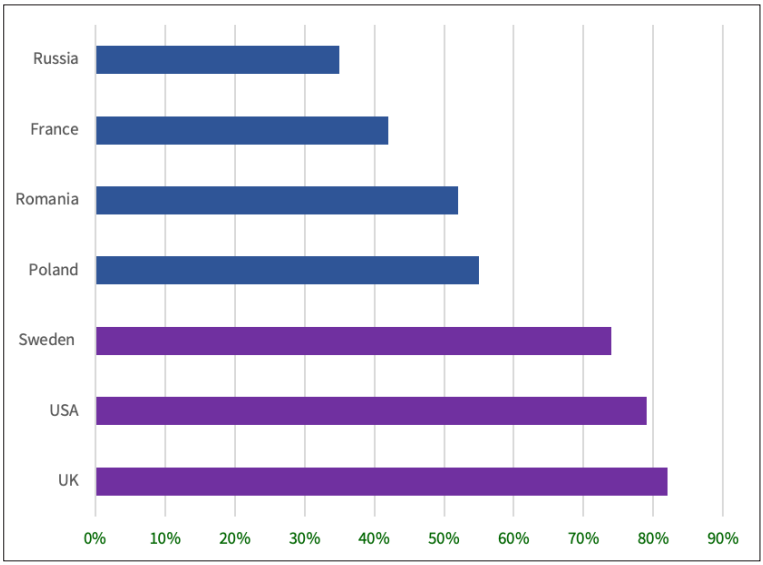

Figure 3 Proportion of female students in Bourdelle's workshop (by country of origin)

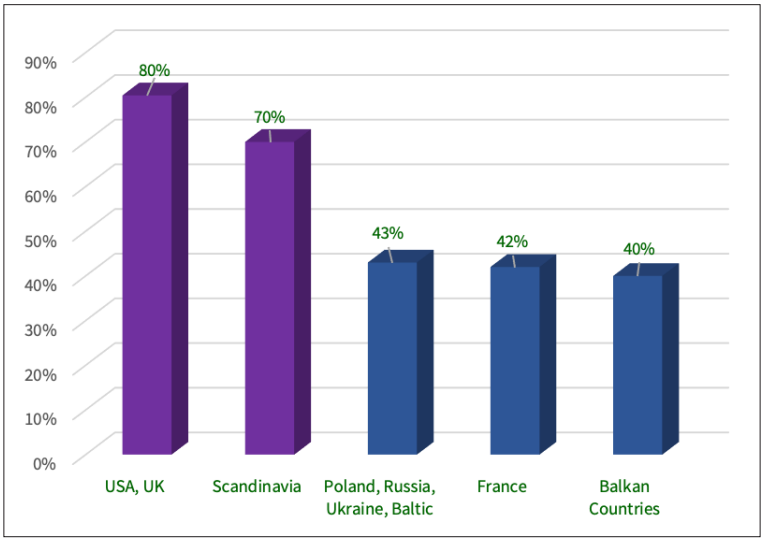

Figure 4 Proportion of female students in Bourdelle's workshop (by region of origin)

The most important finding in the analysis of the profile of students is the emergence of two types of marginality. The first type is based on the country of origin. Remarkably, 70% of the students were non-French, with a large proportion coming from countries on the periphery of the art world: Poland, Ukraine, Sweden or Romania **[fig. 1]**. When aggregated by region **[fig. 2]**, about 18% of students came from the region including Russia, Poland, Ukraine and the Baltic countries. About 15% hailed from the UK and US, with a bit lower proportions originating in Scandinavia and the Balkan region. Notable for their underrepresentation are Germany and Austria (relative to the country size).

The second marginality type is based on gender. Research in both art history and sociology is paying increasing attention to how female artists in the 19th and early 20th century sought to overcome structural obstacles to accessing artistic education. The emergence of independent spaces, such as private schools in Paris, were primordial in allowing women exposure to training in a setting where they could learn alongside male artists. The proportion of female students in Bourdelle's workshop (47%) was significantly greater than in the Academy, testifying that the private schools provided an opportunity to women to further their artistic training. If we take the proportion of French female students as a reference point (43%) we can observe that three countries boast double that proportion: 82% of British, 79% of American and 74% of Swedish students were female

(see **fig. 3**). These elevated numbers imply a mobility trajectory for artistically-oriented women from relatively affluent families in the UK, the US and Sweden. The distribution by region is presented on fig. 4.

The student body constituted a social network, as many maintained contact with each other and with Bourdelle upon the termination of their studies. This network was an active instrument of communication, as suggested by the finding that 22.4 % had some form of exchange with Bourdelle. Unsurprisingly, the network was more valuable to women. Only 17% of male students, but 28% of female students maintained communication with Bourdelle. A regression analysis confirms that it was more likely for a female student to exchange with Bourdelle than a male student (p=.007). The highest probability for exchange with their teacher is observed for Romanian and Czech (female) students.

The collection of such data can be useful not only to historical, but also sociological research. The revealed pattern of dual marginality confirms observations by art historians on mobility in early 20th century. For example, Röstorp (2014) disputes the popular theory that Scandinavian artists left France after the Universal exhibition of 1889, arguing that there were even more such artists in Paris during the late period than in the 1880s. The overrepresentation of Swedish women in the dataset (as compared to the expected number based on the size of the country) lends credence to Röstorp's argument that many Swedish female artists moved to France in early 20th century, because of their desire for emancipation from family constraints or academic conventions by pursuing a career in art. A combination of factors was the driving force of enhanced mobility – female artists had already had access to the Academy of Fine Arts in Sweden since 1864, whereas their French colleagues were not allowed until 1897. However, very few women were accepted as members of the Swedish Federation of artists. Having received rigorous formal training, but lacking opportunities for career advancement, female artists from Sweden were likely to look for such opportunities in France, where they had better working conditions, access to museums, available studios and opportunities to exhibit (Röstorp 2017).

These observations apply as well to female artists from the United Kingdom or United States, as revealed in the workshop data. Consider Reynolds' (2000) account of how Scottish female artists of the 1900 generation crossed multiple symbolic barriers by deciding to pursue a career in Paris. Private schools were more attractive than academic venues, as they were flexible and innovative in their teaching methods. Having had received formal training back home, expatriate women were better prepared and more receptive to the new methods than their male counterparts (Reynolds 2000).

The results of the analysis attest to another mechanism through which private schools allowed female artists to overcome career bar-

riers – access to social networks. A key sociological observation is that women do not have the same access to career-enhancing networks as men (Kanter 1977; Ibarra 1992) and that social networks are instrumental in reducing gender inequality by providing relational or cultural capital (Ibarra 1992, 1993). That female students were significantly more likely to maintain communication with Bourdelle than male students is in full agreement with sociological expectations.

Another way in which the results confirm sociological research on networks is related to the composition of the student body. It is well-established that 'egocentric' social networks (featuring the students of a painter or a sculptor) develop through a dual process, reflecting the personal preferences of the person at the core of the network (i.e. Bourdelle) and the self-selection of students, responding to the preferences of Bourdelle. The relative overrepresentation of Polish and Czech students in the workshop (relative to country size) and underrepresentation of German and Austrian students may be partly due to Bourdelle's personal affinity toward Poland[6] that is likely to have encouraged Czech and Polish students to attend his workshop and German or Austrian students to look elsewhere. Such mechanisms of interplay between preferences and self-selection are common in social networks.

Albeit limited in scope, the workshop data highlight possible synergies between sociological and historical research, and provides a rare opportunity to explore the relationships between centrality and marginality and that between time and space. What confirmed Paris as the capital of the art world in the early 20th century was the influx of artists from all over the world and the appearance of places, such as Bourdelle's workshop, where academic conventions were relaxed or abolished. These places embody the interplay between centrality and marginality, as the increasing salience of Paris fostered mobility from peripheral regions, as attested by the data.

Bridging the core and periphery of the field in this manner, places of this kind are essential in understanding the complex mechanisms responsible for the acceleration of the innovation rate in the early 20th century. Numerous factors affect the innovation rate at any time, but a key factor for its acceleration was the interaction of social structure and mobility. The rising prominence of Paris encouraged the mobility of artists from peripheral locations, tempted by opportunities for career advancement and exposure to new ideas (Joyeux-Prunel 2015). This mobility on its turn reinforced the fragmentation of the social structure, as new locations appeared on the periphery of

6 Bourdelle's most famous work is probably his monument to the Polish hero Mickiewicz in Paris. For details on how his teaching contributed to the social organisation of Polish students in Paris, see Grabska 1996.

core regions, conducive to processes of experimentation. This echoes historical accounts of the interaction of fragmentation and mobility in accounting for the unparalleled economic growth in Western Europe in the 18th century. As Mokyr (2012) argues, fragmentation in the form of multiple competing states encouraged competition and innovation in science and technology, curtailing the abilities of states to control the mobility of scientists across countries. Along similar lines, a continent-wide market for ideas emerged in early 20th century Europe through the mobility of artists.

The Bourdelle workshop represents a notable component of this complex, dynamic process. His dismissal of academic conventions in teaching seemed provocative at the time, but the dismissal only mattered because there already was a critical mass of mostly international students for whom the alternatives to academic training were meaningful and attractive. Research on such forms of interplay and the endogenous process of innovation reinforced require collaboration across disciplinary lines, using diverse methods and data sources. Practices of 'fusion' in science do not mean imposition of one logic or tradition over another, but increasing awareness of developments in other disciplines, and pursuit of synergies in data collection and analysis. New technologies, data sources and methods are making it possible to identify tendencies in innovation over time, sequences of career moves and trajectories of artists, artworks and ideas across time and space. There are good examples of scholars seizing these opportunities – such as the research of Beatrice Joyeux-Prunel (2015, 2017) or Hans van Migroet's projects combining art history, law, economics and sociology.[7] Something on which sociologists and art historians tend to agree is that we need to make our accounts as interesting to and representative of the larger culture around us as possible, without sacrificing scientific rigour (Abbott 2001).

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7 Additional information is available at https://www.dukedalmi.org/about/.

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Merging Music and Landscape: un approccio digitale per lo studio dell'identità culturale della Modena estense

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Abstract The paper aims at proposing a digital project based on the creation of a platform through which to explore the historical soundscape of early modern Modena. Thanks to the use of state-of-the-art web development tools and Geographic Information Systems, the platform will feature an interactive search and navigation environment, plus an interactive map with geo-localized objects and events. This will offer the chance to have new points of view to study a city and its spectacular development. Our project also intends to propose a multidisciplinary model for historical research and provide new ideas for the enhancement of cultural heritage.

Keywords Soundscape. WebGis. Web mapping. Music. Landscape. Modena. Este. Musical Sources. Music Production.

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1 Il suono di Modena

Nel corso del Seicento Modena fu un centro nevralgico di produzione artistica e musicale grazie all'arrivo della corte estense. Nel 1598, a seguito delle convenzioni faentine, gli Este furono costretti a trasferirsi rapidamente da Ferrara a Modena, seconda città del ducato.[1] Il trasferimento della corte rappresentò per gli Este e per Modena un momento di profonda trasformazione, in cui la corte si affrettò a ripristinare nella nuova sede lo splendore artistico e musicale che aveva caratterizzato in precedenza la città di Ferrara.[2]

Seppur in maniera progressiva, il destino e lo status di Modena cambiarono inevitabilmente: in breve tempo la città, da semplice provincia, si trovò a essere capitale di un ducato, interamente gestita dagli Este anche dal punto di vista culturale. La storia musicale della città di Modena è infatti essenzialmente legata all'interesse per la musica esercitato nel corso dei secoli dai duchi d'Este. Prima dell'arrivo della corte, le attività musicali presenti a Modena erano per lo più legate alla Cattedrale cittadina. Grazie proprio alla collaborazione di alcuni musicisti di questa istituzione come Geminiano Capilupi, Giovanni Battista Stefanini e il più celebre Orazio Vecchi, la corte riuscì gradualmente a ripristinare il suo prestigio musicale (Boni 2007, 196). La sinergia tra corte e Chiesa stimolò la creazione di gruppi di musicisti locali e favorì nel tempo la costituzione di una compagine ducale formata da cantanti e musicisti. La Cappella Ducale o 'concerto degli stromenti' fu ufficialmente istituita nel 1629 all'inizio del regno di Francesco I. Essa interveniva non solo in buona parte delle occasioni festive dinastiche, ma anche nella solennizzazione di liturgie in alcune chiese cittadine, negli eventi mondani presso dimore e palazzi nobiliari, nelle rappresentazioni teatrali, negli spettacoli e nelle feste di piazza (Crowther 1990, 212).

Il ducato di Francesco I (1629-1658) diede inoltre un notevole impulso alla trasformazione di Modena in una città di stampo moderno. Furono anni infatti caratterizzati dalla crescita fisica dello spazio urbano: sorsero nuove chiese, conventi, nonché palazzi nobiliari,

La redazione delle sezioni nrr. 1, 2.2, 3.3 di deve ad Angela Fiore; nrr. 2.1, 3.1, 3.2 a Sara Belotti. Le conclusioni sono frutto di un lavoro comune delle Autrici.

1 L'episodio è noto come 'devoluzione di Ferrara', che si riferisce al fatto che la città fosse passata sotto il controllo dello Stato Pontificio retto da Clemente VIII. Alla morte del duca Alfonso II, non essendoci alcun erede diretto, il Papa non rinnovò agli estensi l'investitura del feudo di Ferrara, che pertanto ritornò allo Stato della Chiesa. Il passaggio della corte, guidata dal novello duca Cesare, avvenne nella notte tra 29 e 30 gennaio 1598.

2 La casa d'Este ha rivolto nella sua storia particolare attenzione verso l'arte musicale. Le vicende musicali di casa d'Este hanno avuto inizio a Ferrara, nel Quattrocento. Il *patronage* di Leonello, Ercole I e Alfonso II fece di Ferrara un centro nevralgico di produzione musicale del Rinascimento italiano (Lockwood 1984; Durante, Martellotti 2005).

teatri e conseguentemente aumentarono le occasioni e le possibilità di accrescimento culturale della città.

Le attività musicali conobbero il massimo splendore durante il regno di Francesco II d'Este (1674-1694). Francesco II fu un avido fruitore di musica: il giovane duca sentiva l'esigenza di collezionare e commissionare musica per il proprio svago ed esercizio e per l'intrattenimento a corte. Francesco II si fece promotore di un'intensa attività culturale della città, tra cui il rinnovo dell'Università, le attività delle accademie letterarie, la prosecuzione di opere artistiche e architettoniche di Palazzo Ducale e il riordino della Biblioteca Estense (Cont 2009, 409). Il duca comprese la necessità di ingrandire la Cappella Ducale e fornì anche molte più occasioni per fare musica grazie ai legami con alcune istituzioni cittadine. Spazi ed edifici cittadini divennero man mano partecipi dell'evoluzione stessa del linguaggio musicale, influenzando le modalità di produzione e di fruizione della musica.

A partire dalla metà del XVII secolo prese avvio anche l'attività teatrale cittadina. A Modena erano presenti ben quattro teatri: la sala detta 'della Spelta', ubicata nel complesso del Palazzo Comunale; il Teatro Ducale negli spazi di Palazzo della Ragione, attiguo alla Spelta ed edificato nel 1656 per volontà di Francesco II; il piccolo teatro di corte, una sorta di teatrino da stanza a uso privato della corte, e infine la sala da spettacolo di Palazzo Valentini, che prese il nome di Teatro Fontanelli a fine Seicento (Martinelli Braglia 2007).

Luogo centrale per la produzione musicale locale fu l'oratorio di San Carlo Rotondo,[3] sede della congregazione teatina di San Carlo. Edificato nel 1634, accolse l'esecuzione di oratori per musica durante il periodo quaresimale. Modena fu infatti uno dei centri di maggiore interesse e rilievo per l'evoluzione di questo repertorio. La fulgida produzione oratoriale della corte organizzata presso San Carlo Rotondo permise inoltre di rinsaldare il legame con la potente congregazione teatina di San Carlo, tramite la quale si sarebbe realizzata buona parte del programma politico-culturale estense (Crowther 1992).

