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Digital Repository as a Service (D-RaaS): Enhancing Access and Preservation of Cultural Heritage Artifacts

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Abstract: The employment of technology and digitization is crucial for cultural organizations to establish and sustain digital repositories for their cultural heritage artifacts. This exploitation is also essential in facilitating the presentation of cultural works and exhibits to a broader audience. Consequently, in this work, we propose a custom-developed digital repository that functions as software-as-a-service (SaaS), primarily promoting the safe storage, display, and sharing of cultural materials; enhancing accessibility; and fostering a deeper understanding and appreciation of cultural heritage. The proposed digital repository service is designed as a multitenant architecture, which enables organizations to expand their reach, enhance accessibility, foster collaboration, and ensure the preservation of their content. Moreover, our technology stack incorporates robust and reliable backend technologies, such as Django, to ensure data security and efficient management. Meanwhile, the frontend is powered by Angular, which guarantees a user-friendly and engaging interface for exploring and interacting with cultural materials. Specifically, this project aims to assist each cultural institution in organizing its digital cultural assets into collections and feeding other digital platforms, including educational, museum, pedagogical, and games, through appropriate interfaces. The creation of this digital repository offers a cutting-edge and effective open-access laboratory solution. It allows organizations to have a significant influence on their audiences by fostering cultural understanding and appreciation. Additionally, it facilitates the connection between different digital repositories and national/European aggregators, promoting collaboration and information sharing. By embracing this innovative solution, cultural institutions can benefit from shared resources and features, such as system updates, backup and recovery services, and data analytics tools, attributes that are currently provided by the platform.

Keywords: cultural technologies; cultural industry; gaming technologies; web sharing; digital repository

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1. Introduction

Technology and digitization play a crucial role in cultural organizations' efforts to establish and maintain digital repositories of cultural heritage artifacts [1]. The implementation of open-access digital repositories offers cultural institutions significant support in their efforts to extend outreach and enhance public awareness of their collections [2]. By facilitating increased accessibility, preservation, and promotion of cultural artifacts, these repositories represent a methodologically structured and user-friendly approach to maintaining and displaying them. Through such digital repositories, virtual accessibility of cultural artifacts becomes possible for anyone with internet connectivity, effectively transcending geographical boundaries and facilitating interaction with them. Moreover, these digital repositories often present a plethora of additional features, including the provision

of multimedia content, thus further enriching the overall experience and fostering deeper connections with the cultural material in question. Additionally, web platforms acting as digital repositories provide various ways for visitors to engage with the artifacts, such as accessing additional multimedia content or participating in discussions related to the artifacts. Ultimately, a web platform acting as a repository of digital cultural artifacts serves as an important tool for preserving and promoting cultural heritage for present and future generations [3].

On the other hand, a digital repository can be a centralized platform for cultural organizations or museums to store and manage digital content, such as images, videos, files, and 3D models of cultural heritage objects. Therefore, with all this information organized in a structured form, any cultural organization can readily and effectively make their digital content available to other platforms through suitable interfaces, including mobile games, virtual reality (VR), and augmented reality (AR) applications. For instance, a modern art museum or a cultural heritage institution holds the potential to develop a VR application that functions as a platform for showcasing its exhibits. This innovative approach allows visitors to participate in a virtual museum tour without the necessity of being physically present. Additionally, it is plausible for a cultural institution to conceive an AR application that superimposes three-dimensional depictions of artifacts onto the user's perception of the tangible environment, thereby offering an interactive and captivating means of acquiring knowledge about cultural heritage. Lastly, gaming platforms can leverage a digital repository to store and manage digital materials for game design, encompassing 3D models, textures, and sound effects, enabling game designers to create more immersive and authentic gaming experiences.

To this end, our paper makes a substantial contribution to the domain of digital preservation and cultural heritage accessibility through the introduction of a software-as-a-service (SaaS) digital repository. This novel approach addresses a significant gap in the field, as current digital repositories frequently lack the requisite capabilities and infrastructure for the efficient storage, presentation, and dissemination of cultural materials while simultaneously ensuring their accessibility and preservation [4]. By offering a multitenant architecture, the proposed repository enables organizations to expand their reach, enhance collaboration, and maintain the integrity of their cultural heritage artifacts. Additionally, it should be noted that our approach is intentionally designed to be general and not site specific. It is rooted in the concept of creating an adaptable and versatile platform that can accommodate a wide range of cultural institutions and their diverse content. Our goal is to provide a solution that is accessible to cultural institutes, allowing them to share their content with others in a seamless and standardized manner. This approach is aimed at promoting inclusivity and scalability, enabling any cultural institution to contribute their content to existing platforms, thereby fostering a more collaborative and expansive cultural heritage ecosystem. In addition, we enable the institutions to contribute their data seamlessly to national and European aggregators through RDF graphs, ensuring compatibility and interoperability with broader cultural heritage initiatives. Our approach is underpinned by the belief that cultural institutions should have the autonomy to choose the most suitable digital channels and mechanisms for sharing their valuable content, thus contributing to the richness and diversity of the cultural heritage landscape.

2. Literature Review

The advent of digital repositories has brought about a significant transformation in the way cultural artifacts are accessed, preserved, and promoted. These platforms provide a centralized infrastructure for storing and managing diverse digital content, such as images, videos, files, and 3D models of various cultural heritage objects [3]. Patel et al. [5] describe an in-depth framework that addresses various processes involved in digitally acquiring, modeling, storing, manipulating, and creating virtual exhibitions using 3D museum artifacts. The focus is placed on the significance of metadata in facilitating these processes. Furthermore, the authors discuss the extensive capabilities provided for authoring, main-

taining, and managing metadata. In addition, the potential applications of the system in virtual learning environments and distributed repositories of archives are described, underscoring its wider significance and adaptability in various contexts. Additionally, Karafotias et al. [6] propose the establishment of a digital repository as a core component of the Digital Routes in Greek History's Paths (RoGH) project. This repository serves as a centralized storage system for the historical content and multimedia items contributed by content creators. By leveraging the repository, the RoGH project aims to preserve, organize, and manage a diverse range of historical materials, including descriptive information, geolocation data, images, videos, 360° media, and 3D multimedia objects. Hence, by consolidating and organizing historical content in a digital format, the repository contributes to the preservation and promotion of Greek history, offering a valuable resource for present and future generations. Petersen et al. [7] developed a digital repository, specifically a digital library, to provide public access to cultural heritage archives. Users can create and view exhibitions containing images from these archives, while administrators have the ability to upload bulk video, audio, and image files. The project comprised three subprocesses, involving requirements gathering, design, implementation, and evaluation. The system was built with a component-based architecture and a layered approach, facilitating development and deployment. Extensive testing, including integration, user acceptance, black box, and usability testing, ensured the system's functionality and above-average usability. Moreover, in Concordia et al. [8], the authors shed light on the dual nature of Europeana as it is perceived as both a cultural heritage portal and an open-services platform. The platform's ability to enable users and cultural institutions access to a wide-ranging collection of surrogate objects through an application programming interface (API) is thoroughly examined. The article delves into the specifics of the data space schema, API description, and Europeana portal implementation. Furthermore, it explores potential utilization scenarios; proposes cognitive methodologies for users, particularly within cultural establishments; and addresses associated risks. Notably, the authors play a significant role in the ongoing Europeana specification, development, and implementation process. Nishanbaev et al. [9] present a significant contribution to the digital conservation and dissemination of cultural heritage through a new methodology and web repository. The methodology integrates maps, 3D models, and geospatial data, enabling long-term archiving and visualization of geolocated 3D digital cultural heritage models on the web. The web repository, built using the KeystoneJS content management system and associated frameworks, facilitates the rapid development of repositories for such models, benefiting cultural heritage organizations and professionals.

