

Use, Reuse, and Valorization: A Web App for Italian Cultural Heritage

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1. Introduction to the Research

This article presents an ongoing three-year (2022-2024) doctoral project,¹ developed in collaboration with the Italian company Net7 (Net7, n.d.-a) (based in Pisa and represented by Chiara Aiola), a non-academic partner institution that works in the digital humanities (henceforth DH) field. This partnership is a key factor in the development of this project, given that it is highly interdisciplinary in practice.²

The output is a client application, named CHIt (Cultural Heritage of Italy), which aims at the valorization of Italian cultural heritage (henceforth CH) within the digital paradigm. The application is meant to be an aggregator of digital resources that are now scattered among different platforms on the Web. In fact, this aggregator collects digital objects from different providers (see below, Section 5), and makes them interoperable by organizing them in a new, interactive interface that offers formally coherent, expandable, and reusable representations of data and metadata. In this way, the resources are no longer isolated on the Web, and instead, they are integrated in a uniform system that allows them to enhance their potential by making them interoperable (Gagliardi and Guarino 2021). Moreover, the application will be designed to be intuitive, adaptable to different audiences and purposes, to promote social engagement.

The guiding principle of this project is FAIRness of data and metadata

¹ The project is funded by the National Operational Programme (PON, <http://www.ponricerca.gov.it/pon-ricerca/programme/>) on Research and Innovation 2014-2020, Axis IV *Education and Research for Recovery – REACT-EU..* The project is carried out at Ca' Foscari University of Venice under the supervision of Prof. Marina Buzzoni.

² The recent debate that accompanies the national and international regulations that will be discussed below stresses the importance of cooperation and exchange between the academic and professional domains to favor investment in human capital. Candidates participating in PON programs are obligated to collaborate with partner companies to acquire cross-functional skills and ensure the development of highly specialized profiles.

(GoFAIR, n.d.),³ with a particular focus on reuse and interoperability. In fact, the principle of reuse has played a major role since the very beginning of this project: All the data displayed and the tools used to implement the application are already existing. On the one hand, the work on the resources is their retrieval, uniformity, and integration. On the other hand, the Web application is developed starting from existing tools and adapting them to the needs of this specific project, making the aggregator an innovative tool built from available technology. The adoption of digital standards further enhances the interoperability and findability of the resources gathered from the different providers, valorizing and promoting the work of other institutions and individuals.

The following Section offers an overview of the normative framework in which the project is being developed, while Section 3 presents a state-of-the-art study that eventually turned into an analysis of Web-based resources, given the lack of literary works. In Section 4, the main objectives of this project are summed up to provide the reader with a concise idea before diving into the more operational phases of Sections 5 and 6. In particular, Section 5 describes what tools and methods have been adopted, and Section 6 explains the whole workflow for the implementation of the app. Last, in Section 7 some conclusions are drawn, together with possible future developments.

2. The Normative Framework

Over the past few decades, awareness has increased significantly regarding the preservation of the world's CH and its link to the social domain. Particularly during and after the pandemic, the digital ecosystems for digitized heritage and their contributors have increased considerably, making available a great deal of miscellaneous data (Owens and Padilla 2021; Barbuti 2019). One of the first European moves in this direction was the Faro Convention (CoE 2005), which underscores the significance of heritage in the context of human rights and democracy, advocating broader appreciation of heritage and its connection to communities and society. It urges us to acknowledge that the significance of cultural heritage lies not only in objects and places themselves but rather in the meanings, uses, and values people attribute to them.

³ The concept of FAIR data in the scholarly community has been around since 2016 after an influential article on machine-friendly research infrastructures was published (Wilkinson et al. 2016). However, the topic was no news.

In the following years, the Council of the European Union has promulgated many regulations and statements in line with what was agreed in the conclusions of the Council meeting in 2014 in which it is stated that CH in all of its forms and aspects “originates from the interaction between people and places through time and it is constantly evolving” and, as such, is “of great value to society from a cultural, environmental, social, and economic point of view and thus their sustainable management constitutes a strategic choice for the 21st century” (EUCO 2014).