Centro di scambi per artisti, musicisti e poeti vicini alla corte fu invece l'Accademia de' Dissonanti, fondata nel 1683, con sede all'interno delle mura di Palazzo Ducale. Il repertorio musicale dedicato a questa istituzione era per lo più composto da accademie e cantate da camera. I testi, scritti spesso da aristocratici e poeti di corte, appartenevano alla poesia accademica volta alla glorificazione del prestigio estense (Jander 1975).

Gli Este interagirono anche con diverse istituzioni ecclesiastiche cittadine inviando periodicamente musicisti della Cappella Ducale per solennizzare le celebrazioni liturgiche patrocinate dalla corte. La musica accompagnava infatti la quotidianità devozionale del duca

3 L'appellativo 'rotondo' deriva dalla forma ottagonale della struttura.

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così come le cerimonie straordinarie o dinastiche, organizzate spesso nelle chiese e nei monasteri cittadini.

Anche le piazze e le strade modenesi furono frequentemente proscenio per la celebrazione di eventi straordinari organizzati dalla corte. Piazza grande antistante il Duomo, l'odierna piazza Roma avanti Palazzo Ducale, il Largo Sant'Agostino, il Giardino Ducale furono i luoghi maggiormente utilizzati in occasioni di feste e cerimonie. Gli eventi spettacolari organizzati all'aperto prevedevano un accompagnamento musicale affidato soprattutto a strumentisti a fiato e a percussione il cui compito era di precedere un corteo, di enfatizzare ogni rituale e coinvolgere il tessuto cittadino. Il carattere 'colloquiale' di queste manifestazioni permetteva di creare al meglio specifiche forme di interazione tra diverse tipologie di sorgenti sonore: i suoni della strada e il vociare delle persone si fondevano ai suoni delle performance, consensualmente prodotti e condivisi da gruppi sociali differenti.

A fine Seicento la Modena modellata dagli Este si presentava quindi come un centro ricco di opportunità di consumo spettacolare e musicale, un polo di attrazione per tanti musicisti provenienti sia dalle zone vicine sia da altre parti d'Italia e un luogo di formazione e diffusione di nuovi generi musicali. La musica a Modena era non solo un'attività meramente artistica, ma anche sociale e politica, strumento di costruzione del consenso e affermazione pubblica del potere ducale.

Grazie alla sua storia musicale, alla natura delle relazioni esistenti tra corte e città, alla molteplice presenza di eventi performativi e alle caratteristiche di uno spazio urbano circoscritto tra le mura, Modena rappresenta un osservatorio perfetto per comprendere come produzione musicale e geografia urbana si siano influenzate nel tempo. L'analisi dei differenti contesti produttivi della città porta a comprendere quanto gli spazi urbani non possano essere considerati solo dei semplici luoghi: essi permettono di identificare tempi, cerimonie e pratiche spontanee, cultura performativa e dell'ascolto. Sono questi gli elementi che permettono oggi di definire il suono della Modena estense.

2 *Este Soundscape*: un progetto in fieri

Il progetto *Este Soundscape*, basato sulla costruzione di una piattaforma digitale, nasce nell'ambito del programma *Digital Humanities – per la ricerca e la valorizzazione del patrimonio storico documentario-estense* all'interno del quale sono stati avviati due progetti di ricerca, per lo studio e la catalogazione dei fondi musicale e cartografico posseduti dalla Biblioteca Estense Universitaria.[4] In paral-

4 Il progetto *Este Soundscape* si inserisce all'interno delle attività condotte dal Centro interdipartimentale di ricerca sulle Digital Humanities (DHMoRe) dell'Università di

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lelo, nel 2018, è iniziato un importante progetto di digitalizzazione del patrimonio documentario della Biblioteca volto alla creazione di una *digital library*.[5]

Il lavoro condotto su queste collezioni ha portato le Autrici a una riflessione sulla valorizzazione di tale patrimonio, consentendo di ripensare non solo alle modalità di fruizione, ma anche alle possibilità di mettere in relazione fonti e dati differenti al fine di proporre una mappatura culturale del contesto estense.

2.1 Presupposti metodologici

Il paesaggio è una delle configurazioni della territorialità, mediante la quale l'osservatore può interpretare il complesso di stimoli prodotti dai segni generati dalla cultura che si è sedimentata nei luoghi. Tali stimoli possono essere percepiti in modo diverso dai vari soggetti, concorrendo alla costruzione dell'immagine del luogo, assumendo significati e suscitando emozioni (Cortesi 2010). Gli studi condotti da Raymond Murray Schafer hanno contribuito a portare il 'paesaggio sonoro' al centro di una intensa discussione in ambiti disciplinari diversi, impegnati nello studio della relazione tra suono e spazio. Seppure con differenti obiettivi e approcci metodologici, lo sviluppo di questi filoni di ricerca ha avuto un orientamento comune, ossia la rivalutazione dell'ascolto quale senso privilegiato per la conoscenza del territorio. Secondo Schafer il *soundscape* è «un qualsiasi campo di studio acustico [...], una composizione musicale, un programma radio o un ambiente acustico» (1977, 19), che consiste nei suoni della natura e degli animali inclusi gli uomini, esso è una parte costitutiva e imprescindibile del paesaggio, poiché «l'orecchio non ha palpebre» ed è condannato ad ascoltare (24). E se il suono influenza la percezione del paesaggio, allo stesso modo la musica può essere un veicolo di costruzione del territorio inteso come il risultato dell'azione di una società su di uno spazio (Turco 2010). I nomi dei luoghi, gli edifici, il modo in cui le risorse vengono sfruttate, l'organizzazione della vita sociale costituiscono le azioni mediante le quali lo spazio acquista un valore antropologico e il territorio diviene momento di espressione e identificazione della società.[6]

Modena e Reggio Emilia, che ospiterà la piattaforma web, attualmente in costruzione.

5 La biblioteca digitale è accessibile all'indirizzo `https://edl.beniculturali.it/home/cover`. Il fondo carte geografiche è interamente consultabile; prosegue tuttora l'opera di digitalizzazione del fondo musicale.

6 Secondo il geografo Angelo Turco, la territorializzazione, ossia il processo mediante il quale una società costruisce il proprio territorio, si articola in tre atti: denominazione, che implica un controllo simbolico del territorio mediante il conferimento di nomi alla superficie terrestre; reificazione, ossia la trasformazione materiale dello spazio; strutturazione, per la definizione del controllo organizzativo del territorio (Turco 2010).

Nel mondo contemporaneo la musica identifica spesso gli spazi pubblici che frequentiamo e, diventando parte di un *soundscape* della quotidianità (Smith 1994), riesce talora a creare una connessione indelebile fra paesaggi simbolici, spazi di vita e memoria. Allo stesso tempo, essa può abbattere le barriere sia linguistiche sia sociali, oppure può veicolare un particolare messaggio, anche politico, diventando un *cultural marker*, un elemento unificante per una società, oppure un *ethnic boundary*, ossia un elemento divisivo (Dell'Agnese, Tabusi 2016). Anche il dove si fa e si ascolta musica influisce sulla relazione che si instaura con il luogo, definendo anche lo stile musicale o l'obiettivo della performance. Come oggi consideriamo il *freestyle* e la musica *rap* strumenti di riappropriazione dei luoghi marginali della città (Di Quarto 2016), nel passato le rappresentazioni spettacolari promosse da una corte ed esibite nello spazio pubblico erano funzionali alla costruzione dell'immagine del principe e alla manifestazione del suo potere e della sua grandezza (Piperno 2008).

Leggere e interpretare luoghi e spazi cittadini attraverso la produzione sonora in essi avvenuta costituisce un punto di confluenza tra musicologia e geografia (Giuriati 2015, 115). Infatti, il suono è stato una delle componenti essenziali nello sviluppo degli spazi e degli organismi cittadini. Anche nel corso della storia, la produzione musicale è stata condizionata dal luogo per il quale e nel quale è stata eseguita. Al contempo, la musica stessa ha creato nuovi paesaggi, influenzando i luoghi, e in alcuni casi anche l'architettura, contribuendo a definirne l'identità (Dell'Agnese, Tabusi 2016; Rocca 2013).

Per questa ragione, lo studio del *soundscape* può essere condotto in prospettiva storica. Una più ampia comprensione degli eventi sonori che hanno caratterizzato l'evoluzione della città aiuta infatti a definire il ruolo della musica nel determinare il valore sociale e simbolico dei luoghi e nel misurare il loro contributo alla costruzione dei caratteri identitari (Knighton, Manzuela Anguita 2018).

La città rappresenta un ambiente privilegiato per la creazione musicale, mostrando attraverso la sua storia la complessa rete di relazioni istituzionali che l'ha resa possibile; le modalità di circolazione della musica, di fonti e generi; la condizione sociale e la mobilità dei musicisti (Bombi, Carreras, Marín 2005, 18).

2.2 Le fonti

Modena è oggi una città straordinariamente ricca di testimonianze musicali e archivistiche. In particolare, la sua storia musicale è ben rappresentata dalla collezione musicale oggi conservata presso la Biblioteca Estense Universitaria, considerata una delle più prestigiose raccolte dinastiche europee. La collezione copre un arco cronologico molto ampio: manoscritti ed edizioni rare a stampa vanno da metà XVI a fine XIX secolo.

L'odierna configurazione della collezione corrisponde solo in parte all'antico deposito musicale di casa d'Este. Tra XVIII-XIX secolo, all'originario corpus furono infatti aggregati altri importanti nuclei di musica provenienti da raccolte straniere, lasciti e donazioni.

Le fonti estensi possono essere in alcuni casi considerate un riflesso del collezionismo dei duchi d'Este, più spesso però i documenti riferiscono delle attività di produzione, esecuzione e committenza musicale della corte. Diversi i generi rappresentativi del gusto, degli interessi della corte e della stessa città di Modena: oratori, cantate, melodrammi oltre a musica strumentale e musica sacra. La maggior parte delle fonti musicali è riferibile alle attività di istituzioni legate alle corte, quali l'Oratorio di San Carlo, l'Accademia de' Dissonanti, la Cappella Ducale, i diversi teatri cittadini. La collezione fornisce infatti indicazioni anche su come gli Este abbiano interagito con la città attraverso la musica.

Molteplici quindi le informazioni che possono essere desunte dall'analisi di una fonte musicale: non si ottengono solo dati relativi al compositore e al processo compositivo di un'opera, ma anche notizie sulla circolazione del genere e sul repertorio, sulla provenienza e sulla redazione del manoscritto.

Un'altra risorsa indispensabile è rappresentata dai fondi dell'Archivio di Stato di Modena, e in particolare dall'Archivio Segreto Estense, depositario della storia della casata. Al suo interno è possibile rintracciare documentazione di vario tipo legata alla musica, ai musicisti, agli spettacoli e alle istituzioni cittadine (note di spesa, registri contabili, lettere, cronache ecc.).

Gli studi pioneristici sulla raccolta e le sue fonti musicali condotti da Catelani, Spinelli, Dall'Olio, Luin uniti alle più recenti ricerche di studiosi della produzione musicale modenese, portano nuova luce sulle attività di specifiche istituzioni, sulle singole carriere di artisti di corte, sul mecenatismo ducale, sulla circolazione della musica a Modena e oltre i confini del ducato.[7] Affiancando alla lettura di manoscritti musicali fonti in qualche modo 'secondarie' come libretti, documentazione d'archivio, cronache, testimonianze storiche, è

7 Gli studi citati riguardano essenzialmente lavori condotti dai diversi bibliotecari dell'Estense nel XIX secolo e dedicati soprattutto al riordino della collezione. Questi studi, cataloghi e inventari, si conservano in forma manoscritta presso la Biblioteca Estense. Essi hanno avuto il merito di portare alla luce il patrimonio musicale estense e le sue peculiarità. Si tratta dei lavori: *Descrizione della musica stampata e ms. della R. Biblioteca Estense*, compilata da Giambattista Dall'Olio tra 1815 e 1817; i cataloghi *Musica ecclesiastica esistente nell'Archivio privato della R. Corte di Modena* e *Spartiti teatrali esistenti nell'Archivio privato della R. Corte di Modena* compilati dal musicista, musicologo e bibliofilo Angelo Catelani a metà Ottocento e infine Alessandro Giuseppe Spinelli, autore del *Catalogo alfabetico descrittivo della Raccolta musicale estense*. Ad essi si aggiunge il lavoro successivo compiuto da Elisabeth L. Luin dedicato alle fonti musicali collezionate da Francesco II d'Este (Luin 1936).

possibile decodificare il paesaggio musicale diffuso della città, il suo quotidiano, le implicazioni funzionali dell'attività sonora delle istituzioni che le davano forma.

Essenziale però è lo studio comparato di fonti storico-musicali con quelle cartografiche: Modena possiede infatti anche una ricca collezione di carte geografiche antiche, rintracciabili presso la Biblioteca Estense, l'Archivio di Stato e l'Archivio Comunale che consentono di seguirne l'evoluzione urbana. Tale comparazione offre numerosi dettagli sulle tradizioni locali e sulle complesse relazioni tra suono e spazio all'interno del contesto cittadino, mostrando chiavi di lettura alternative delle stesse fonti musicali come prodotto della quotidianità sonora e spettacolare della città.

3 La Piattaforma digitale

Nella diversità dei dati desunti da questa tipologia di analisi, gli strumenti digitali sviluppati nell'ambito delle *digital humanities* sono fondamentali per affrontare l'esplorazione del *soundscape* secondo una prospettiva metodologicamente più attuale. In effetti, l'evolversi di questo campo di studi, negli ultimi anni, ha aperto nuove opportunità per la ricerca, consentendo non solo la digitalizzazione dei documenti, ma anche la predisposizione di cataloghi, di spazi virtuali, di ricerche collaborative e di percorsi di approfondimento. In particolare, la comparazione e l'incrocio dei dati mediante nuove modalità di visualizzazione offre l'opportunità di evidenziare l'esistenza di reti e relazioni non analizzabili altrimenti.[8]

Nasce così l'idea della piattaforma digitale *Este Soundscape* dedicata ai risultati ottenuti dallo studio del patrimonio musicale e cartografico della Modena estense. Il progetto intende far conoscere ed esplorare i luoghi, gli eventi, le persone che hanno contribuito alla costruzione del paesaggio sonoro della città di Modena, sfruttando le potenzialità delle *digital humanities*. L'arco cronologico considerato dal progetto è il XVII secolo: è infatti in questo secolo che Modena diventa un centro culturale di prim'ordine e crea la sua 'identità sonora'.

La piattaforma digitale, attualmente in fase di costruzione, è basata su di una mappa virtuale sottesa da una banca dati.[9]

8 Grazie alla facilità di incrociare grandi quantità di dati, questi strumenti offrono nuovi punti di vista per l'analisi in molti campi del sapere (Burdick et al. 2012).

9 La realizzazione informatica della piattaforma è affidata a Lorenzo Baraldi, ingegnere informatico del centro AImageLab, dipartimento di Ingegneria 'E. Ferrari', Università di Modena e Reggio Emilia.

3.1 Il sistema cartografico *Este Soundscape*

Tra gli strumenti digitali, anche i supporti cartografici possono contribuire a nuove visualizzazioni dei dati, grazie allo sviluppo di numerosi *tools* di *mapping* e, in particolare, dei GIS (Geographical Information Systems), ossia sistemi informativi territoriali che ci consentono di acquisire, immagazzinare, organizzare, catalogare, modificare, rielaborare, integrare, restituire dati riguardanti fenomeni che si svolgono sul territorio. La struttura di tali sistemi si basa su di un archivio digitale (database) a cui sono associate le informazioni geografiche (coordinate) per la georeferenziazione dei dati stessi. Un GIS utilizza un modello logico che suddivide gli elementi in strati sovrapposti (*layers*), con numerosi benefici tecnici e di gestione dei dati, permettendo interrogazioni simultanee sui vari livelli informativi ed estrazione di informazioni in base al loro posizionamento (Fea, Loret 2010).