In the ever-evolving landscape of digital cultural heritage preservation and access, an exciting and forward-thinking approach is the development of ontology-driven digital repositories. The research presented in Briola et al. [10] centers on IndianaMAS, a multiagent system meticulously designed for the classification and management of images, sketches, and multilingual documents within the cultural heritage domain. This system harnesses the power of ontology for seamless semantic integration, modularity, and reusability, ultimately resulting in the creation of a digital library for classified data. The paper underscores IndianaMAS's architectural adaptability, which allows it to effectively address similar classification and management challenges across diverse domains.

Additionally, Casillo et al. [11] delve into the utilization of ontology modeling within the context of cultural heritage, with a specific focus on the extensive dataset of the Naples Urban Archaeological Park. The authors introduce an ontology-based approach aimed at enhancing data retrieval, making it more user-friendly for field experts by converting extensive data into interconnected concepts, thereby enhancing the accessibility and retrieval of information. The paper also discusses the outcomes of an experimental campaign involving expert users, highlighting promising results achieved through Sparql queries.

Moreover, Niccolucci et al. [12] explore the conceptualization of a semantic infrastructure for the digital domain of cultural heritage, aligning it with the vision set forth by the European Commission. This initiative introduces an innovative ontology rooted

in the digital twin concept, designed to comprehensively represent cultural heritage assets within the digital realm. The proposed ontology not only meets existing standards but is also interoperable with platforms like Europeana. The paper delineates the key features of the Heritage Digital Twin ontology and provides illustrative examples of its potential applications. Ongoing efforts involve further development of the ontology and rigorous testing across various sectors within the cultural heritage community. These pioneering approaches leverage the power of ontologies to elevate knowledge representation and accessibility, offering substantial benefits to expert users and the wider cultural heritage community.

AR and VR technologies have revolutionized the conservation and exhibition of cultural heritage, facilitating immersive experiences that animate ancient sites and artifacts. These technologies effectively bridge intergenerational divides, increasing the accessibility of heritage while ensuring its perpetual source of inspiration and educational value [13]. However, the establishment of a comprehensive digital repository is crucial to harnessing the full potential of AR and VR applications in the realm of cultural heritage. By utilizing a digital repository, these applications can provide users with enriched and authentic encounters with heritage, fostering a deeper understanding and appreciation of our collective cultural legacy.

VR technologies have found a wide array of applications, encompassing educational endeavors [14,15] and training activities [16]. Additionally, virtual reality has been harnessed for diverse visualizations, spanning fields such as engineering [17,18], software data [19], and smart city applications [20]. The cultural sector too has been substantially impacted by the ongoing technological changes associated with the Industry 4.0 era, with virtual reality emerging as a pivotal driver.

In this evolving landscape, virtual reality is not merely a groundbreaking means for virtual tourism experiences [21,22], but it also serves as a tool for educational and entertainment purposes, often termed "edutainment" [23]. Furthermore, it significantly enhances user experiences [24,25]. In the contemporary context, virtual reality is increasingly acknowledged as a "time-travel" mechanism, enabling virtual visits to historical places, cities, and buildings, effectively replacing physical artifacts [26]. This creates a realistic environment, even for sites that may have suffered damage or destruction [27], positioning virtual reality as a catalyst for change within the cultural sector [28]. Virtual reality finds application in a variety of contexts, including skill development programs [29], formal educational processes [30], informal learning, and experimental scenarios [31]. It also addresses special cases involving high risks or physical constraints [32]. However, achieving educational goals within this context is complex due to the absence of traditional face-to-face interactions [33]. Various models and theoretical frameworks have been developed to harness the educational potential of virtual reality [34]. Still, there is an existing research gap in integrating conventional knowledge diffusion models into virtual environments [31]. Researchers and experts in VR generally concur that virtual reality technologies and applications

- Function as self-educational tools, facilitating the development of problem-solving skills [35,36];
- Promote greater technology adoption among end users as a means of accessing information, knowledge, and training [32];
- Provide a more effective and immersive avenue for end users to access information, knowledge, and training compared with traditional tools [37];
- Offer a more realistic and secure means of acquiring knowledge [38];
- Support both individualized learning experiences [35] and collaborative teamwork [37,39].

Furthermore, virtual reality technologies significantly facilitate both formal and informal learning in scenarios where physical place-related restrictions or high-risk factors are present [32]. In environments such as museums and archaeological sites, characterized by constraints and risks due to the nature of cultural artifacts, cultural organizations increas-

ingly adopt virtual reality technologies to engage and educate new generations [40,41]. This assumption is based on the notion that newer generations are more inclined to embrace advanced technologies (including virtual reality and augmented reality) for both educational and cultural purposes [42]. Recent projects have corroborated this relationship [43–46]. The authors in Kargas et al. [47] utilized a digital repository to develop the virtual reality (VR) application known as RoGH with the primary objective of promoting Greek cultural heritage and facilitating an immersive journey through history. Specifically, RoGH caters to tourists, teachers, and researchers, allowing them to explore archaeological ruins and historical monuments. The application utilizes a dynamically organized chronology, enabling users to select specific locations and time periods. Through the repository, diverse content, including 2D/3D models, text, photos, and multimedia resources, is stored and accessed. Hence, by leveraging this repository, the development team successfully constructed a bilingual platform that offers a distinctive digital experience for individuals interested in learning about Greek culture, thereby supporting history education, advancing research endeavors, and catering to a diverse range of languages and interests.

Bruno et al. [48] present a comprehensive approach to leveraging VR technologies in the field of cultural heritage. They provide guidelines for developing VR systems, emphasize the importance of realistic 3D models, and introduce a cost-effective multimedia stereoscopic system for user interaction. The proposed solution aims to enhance the safeguarding, protection, and enjoyment of archaeological remains by leveraging the potential of immersive visualization and 3D reconstruction. In addition, Jevremovic et al. [49] employed a digital repository to facilitate their project, which focused on AR and VR experiences based on QR codes at the Serbian National Museum. The museum had been closed for an extended period, resulting in valuable artifacts being inaccessible in museum depots. Strategically positioned QR codes outside the museum premises granted smartphone users access to AR representations sourced from the digital repository. The primary objective of the project was to revolutionize the dissemination of cultural heritage, ensuring widespread accessibility and cost-effectiveness, thereby initiating discussions regarding the utilization rights of digital cultural heritage.

3. Methodology

The proposed custom-developed digital repository (Figure 1) service aims to establish a secure and user-friendly platform for cultural institutions to manage various aspects of their valuable cultural materials. This service facilitates the import, export, storage, display, and sharing of cultural materials, promoting accessibility and contributing to a deeper understanding and appreciation of cultural heritage. The primary objective is to assist each cultural institution in effectively organizing their digital cultural exhibits into collections and sharing them securely and under constraints to other digital platforms, including educational, museum, pedagogical, and gaming platforms, through interfaces that best suit their needs. Curators of each cultural organization play a vital role in the utilization of the digital repository. Specifically, they have the ability to upload a diverse range of items, including 2D or 3D models, high-resolution photos, multimedia elements, etc.