Following the pandemic, the Recovery Assistance for Cohesion and the Territories of Europe program (REACT-EU, EC, n.d.-b) was established to support European countries in addressing social and economic repercussions of COVID-19. The main operational approach involves financing projects to enhance the economy through the creation of job opportunities and the improvement of working conditions, with an emphasis on youth and healthcare. Thanks to additional resources allocated by the European Social Fund (ESF, EC, n.d.-a)⁴ REACT-EU, the Italian Ministry of University and Research could fund more projects on innovation, digital advancements, enabling technologies, and the enhancement of human capital.

Another strategic move in Italy has been the preparation of the National Digitization Plan (PND, MiC 2023),⁵ which aims to establish a digital cultural ecosystem by strengthening existing digitization efforts and developing public policies for collaboration and integration. By fostering new networks and semantic relationships, the plan eases the creation of innovative meanings, independent of institutional constraints, through diverse perspectives. In this ecosystem, interconnected associations among information enable the generation of novel representational models of knowledge. For this to happen, digital objects must adhere to common standards, ensuring they become FAIR resources.

3. The State of the Art

As mentioned above, a systematic literature review proved inefficient because of the limited number of works on the subject. Therefore, the search was extended to Web-based resources aligned with our required criteria, as illustrated below.

⁴ The ESF is available through the member states and the regions. The official Web site explains what the activities are and how beneficiaries can apply for funding.

⁵ The Web site presents the vision, the strategy and the guidelines – the three sections that interact with each other to create the process of digital transformation.

The desired output was a digital “container” that would allow access to resources aggregated from different providers and organize them in an easy-to-use client application suitable for different types of users. Since the beginning, the goal has been to integrate two tools for the visualization and the annotation of the resources. According to a review on research data management carried out by the University of Oxford in 2020 (Chiarelli et al. 2022), research data related to the CH field fall into the category of living/semi-active/warm data. This label identifies data that are rarely accessed but still in use, in comparison with and in the middle of active/hot data (frequently accessed) and archived/cold data (rarely accessed). They are usually files and metadata related to open-access digital objects, which will presumably be updated and/or added according to the life of the project they belong to. Unfortunately, too often they are in different formats, follow different standards and schemata, or stored in individual repositories developed *ad hoc* for specific projects. Such practices undermine the possibility to find, access, interoperate with, and reuse these resources, not to mention the life span that is inevitably short because “as long as they depend on a single individual and/or funding source, long-term sustainability is challenging” (ERC 2022). All of these features have been of major concern while designing this aggregator.

In practice, our state-of-the-art study started from the examination of what had already been done in Italy. In particular we examined two regional digital ecosystems, namely Mèmora Piemonte (Regione Piemonte, n.d.) and Puglia Digital Library (Regione Puglia, n.d.). These platforms are in line with our research, because they offer open access to the regional digital heritage they preserve and describe within a user-friendly and intuitive interface. Controlled vocabularies and international standards are adopted, which allow the reuse of data and metadata thanks also to detailed documentation.⁶

Another similar platform is CulturaItalia (MiC, n.d.), the portal of Italian culture managed by the Italian Ministry of Cultural Heritage and Activities and Tourism (MiBACT) via the Central Institute for the Union Catalogue of Italian Libraries (ICCU). This initiative benefits from the collaboration of strategic partners from different cultural sectors and is the biggest Italian provider for Europeana (EU, n.d.).⁷ It is the main access point to consult

⁶ More information on these platforms can be retrieved in Di Noia et al. (2016) and Brunetti (2018).

⁷ Europeana is the European cultural portal that retrieves data and metadata from more than 2,000 providers through a network of aggregators. The nature and goals of this

Italian CH, and the available resources adhere to international standards and open-access licences (Caffo 2008).

The last portal that has been studied is the NetInteractive Documents (NID, n.d.), an innovative digital library that relies greatly on users' experience and contribution. In particular, the annotation tool is a sophisticated feature that can be enabled on every resource and allows users to add comments as well as images and other types of multimedia objects (Zaka 2022; Zaka and Maurer 2022).