L'uso dei GIS, iniziato negli anni Sessanta prevalentemente nella pubblica amministrazione o nel campo delle scienze della Terra, si è progressivamente diffuso in numerosi settori, tra cui l'archeologia, i beni culturali, il marketing. Un notevole successo è riscontrabile anche nell'applicazione all'analisi storica, essendo i GIS strumenti utili non solo alla realizzazione di mappe, ma anche all'estrapolazione e alla rielaborazione di informazioni relative al territorio in varie fasi storiche, consentendo di rilevarne le dinamiche in atto (Vagnini 2010)

Tali strumenti possono essere utilizzati anche in diversi ambiti disciplinari interessati alla storia urbana, ad esempio la musicologia. Gli strumenti cartografici, agevolando la visualizzazione di luoghi, istituzioni, aree urbane, percorsi interessati dalle attività musicali di una città, permettono di indagare, attraverso una prospettiva ad ampio raggio, il paesaggio sonoro delle città e più in generale i suoi caratteri identitari. Essendo fulcro di numerose attività sociali e culturali, le città, con i loro spazi e le loro occasioni di consumo, sono infatti state un prerequisito per la crescita della produzione musicale in un determinato territorio.

La cartografia digitale realizzata con i GIS offre la possibilità di apprezzare i cambiamenti territoriali sovrapponendo, ad esempio, mappe storiche a immagini satellitari. Ai fini della ricerca musicologica, la cartografia è molto utile per localizzare i centri di produzione musicale all'interno del contesto urbano, migliorare la conoscenza dei luoghi e delle modalità di produzione e circolazione della musica e soprattutto comprendere in quali modi territorio ed espressione musicale hanno interagito fra loro.

Partendo da tale presupposto, fulcro del progetto *Este Soundscape* è la presenza di una mappa interattiva all'interno della piattaforma. La mappa, come si vedrà nelle pagine seguenti, consentirà l'identificazione dei centri musicali della Modena estense, di fare ricerche

avanzate per filtrare i dati e di visualizzare approfondimenti mediante pop-up e collegamenti ipertestuali.

Per la creazione della mappa digitale abbiamo scelto di utilizzare come base una carta, appartenente alla collezione della Biblioteca Estense e relativa alla Modena di fine Seicento. Nello specifico, la mappa scelta è opera del cartografo Domenico Vandelli:[10] si tratta di una riproduzione settecentesca della celebre mappa di Gian Battista Boccabadati del 1684, attualmente conservata preso l'Archivio Storico Comunale di Modena.[11]

La mappa mostra la Modena di superficie, con il disegno in pianta degli edifici della città e delle strade, a cui si aggiunge la Modena sotterranea, con i canali e gli scoli. Si tratta di un documento molto dettagliato che mostra la *forma urbis* della città dopo la grande addizione erculea del XVI secolo e già con la Cittadella del Castellamonte e il Palazzo Ducale costruiti nel Seicento.[12] Questa sarà la struttura che Modena manterrà fino alla fine del Settecento, quando vari interventi, promossi sia da Francesco III che da suo figlio Ercole III, ne modificheranno completamente l'assetto urbano, in particolare sull'asse della Via Emilia (Bertuzzi 2001). È quindi una mappa che vuole descrivere la città nel dettaglio, utile al nostro scopo perché possiamo identificare con facilità gli edifici oggetto di approfondimento grazie alle numerose etichette che completano la rappresentazione e identificano i palazzi, le vie, le piazze e le infrastrutture principali. Al tempo stesso, la mappa è l'opera di due importanti personalità modenesi, Boccabadati che ne fu l'ideatore e Vandelli che ne produsse una copia – cartografi della corte, ma anche colti rappresentanti dell'am-

10 Domenico Vandelli (Levizzano Rangone 1691-Modena 1754) studiò dai gesuiti, seguendo la carriera ecclesiastica diventando poi Abate, e presso l'Università di Modena applicandosi in filosofia, matematica e teologia. Grazie ai suoi studi fu docente di matematica e ingegneria nell'ateneo cittadino e venne nominato prima geografo e antiquario ducale e poi ispettore dei fiumi e delle bonifiche.

11 Giovan Battista Boccabadati (Modena 1635-1696) conosciuto per il suo lavoro di avvocato e come autore di versi e prose, si occupò di studi matematici e scientifici, tenendo anche lezioni all'Università di Modena. Nel 1671 fu nominato bibliotecario di corte dal duca Francesco II e nel 1681 ingegnere. Nel 1684 venne incaricato dalla Comunità di Modena della realizzazione di una pianta della città, mentre nel 1687 elaborò una mappa topografica del distretto di Modena. La mappa di Modena realizzata da Boccabadati e copiata dal Vandelli si conserva oggi presso l'Archivio di Stato di Modena.

12 Con l'investitura di Modena a capitale del ducato iniziò un processo di rinnovamento urbano per darle un aspetto più consono alla nuova funzione. Infatti, a eccezione dell'addizione erculea che nella seconda metà del XVI secolo aveva ampliato verso nord l'area urbana, la città conservava ancora un impianto di tipo medievale. Nonostante nel corso del Seicento furono aperti numerosi cantieri (per la costruzione di chiese e l'abbellimento dei palazzi nobiliari), il volto della città venne parzialmente rinnovato solo con la revisione del piano urbanistico attuata da Francesco III nella seconda metà del Settecento. Nel corso del Seicento furono realizzati solo due importanti progetti: la Cittadella militare, tra il 1635 e il 1642, e il Palazzo Ducale in sostituzione del vecchio castello, entrambi per volere di Francesco I.

biente culturale estense. Infine, la mappa costituisce una significativa testimonianza per la città di Modena, poiché nasce a 'servizio della città': difatti, la mappa fu commissionata a Boccabadati dalla Comunità di Modena, mentre il Consiglio dei conservatori della città di Modena del 14 agosto 1684 decise che dovesse essere esposta «nella Camera del Consiglio per servizio della città, con ordine che non si rimovesse mai da detta camera» (*Quaderni dell'Archivio Storico di Modena*, 2009, 4).

3.2 Struttura e funzionalità della piattaforma

La piattaforma è costituita da un database relazionale, contenente metadati desunti dall'analisi, dallo studio e dalla schedatura delle fonti musicali, cartografiche, storiche e archivistiche; uno *storage* che detiene l'immagine della mappa digitale e un *application server* che dialoga con entrambi. Il database relazionale è creato in Django Framework e suddiviso nelle entità *Fonti*, *Persone*, *Generi* ed *Eventi* ed è collegato a una mappa interattiva attraverso l'entità denominata *Istituzioni* **[fig. 1]**.

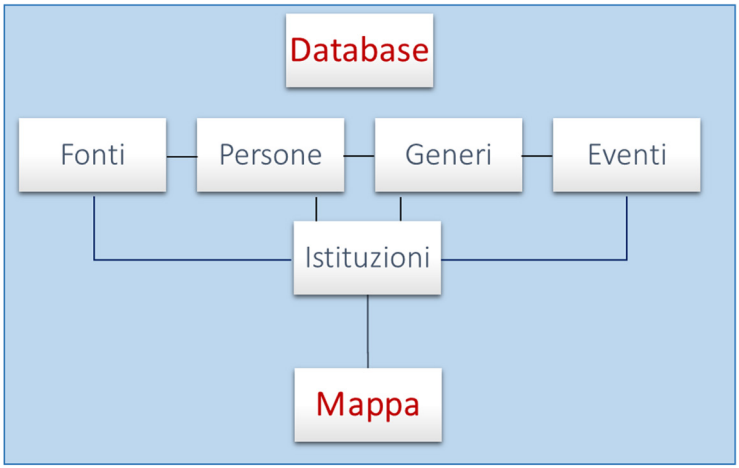


Figura 1 Struttura della piattaforma web

L'entità *Fonti* rappresenta il nucleo principale della banca dati e contiene le schede di descrizione dei documenti di interesse musicale presi in esame. L'entità *Persone* contiene un indice dei soggetti che, sulla base dei documenti d'archivio e musicali, risultano collegati alle istituzioni cittadine. Nello specifico, si tratta di musicisti, compositori, librettisti ecc., ossia autori delle fonti musicali inserite nella

piattaforma o personaggi che, a vario titolo, hanno collaborato con gli enti modenesi. A ogni nome corrisponde poi una breve scheda biografica, che evidenzia il ruolo svolto dall'artista all'interno corte o della città di Modena. In *Generi* si trova l'elenco delle forme musicali in uso nel XVII secolo a Modena. In *Eventi*, infine, si trovano tutti gli eventi spettacolari e musicali realizzati negli spazi pubblici cittadini. Inoltre, le quattro entità sono tra loro messe in relazione, consentendo, per esempio, di visualizzare la scheda di un manoscritto musicale, da cui poi accedere alla scheda biografica dell'autore e via di seguito.

Allo stesso tempo *Fonti*, *Persone*, *Generi* ed *Eventi* sono interrelati alle *Istituzioni*. Anche in quest'ultimo caso è stata creata una scheda di descrizione relativa ai luoghi cittadini, enti civili e religiosi legati alla produzione musicale della corte. Ogni scheda consente di avere informazioni sulla storia dell'ente, sul numero di fonti e sulle persone a esso collegate. A ciò si aggiunge un set di coordinate definito grazie alla funzione di georeferenziazione che, con il supporto del *plug-in* di OpenStreetMap inserito nel database, ha permesso di identificare sulla mappa la localizzazione di ogni istituzione all'interno della città, creando un file vettoriale. La *Istituzioni*, quindi, sono l'elemento di connessione tra il database e la mappa virtuale.

All'interno del database sono previste varie possibilità di accesso ai dati. In primo luogo, le risorse tradizionali di *search* e *browse*; la ricerca testuale libera; la possibilità di scorrere i diversi indici e la ricerca per data attraverso una ghiera temporale.

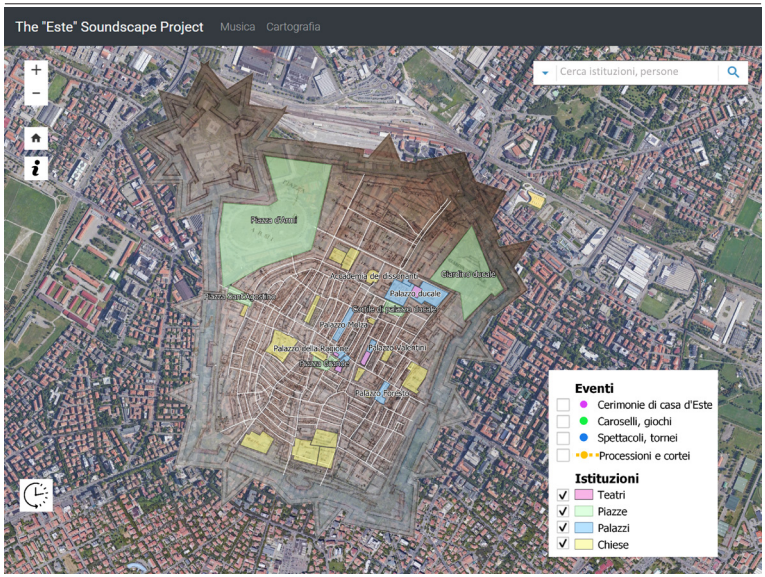
La mappa interattiva permette di 'navigare' il territorio della città di Modena attraverso il servizio di mappatura Web Google Satellite, al quale sono stati sovrapposti vari livelli informativi. Innanzitutto, grazie alle funzionalità del *software* QGIS, è stata georeferenziata la mappa storica di Vandelli, facendola combaciare con l'immagine satellitare della Modena odierna. Tale sovrapposizione consente, semplicemente spuntando o deselezionando il *layer* della carta storica, di confrontare la struttura urbana contemporanea con quella del XVII secolo.

Alla mappa si è poi aggiunto il *layer* vettoriale delle istituzioni. Tale livello informativo, nello specifico, è composto da poligoni che recuperano la forma degli edifici sede delle istituzioni identificate nel corso del progetto. Ogni poligono è collegato al database relazionale **[fig. 2]**.

Ai fini della visualizzazione, i poligoni sono poi stati tematizzati sulla base della tipologia, definendo quattro categorie: *teatri*, *chiese*, *palazzi*, *piazze*.

In tal modo, sfruttando le potenzialità del modello logico del GIS basato su *layer*, è possibile creare diverse visualizzazioni, mostrando tutte le quattro categorie o viceversa una sola: è possibile, ad esempio, evidenziare le chiese, piuttosto che i teatri o le piazze **[fig. 3]**.

Allo stesso tempo, grazie al modello relazionale del database collegato alla mappa, è possibile selezionare ogni singolo poligono che rappresenta un'istituzione per aprire una finestra pop-up contenente



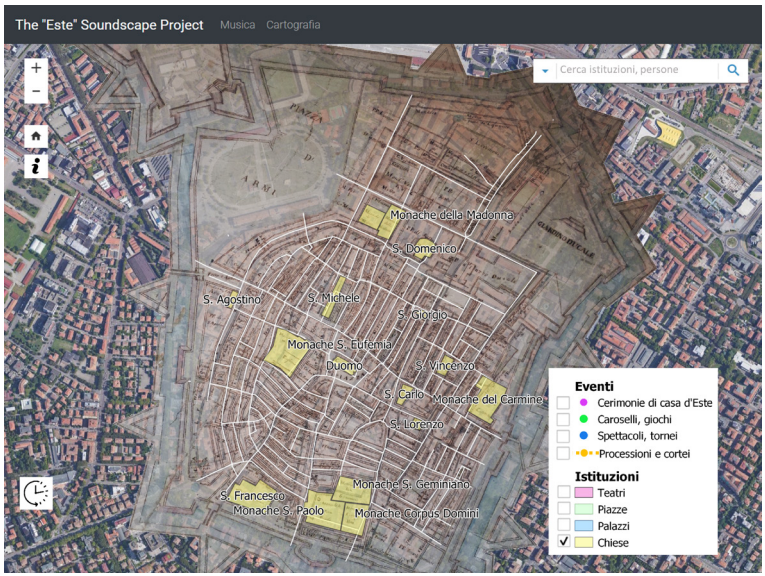


Figura 2 Mappa digitale. *Istituzioni*

Figura 3 Mappa digitale. *Chiese*

alcune informazioni di base e tramite link ipertestuale, accedere alle schede di approfondimento riguardanti l'istituzione, le persone o le fonti collegate.

Infine, tramite la funzione di ricerca, è possibile applicare dei filtri avanzati per la selezione dei documenti, sulla base del luogo, del periodo di produzione, dell'autore, del genere, ecc. I risultati della ricerca saranno visualizzabili direttamente sulla mappa, dalla quale poi si potrà, ancora una volta, selezionare la singola istituzione e approfondire le informazioni riferite alla selezione applicata.

La mappa, inoltre, include un *layer* informativo che identifica gli spazi pubblici in cui sono stati realizzati gli eventi, di cui distinguiamo quattro categorie: *caroselli*, *spettacoli*, *cerimonie*, *processioni*. Le piazze e le strade modenesi furono infatti spesso palcoscenico di eventi straordinari organizzati dalla corte. Negli spazi aperti cittadini si assisteva a mascherate e quintane con carri allegorici e rappresentazioni teatrali. Numerose anche le processioni e le cerimonie dinastiche organizzate in occasione di genetliaci o di visite illustri. In questo tipo di eventi, in cui aspetti dotti si fondevano a quelli popolari, prendevano vita macchine effimere e palcoscenici itineranti. Le fonti documentarie superstiti contengono descrizioni e testi, apparati iconografici, ma esigue sono le indicazioni relative alla musica **[fig. 4]**.