In order to establish a comprehensive digital repository, the research team has integrated two prominent institutions: (a) the Macedonian Museum of Contemporary Art, which is widely acknowledged for its diverse array of activities and exhibitions that enrich the contemporary cultural milieu, and (b) the Peloponnesian Folklore Foundation, which is esteemed for its vast assortment of folklore and cultural artifacts. The intention is to create a community of multiple independent cultural organizations that are willing to upload their creations in order to achieve recognition and promotion or even be paid per view by end users. Furthermore, each organization has the option of licensing their digital exhibits to third-party applications, such as mobile games or web platforms, for which they may receive compensation based on the number of exhibits or on a monthly basis.

From the technical point of view, the web platform that acts as a digital repository has been constructed with an Angular frontend, complemented by a Django rest-framework

backend. These components are interconnected, utilizing a PostgreSQL database as a centralized repository for all the content. Additionally, the architecture of the digital repository adopts a multitenancy approach, signifying its ability to accommodate multiple cultural entities on a single platform. By adopting a multitenant architecture, each cultural institution gains access to their own dedicated resources and data, thereby ensuring the security and privacy of their respective collections. Simultaneously, they can leverage shared resources and features, such as system updates, backup and recovery services, and data analytics tools, provided by the platform for enhanced efficiency and functionality.

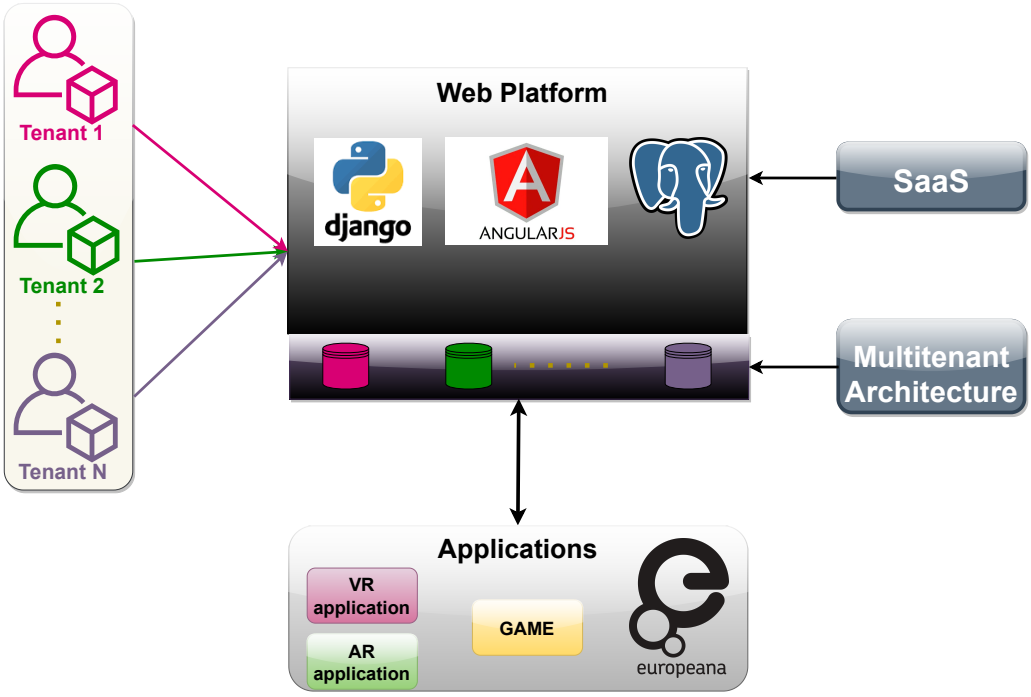

Figure 1. Digital repository as a service (D-RaaS).

The research design of this study revolves around the technical construction of a web platform serving as a digital repository. As mentioned before, this platform has been meticulously crafted with a well-thought-out combination of Angular for the frontend and a Django rest framework for the backend. This choice of technologies not only reflects a contemporary approach to web development but also underscores the study's commitment to harnessing the latest tools and frameworks to achieve its research objectives. By utilizing Angular for the frontend, the study ensures a user-friendly and responsive interface, catering to the needs and preferences of modern users. On the other hand, the Django rest framework for the backend emphasizes efficiency, security, and robust data management, vital aspects for the successful operation of a digital repository. This thoughtful selection of technologies forms the cornerstone of the research design, providing a solid foundation for the study's investigation into the platform's functionality and effectiveness as a digital repository. Our choice of Django as the backend framework and Angular as the frontend framework for this research project is based on a comprehensive evaluation of various performance indicators, as summarized in Tables 1 and 2, respectively. Specifically, in the backend framework comparison (Table 1), we considered factors such as rapid development, security features, community support, object-relational mapping, scalability, database integration, and support for real-time applications. These criteria were chosen to assess the suitability of each backend framework for various development scenarios, encompassing both speed and security. Similarly, in the frontend framework comparison (Table 2), we focused on attributes like ease of learning, component reusability, community support, performance, library size, and real-time updates. These factors were selected to gauge the

advantages and drawbacks of each frontend framework concerning aspects like ease of development, community resources, and performance efficiency.

These frameworks align well with our research project's specific requirements, ensuring a balance between ease of development, security, performance, and scalability.

Table 1. Comparison of main properties of backend development frameworks.

Performance Indicator	Django	Express.js (Node.js)	Ruby on Rails	ASP.NET Core
Rapid Development	High	High	High	Medium
Security Features	High	Medium	Medium	Medium
Community Support	High	High	High	High
Object-Relational Mapping	Excellent	Limited	Excellent	Excellent
Scalability	Excellent	Good	Good	Good
Database Integration	Excellent	Good	Excellent	Excellent
Real-Time Applications	Yes	Yes	Limited	Yes

Table 2. Comparison of main properties of frontend development frameworks.

Performance Indicator	Angular	React	Vue.js	Svelte
Ease of Learning	High	High	Medium	Low
Component Reusability	High	High	High	High
Community Support	High	High	High	Medium
Performance	Excellent	Good	Good	Excellent
Size of Library	Large	Medium	Small	Tiny
Real-Time Updates	Yes	Yes	Yes	Yes

In the context of robustness and longevity considerations, we have implemented a sophisticated and comprehensive system management framework. This framework incorporates crucial components, such as virtual machines, to effectively tackle challenges related to hardware and software interdependencies, scalability, and the long-term preservation of the system. Notably, we employ Docker and Kubernetes to efficiently manage our virtualized environment. Regular updates and modifications take place within this environment, with a meticulous snapshot and restore mechanism in place to preserve system integrity. To safeguard data, automated backups are scheduled routinely, with offsite storage for disaster recovery preparedness. Regular test restores validate the reliability of our backup systems. Our meticulous documentation ensures that configurations and backup procedures are well documented, enhancing the overall robustness and resilience of our digital repository system.

4. Results

This section presents the results of our research work, focusing on the organization of digital exhibits into a collection, their integration into games, and the provision of data and metadata in RDF format, enabling seamless integration with Europeana. We demonstrate the effectiveness of our digital repository in various aspects of managing and sharing cultural exhibits. Specifically, we discuss the organization of digital exhibits into collections and the performance of CRUD operations, the integration of exhibits into games, and the provision of data and metadata in RDF format linked to Europeana repositories. These findings highlight the capabilities and contributions of our digital repository in enhancing the accessibility, engagement, and interoperability of cultural heritage materials.