From the surveyed platforms, we noted the interoperability of data and intuitiveness of the interface, as well as the need of annotation and visualization tools. Nonetheless, some differences arise when the nature of the resources retrieved comes into play. In fact, as mentioned before, the platform that we are developing gathers data and metadata from online repositories and similar. The initial criterion was to retrieve resources from secondary – not in importance – scholarly projects, that are somehow overshadowed by the big aggregators and are “invisible” in the wider Web. In fact, many of these are developed under strict scientific rigor and deserve more visibility and integration with other works.

However, these standalone projects and the digital libraries and virtual museums that we looked for present two major issues: Either their data are not open-access⁸ or they do not state clearly how to reuse them. Therefore, we had to change our approach slightly and decided to aggregate objects from larger platforms, the first prerequisite being the availability of an application programming interface (API). This did not prevent us from including smaller projects and is one of the main aspects that differentiates CHIIt from the other platforms cited above, together with interoperability with a SPARQL query-language endpoint (see Section 5).

4. The Goals of CHIIt

The main output of this project is the implementation of the aforementioned cultural aggregator, whose architecture is described in detail in the following Sections. However, given the nature of the Web application being

platform are closely akin to those of CHIIt. For this reason, Europeana was the starting point for testing the methodology of CHIIt and is its main provider (see Section 5).

⁸ Wallace and McCarthy (2023) examine the availability of open-access data of GLAM institutions worldwide and constantly update their record. Europe holds a major portion of the world total at the time of writing, 71.6 percent, with 1,177 institutions. However, only twenty-three of these are Italian.

developed, there is also an indirect aim. CHIIt seeks to contribute to the valorization of the rich Italian CH by strategically harnessing through reuse the potential of existing resources and tools within the digital landscape. The aggregator that is being developed proves that it is possible to create new tools that exploit the potential of the research done by other scholars and experts if the starting point is FAIR material produced following good practices. This project has been implemented in a bottom-up approach, designed to cater to a diverse spectrum of users, all united by the common goal of exploring and uncovering facets of Italian CH within the expansive digital ecosystem. By emphasizing the reuse of existing resources, the initiative seeks to optimize efficiency and also underscores the democratization of access, ensuring that a wide-ranging audience with varied interests, objectives and skills can seamlessly navigate and engage with the wealth of Italian CH offerings available in the digital realm. In fact, much information can be found, for example, in Europeana through a simple query, but these kinds of operations if performed on large repositories as the Europeana aggregator could be confusing and not advantageous for research as they can give back thousands of results. On the other hand, a single work that could be valuable for a scholar risks remaining hidden in a heterogeneous platform and losing its potential.

Nevertheless, within our aggregator, users are given the opportunity to engage with a delimited subset of data. For instance, a scholar has the capability to query the ontology associated with a SPARQL endpoint (see next Section), enhance data using an annotator, and utilize APIs, XML files, and IIIFs when made available by the original sources. Conversely, a tourist may seek details on a particular area of interest, explore images related to specific items, and access accompanying information. Designed to be open, flexible, intuitive, and user-friendly, the platform is meticulously crafted to accommodate a diverse range of users and their unique needs, ensuring a seamless and enriching experience for both scholarly and nonspecialized audiences.

5. Tools and Methods

The principal output of the project encompasses the deployment of a cultural aggregator platform. The architectural foundation for project development adheres to a three-tier model. This terminology, “three-tier architecture,” refers to a specific multi-tier software and hardware architecture designed for Web application execution, which organises the appli-

ation into three distinct layers or modules dedicated respectively to user interface, business logic, and persistent data management.

More specifically, the framework employed for this project is Muruca (Net7, n.d.-b), a system developed by our partner company. Muruca was selected because of its architecture, which offers an accessible and user-friendly interface that is both standard and adaptable. Among its many features, Muruca facilitates the creation of item collections to enhance resource findability, as delineated in the scholarly work of Aiola and Lombardo (2022). The architectural principles of Muruca have been applied across the entirety of the aggregator, details of which are elucidated in the subsequent Section.