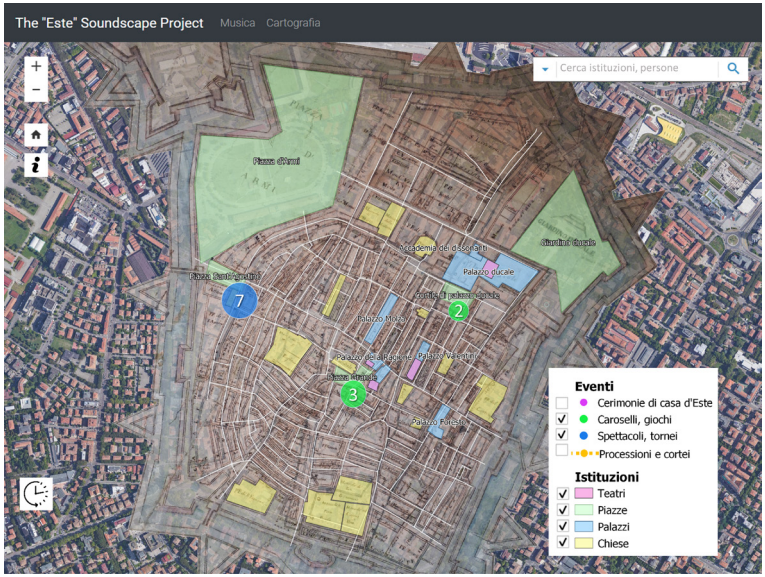


Figura 4 Mappa digitale. *Eventi*

Sulla mappa, in particolare, vengono visualizzati sia gli spazi in cui sono stati realizzati sia, nel caso di avvenimenti itineranti, i percorsi. Inoltre, nel caso in cui più eventi siano stati svolti negli stessi luoghi, un *cluster* ne indicherà il numero totale, ma sarà anche possibile accedere ai singoli eventi e a sintetiche finestre di dialogo e alle loro schede di approfondimento.

Infine, tramite la funzione di ricerca sarà possibile filtrare i risultati, mentre una barra di scorrimento temporale permetterà di visualizzare l'evoluzione cronologica degli eventi spettacolari.

Oltre a ciò, lo *slider* temporale sarà utile per ottenere informazioni sul periodo di attività di un'istituzione presente sulla mappa oppure per conoscere il numero delle attività musicali presenti nella città in un arco di tempo limitato.

Figura 5 Mappa digitale. *Slider*

3.3 Due esempi applicativi

Proponiamo di seguito due differenti esempi applicativi che permetteranno la comprensione delle funzionalità della piattaforma e delle principali modalità di visualizzazione del *front-end*.

Prendiamo in considerazione una delle istituzioni teatrali più prestigiose della città: il Teatro Valentini che acquisirà nel corso del Seicento il nome di Teatro Fontanelli. L'attività teatrale di questa istituzione è particolarmente interessante dal punto di vista dei rapporti tra corte e città. Il teatro era una sorta di camerone 'da spettacolo'

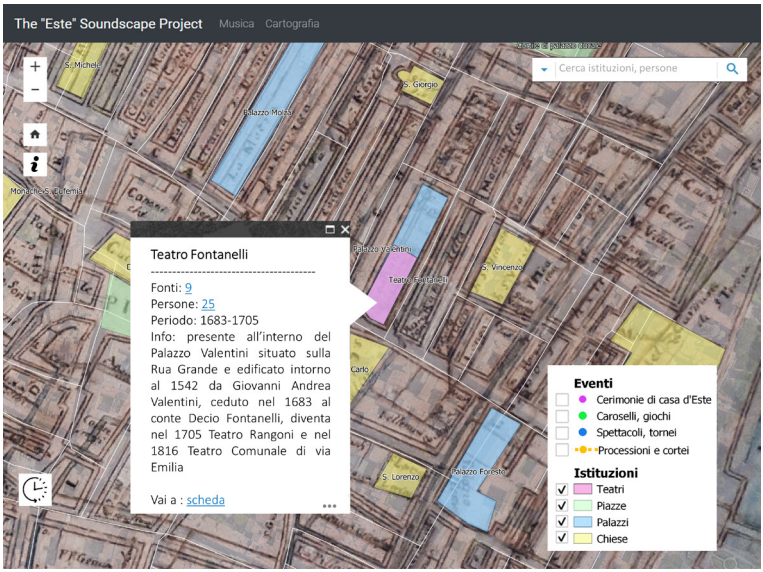


Figura 6 Mappa digitale. *Istituzioni: Teatro Fontanelli*

presente all'interno di un palazzo nobiliare chiamato Palazzo Valentini ed edificato intorno al 1542 da Giovanni Andrea Valentini. Il Valentini era conosciuto per essere 'il teatro pubblico delle commedie' perché inizialmente adibito alle sole recite dei comici al servizio della corte. Nel 1681 il Valentini fu interamente distrutto da un incendio. Riprenderà nuova vita qualche anno più tardi, nel 1685, grazie al marchese Decio Fontanelli che lo rilevò e lo consacrò al melodramma. Il teatro, ribattezzato col nome di Teatro Fontanelli, fu infatti scelto da Francesco II come luogo dove ospitare le rappresentazioni teatrali patrocinate dalla corte ma aperte a un pubblico pagante e divenne in breve tempo il teatro più importante degli Stati estensi, direttamente legato alla politica culturale del duca (Martinelli Braglia 1985). Nel ducato di Francesco II, il teatro ospitò le rappresentazioni di diversi compositori afferenti alla corte come Domenico Gabrielli, Carlo Pallavicini, Antonio Giannettini, affiancate da riprese di spettacoli veneziani. Il Fontanelli diventerà un centro nevralgico di produzione musicale cittadina. La Biblioteca Estense custodisce oggi, oltre ad alcune partiture di melodrammi eseguiti presso il Teatro Fontanelli, anche la collezione di libretti della famiglia Fontanelli.[13] La presen-

13 La collezione di libretti della famiglia Fontanelli consta di un migliaio di libretti per musica datati da inizio Seicento a circa il 1760. La raccolta venne acquistata dalla

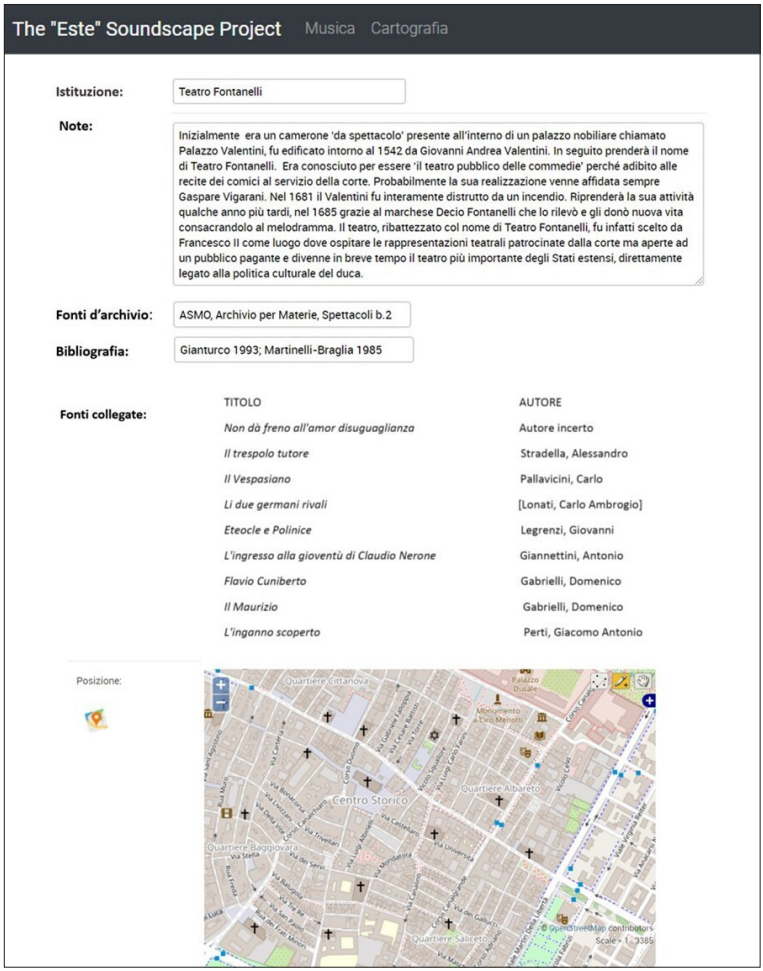


Figura 7 Scheda di approfondimento. *Istituzioni: Teatro Fontanelli*

za e la corrispondenza di documentazione d'archivio, fonti librettistiche e fonti musicali permette di ricostruire l'intero processo produttivo degli allestimenti del Fontanelli, fornendo una copiosa serie di

Biblioteca Estense alla fine del XVIII secolo. Nella collezione figurano libretti di drammi per musica ma anche oratori e azioni drammatiche. Molti di essi sono relativi a esecuzioni modenesi di drammi per musica avvenute proprio presso il Fontanelli durante il ducato di Francesco II (Chiarelli 2009).

dati sulle rappresentazioni, sui cast impiegati e le maestranze **[fig. 6]**.[14]

L'ubicazione del teatro resta oggi visibile soltanto in alcune piante storiche della città di Modena, per cui la mappa di Vandelli ne consente l'identificazione. La posizione del teatro nella geografia urbana risultava strategica: il teatro era situato tra la via Emilia e la Rua Grande (attuale via Farini) e direttamente connesso al Palazzo Ducale. Tramite un pop-up velocemente si ottengono informazioni relative all'istituzione: il numero di fonti e delle persone legate al teatro, delle brevi note esplicative e un link ipertestuale che permette di accedere direttamente alla scheda di approfondimento **[fig. 7]**.

In quest'ultima scheda relativa a ogni istituzione, troviamo informazioni sulla storia dell'ente, oltre ai rimandi archivistici e bibliografici. Dalla scheda è inoltre possibile ottenere dati sintetici sui documenti musicali legati all'attività dell'ente e visualizzare la posizione del teatro nella geografia odierna della città grazie a una miniatura della mappa di OpenStreetMap aggiunta al database per la georeferenziazione dei luoghi. Grazie alle relazioni presenti tra le differenti entità della piattaforma, come accennato in precedenza, dalla scheda dedicata all' *Istituzione Teatro Fontanelli*, è possibile accedere a quelle relative alle *Fonti*. Immaginando di voler informazioni su uno dei documenti musicali legati al teatro, ad esempio il *Flavio Cuniberto* di Domenico Gabrielli, rappresentato nel 1688, sarà possibile accedere alla scheda dedicata **[fig. 8]**.[15]

Ogni scheda prevede dati di descrizione della fonte e dati di contestualizzazione. Le informazioni sono tratte dallo studio e dall'analisi della fonte musicale, della documentazione d'archivio e bibliografica. Un link permetterà di accedere alla versione digitale del manoscritto e del libretto (nel caso di repertorio vocale) e, ove possibile, ad una traccia audio.[16] A sua volta, la pagina relativa alla fonte permette l'accesso a quella del compositore, del genere, dell'istituzione etc. con altrettanti approfondimenti.

14 Nove i manoscritti musicali di drammi per musica rappresentati al Fontanelli e oggi conservati presso la Biblioteca Estense Universitaria. Inoltre, presso l'Archivio di Stato di Modena, il fondo Archivio per Materie, *Spettacoli*, conserva documentazione varia relativa all'attività del teatro: note di spesa per gli allestimenti, informazioni sui cast e sull'ingaggio di musicisti nelle differenti rappresentazioni, avvisi a stampa delle rappresentazioni etc.

15 Il dramma per musica *Flavio Cuniberto* fu composto da Domenico Gabrielli su libretto di Matteo Noris. La prima rappresentazione ebbe luogo presso il Teatro San Giovanni Grisostomo di Venezia nel 1682, successivamente venne rappresentato a Modena presso il Fontanelli nel 1688 grazie a Francesco II d'Este. La Biblioteca Estense conserva oggi il manoscritto della seconda rappresentazione modenese e il libretto. Dal libretto è possibile desumere informazioni sulla data di rappresentazione, la dedica (in questo caso a Francesco II), e i nomi dei cantanti. Inoltre, alcuni documenti dell'archivio di stato di Modena offrono informazioni dettagliate sulla rappresentazione del 1688, ad esempio il cast coinvolto nella performance.

16 La piattaforma beneficerà del collegamento diretto alle collezioni digitali dell'Estense Digital Library.

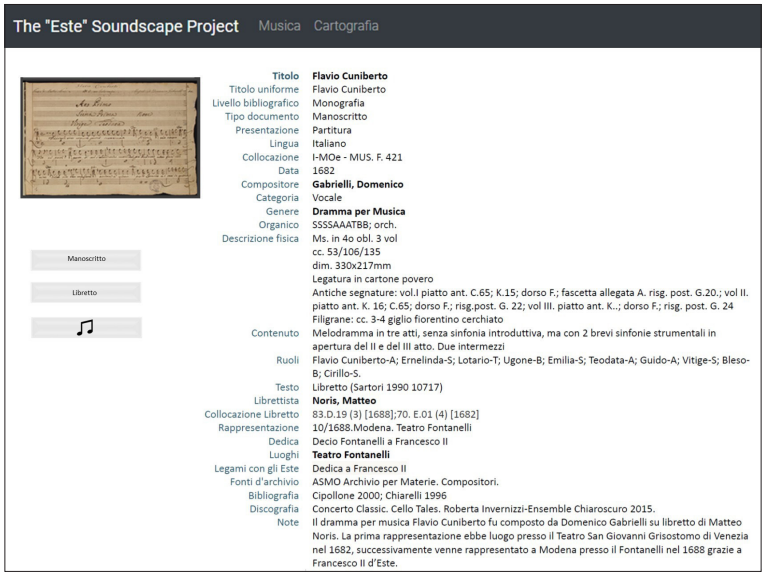


Figura 8 Scheda di approfondimento. *Fonti. Flavio Cuniberto*

In questo modo è possibile legare direttamente una fonte al luogo nel quale o per il quale è stata composta o eseguita.

Il secondo esempio è invece relativo alla visualizzazione per *Eventi*.

Tra le feste di piazza, l'evento probabilmente più celebre nella storia della spettacolarità modenese fu la sontuosa cerimonia organizzata per la nascita di Francesco II nel 1660: una 'festa d'armi' sul tema della vittoria della virtù sul vizio, indetta nello stesso giorno del battesimo del nuovo erede del casato, il 12 giugno. L'evento era stato organizzato negli spazi dell'imponente Palazzo Ducale quali la corte d'onore e il piazzale antistante.