4.1. Web Platform: Organizing Digital Exhibits into a Collection and Performing CRUD Operation

The main menu of the web platform for collecting and organizing content, as depicted in Figure 2, plays a pivotal role in facilitating a variety of functions. The access to this platform is restricted to authorized users, principally administrators and staff members. Within the platform, these two distinct user groups have distinct functions and responsibilities. Hence, as can be observed in Figure 2, there are six tabs: Users, Collections, Cultural Assets, Tools, Creators, and Games. Each of these tabs is designed to enable CRUD operations, encompassing the creation, reading, updating, and deletion of various entities associated with the respective tab. Administrators, as the highest authority on the platform, wield the power to oversee and manage the entire system. More specifically, they are able to conduct these CRUD operations across all tabs, giving them complete control over the repository's content and structure. In contrast, staff members play a vital role in the day-to-day management of the repository. They are responsible for specific areas and functions, as designated by administrators. Their access and permissions are tailored to their roles and responsibilities within the organization, limiting their actions to the relevant tabs in the main menu. This distinction ensures that staff members can efficiently contribute to content management without compromising the overall system's stability.

- **Users**: In the Users tab, the administrator has the authority to create new user accounts by gathering relevant information, such as usernames, passwords, and profile details. Additionally, user information, such as profile pictures or contact details, can be updated with the appropriate authorization granted to the admin role. Lastly, if necessary, the administrator can delete user accounts with the proper permission and adherence to applicable regulations.
- **Collections**: In the Collections tab, staff and admin members are allowed to create new collections of cultural heritage objects by specifying their names, descriptions, and any relevant metadata. They have the ability to read and retrieve collections in order to display their contents and associated information. Updating a collection grants them the authority to modify its attributes or add/remove items from it. Lastly, if necessary, staff and admin members can delete entire collections along with their contents, in accordance with the appropriate permissions and regulations.
- **Cultural Assets**: The Cultural Assets tab specifically focuses on managing the digital representation of cultural heritage objects. These digital objects encompass various forms, such as images, videos, and 3D files. Staff and admin members are granted the ability to perform CRUD operations on these digital assets within this tab. They can create new digital objects by uploading files and providing essential metadata, including titles, descriptions, or tags. Accessing digital objects allows for retrieving and displaying their information. Updates to digital objects enable modifications to attributes or replacement of associated files. Furthermore, if necessary, staff and admin members can delete digital objects in compliance with their role permissions and applicable regulations. This ensures efficient management of the digital representation of cultural heritage objects
- **Tools**: The Tools tab grants admin members advanced data management capabilities. They can easily import and export data, facilitating smooth information transfer to and from the platform. Furthermore, admin members can efficiently adjust the content, enabling straightforward customization and precise fine-tuning of data to meet specific requirements. Additionally, they have the authority to designate mandatory and optional fields, ensuring comprehensive and accurate data collection from other members. This level of control guarantees data integrity and enhances the effectiveness of the system.
- **Creators**: The Creators tab empowers staff members and admin members in managing creators of cultural heritage objects through CRUD operations. This section allows users to create new creator profiles by collecting essential details, like their full name, profile description, and digital presentations. Accessing creator profiles enables the retrieval and display of relevant information. Modifying creator profiles allows for

adjustments to attributes such as profile images and other details. When necessary, staff and admin members have the authority to delete creator profiles and their associated content, ensuring streamlined platform management.

- **Games**: The menu's 'Games' tab functions as a portal for platform users to enable third-party applications to access their content. The platform enables cultural institutions to curate particular collections from their digital assets and tailor game parameters accordingly. This particular tab offers a mechanism for cultural organizations to efficiently exhibit their digital materials and customize the gaming encounter according to their predilections.

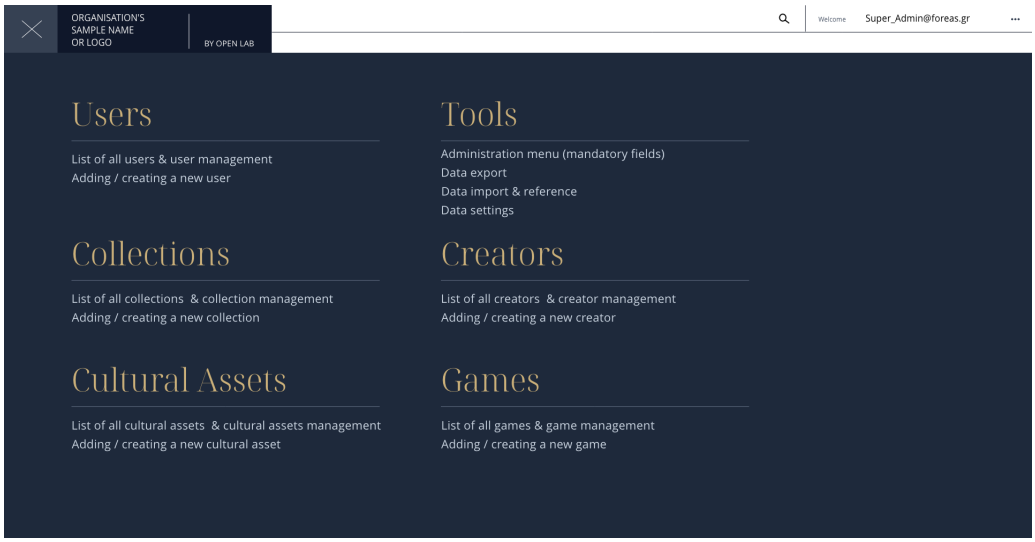

Figure 2. Main menu of the web platform.

In Figure 3, a visual representation of collections is provided, illustrating the organizational framework within our digital repository. Each collection is interactively accessible, allowing for modifications through a user-friendly interface. By selecting and interacting with individual collections, users can efficiently tailor and update content to suit their specific requirements. This feature empowers administrators and authorized users to curate and refine the collections, optimizing metadata management and exhibit organization within the repository.

Figure 4 showcases the dual functionality of the Delete and Update operations within our digital repository. This visual representation highlights the ability to remove exhibits from the collection through the Delete function and modify existing exhibit information using the Update feature. By providing these essential functions, our repository empowers users to effectively manage and refine their digital exhibits, ensuring that the collection remains up-to-date and relevant. These capabilities contribute to the overall efficiency and effectiveness of the digital repository system.