For annotation purposes, Pundit (Net7, n.d.-c) was utilized, another tool developed by Net7. Available as a browser extension, Pundit is distinguished by its intuitive design. Technologically, Pundit's structure is segmented into four discrete modules: annotator, backend, data layer, and application interface. It is important to note that Pundit's software architecture has gone through considerable alteration since its initial development in 2009, with substantial redevelopment efforts focused on the annotator and backend modules, both of which were completely restructured. Further exploration of its architecture is available in De Santis et al. (2021). Pundit's main functionalities include text highlighting, commenting, tagging, and semantic annotation. Annotations are organized into notebooks, which users may opt to keep private or share publicly, thus promoting collaborative engagement and idea exchange. For visualization purposes, the software Edition Visualization Technology (EVT, Rosselli Del Turco, n.d.), developed in Angular, will be integrated. EVT is widely used within the Italian scholarly community for creating digital scholarly editions due to its versatility, as discussed by (Cacioli et al. 2022).

Regarding resource retrieval, experimentation was initially conducted with Europeana, attributed to its comprehensive APIs, which established it as a viable candidate. Subsequently, an API call was formulated that successfully aggregated a significant collection of resources pertaining to Italian cultural heritage (CH), many of which were sourced from CulturaItalia. Nevertheless, to respect the project's original vision of highlighting smaller works, the inclusion of Zenodo and GitHub was deemed necessary. These repositories host a variety of resources, whereas previously mentioned platforms mainly focus on cultural objects of diverse natures. This endeavour presented challenges. In spite of the availability of APIs, it was not feasible to orchestrate a bulk retrieval through a single call, necessitating manual selection via resource ID retrieval. It is imperative to acknowl-

edge that this method resulted in a comparatively lower data volume than that obtained through Europeana. However, this approach has enabled the platform to provide exposure to scientifically significant individual resources that might not have received recognition otherwise.

Last but not least, we created the connection to a SPARQL endpoint that is being developed at Ca' Foscari University of Venice as part of another research PON project for the creation of a knowledge base of the Germanic CH in the Veneto region, OntoVE. Through this collaboration, we are exploring how to create a reusable model for the connection to other SPARQL endpoints (De Bastiani and Fabbris 2023; 2023 presentation). The ontology was integrated within the application through a triple store, Fuseki (Apache Software Foundation, n.d.). The application is responsible for composing SPARQL queries to this database based on the resources requested by the user.

To sum up, the digital scholarly resources are gathered from GitHub, Zenodo, and OntoVE, because harvesting from these providers is meticulously controlled and the single choice of each resource ensures scientific accuracy. On the other hand, the bulk import from Europeana aggregates a large number of objects, and this may affect the quality of some resources. This is one of the issues to be investigated more in detail in the near future.

Data organization within the project adhered to the FAIR principles, which advocate that data be Findable, Accessible, Interoperable, and Reusable. These guiding principles ensure that the data managed and disseminated by the cultural aggregator are maintained in a way that maximizes its utility and accessibility for scholarly and research purposes.⁹

6. The Implementation of CHI

As outlined above, we opted for the Muruca framework for the management, aggregation, and visualization of cultural data (Smith 2022). The platform is thus divided into three main layers that work in synergy: the back end, the middleware and the front end (IBM, n.d.).

The back end plays a crucial role in the storage and administration of data. Within this framework, its tasks are the collection, storage, and management of data from diverse cultural sources. The back end utilizes both structured query language (SQL) and non-SQL databases to effectively store extensive datasets.

⁹ The workflow of CHI was presented during the DRHA2023 conference held in Turin in September 2023. See Fabbris (2023).

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The middleware plays a major role, because it is the central layer and acts as a bridge between the back end and front end, processing users' requests, querying the back end, and preparing data for presentation. It implements business logic and data transformation rules, crucial for ensuring that users' expectations are met. This layer may include caching capabilities to enhance performance and reduce database load. It also plays a key role in ensuring interoperability, facilitating communication between different data formats and systems.

The third and last layer is the front end, the user-visible part, which is responsible for presenting aggregated data in an accessible and comprehensible format. It typically includes user interfaces like dashboards, interactive maps, virtual galleries, and search tools, allowing intuitive system interaction. This layer is designed to be user-friendly, ensuring that even nontechnical users can easily access and use the platform's resources. The main interface presents a list of cultural materials filterable by criteria. Users can select an item for a detailed exploration. Each resource is accompanied by a summary and key metadata, with a further detailed page providing in-depth information.