L'architetto ducale Gaspare Vigarani fu incaricato dell'allestimento scenografico, mentre, il poeta di corte Girolamo Graziani compose i versi del torneo celebrativo e il maestro di cappella Benedetto Ferrari ebbe l'incarico della composizione della musica a oggi perduta.[17]

17 Girolamo Graziani (1604-1675), urbinate di nascita e modenese d'adozione, divenne poeta di corte estense. Dal 1637 al 1660 compose tutti i libretti di tornei e spettacoli indetti a corte. Benedetto Ferrari (1597-1681), detto anche Benedetto della Tiorba, fu un eccellente tiorbista. Nato a Reggio Emilia, lavorò a Roma, Parma, Venezia dedicandosi soprattutto alla composizione di melodrammi. Fu a Modena dal 1623 al 1637, e una seconda volta a partire dal 1653, dopo aver ricevuto l'incarico di maestro della cappella ducale da Francesco I d'Este. Gaspare Vigarani (1588-1663) è stato un architetto attivo presso casa d'Este a partire dal 1631, anno in cui venne nominato da Fran-

La Biblioteca Estense conserva il pregiato manoscritto che descrive nei dettagli il torneo e i suoi apparati, i costumi e il progetto per il teatro costruito in occasione della cerimonia **[fig. 9]**:

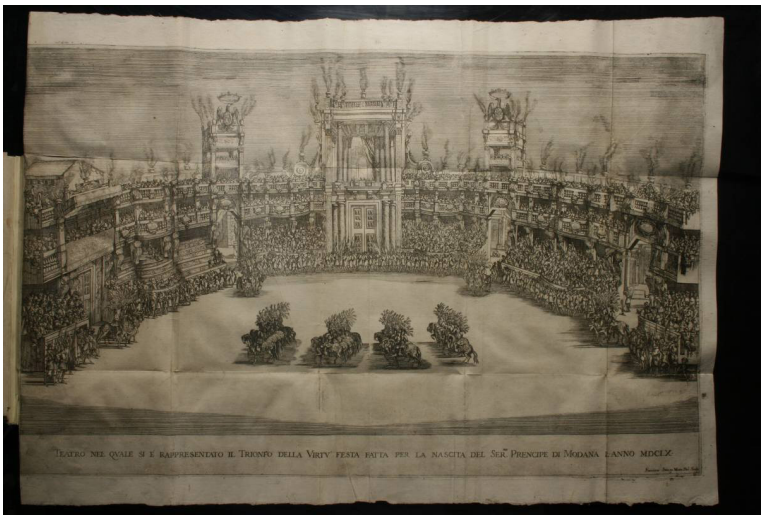


Figura 9 Francesco Stringa. *Progetto del teatro effimero realizzato per il 'Trionfo della Virtù*. Incisione. 1660. Modena. Biblioteca Estense Universitaria. Girolamo Graziani. Il trionfo della virtù. Bartolomeo Soliani, 83.R.12 - Tavola 22, su concessione del Ministero per i Beni e le Attività Culturali

La descrizione, presente all'interno del manoscritto, sottolinea il fasto, la grandiosità dell'architettura effimera, dei giochi di luce organizzati per l'occasione. La cerimonia aveva previsto il concorso della «più qualificata nobilità» e la resa sonora dell'evento era stata affidata a «più chori di esquisiti musici, secondati dal rimbombo strepitoso de bronzi tonanti e dalle acclamationi festose del popolo». Spettacolari furono anche i costumi dei fanti «guerniti di armi forbite, e di ricche bande, e di gran pennacchi» e le coreografie a cavallo, le cui movenze erano scandite dallo «strepito de risuonanti Tamburi» **[figg. 10-11]**.[18]

In questo caso non si conserva il manoscritto musicale, la mappa quindi oltre alla visualizzazione dello spazio di rappresentazione della cerimonia, ad una scheda di descrizione dell'evento, propone

cesco I 'Ingegnere e Soprintendente generale delle fabbriche e delle feste'. Vigarani si dedicò molto all'allestimento delle macchine effimere per spettacoli e feste di piazza e alla progettazione di teatri e sale da spettacolo.

18 Modena, Biblioteca Estense Universitaria, Gamma. B.1.17. Graziani, G. I*l Trionfo della Virtù. Festa d'armi a cavallo rappresentata nella nascita del Sereniss. Sig. Prencipe di Modona l'anno MDCLX*, cc.6-7. Esiste anche una versione a stampa relativa al libretto poetico della rappresentazione con incisioni di Francesco Stringa (Graziani 1660).

Figura 10 Girolamo Graziani. *Carro allegorico per la festa d'armi 'Il Trionfo della Virtù'*. 1660. Modena. Biblioteca Estense Universitaria. Gamma. B.1.17 c. 10, su concessione del Ministero per i Beni e le Attività Culturali

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Figura 11 Girolamo Graziani. *Costume dei cavalieri per la festa d'armi 'Il Trionfo della Virtù'*. 1660. Modena. Biblioteca Estense Universitaria. Gamma. B.1.17 c. 13, su concessione del Ministero per i Beni e le Attività Culturali

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l'accesso alle fonti storiche collegate, a gallerie di immagini dei luoghi e degli spazi, infine consente di leggere la sintetica descrizione dell'evento tramite un pop-up **[fig. 12]**.[19]

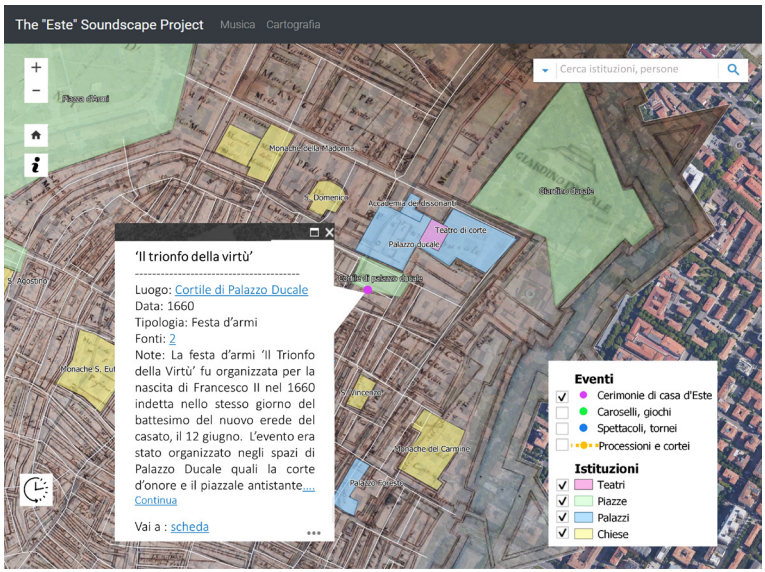

Figura 12 Mappa digitale. *Eventi: Trionfo della virtù*

4 Conclusioni

Come abbiamo potuto vedere con gli esempi applicativi, le potenzialità della piattaforma sono numerose: l'interazione tra le parti costitutive della piattaforma consentirà di passare liberamente dalla visualizzazione spaziale alle schede di approfondimento, ottenendo informazioni su documenti, attività musicali, persone ed eventi spettacolari.

La mappa interattiva è stata attualmente realizzata in una versione Beta, che prevede l'uso di una sola carta storica riferita al perio-

19 Dato il carattere effimero di eventi all'aperto si conservano ben poche testimonianze musicali. Le fonti maggiormente significative sono invece le cronache cittadine molto spesso prodighe di indicazioni su spazi e rappresentazioni. La cronaca più significativa del primo Seicento modenese è quella di Giovan Battista Spaccini, un resoconto prezioso che offre un quadro vivo degli avvenimenti più importanti della città di Modena. Spaccini produsse ben nove volumi di cronache: i primi due sono un rifacimento dei diari cinquecenteschi di Iacopino e Tommasino Lancellotti, mentre i restanti riportano gli episodi di cui Spaccini stesso fu testimone tra il 1588 e il 1636 (Spaccini 1993-2008).

do di riferimento del progetto, ma la flessibilità del GIS consentirà, nel futuro, l'inserimento di altre mappe, anche prodotte in periodi diversi, che, sovrapponendosi, permetteranno di apprezzare le modifiche subite dalla struttura urbana della città. Nel tempo infatti la città e le sue istituzioni hanno cambiato volto, talvolta posizione, denominazione o addirittura lo stesso significato.

Al contempo, l'arco cronologico scelto per l'avvio del progetto, attualmente focalizzato sul Seicento, potrebbe essere esteso per mostrare l'evoluzione culturale della città su di una scala temporale più ampia. A ciò si aggiunge la possibilità di inserire, accanto alle informazioni sulla produzione musicale modenese, altri dati di carattere storico, artistico, iconografico riguardanti i luoghi della città presi in analisi, consentendo di ampliare le applicazioni, al fine di restituire l'identità storica locale nella sua complessità e ricchezza.

Per favorire il riutilizzo, la riproducibilità e l'ulteriore adozione da parte di altri studiosi, il codice sorgente della piattaforma sarà reso pubblicamente disponibile.

In tale prospettiva, la piattaforma non fungerà solo da 'catalogo' per la consultazione dei dati, ma viceversa punta a diventare un mezzo di esplorazione e scoperta, di connessioni e narrazioni inedite, nonché strumento di disseminazione scientifica nonché di comunicazione storica, in grado di fornire conoscenza e coinvolgimento per un pubblico più ampio.

In conclusione, questo tipo di mappatura digitale può trasformare la comunicazione dei risultati della ricerca e consentire di immaginare nuove intersezioni, proponendo un modello collaborativo e multidisciplinare per la ricerca storica.

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The Digital Enhancement of a Discipline
Byzantine Sigillography and Digital Humanities

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Abstract Byzantine sigillography is intrinsically interdisciplinary. Unlike other sister auxiliary disciplines, such as epigraphy or numismatics, sigillography has not yet benefited from the experience gained within the Digital Humanities. SigiDoc, the newborn encoding standard for Byzantine seals, is the first attempt to bridge this gap. This paper is aimed at investigating the interactive fusion of aspects of interdisciplinarity between Byzantine Sigillography and the Digital Humanities whilst illustrating the 'digital genealogy' of SigiDoc in the broader context of TEI, as well as its relationship of reciprocity with open source initiatives and tools, such as EpiDoc and EFES (EpiDoc Front-End Services).

Keywords Byzantine Sigillography. Byzantine Studies. Numismatics. Epigraphy. EpiDoc. Digital Scholarly Edition. EFES (EpiDoc Front-End Services). SigiDoc.

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1 Introduction. Byzantine Sigillography and Its Object: A Multi- and Interdisciplinary Field

Byzantine sigillography is the research field studying seals formerly attached to official documents in the Christian eastern medieval empire centred upon Constantinople. Sigillography is a pivotal discipline within the broader domain of Byzantine studies, because seals are the only remnants of the written documents used for daily administration and private correspondence from the 4th to the 15th century CE in the Byzantine Empire, whose public and private archives are nearly entirely lost. As such, seals do not supplement archival material but have to substitute it, which explains the unique importance of sigillography for Byzantine studies.

Byzantine seals are coin-like objects mostly made of lead, whose two sides display iconographic depictions and/or legends (i.e. inscriptions). They are produced with a matrix called *boulloterion* (a plier-like object), leaving an imprint on the two faces of the blank. We use the term 'seal' to refer to both the object and the imprint it bears.

Figure 1 Seal of Michael, vestarches and oikonomos of the Nea Church, mid-11th century (Collection Sopracasa, inv. no. 53; published in Sopracasa, Prigent 2017)

A large part of the 80,000 extant seals consists of unique specimens, which were the possession of a single individual or institution in Byzantium. Whilst the mass of seals provides insights into historical, administrative, and economic aspects of the Byzantine empire, each individual seal grants us access to the citizens of the empire, almost half of whom are attested only through their seals (Cheynet 2008, 74). Byzantine sigillography contributes significantly to the advancement of various research fields within the broader domain of Byzantine studies, such as prosopography, administrative geography, political, social, economic, and art history, epigraphy and philology. We argue here that Byzantine sigillography is intrinsically interdis-

ciplinary, with an extremely wide coverage of, and overlap with, other disciplines: sigillography shares issues, tools, solutions, and questions, with fields including epigraphy, numismatics, and art history.

1.1 Scholarly Editions in Byzantine Sigillography

It is important to highlight that, aside from a few attempts to give some very general guidance (Oikonomides 1986; Tsougarakis 1999; Cheynet 2008, 1-82), there are no manuals for Byzantine sigillography, and edition standards have been developed over the last century in a somewhat haphazard fashion in individual publications, never being systematically and unanimously established. Moreover, there is a lack of consistency in the use of edition criteria among scholars and their schools: the features that differ most are those of epigraphical rendering, normalisation of language variants of Byzantine Greek, consistent use of the Leiden conventions, iconographical analysis, and historical commentary.[1]

Paper publication is the rule for Byzantine sigillographers. This materialises mainly in ponderous, limited-edition corpora[2] or small articles scattered in journals and miscellaneous books, the *Studies in Byzantine Sigillography* being the only journal that specialises in this field.[3] Existing paper publications are not readily available, rather expensive, and do not allow for updating, amending, or improving. There are also significant issues of image quality (even if greater efforts have been made recently).[4]

1.2 Byzantine Sigillography and Digital Humanities

In the last few years, sigillography has received increasing attention from experts in Digital Humanities, Western Mediaeval seals being at the forefront.[5] But this increased attention is far from being sufficient

1 This lack of consistency hinders the cross-referencing of information among different collections. See, e.g. Zacos, Veglery 1972; Seibt 1978; Zacos 1984; Oikonomides et al. 1991-2009; Seibt, Wassiliou 2004.

2 See most recently Cheynet, Bulgurlu, Gökyıldırım 2012; Cheynet, Campagnolo-Pothitou 2016; Cheynet 2019.

3 The journal is published every four years and the latest volume is *Studies in Byzantine Sigillography*, 13, 2019.

4 See, e.g. Cheynet 2019. One must notice, however, that the publication has been fully financially supported by the private collector whose seals have been edited, thus making the high definition of the images an exception rather than the rule.

5 See projects such as Sigilla (`http://www.sigilla.org/`) and DigiSig (`http://digisig.org/`).

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to narrow the gap with sister auxiliary disciplines, such as numismatics, epigraphy, and papyrology, which, during the last 20 years, have developed their own digital approaches, stimulating the growth of online corpora. Unlike these disciplines, Byzantine sigillography has not yet benefited from the experience gained within the Digital Humanities. Within the scope of this paper, we discuss EpiDoc, an international, collaborative effort using a subset of the Text Encoding Initiative (TEI) that provides a standard, guidelines, and tools for creating and encoding scholarly editions of ancient texts and documents produced on various text-bearing objects other than parchment or paper, such as stone or papyrus.[6] In the field of Byzantine sigillography the only consistent online presence is the ongoing Online Catalogue of the Dumbarton Oaks Research Library and Collection (Trustees for Harvard University) in Washington, DC, which holds the largest collection of Byzantine seals worldwide, with around 17,000 specimens.[7]

SigiDoc, the new encoding standard for Byzantine seals that has been developed since 2015 between Paris and Cologne by Alessio Sopracasa and Martina Filosa, is the first attempt to bridge this gap: the discipline is now ready to benefit fully from the method-oriented interdisciplinarity of the Digital Humanities, leveraging standards, tools, and practices developed in neighbouring disciplines and adapting these to its specific needs and materials.

SigiDoc is an XML-based and TEI-compliant encoding standard for producing digital editions of Byzantine seals and digitally enhanced versions of printed editions.[8] It is largely based on the ongoing experience of TEI, EpiDoc, and EFES (EpiDoc Front-End Services) – a highly customisable platform for the online publication of ancient texts in EpiDoc XML, as will be illustrated in the examples below.[9] The developers plan to release version 1.0 in the spring of 2021: a GitHub repository is already available with an in-progress version of

6 EpiDoc: Epigraphic Documents: `https://epidoc.stoa.org/`. For a list of projects related to inscriptions, coins, and papyri in Digital Humanities: `https://wiki.digitalclassicist.org/Category:Projects` (updated to 2016-05-31).

7 See `https://www.doaks.org/resources/seals`.

8 See Sopracasa, Filosa 2020; see also "Sunoikisis Digital Classics: Spring 2020. Session 5. EpiDoc 2: publishing and querying with EFES" (`https://github.com/SunoikisisDC/SunoikisisDC-2019-2020/wiki/DC-Session-5-EpiDoc-2`) and "Summer2020 Session 4. Text-Bearing Objects 2" (`https://github.com/SunoikisisDC/Sunoikisis-DC-2019-2020/wiki/Summer2020-Session-4`).

9 EFES is a fork of the open source XML publishing platform Kiln developed by the Department of Digital Humanities at King's College London between 2012 and 2019. See `https://github.com/kcl-ddh/kiln` and `https://kiln.readthedocs.io/en/latest/` for the documentation. For a thorough analysis of EFES and its potential, see most recently Bodard, Yordanova forthcoming.

the code[10] and a website (`http://sigidoc.huma-num.fr/`, empty for now) is ready to host documentation, guidelines, and general information about the project, as well as a test corpus consisting of a digitally enhanced version of a printed article (Sopracasa, Prigent 2017).