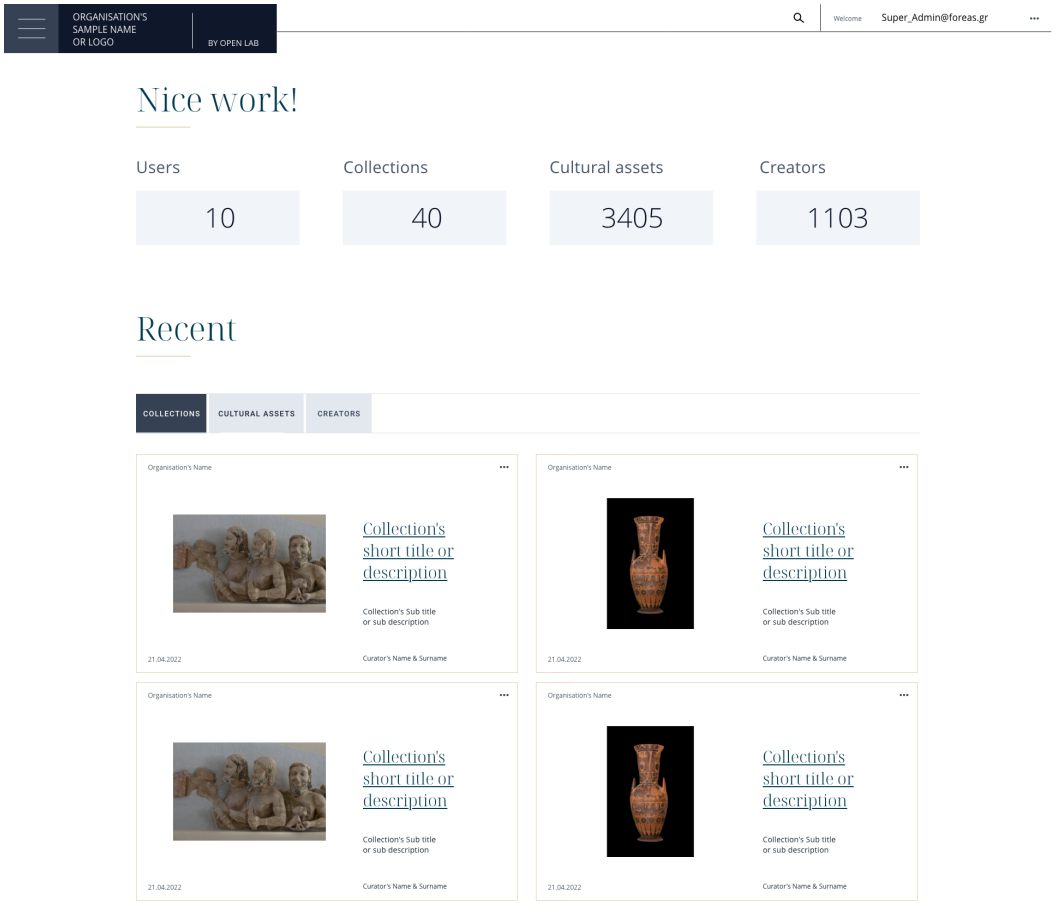

Figure 3. Manipulation of collections.

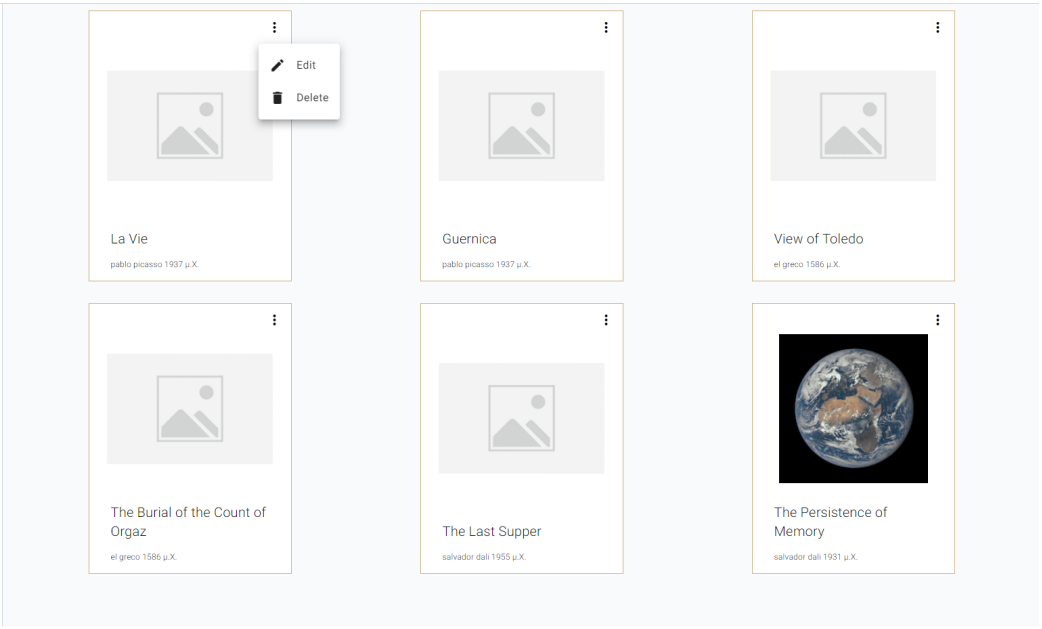

Figure 4. Delete–Update functionality of collections.

Figure 5 provides an in-depth view of the search and filtering interface within our digital repository, a critical tool for accessing cultural heritage objects. This interface has been thoughtfully designed to enhance user experience and facilitate efficient exploration of our rich cultural heritage collection. At the top of the interface, a prominent search bar takes center stage, allowing users to input specific queries, ensuring that the desired

cultural artifacts can be easily located. The intuitive design ensures that users can initiate their searches with ease, making it a welcoming gateway to our repository. Adjacent to the search bar, a comprehensive filtering panel is prominently displayed. This panel features a range of filtering options to cater to various search preferences. Users can fine-tune their search results by utilizing categories such as 'Type', 'Date', 'Category', 'Method', and 'Curator'. This flexibility ensures that users can precisely tailor their searches to meet their research needs, making the retrieval of relevant cultural heritage objects straightforward and efficient. Moreover, the user interface includes a well-considered pagination system to handle large sets of search results. This ensures that even extensive collections of cultural artifacts can be navigated with ease. Users can smoothly navigate through multiple pages of search results, enhancing the overall accessibility of our digital repository.