The heart of the architecture is the middleware because it coordinates interaction between the back end and the front end. This software works as a connector because it calls the resources via APIs from the various external platforms or from the back end, re-elaborates them and sends them to the front end for consultation. It is developed in a Node.js (OpenJS Foundation, n.d.-b) runtime, an asynchronous event-driven, open-access and cross-platform environment that executes JavaScript code outside a browser. Its scalability and adaptability make it one of the most used runtimes. Among the other advantages, it works on different operating systems and it can “start a potentially long-running task and still be able to be responsive to other events while that task runs, rather than having to wait until that task has finished. Once that task has finished, your program is presented with the result” (MDN 2023).¹⁰ The middleware is developed using Express (OpenJS Foundation, n.d.-a) as framework for Node.js, which is fast and minimalist, ensuring flexibility and control over the application. It allows the middleware to manage HTTP requests and responses, making it highly adaptable for routing and API management. The APIs provide a standardized interface for communication between the platform's different layers and for interaction with external systems,

¹⁰ For a deeper analysis of the advantages offered by Node.js, see Dziuba (2023).

allowing other applications to query the system, retrieve data, and interact with Muruca's data stored at the back end.

The middleware's main function in the Muruca platform, developed with Node.js and Express, focuses on ensuring standardized and optimized access to data sources for the front end. This entails a series of operations crucial for the platform's proper functioning and efficiency.

First of all, the middleware is designed to make asynchronous requests and handle responses from the back end or external data sources. Therefore, it fetches resources either from external providers or directly from the back end via the front end.

After that, one of the most important operations takes place, as resources are mapped from an input model to an output model. In this phase, the middleware performs a data transformation process, converting the data model received from the back end or an external source (input model) into a format suitable for the front end (output model). In fact, these objects do not always adhere to internationally recognized standards, which is a hot topic in modern literature. This is one of the reasons why it happens more than it should that scholarly projects are valuable only within the borders of their Web site and cannot be further exploited for research in wider contexts. This process involves not just a mere format transformation but also a potential reorganization of data to align with the front end's specific needs, such as complexity reduction or data enrichment with additional information (Frosini et al. 2018).

After the mapping is done, the middleware defines and maintains the data models used within the platform. Through well-defined schemas and data structures, the middleware ensures that all data interactions between the back end, the middleware itself, and the front end conform to established standards, thereby ensuring rapid and error-free integration within the platform.

To conclude this section, we provide an example to better illustrate the role of the middleware by presenting a request flow to an external data source, Europeana.

Let's assume that a user, through the platform's interface, requests the following document: *Gerardi Mercatoris Atlas siue cosmographicae meditationes de fabrica mundi et fabricati figura. Denuo auctus.*

1. The front end takes charge of the request and sends it to the middleware's API. The corresponding resource ID is passed to the middleware to construct the request.

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2. The middleware recognizes that the resource comes from Europeana.
3. Based on the resource ID and provider, the middleware requests the data from the correct source, using a connector. In this case, the resource is requested from the Europeana API, using the following request: <https://api.europeana.eu/record/v2/930/RMSE073930.json?wskey=abcd1234>.
4. Upon receiving a response from the Europeana API, the middleware remaps the request from the data model returned by Europeana to a data model adapted for our platform's frontend.
5. The request is returned to the front end.
6. The requested resource is displayed on the user's interface and is represented in Figure 1.¹¹

Figure 1. *Example of resources retrieval from Europeana (top) and single resource visualization (bottom)*

The image shows a digital library interface. The top section, titled "Records", displays search results for "500 Tales". It includes a search bar, a "Filter results" section with various subject tags like "map", "manuscript", "west", "art", and "archaeology", and a grid of four book covers. The first cover is highlighted with a red border and shows the title "Gerardi Mercatoris Atlas siue cosmographicae meditationes de fabrica mundi et fabricati figura. Denuo auctus". Below the covers, there are two text snippets: "Chronologia. Hoc est temporum demonstratio exactissima, ab initio mundi, usque ad annum Domini 1564. Ex eclipsibus et" and "La prima parte della Geografia di Strabone, di greco tradotta in volgare italiano da M. Alfonso Buonacciuoli ... con due copiosissime tauole l'una de'".