SigiDoc 1.0 will finally provide something that has been long awaited and discussed since 2006 amongst the community of Byzantine sigillographers, being something of a chimera for Byzantine studies at large, often announced but never seen.[11] However, we are aware that it can be improved and we have therefore tried to anticipate future developments and needs: a second round in SigiDoc's development is currently already seeking funding.

As already stated elsewhere (Sopracasa, Filosa 2020, 241), SigiDoc is:

- a schema, compatible with the EpiDoc and TEI All schemas;
- a template, i.e. SigiDoc's edition structure (partially reproduced below);
- a stylesheet for HTML transformation;
- a set of stylesheets for scholarly editions of the legends on seals;
- a highly customised version of EFES;
- a set of encoding guidelines;
- a set of files intended to be shared among all future SigiDoc projects (ID lists, controlled vocabularies, authority lists, ontologies etc.).

From a SigiDoc point of view, we consider Byzantine seals as compounds of three different, intrinsically intertwined, aspects: the object, the text, and the image. As objects, seals in many ways resemble coins, thus enabling sigillographers to leverage the experience gained in the neighbouring field of numismatics. As the study of text-bearing objects, sigillography utilises standards and criteria developed for editions of papyri and inscriptions, such as the Leiden conventions, whilst customising them to best suit the different kinds of material being treated. Finally, seals are also treated as images, both as digital facsimiles and as bearers of iconographic depictions. This paper, however, will only deal with the first two aspects. In addition, as a minor but relevant point, this paper will devote special attention to some aspects of the relationship between print and digital publication, whilst addressing the topic of the degree of digital enhancement of the discipline offered by the current state of SigiDoc.

10 SigiDoc's GitHub repository `https://github.com/SigiDoc/SigiDoc`. We invite potential users not to fork this repository yet, as it will be updated before releasing the 1.0 version.

11 A Wiki, last updated in 2011, illustrates the first round of discussions about SigiDoc: `http://sigidoc.wikidot.com/`.

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2 The Seal as an Object: The Metadata

With regard to metadata on the EFES-generated webpage,[12] the structure of a SigiDoc edition will be similar to that of other EpiDoc-based projects.[13] The digital edition appears more organised and better structured in comparison with the printed one, where the metadata are usually grouped, in a smaller font, under the main title of the seal, including a mention of the date (without dating criteria); the inventory number of the edited seal; its diameter (with no further measurements); a simple physical description, focusing mainly on the state of conservation of the seal; and, finally, a mention of its edition(s) and parallel(s), if applicable. As far as further metadata are concerned, these can be either found scattered within the commentary of the edition or are not registered by the editors at all. In SigiDoc, however, specific fields have been created to deal with these individual aspects of metadata. Examples of these include: *Channel orientation* and *Axis*, expressed with reference to the numbers on a clockface (e.g. thread channel at 1 o'clock) and mostly omitted by printed publications, the former showing the position of the thread channel in relation to the imprint, the latter showing the orientation of the imprint on the obverse in relation to the one on the reverse; *Seal's context*, *Issuer*, and *Issuer's milieu*, giving broad insights into the owner of the seal; *Acquisition* and *Previous Locations*, retracing the history of the seal until its current location; and *Decoration*, giving insights into borders and decorative elements on the seal.

Beyond making the information more structured, organised, and easily comprehensible, the encoding template prioritises some elements of the metadata which, in a printed edition, would be likely to go unnoticed. That is the case, above all, for the field *Lettering*, i.e. the information concerning the appearance of the letterforms on the seal, which is one of the key factors in the dating of a specimen.

Further, in the digital edition, there will inevitably be some blank fields in which the information is replaced by, e.g. an em-dash or by the use of the phrase *not applicable/not available*. After much discussion with our colleagues – sigillographers and digital humanists alike – on whether to delete those fields with lack of information, we concluded that the lack of information is still information *per se*.

12 Metadata are, from a SigiDoc point of view, all information contained in the TEI-header. They concern appearance and physical description of the seal; its dating and dating criteria; its history – ancient and modern alike – spanning, therefore, from the time of the seal's issuer until the acquisition of the seal in a collection; a description of both sides of the seal, including a thorough description of the iconography; and bibliographical references to the seal and to its parallels, when applicable.

13 For a glimpse of the layout of the prospective webpage generated through EFES see `https://iospe.kcl.ac.uk/5.48.html` (accessed: 2020-07-14).

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2.1 Manuscripts with Seals and Seals without Manuscripts: TEI Standards and Byzantine Seals

In the 'digital genealogical tree' of SigiDoc, the oldest ancestor is represented by TEI, whose aim is "to develop and maintain guidelines for the digital encoding of literary and linguistic texts".[14] Even though this definition embraces a very wide range of texts, some are only marginally or approximately represented: this is true, e.g. for inscriptions and seals' legends. The privileged supports of the texts considered by the TEI guidelines are those of paper or parchment, much less stone or lead: this becomes extremely clear upon reading the guidelines about the description of the text-bearing object, explicitly defined as "Manuscript description", and, more broadly, the names chosen by the TEI consortium for the elements.[15]

This remark leads directly to the next generation of SigiDoc's genealogy, i.e. EpiDoc. As a matter of fact, EpiDoc has been the starting point for the development of several aspects of SigiDoc, mainly because this standard, now long established, represents a selection and a semantical adaptation of TEI's standards in a direction very suitable for – even if not entirely coincident with – sigillography. Hence, placed under the large umbrella of TEI, SigiDoc greatly benefited from the experience of (digital) epigraphy.

Whilst the elements chosen by SigiDoc are TEI, they no longer refer to a manuscript:

```
<TEI xmlns="http://www.tei-c.org/ns/1.0">
   <teiHeader>
      <fileDesc>
         <titleStmt/>
         <editionStmt/>
         <publicationStmt/>
         <sourceDesc>
            <msDesc>
               <msPart n="r"/>
               <msPart n="v"/>
            </msDesc>
         </sourceDesc>
      </fileDesc>
      <encodingDesc/>
      <revisionDesc/>
   </teiHeader>
   <facsimile/>
   <text>
      <body>
         <div type="edition" subtype="editorial" xml:space="preserve"
xml:lang="grc"/>
         <div type="edition" subtype="diplomatic" xml:space="preserve"
xml:lang="grc"/>
         <div type="apparatus"/>
         <div type="translation"/>
         <div type="commentary" subtype="edition"/>
         <div type="commentary" subtype="translation"/>
         <div type="footnotes"/>
         <div type="bibliography"/>
      </body>
   </text>
</TEI>
```

14 See https://tei-c.org/about/.

15 See TEI Guidelines §10, https://tei-c.org/release/doc/tei-p5-doc/en/html/MS.html.

As it shows, the basic structure of a SigiDoc edition structure is extremely close to that of EpiDoc, and it is organised around three main elements: the <teiHeader>, designed to collect the metadata; the <facsimile> for the images of the edited seals; and the <text> for the edition of the seals' legends, apparatus, and commentary, including bibliography and footnotes.[16]

A TEI element <sealDesc> does exist and, according to the TEI standards, it is designed to describe "the seals or similar items related to the object described, either as a series of paragraphs or as a series of seal elements";[17] this element may contain only a handful of other ones, such as <p>, <ab>, <condition>, <decoNote>, <summary>, and, of course, <seal>, the latter being suitable for "a description of one seal or similar applied to the object described".[18]

These elements are manifestly not sufficiently detailed to properly encode a Byzantine seal, because – as the previously quoted definitions clearly show – the seal is considered as a part of the very object of the description, i.e. the manuscript, <sealDesc> being nested inside <physDesc>. This approach implies a strict interdependence between the document and the seal, which is neither consistent nor realistic with the material available to Byzantine sigillographers: as we saw before, due to the nearly complete loss of Byzantine private and public archives, finding a Byzantine seal still attached to the document it authenticates is extremely rare (Cheynet 2008, 13-14 with references).

The adoption of the TEI standards by SigiDoc involves, therefore, a semantic 'betrayal' of some of them or, in a more positive way, their semantic extension.[19] This is particularly true for the metadata, all nested inside a <sourceDesc> element which, at least by its name, can be adapted to multiple materials, but which is extremely stretched by EpiDoc's and SigiDoc's use of it if we consider the role that TEI assigns to it.[20]

16 For the structure of an EpiDoc edition see https://epidoc.stoa.org/gl/latest/supp-structure.html.

17 See TEI Guidelines <sealDesc>, https://tei-c.org/release/doc/tei-p5-doc/en/html/ref-sealDesc.html.

18 See TEI Guidelines <seal>, https://www.tei-c.org/release/doc/tei-p5-doc/en/html/ref-seal.html.

19 A lively and fruitful debate about this topic took place during the workshop "Digitizing and Encoding Seals: SigiDoc and RTI-Dome in Action", organised by the Venice Centre for Digital and Public Humanities at Ca' Foscari University, on January 20-21, 2020. For programme and teaching materials see: https://www.unive.it/data/33113/2/35921.

20 See TEI Guidelines § 2.2.7 "<sourceDesc> (source description) describes the source(s) from which an electronic text was derived or generated, typically a bibliographic description in the case of a digitized text, or a phrase such as 'born digital' for a text which has no previous existence". Available: https://tei-c.org/release/doc/tei-p5-doc/en/html/ref-sourceDesc.html.

Next there is <msDesc>: in order to meet sigillographic needs and to upgrade the place of a seal, assigning to it a central role, it should hypothetically be replaced by the already mentioned <sealDesc>. If SigiDoc's use of <msDesc> does not strictly respect its semantics, one should also stress that the TEI consortium intends the *msdescription module* as "general enough" to be "extended [...] and [...] potentially useful for any kind of text-bearing artefact",[21] even if the original aim, i.e. working with Mediaeval manuscripts, is predominant. This clarification has been introduced in the current TEI Guidelines (P5) since the 1.0.0 version dating back to 2007; most recently, for the latest release (4.0.0), the consortium wanted to stress further and clarify that the <msDesc> element could be used for all text-bearing objects.[22] A discussion took place about the possibility to expand the semantic area of <msDesc>, changing it to <TBODesc> (for text-bearing object description), but the idea was soon abandoned, because the priority was given to backward compatibility, concluding that any <ms*> element could and should be used for *any* text-bearing object.[23]

2.2 Seals as Coin-Like Objects: Seriality vs (Relative) Unicity

Coins share some key features with seals, such as two faces, the presence of images and inscriptions, materials, and techniques of production. Coins are the closest objects to seals having already benefited from an important digital attention and they also have 'their own TEI', i.e. the Nomisma project.[24] Its Numismatic Description Schema/Standard (NUDS) is XML-based and influenced by the structure of, among others, TEI.[25] Looking at what neighbouring disciplines had found in order to represent their data in digital form, in one of SigiDoc's previous development steps, Alessio Sopracasa, at that time the sole developer, tried to evaluate the possibilities of a close interaction between SigiDoc and NUDS, designing a template for the metadata of the seals based on NUDS, but largely adapted to the needs of sigillography, with its own schema to validate it, thereby seriously discuss-

21 See TEI Guidelines § 10.1, https://tei-c.org/release/doc/tei-p5-doc/en/html/MS.html#msov.

22 TEI Consortium (2020-02-13). TEI P5: Guidelines for Electronic Text Encoding and Interchange (Version v 4.0.0). Zenodo. http://doi.org/10.5281/zenodo.3667251, and the discussion: https://github.com/TEIC/TEI/issues/1835.

23 This discussion took place on the TEI-List on 2018-09-28, see https://listserv.brown.edu/cgi-bin/wa?A2=ind1810&L=TEI-L&P=72748.

24 See http://nomisma.org/.

25 See http://nomisma.org/nuds and https://www.greekcoinage.org/nuds.html.

ing the possibility of adapting NUDS for SigiDoc.[26] Traces of this attempt are still visible today in NUDS, where sigillographic elements (or elements used in a 'sigillographic way'), have been included:

- <channelOrientation> is an exclusively sigillographic feature, as it represents the channel through which the thread attaching the seal to the document passed;[27]
- <date> and <dateRange> have been included inside both <obverse> and <reverse>, because seals may be struck by means of an assembled matrix, whose two sides date to a (slightly) different timeframe;
- <ab>, borrowed from TEI and added "for greater flexibility in the encoding of prose": this is the element used by EpiDoc and, now, SigiDoc to encode inscriptions on stone and legends on seals;[28]
- more generally, NUDS now "allows for the optional namespacing of EpiDoc TEI elements for legends and descriptions for more complex tagging of inscriptions and prose".[29]

Beside some minor additions, it seems clear that the inclusion of the TEI-EpiDoc features in the numismatic description was intended to provide the user with much more latitude, particularly for tagging the legends, as explicitly stated in the description of NUDS' element <legend>: "Typically, the legend will be a *literal transcription* [...]. Alternatively, one or more <tei:div> elements may be namespaced in for a greater degree of transcriptive accuracy, following the EpiDoc schema".[30]

This kind of addition is not accidental: in the editions of coins, the legend is in plain text without editorial intervention, reproduced as it appears on the coin, and followed (or preceded) by a short description of the iconography – the main focus of the edition being the numismatic identification by means of the typological description (so as to obtain a 'coin-type') and references to standard works.[31] It is precisely here that coins and seals differ the most: the seriality of coin production is far greater than that of seals. Suffice it to say that coins are usually found in hoards, whereas seals are mostly found

26 This attempt was made during Alessio Sopracasa's Marie Curie fellowship at King's College London, between 2015 and 2016. For a report on the activities see: https://cordis.europa.eu/project/id/655492/reporting/fr.

27 See http://nomisma.org/nuds#channelOrientation.

28 See http://nomisma.org/nuds#ab.

29 See http://nomisma.org/nuds#toc-elements.

30 Italic added. See http://nomisma.org/nuds#legend.

31 See, e.g. a bronze of Diocletian from the online collection of the American Numismatic Society (http://numismatics.org/collection/1944.100.4191), with the standard reference to the *Roman Imperial Coinage* catalogue (RIC) and the link to the typological description (http://numismatics.org/ocre/id/ric.6.anch.54a?lang=en).

as single specimens. Thus, in Byzantine sigillography each specimen counts and every part of it needs to be thoroughly investigated, especially legends and iconography. This was one of the reasons why the rapprochement between SigiDoc and NUDS was not as effective as initially thought: the core elements necessary to the former were external to the latter.[32]

However, far from being unhelpful, this attempt was interesting for SigiDoc with regard to the metadata. NUDS is a very good working example of a standard for the description of objects closely related to seals, and this had its share of influence on the future development of SigiDoc. However, since NUDS counts TEI among its inspirations, the difference between the two standards lies sometimes solely in the name of elements that have, after all, the same function – names more discipline-oriented and semantically consistent in NUDS than in a SigiDoc-adapted <teiHeader>. The clearest examples of this difference are in the NUDS elements <obverse> and <reverse>, for which SigiDoc uses <msPart> nested inside <msDesc>.