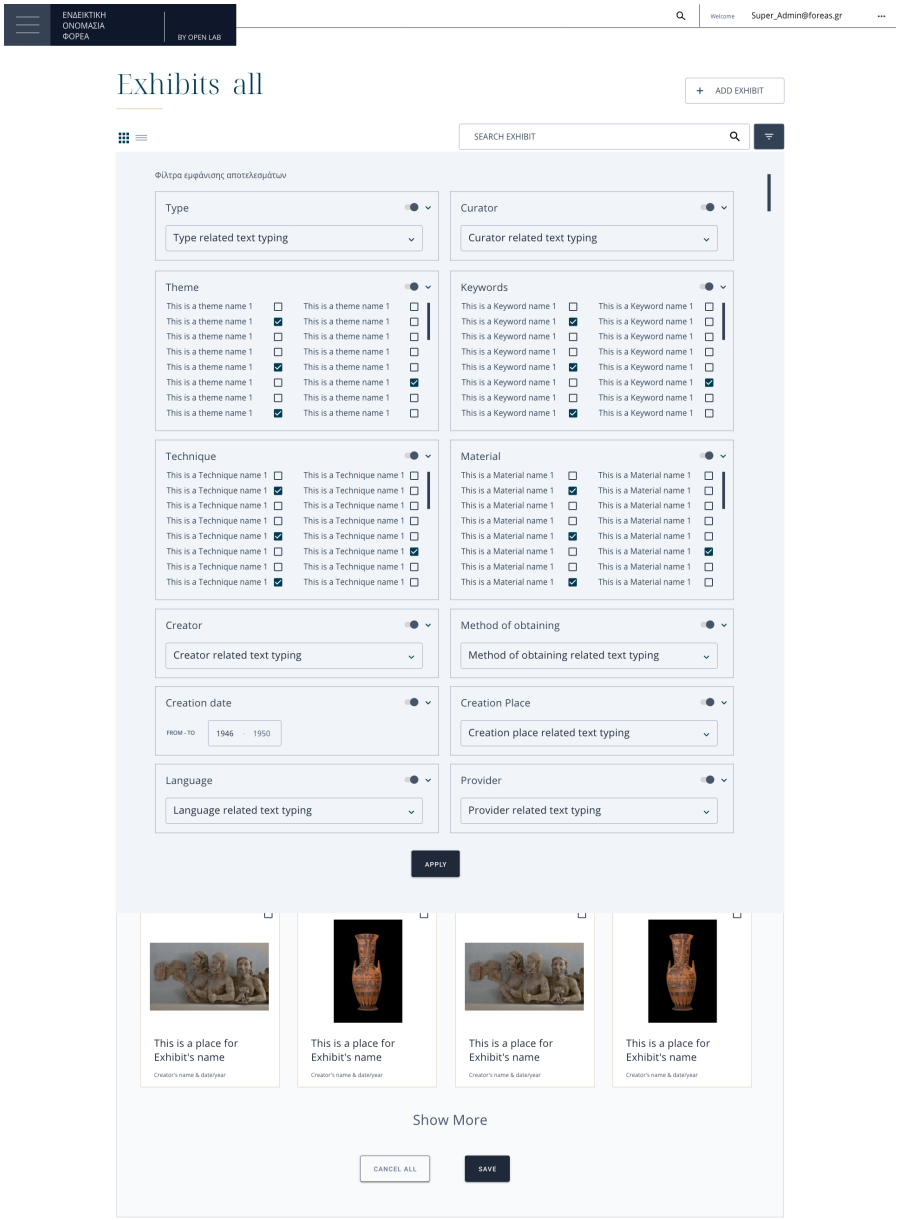

Figure 5. Search and filter functions.

4.2. Multitenant Architecture

The multitenant mechanism is a key design feature of this platform, enabling open access for cultural institutions to the dedicated digital repository. In particular, the proposed scheme utilizes a shared database with isolated schemas, guaranteeing the segregation and

security of data for each participating organization, commonly known as a tenant, within the digital repository. To elucidate the concept of a "shared database with isolated schemas", it can be likened to directories within an operating system, wherein each directory (schema) contains its distinct set of files (tables and objects). Such a structure facilitates the usage of identical table names and objects across various schemas without encountering conflicts. Hence, upon the registration of new cultural institutions (tenant) in our platform, a new schema is dynamically generated for them. This newly created schema includes the tables illustrated in Figure 6, which represent the standardized metadata schema shared among all tenants. Notably, it is essential to highlight that this common schema adheres to the EDM (Europeana Data Model) metadata model, a widely recognized standard in the field of cultural heritage information management. By generating a unique schema for each tenant, we ensure that they have their own dedicated space to store and manage their data while adhering to the common metadata structure. This approach enables flexibility and scalability as new tenants can seamlessly integrate into the platform with their own independent data storage while benefiting from the consistent metadata framework.

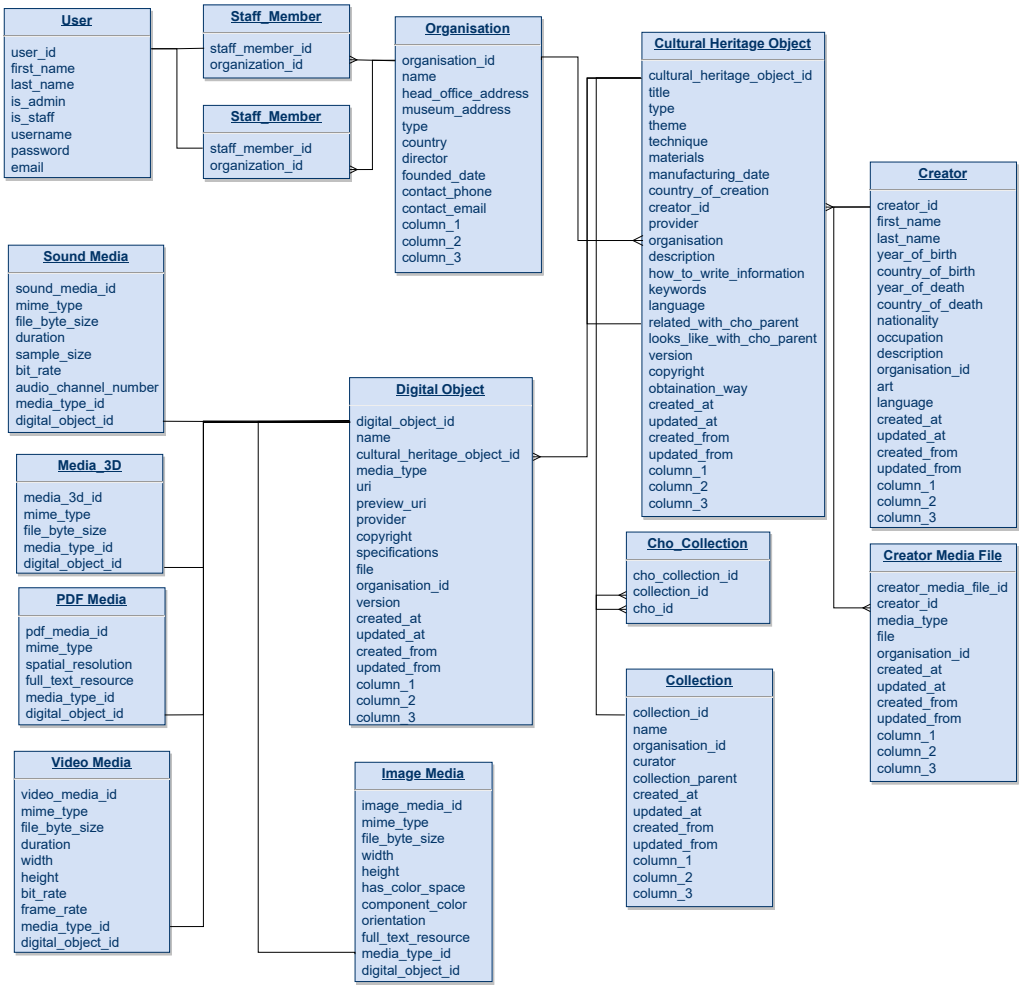

Figure 6. Architectural overview of digital repository database structure.

From a technical perspective, we have employed the Django Tenant Library, which provides a range of approaches to achieve multitenancy within our application. Tenants within the system are uniquely identified based on their hostnames (e.g., tenant_1.domain.com). This pertinent information is stored and managed within a public schema table. Whenever a request is received, the hostname is utilized to discern the corresponding tenant within the database. Once a match is successfully established, the search path is dynamically adjusted to incorporate the identified tenant's schema. Consequently, all subsequent queries are directed to and processed within the context of that specific tenant's schema. Consider, for instance, a scenario with two tenants: "tenant_1" and "tenant_2". When a request is made to http://tenant_1.example.com, the system identifies the tenant as "tenant_1", activates their schema, and handles all queries within its context. The same applies to http://tenant_2.example.com for the "tenant_2" tenant. However, if an incoming request features an unregistered hostname, the system produces a 404 error, indicating that the tenant does not exist in the database.