The bottom section shows a detailed record view for the highlighted book. It includes a title bar, a "Metadata" table, and a "Description" field.

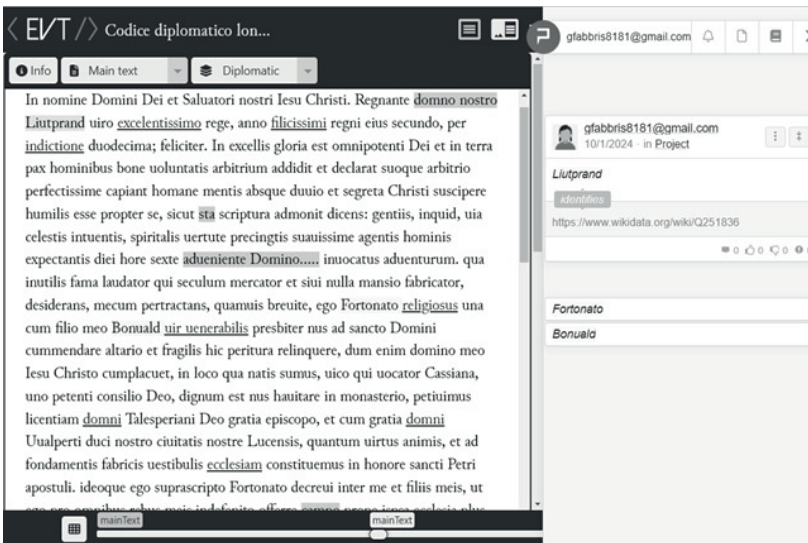
Metadata	Description
Referimenti	Catálogo Colectivo del Patrimonio Bibliográfico Español on-line ; Front. Indco ; Testate. Iniz. e fin. ablogr ; Errori nella numerazione delle p. ; ripetute le p. 260-261, 272-273
Subject	http://culturaitalia.it/pico/thesaurus/4.2#en_librari
Language	lat, it
DataProvider	Comune di Macerata
EdmProvider	Culturaitalia
Link	https://www.internetculturale.it/gmna/fccu/lever/fccu/?id=ca%3Awww.internetculturale.sbn.9%27Tca%3A20%3ANT0000%3AN%3ARMSE073930

¹¹ Please note that the project is still in progress and the images presented here may be subject to slight changes.

After the resource has been retrieved, the user can enable the Pundit annotator and add comments, tags, or highlight portions of text.

If the original resource provides attached files, thanks to the integration of EVT, these can be opened, visualized, and further annotated. Figure 2 shows an example of how an XML file is visualised with EVT and some annotations are added with Pundit.

Figure 2. *Example of XML file visualization with EVT (left) and annotation with Pundit (right)*



7. Concluding Remarks and Further Developments

In conclusion, the current state of CHIIt marks a notable stride forward, showcasing its proficiency in retrieving diverse formats such as PDFs, XML files and images (IIIF included). Our vision for future enhancements centers on broadening its capabilities to seamlessly integrate videos, recordings, and 3D scans, thereby enriching the user experience and expanding the range of supported media types. The team at Net7 is working on improving collaborative features in the Pundit notebooks and are further developing the semantic annotations.

Looking ahead, we aspire to broaden our network of content providers, aiming at unlocking the potential for valorizing a wider array of cultural

works. This expansion would enhance the reusability of digital assets and also elevate the visibility of smaller-scale cultural contributions.

Moreover, our ambition extends beyond the immediate scope of Italian CH. We envision that the flexible framework described can be adapted to accommodate different contexts, proving its versatility and effectiveness. This broader application would serve as a testament to the genuine potential and adaptability of our FAIR choices.

In essence, CHIIt emerges as an innovative and forward-looking tool for the valorization of CH. Its commitment to adhering to the FAIR principles reflects a conscientious response to the evolving expectations of the scholarly community. By continually pushing the boundaries of its capabilities and fostering a more inclusive approach, CHIIt contributes to the ongoing discourse surrounding the management and accessibility of CH resources in the digital era.

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