Here is an example for the obverse of the seal in fig. 1:[33]

```
<msPart n="r">
   <msIdentifier>
      <idno/>
   </msIdentifier>
   <msContents>
      <summary n="r">
         <seg xml:lang="en">Obverse</seg>
      </summary>
   </msContents>
   <physDesc>
      <objectDesc>
         <layoutDesc>
            <layout n="r">
               <dimensions type="written" unit="mm">
                  <dim type="diameter"/>
               </dimensions>
               <rs type="layout">
                  <seg xml:lang="en">Iconography</seg>
                  <seg xml:lang="fr">Iconographie</seg>
               </rs>
               <p xml:lang="en">Iconography</p>
               <p xml:lang="fr">Iconographie</p>
            </layout>
         </layoutDesc>
      </objectDesc>
      <handDesc>
         <handNote n="r">
            <seg/>
         </handNote>
      </handDesc>
      <decoDesc>
         <decoNote>
            <figure>
               <figDesc n="r">Buste de saint Michel, au nimbe de grènetis, tenant dans la main
                  droite un long sceptre orné de trois boules dans sa section supérieure;
sigla de
                  part et d'autre de l'effigie.</figDesc>
               <figDesc n="decoR">Bord non identifiable</figDesc>
            </figure>
         </decoNote>
      </decoDesc>
   </physDesc>
   <history>
      <origin>
         <origDate>
            <seg xml:lang="en"/>
         </origDate>
         <date/>
      </origin>
   </history>
</msPart>
```

32 NUDS being not TEI-compliant played a major role in the unsuccessful rapprochement between NUDS and SigiDoc, as this would have involved losing all the infrastructure related to TEI.

33 The structure of the reverse is identical, except for the @n's value, which is "v".

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The seriality in numismatics and sigillography involves the use of tools in the production of these objects: the die (for coins) and matrix (for seals) can strike a series of identical objects. However, in numismatics this feature is not as prominent as it is in sigillography. In this lies a methodological difference: the seals struck by the same matrix represent a specific category in sigillography, so-called 'parallels' or 'parallel seals'. In sigillographic editions, known parallels should always be cited: they help in the reading of a damaged seal, the number of extant parallels might represent an element discussed in the commentary, or, further, they allow for the reconstitution of the lost matrix from which they come.

2.3 A Digital Identity for Byzantine Seals

Matrices and parallels bring us back to the medium of publication. What is regrettably lacking in traditional sigillography is the unambiguous identification of the specimens. Whether belonging to a private collection or to a public archive, each seal has an inventory number, which is modelled according to changing criteria internal to each holding institution, thereby hindering cross-references across collections and publications. One of the major achievements of a digital scholarly edition in SigiDoc is that a unique identification number will be assigned to each seal. The importance of this feature becomes even clearer when it comes to parallel seals: aside from attributing a unique ID to each seal, it is of paramount importance to gather all the seals coming from the same matrix and bearing the same imprint. This is done by modelling an ID composed of a part shared by all the parallels and a part pinpointing each individual seal. The ultimate goal is to identify the matrices. One must note that, compared to the estimate of 80,000 extant Byzantine seals, only six matrices survive nowadays, hence a proper identification of the parallels would allow for a virtual reconstruction of the countless missing matrices. It is in this respect that the seriality of the seals' production appears more clearly and that is the reason why SigiDoc also attributes a unique ID to the matrices, thus enabling the gathering of all the seals produced by a given matrix. Stretching this approach further, it is also possible to think that, in some cases with seals with a significant number of parallels, Byzantine sigillography, too, could develop the concept of 'seal-type', similarly to numismatics. This is the path taken by the project Sigilla, where a seal-type is virtually reconstructed from a number of specimens belonging to the same seal issuer.[34] Finally, the IDs are essential when it comes to overstrikes: just like coins, seals

34 See http://www.sigilla.org/.

may be struck twice or more, leaving us with two or more imprints on the same support. This means that the ratio 'one imprint equals one object' no longer applies, and the IDs ought to express this new situation clearly enough to be understood.

3 The Seal as a Text-Bearing Object

3.1 The Editions of the Legend: Diplomatic, Interpretive, Digital

The diplomatic and interpretive editions are displayed by SigiDoc in two different tabs in our EFES visualisation and, consistently with all EpiDoc projects which use this platform, the XML markup of the legend is available in a third tab. Conversely, unlike EpiDoc, in SigiDoc the two editions are placed within two separate s, as shown by the code snippet on page 107 and as discussed in the following sections.

3.1.1 The Diplomatic Edition and the Epigraphy of a Seal: Typological vs Visual Rendering of Lettering

The semantic content of the legend of a seal is not the only meaningful aspect. The transcription of the characters 'as they appear' on the seal is the first step towards a scholarly edition of a legend. Nevertheless, there is no established practice in the rendering of the lettering among Byzantine sigillographers, thus leading to a variety of outputs. Here follow examples of diplomatic editions of six different seals from publications dating from 1884 to 2019:

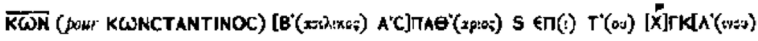

Figure 2 Schlumberger 1884, 469 no. 8. Collection Schlumberger, s.n.

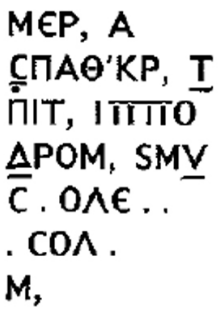

Figure 3 Laurent 1981, no. 153. Fogg Museum of Art, inv. no. 244

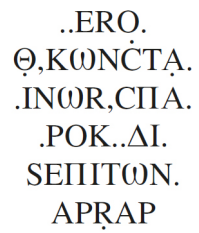

Figure 4 Seibt, Wassiliou 2004, no. 24.
Münzkabinett des Kunsthistorischen Museums Wien, inv. no. 470

Figure 5 Jordanov 2006, no. 390.
Archaeological Museum Veliki Preslav, inv. no. 21588

Figure 6 Cheynet 2008, no. 9.
Collection Zacos, Bibliothèque Nationale de France, inv. no. 225

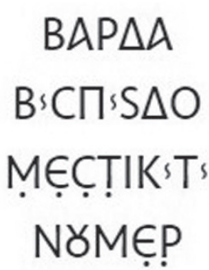

Figure 7 Dumbarton Oaks Online Catalogue.
Dumbarton Oaks Collection, inv. no. BZS.1955.1.716[35]

From its very beginning, one of the major questions raised by SigiDoc's development was how to produce a diplomatic edition of the legends on the seals, i.e. how to render the lettering. Sigillography shares this issue with epigraphy, but the scarcity of the available space – and the problems it raises – brings the seals even closer to the coins. The need for a (digital) instrument allowing for a better understanding of the evolution of the lettering and, more generally, of the writing practices, as well as of improving and simplifying the scholarly activity, is already a *desideratum* for other sister dis-

35 Available on https://www.doaks.org/resources/seals/byzantine-seals/BZS.1955.1.716/view.

ciplines. Scholars in numismatics now increasingly devote attention to the legends of the coins[36] – attention that was beneficial for projects in Western Mediaeval seals, too – by means of the development of dedicated fonts.[37]

A different approach has been developed by Archetype for the study of palaeography.[38] Built on its predecessor DigiPal, Archetype is an open-source web-based suite of tools for the study of handwriting, palaeographical features, and iconography. The scholar defines a highly structured taxonomy of descriptions of characters, allographs, their components and features. These descriptors are then used to annotate images and further, to search, compare, and sort through scripts, characters, scribal hands etc., providing also a quantitative approach to, e.g. tracing the evolution of scripts or identification of scribes.

In epigraphic and papyrological editions a diplomatic transcription records the characters extant on the support, without any editorial intervention, as is the practice in EpiDoc. This diplomatic view, however, does not attempt to represent letterforms, ligatures, and decorative elements graphically.[39] Considering the wealth of inscribing traditions, scripts, variations of letterforms and ligatures within the wider EpiDoc community, it would be impossible and impractical to attempt faithful visual representation in the diplomatic view, not least because individual characters are identified in Unicode code points. Thus, the diplomatic transcription is considered complementary to photographs/drawings.

Conceptually, with SigiDoc the choice has been between a typological and a visual rendering of the characters. With the former solution, what counts is the presence of the main types of letters, variant letters, and ligatures rather than the completeness of the palette, and it is aimed at creating broad categories of single letter types; conversely, the latter option aims at exhaustiveness and is intended to reproduce as faithfully as possible the appearance of all the characters, thus making the palette constantly grow as new editions appear. SigiDoc ultimately chose the visual rendering through a specialised font called Athena Ruby.

In Byzantine studies, a ground-breaking True Type font for polytonic Greek called Athena, suitable for the diplomatic edition of both coins and seals, was developed at Dumbarton Oaks under the super-

36 See Codine 2013 as well as an online report by the same author titled *Epigraphie monétaire mérovingienne: nouveaux outils et nouvelles perspectives*: `http://www.archeologiesenchantier.ens.fr/spip.php?article161`.

37 The project Sigilla is planning to update its legends' transcriptions thanks to the achievements of the PIM project (about which, see Codine 2013).

38 See `https://archetype.ink/#top`.

39 For further discussion, see the EpiDoc Guidelines `https://epidoc.stoa.org/gl/latest/trans-diplomatic.html` and the MARKUP-list.

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vision of the late Nicolas Oikonomides, historian of Byzantium and eminent sigillographer, and used by him for the first time in 1986 (Kalvesmaki 2015, 122): the goal was "to give sigillographers direct control over nuances in the typography" in order to, e.g. "choose variant letterforms and ligatures".[40] It represents a typological, abstract rendering of the lettering found on Byzantine coins and seals. This font is used in fig. 6 above and it is nowadays the specialised font most frequently used by Byzantine sigillographers, despite it not being the standard, as figs. 4 and 5 clearly show.

Moreover, Byzantine sigillography can count on a font (used in fig. 7) which is an answer to the above-mentioned *desideratum*. This font is called Athena Ruby and it was conceived as both an evolution of Athena and its unification with other fonts for coins developed at Dumbarton Oaks under the project management of Joel Kalvesmaki. Athena Ruby – OpenType and Unicode-compliant – is specifically designed for the epigraphy of Byzantine coins and seals, and goes in the direction of what we called a 'visual rendering' of the legend. This font "has been designed to anticipate the needs of digital projects that use XML, JSON or other structured text formats", and the wish of its developers is the inclusion of Athena Ruby in projects using EpiDoc standards.[41] Accordingly, SigiDoc encourages its use and the encoding for the diplomatic edition is as follows:[42]

```
<c type="glyph" ref="glyphs.xml#Alpha.2">A</c>
```

Should, then, Athena Ruby be used to replace the images? Its glyphs are intended to be "idealized replicas of letterforms" and are, more precisely, "meant to evoke, but not replicate, types of letters".[43] Nevertheless, one should note that Athena Ruby has, e.g. twenty-eight variants of the Greek letter alpha,[44] whereas Athena only six, and, further, that the former has an ever growing palette.[45] The trend is clearly that of replicating the letterforms as faithfully as possible without, however, aiming at photographic exactness. Using an ev-

40 See https://www.doaks.org/resources/athena-ruby.

41 Kalvesmaki 2015, 123; on Athena Ruby, see also Codine-Trécourt, Sarah 2012, 276-7.

42 The only technical infelicity is that Oxygen editor reads Athena Ruby only in Author Mode.

43 See https://www.doaks.org/resources/athena-ruby/users-manual.

44 Database of the Athena Ruby Glyphs (HTML): https://www.doaks.org/resources/athena-ruby/database-of-characters-in-html.

45 The font is now under the management of Colin Whiting at Dumbarton Oaks and periodical additions of new characters will henceforth take place (on a biannual rhythm) concurrently to the upcoming publications of seals in the Dumbarton Oaks collection – as Whiting told us *per litteras*.

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er-growing font like Athena Ruby will give SigiDoc (and Byzantine sigillographers) an increased and 'atomic' character-level searchability of the text's lettering as well as a more accurate analysis of the evolution of the sigillographic epigraphy, one of the major criteria for dating a seal. Scholars of Byzantium have already delivered some important contributions to our knowledge of the epigraphy of Byzantine coins and seals (Oikonomides 1986, 165-9; Morrisson 1994; Oikonomides 2004), but the constant increase in the number of published seals results in a constant expansion of this knowledge. The font's effectiveness will be enhanced by its inclusion in SigiDoc: the epigraphy will be contextualised thanks to the other data available, such as dating, places, social milieu of the seal's issuer etc., all materialising in a search form that takes all these factors into account.

The main difference between Archetype's approach to the script and the one using Athena Ruby lies in their ultimate goal. Archetype provides a framework and methodology for palaeographical analysis that can be adapted to a wide range of alphabets, scripts, and decorative elements, based on the comparison of structured descriptions provided by specialists in their respective fields. Here the standardisation comes in the approach, methods, and tools, rather than in any specific vocabulary used for the distinct letter components.

The idea underlying the development of Athena Ruby is, however, to develop a shared editorial standard for the diplomatic edition. This is arguably beyond the scope of both palaeography and epigraphy, and intrinsic to Byzantine sigillography and numismatics. It aims at providing sigillographers with a single point of reference for the diplomatic transcription in a critical edition, which is both Unicode-compliant (and thus computationally solvent) and reflective of the disciplinary requirements in this particular publishing tradition. Nevertheless, Athena Ruby is still little used by Byzantine sigillographers, and sometimes, when used, its richness is not fully exploited. In order to be properly used, it is good scholarly practice to fully exploit its palette, otherwise – with an inaccurate character choice – there is a danger of providing the readers with the wrong idea of the epigraphy. Paradoxically, the wide range of choice offered by this font has constituted a deterrent to its use, and for a valid reason: Athena Ruby allows for more subjectivity in the diplomatic edition, thus multiplying the possibilities of mistakes. However, 'subjectivity' here stands for 'editorial choices' and every edition largely relies on them: a large palette pushes us to be more detailed and this is a *desideratum*, which, of course, makes the work harder. It is true that sometimes, e.g. with a damaged seal, the degree of speculation is very high. For this reason and to limit the subjectivity, SigiDoc allows character-level queries not only as Athena Ruby variant, but al-

so under the normalised Greek version of the letter they represent.[46]

In light of these issues, the question asked above ought to have a negative answer: Athena Ruby cannot and will not replace the images.

3.1.2 The Interpretive Edition: Layers of Leidenisation

The genetic ancestry from EpiDoc to SigiDoc is self-explanatory when it comes to the seals' legends: the experience gained by EpiDoc on inscriptions has been crucial for the establishment of accurate edition standards for seals in SigiDoc. EpiDoc is a well-established and widely used standard for scholarly editions of epigraphic material which does not need any presentation; Charlotte Roueché and Julia Flanders explained to epigraphers that:

> the EpiDoc customization removes irrelevant elements from the main body of the TEI, and it adds provisions for the specific kinds of transcription, analysis, description, and classification that are essential for epigraphic work. The result is a simple yet powerful language which can be used to mark all of the significant features of inscriptions and also represent the accompanying information about the epigraphic object itself.[47]

SigiDoc did the same with EpiDoc. The interpretive edition shows the intervention of the editor on the text itself, primarily through the application of conventions for the representation of non-verbal information such as lacunae, abbreviations etc., with symbols, brackets, and dots; the implementation of these rules is called by SigiDoc 'leidenisation', from the well-known Leiden conventions.[48]

In relation to this, one of the major problems in sigillography is the lack of consistency found in printed editions. One of SigiDoc's main objectives is the spreading of established and well-rounded edition criteria: this achievement will not only improve the quality of the scholarly edition, but will also enable effective interoperability and easier searchability across corpora. At the same time, consistency is ensured by the use of an encoding standard enforced by the machine, thus removing approximation. Nevertheless, the willingness of scholars to accept rules that are not always in accordance with their habits will be a major factor in the success of this approach.

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46 Taking the above-mentioned example of the alphas, the variants – e.g. Α, Α, *Α*, Ᾱ, ∀ etc. – will be also indexed and made searchable under the generic Greek alpha (Α).

47 C. Roueché, J. Flanders, Gentle Introduction To Mark-up for Epigraphers, available: `https://epidoc.stoa.org/gl/latest/intro-eps.html`.

48 See Galsterer 2006 with previous literature.

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The leidenisation developed for SigiDoc can be summarised in four major groups, the first two being by far the most important and common ones:

- transcription: this concerns mainly lost or illegible lines or characters, as well as the lines organising the text and the words split across lines;
- editorial intervention: restoration of characters, expansions of abbreviations, omissions or corrections, and resolutions of monograms;
- form and appearance: of very limited use, as the use of Athena Ruby has been preferred;
- interpretation: mostly limited to numerals, uncommon on seals.