4.3. Integration of Cultural Exhibits in Games

In this section, we present a detailed account of the mechanism enabling organizations to provide their exhibits to a variety of gaming applications. As can be observed in Figure 7, the process is facilitated through a user-friendly form accessible to administrators or staff members of each organization. Within this form, they can carefully select the exhibits to be utilized and specify the type of games suitable for their chosen exhibits. The platform incorporates a comprehensive list of criteria, each pertaining to specific requirements for the games. For instance, a game may necessitate 5 images to be displayed over a 10-min duration, achieving a minimum score of 20 points and a maximum of 100. These criteria, dictated by the respective organization, are seamlessly integrated into the applications through a flexible and powerful API suite. As a result, our platform introduces novel opportunities for interactive experiences, combining tangible exhibits with captivating virtual gaming environments. Hence, in Figures 8 and 9, visual representations are depicted of digital exhibitions featuring cultural heritage artifacts sourced via our dedicated REST API and displayed within the game. Additionally, our platform employs JWT (JSON Web Tokens) for secure authorization. Each registered game is provided a unique JWT token, acting as a digital key for accessing selected exhibits and content. These tokens specify permissions and restrictions, ensuring that games can only interact with authorized content. This robust security mechanism protects valuable cultural heritage artifacts and sensitive data, allowing for both flexibility and scalability within the platform.

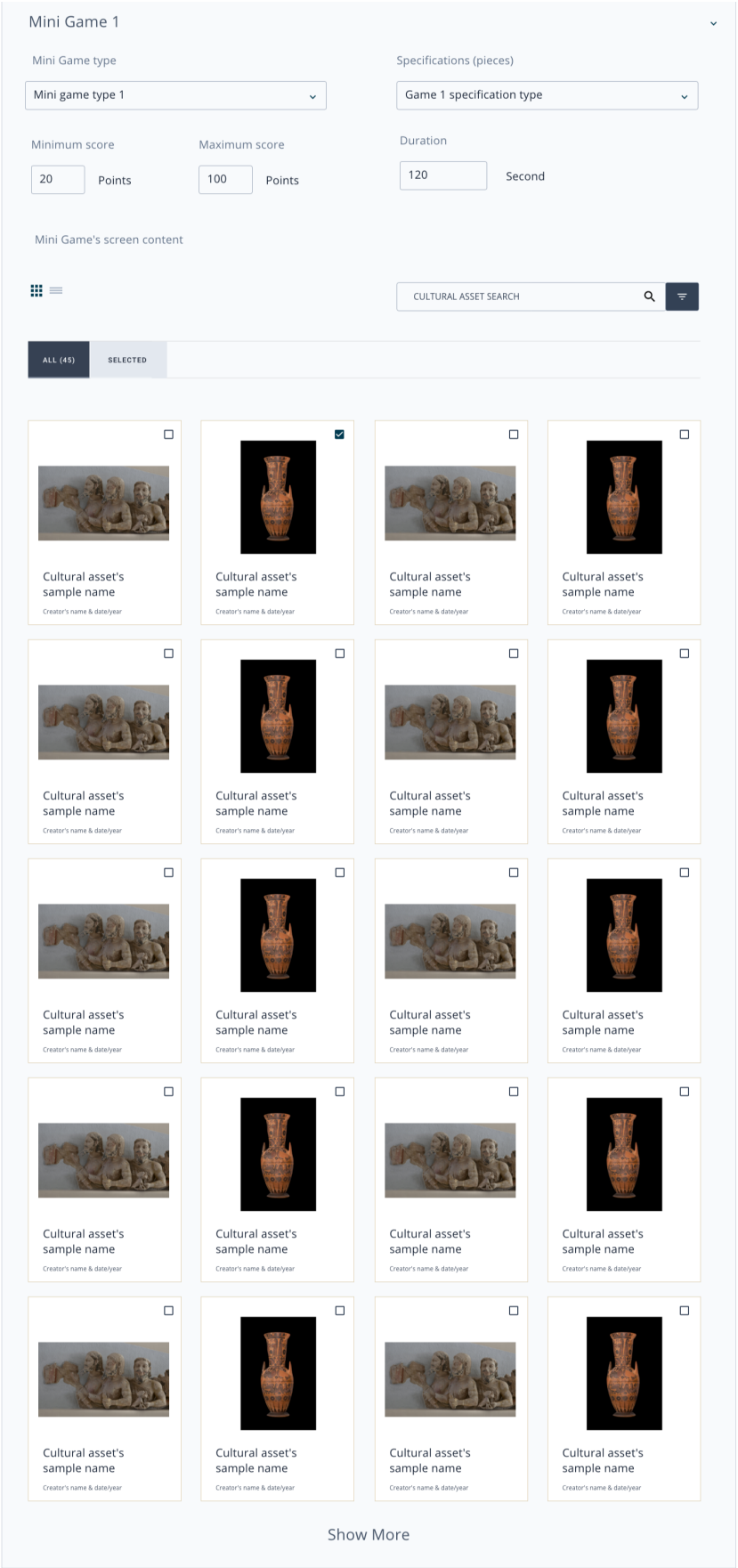

Figure 7. Game creation and manipulation menu.

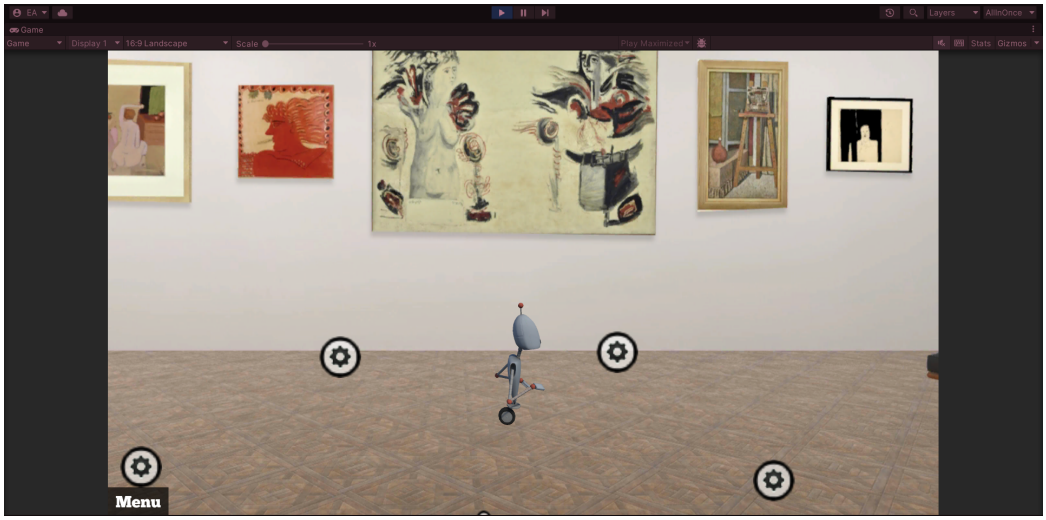

Figure 8. Utilization of digital objects in gaming.

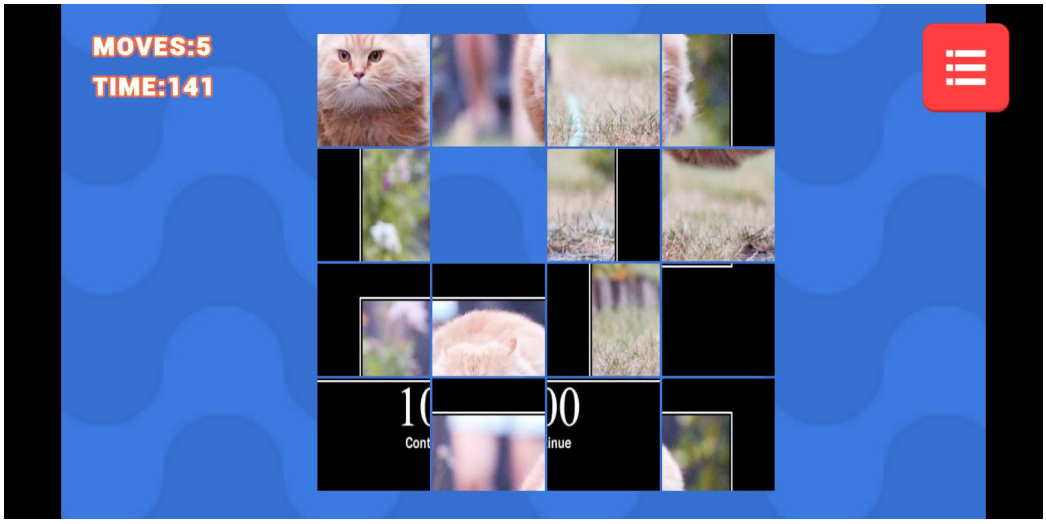

Figure 9. Utilization of digital objects in gaming.