Alongside the selection of the TEI-EpiDoc criteria, the visualisation of these tags after transformation has sometimes been slightly modified, especially for the element <gap>.

Whilst the interpretive edition includes the encoding of the legend's text, in the diplomatic edition, features such as lost characters and ligatures are represented with Athena Ruby and encoded accordingly as characters. Here follows an example of both diplomatic and interpretive edition of the legend of the seal in fig. 1:[49]

Diplomatic edition: +ϗϵR,Θ,|ϺIXAHΛ|RϵCTAPX|.OIϗONO|.THCN.|.C

```
<div type="textpart" subtype="face" n="rev" rend="linear">
   <ab>
      <lb n="1"/>+<c type="glyph" ref="glyphs.xml#Kappa.1" subtype="K">ϗ</c>ϵ<c
type="glyph" ref="glyphs.xml#Beta.1" subtype="B">R</c>,Θ,
      <lb n="2"/><c type="glyph" ref="glyphs.xml#Mu.1">Ϻ</c>IX<c type="glyph"
ref="glyphs.xml#Alpha.2">A</c>HΛ
      <lb n="3"/><c type="glyph" ref="glyphs.xml#Beta.1">R</c>ϵCT
<c type="glyph" ref="glyphs.xml#Alpha.2">A</c>PX
      <lb n="4"/>.OI<c type="glyph" ref="glyphs.xml#Kappa.1">ϗ</c>ONO
      <lb n="5"/>.THCN.
      <lb n="6"/>.C
   </ab>
</div>
```

Interpretive edition: +K(ύρι)ε β(οή)θ(ει) Μιχαὴλ βεστάρχ(ῃ) [(καὶ)] οἰκονό[μ(ῳ)] τῆς Ν[έα]ς

49 For the sake of clarity, we reproduce here only the encoding referring to Athena Ruby characters differing from the standard Byzantine Greek alphabet, i.e. for A (alpha), R (beta), ϗ (kappa), Ϻ (my).

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Upon seeing this, users of EpiDoc will not be bewildered and this could be an important factor in the wider use of SigiDoc in the future.

A scholarly edition, though, would not be complete without a critical apparatus. While it is a common feature of printed editions of texts and inscriptions, a place specifically devoted to variant readings and discussions of editorial choices is usually missing in current sigillographic publications; these topics are discussed – in varying degrees of detail – as part of the commentary. We argue that having a specific place to discuss more technical aspects of the legend's edition, without burdening the commentary, could push sigillographers to be more explicit in their editorial processes and methods, greatly benefiting current and future colleagues. For example, whether normalising the spelling of a word in the edition, mentioning the normalisation in the apparatus, or preserving the original spelling and discussing it in the apparatus, is a typical editorial choice that SigiDoc leaves to editors. In the current state of its development, SigiDoc indexes the normalised version of the words. However, the original (declined or conjugated) word is available in an index of lemmata, generated by means of tokenisation and lemmatisation of the legend, the former being defined as the "explicit mark-up of words" and the latter as the "identification of their dictionary headwords",[50] through the element <w> and the attributes @lemma and @lemmaRef. Despite being specifically designed for words not included in the categories of terms to which a specific index is devoted, nothing prevents the user from adopting this markup for all terms. In this way, both normalised and original spellings will be searchable, which represents a major step forward for Byzantine sigillography and for its philological implications. Using the appropriate TEI elements,[51] the apparatus avoids "the idea that texts exist outside the dialectic between documents and editors, and that editions can possibly establish texts once and for all" (Pierazzo 2016, 6).

This leads directly to one of the main advantages and challenges derived from a digital edition of Byzantine seals, i.e. fluidity (Sahle 2016, 29). This becomes especially evident in the edition of the legend, but concerns all aspects of the editorial work. SigiDoc will enable sigillographers to easily update and emend their editions. Editions of seals are usually reviewed in specialised journals, emended in other publications, and the same scholars can change their own views on an edition they published in the past. All this important information, instead of remaining scattered among several publica-

50 EpiDoc 9.1 Guidelines, Word and Lemmatization: https://epidoc.stoa.org/gl/latest/idx-wordslemmata.html.

51 See TEI Guidelines § 12, https://www.tei-c.org/release/doc/tei-p5-doc/en/html/TC.html.

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tions, will be directly integrated into the digital edition, 'socialising' it and making it more collaborative. Virtually, the final word will never be written and the SigiDoc edition will always hold the best possible version of the knowledge regarding each seal without separate fascicules of *addenda et corrigenda*, provided the editors are sufficiently careful in updating their material.[52]

It is obvious that the updates and the amendments present another question: what to do with older versions of an edition? This topic is particularly sensitive for ongoing editions of large amounts of material, such as sigillographic corpora encoded in SigiDoc, because the increasing number of seals will necessarily lead to a better or different understanding of previously edited material. SigiDoc 1.0 will be able to record these changes in the critical apparatus for the legend, or in plain text with regard to other aspects of the edition: a stable solution for a proper versioning is part of the work already planned for SigiDoc's future development.[53]

3.2 The Seal as a Meaning-Bearing Object: Semantic Annotation

Alongside the peculiarities of a strictly sigillographic analysis, which focuses on the seal as an object and on the markup of the legend as explained above, what matters most is the information these data convey. They represent the historical information extracted from a single seal and transcending the seal itself to become a source, possibly related to others of non-sigillographic nature and thereby significantly feeding the historical debate.

The first step in this direction is to allow the editors to extract what they consider to be the most important data coming from the seals they are working on: this usually takes the form of indices. With regard to sigillographic printed editions, indices are mostly available in larger corpora, but not in journal articles, with the praiseworthy exception of those published in the above-mentioned *Studies in Byzantine Sigillography*. All these indices are published to very different degrees of detail, and the choice of which terms should be indexed is variable. There are corpora which index separately proper names, dignities, and functions of the clergy and non-clerical ones (Zacos 1984; Zacos, Veglery 1972); corpora giving special atten-

52 Nevertheless, it must also be considered that the timeframe of the publication of the amendments does not always depend on the will of the editors. E.g. some hosting platforms are not keen to accept frequent uploads with new versions of the material. We plan therefore to deliver batches of digital *addenda et corrigenda* once a year. Fluidity also raises the issue of the authorship, connected to the easy reuse of the XML data.

53 On the topic of versioning for scholarly editions see most recently: Bleier, Winslow 2019 and Bürgermeister 2020.

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```
<div type="textpart" subtype="face" n="rev" rend="linear">
   <ab>
      <lg type="legendsCases" ref="legendsCases.xml#Dat">
         <l>
            <lb n="1"/>
            +
            <rs type="invocation" ref="invocation.xml#Κύριε" rend="linear">
               <w lemma="Κύριος"
lemmaRef="http://www.perseus.tufts.edu/hopper/morph?l=kurie&amp;la=greek">
                  <expan>
                     <abbr>Κ</abbr>
                     <ex>ύρι</ex>
                     ε
                  </expan>
               </w>
               <w lemma="βοηθέω"
lemmaRef="http://www.perseus.tufts.edu/hopper/morph?l=bohqei&amp;la=greek">
                  <expan>
                     <abbr>β</abbr>
                     <ex>οή</ex>
                     <abbr>θ</abbr>
                     <ex>ει</ex>
                  </expan>
               </w>
            </rs>
            <lb n="2"/>
            <persName type="unattested" ref="prosopography.xml#Μιχαὴλ_1">
               <name>Μιχαὴλ</name>
            </persName>
            <lb n="3"/>
            <rs type="dignity" ref="dignities.xml#βεστάρχης">
               <expan>
                  <abbr>βεστάρχ</abbr>
                  <ex>ῃ</ex>
               </expan>
            </rs>
            <lb n="4"/>
            <w lemma="καί" lemmaRef="http://www.perseus.tufts.edu/hopper/morph?
l=kai&amp;la=greek">
               <supplied reason="lost">
                  <expan>
                     <ex>καὶ</ex>
                  </expan>
               </supplied>
            </w>
            <rs type="officeCivil" ref="officeCivil.xml#οἰκονόμος_τῆς_Νέας">
               <expan>
                  <abbr>
                     οἰκονό
                     <lb n="5" break="no"/>
                     <supplied reason="lost">μ</supplied>
                  </abbr>
                  <supplied reason="lost">
                     <ex>ῳ</ex>
                  </supplied>
               </expan>
               <w lemma="ὁ" lemmaRef="http://www.perseus.tufts.edu/hopper/morph?
l=ths&amp;la=greek">τῆς</w>
               <placeName ref="geography.xml#Νέα">
                  N
                  <supplied reason="lost">
                     é
                     <lb n="6" break="no"/>
                     α
                  </supplied>
                  ς
               </placeName>
            </rs>
         </l>
      </lg>
   </ab>
</div>
```

tion to iconography and metrical legends (Jordanov 2006; Cheynet, Campagnolo-Pothitou 2016) and others which do not register either (Oikonomides et al. 1991-2009); whilst in the *Studies in Byzantine Sigillography* all terms deemed relevant are grouped under a single, broad category, named "Index of proper names and terms", followed by an iconographic index. It is clear that such an approach, lacking common rules, hinders the analogical interoperability of these indices. Despite being time-consuming and not always as effective as hoped, this perusal of published material remains one of the first and unavoidable steps in studying a Byzantine seal, as it is necessary to ascertain whether the seal has already been published and whether parallels exist.

SigiDoc solves this shortcoming by means of the semantic encoding of the legends: this markup, aimed at extracting the most valuable information coming from the material, has been designed to work best with the EpiDoc Front End Services publishing platform (EFES). EFES provides SigiDoc with two major assets: web visualisation and data valorisation, which is expressed in customisable, automated indices and faceted federated search. Knowing that EFES allows for the creation of a potentially unlimited number of indices, the developers of SigiDoc encourage its users to prepare a common set of indices, to ensure optimal cross-referencing across different corpora.

Table 1 Suggested shared indices in SigiDoc corpora

Editorial and Philological Features	**Prosopography and Geography**	**Sacred Nomenclature**	**Iconography**
Abbreviations	Personal names	Invocations	Iconography
Monograms	Place names	Marian terms	
Glyphs	Dignities	Christ-related term	
Lemmata	Offices	Saints-related terms	
Legends' cases			
Metrical legends			

The indices are generated on the basis of Authority Lists used in EFES, to which the markup points by using the attribute @ref. Here is an example of the legend of the seal in **[fig. 1]** with only the markup relevant for the indices:

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```
<div type="textpart" subtype="face" n="rev" rend="linear">
   <ab>
      <lg type="legendsCases" ref="legendsCases.xml#Dat">
         <l>
            <lb n="1"/>
            +
            <rs type="invocation" ref="invocation.xml#Κύριε" rend="linear">Κύριε
βοήθει</rs>
            <lb n="2"/>
            <persName type="unattested" ref="prosopography.xml#Μιχαήλ_1">
               <name>Μιχαὴλ</name>
            </persName>
            <lb n="3"/>
            <rs type="dignity" ref="dignities.xml#βεστάρχης">βεστάρχῃ</rs>
            <lb n="4"/>
            καὶ
            <rs type="officeCivil" ref="officeCivil.xml#οἰκονόμος_τῆς_Νέας">
               οἰκονό
            <lb n="5" break="no"/>
               μῳ τῆς
            <placeName ref="geography.xml#Νέα">Νέ
            <lb n="6" break="no"/>
                  ας</placeName>
            </rs>
         </l>
      </lg>
   </ab>
</div>
```

The Authority Lists will be shared among all SigiDoc-based projects, which will have the responsibility of supplementing them with new entries arising from their own materials.

The approach used for indices is part of a broader objective of simplified data searchability, on the basis of developing a standard: creating a set of common and shared rules allowing for proper interoperability. Such interoperability will be realised primarily through a centralised search interface, which will allow for a virtual unification of all the corpora encoded in SigiDoc, thus going beyond the indices themselves and single search forms of each EFES corpus. The functionality of this interface will be based on the shared application of the principles currently employed in the creation of indices and search forms for individual projects. The unified search interface is not yet available and represents the main goal of the next round of SigiDoc's development, currently seeking funding.

If appropriate indices and search forms are effective with large amounts of data coming from large quantities of seals, the meaning of each seal needs to be fully explained in its commentary. In printed sigillographic editions, commentaries greatly differ in structure among publications, especially when it comes to a proper historical analysis connecting the seal to people, sources, and events related to the broader context of Byzantine history. SigiDoc gives its users the freedom to choose the approach they judge best for their data. The commentary takes the form of a separate , organised in several <p>s containing also bibliographical references, automatically

generated by EFES on the basis of a TEI bibliographical list; bibliography, too, will be shared and available to all SigiDoc-based projects.

As it is also designed for the digitally enhanced edition of material already published in print, after a long and lively debate we decided that SigiDoc's template should include a specifically designed for footnotes. Footnotes play a major role in scholarly publications in the Humanities and represent more than a place to store bibliographical references: they show the sources of a statement written in the main text, they offer a space for further argumentation and demonstration, and offer a chance to discuss other publications without burdening the main text. In EpiDoc-based projects this feature is not explored, and the rule is to have short references for the bibliographical apparatus or written in brackets inside the commentary. However, if one wants faithfully to transpose a printed publication into a digital form, one should find a place for footnotes:[54] the amount of information they convey might be too rich to be incorporated into the main text without jeopardising its legibility, as has been shown clearly by the experience in progress of transposing a journal article into digital form with SigiDoc (Sopracasa, Prigent 2017).

Furthermore, thanks to the possibilities offered by EFES, the corpora encoded in SigiDoc will be multilingual by default. The accessibility of the data coming from seals will thereby be increased, reaching non-specialists, too: the user will find a multilingual version of the frame of the standard webpage, including the field names structuring the data, as well as the indices; however, the data themselves (including the text of the legend) and the plain text will have to be manually translated.

4 Conclusions

By means of the new encoding standard SigiDoc, the digital enhancement of a discipline in the Humanities, Byzantine sigillography, has finally been reached: it manifests itself through searchability, interoperability, and accessibility of data. SigiDoc was not born out of nothing and is not creating a digital approach anew: we have assessed already existing and well-supported standards to build upon and customise as needed. This choice allows in turn for interoperability with adjacent disciplines, e.g. epigraphy, papyrology etc., giving us the opportunity for comprehensive analysis of inscribed material in a larger context.

The new standard will express its full potential in ongoing editions of large amounts of data, such as sigillographic corpora. For

54 By faithfulness, we do not mean that the webpage with a seal's edition should be a replica of the printed one, but that its content should not suffer any loss.

further development, however, it is crucial to release the project as soon as possible and let interested users experiment with it. We now have the first SigiDoc-based funded project, soon to be undertaken at the University of Oxford, on a collection of Sicilian *signacula*; this project provides a concrete use-case of a small corpus, and will produce more documentation, and the possibility for student training and contributions.[55] Testing on different material leads to improvements as the standard grows over time.[56] Moreover, thanks to its interaction with EpiDoc and EFES, SigiDoc allows the editors both to create accurate and reliable data and to take care of, and have control of, specific aspects of the online publication.

In light of what has been analysed in this paper, we argue that widespread use of SigiDoc will enable the digital enhancement of Byzantine sigillography, thus permitting not only the conversion of analogue information into digital form, but also an extensive exploration of the possibilities provided by the Digital Humanities for the enhancement of the entire editorial process.

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55 The title of the project is *From Sicilian Signacula to Student Epigraphic Editions: Building Sustainable Epigraphic Tei Publishing for Oxford* and will be led by Prof. Jonathan Prag.

56 See e.g. Werning 2016 and the Open Access Wiki on the adaptation of TEI-XML in Egyptology and Coptic Studies edited by Daniel A. Werning: https://wikis.hu-berlin.de/teiegyptology/Main_Page.

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