4.4. Providing Data and Metadata in RDF Format and Linking with Europeana Repository

In this subsection, we focus on the significance of providing data and metadata in RDF format and establishing links with Europeana, a prominent digital platform for cultural heritage collections. Adopting RDF and linking with Europeana not only ensures interoperability but also enhances the visibility and accessibility of our cultural assets within the European cultural heritage community. Figure 10 provides a clear visual representation of how our data are organized and structured using the RDF (Resource Description Framework) format, which conforms to the Europeana Data Model. This figure visually highlights the relationships, entities, and attributes within the RDF framework, emphasizing our adherence to the standardized data model endorsed by Europeana. By following this model, our data maintain a consistent and harmonized structure, ensuring compatibility and easy integration with the Europeana platform. This alignment enables seamless interoperability and facilitates the efficient exchange and sharing of our data with Europeana, enhancing the accessibility and discoverability of our cultural heritage assets.

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns:edm="http://www.europeana.eu/schemas/edm/"
  xmlns:ore="http://www.openarchives.org/ore/terms/"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:dcterms="http://purl.org/dc/terms/"
  <edm:WebResource rdf:about="http://test-schema.localhost:8000/media/%CE%94%CE%BF%CE%BA%CE%B9%CE%BC%CE%B1%CF%8
    <dc:format>image/png</dc:format>
    <dcterms:extent>200x200 px</dcterms:extent>
    <edm:rights rdf:resource="https://testcopyright.net"/>
  </edm:WebResource>
  <ore:Aggregation rdf:about="http://test-schema.localhost:8000/viewer/1">
    <edm:aggregatedCHO rdf:resource="884f7ed843e9f5a07d9210eb2eacb9c2d8c94d08-1"/>
    <edm:dataProvider>Test Museum</edm:dataProvider>
    <edm:isShownAt rdf:resource="http://test-schema.localhost:8000/viewer/1"/>
    <edm:isShownBy rdf:resource="https://testpreviewuri.net"/>
    <edm:object rdf:resource="https://testpreviewuri.net"/>
    <edm:rights rdf:resource="https://testcopyright.net"/>
  </ore:Aggregation>
  <edm:ProvidedCHO rdf:about="884f7ed843e9f5a07d9210eb2eacb9c2d8c94d08-1">
    <dc:creator>salvador dali</dc:creator>
    <dc:description>The Persistence of Memory is a 1931 painting by Spanish surrealist artist Salvador Dalí.
    It depicts melting pocket watches, which are a symbol of the inevitability of the passing of time.
    The painting is in the collection of the Salvador Dalí Museum in St. Petersburg, Florida, United States.
</dc:description>
    <dc:language>en</dc:language>
    <dc:title>The Persistence of Memory</dc:title>
    <dc:type>painting</dc:type>
    <edm:type>IMAGE</edm:type>
  </edm:ProvidedCHO>
</rdf:RDF>
```

Figure 10. RDF-based data organization and structuring.

5. Conclusions and Discussion

In conclusion, this paper proposes a digital repository as a vital solution for cultural organizations seeking to preserve and share their cultural heritage. Through the adoption of technology and digital tools, this repository facilitates secure storage, display, and sharing of cultural materials, enhancing accessibility and fostering a deeper appreciation of cultural heritage among a wider audience. The implementation of a multitenancy architecture enriches the repository's diversity and safeguards its content with robust security measures. Furthermore, with its user-friendly Angular frontend and Django backend, the platform ensures a seamless experience while prioritizing data privacy and providing shared resources for enhanced efficiency. The technologies and applications discussed in this study have the potential to assist cultural industry organizations in the distribution of their digital content and the enhancement of the overall experience of physical visitors. The implementation of such technologies encompasses more than just promotional efforts; it entails a strategic approach to engage a worldwide audience and provide services that appeal to this target demographic, encompassing both in-person and digital visitors. Additionally, Table 3 offers a comprehensive comparison of our digital repository with other well-known repositories, such as DSpace and EPrint, to underscore key distinctions and advantages.

Possible future directions include the implementation of artificial-intelligence-based recommendations, specifically by leveraging AI algorithms [50–52]. The digital repository could offer personalized recommendations to the organization's staff users, suggesting cultural works, exhibits, or collections based on their interests and past interactions. Additionally, the integration of multilingual support is of potential interest. This feature would allow users to access content and descriptions in their preferred language, breaking down language barriers and making cultural heritage more accessible to a broader international audience.

Table 3. Comparison of digital repositories.

Feature	Proposed Digital Repository	DSpace [4]	EPrint [4]
Flexibility	Highly flexible with a multipurpose design tailored for various domains and use cases.	Primarily domain specific, limited flexibility.	Primarily domain specific, limited flexibility.
Storage	Offers safe storage, display, and sharing of cultural materials.	Provides storage and sharing capabilities.	Primarily for research publications.
Accessibility	Enhances accessibility to a broader audience.	Enhances accessibility but limited to specific domains.	Enhances accessibility but limited to research publications.
Multitenant Architecture	Designed as a multitenant architecture, allowing organizations to expand their reach and foster collaboration.	Not inherently multitenant, may require custom configurations.	Not inherently multitenant, may require custom configurations.
Content Integration	Assists in organizing digital assets into collections and feeding other digital platforms.	Lacks this feature.	Lacks this feature.
Open-Access Laboratory	Offers a cutting-edge open-access laboratory solution.	Not designed as an open-access laboratory.	Not designed as an open-access laboratory.
Collaboration	Promotes collaboration and information sharing with different repositories and aggregators.	Collaboration may require additional setup and customization.	Collaboration may require additional setup and customization.

Additionally, in our future work, we will incorporate real-world testing and data collection from two significant sources: the Macedonian Museum of Contemporary Art, renowned for its diverse range of activities and exhibitions that enrich the contemporary cultural milieu, and the Peloponnesian Folklore Foundation, esteemed for its extensive collection of folklore and cultural artifacts. This evaluation aims to assess the practicality and user-friendliness of our platform. This approach aligns seamlessly with our intention to ensure the platform's effectiveness in a practical setting. By actively involving these cultural institutions, we can analyze real audience usage and gauge the utility of the integrated applications. This, in turn, provides a solid foundation for refining and optimizing the user experience. These insights will not only enhance the immediate functionality and relevance of the digital repository but also unlock a range of invaluable research opportunities, enabling us to further customize our solution to the specific needs of cultural organizations and their audiences. Finally, we envision expanding our platform to offer engaging content tailored for AR and VR experiences. User-centric considerations will be at the forefront of our development, ensuring an immersive and interactive environment that seamlessly integrates AR and VR elements.

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