Information Technologies of Digitization of Museum Collections: World Experience and Ukrainian Realities

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Abstract

The article deals with the foreign experience of implementing information technologies of large-scale digitization of museum collections, as well as projects of digitization of national cultural heritage. It has been proven that with the beginning of a full-scale war, the need for digitalization of Ukrainian museum resources became acute, and the problems of preserving cultural values, their transmission, and promotion are now issues of national security. Digital transformation, in particular the creation of the Unified state electronic system for monitoring and accounting of the state museum fund, is carried out thanks to international support. The mechanism of the institution's use of digital technologies, platforms and tools in order to achieve its goals, improve the impression of visitors and expand the scope of coverage and influence in the digital sphere has been studied.

Keywords

Information technologies, digitization, museum collection, museum fund, cultural heritage

Introduction

February 24, 2022 became a turning point not only for every Ukrainian, but also for the whole world. Life began to be delimited by an imaginary red line and called BEFORE and AFTER. Despite all the narratives created by Russian propaganda, it is obvious that the main goal of the war is Russia's intention to destroy Ukraine as a sovereign state, and Ukrainians as an independent and free nation. The occupiers understand (and this understanding is not new for them, it has been preserved for centuries) that the culture of Ukraine, especially its cultural heritage, must be the primary target and remain under attack until it is completely destroyed (Figure 1) [1].

Having faced with such a problem, Ukraine should rely on the world experience laid down in the norms of international law, in particular on the Hague Convention on the Protection of Cultural Property in the Event of Armed Conflict of 1954, the First and Second Protocols to it (international agreements that combine legal norms on the protection of cultural heritage on a global scale). However, the realities of the war testify to the ineffectiveness of the provisions of the Hague Convention, which refer to the obligation of the contracting parties to refrain from any hostile actions regarding cultural values, their looting and illegal appropriation, as well as acts of vandalism in relation to them, etc. Such a situation makes it possible to classify the actions of the Russians as crimes and imposes an obligation on both Ukraine and the international community to make efforts to investigate each such recorded crime and bring the perpetrators to justice.

As a result of Russian aggression, more than 1,500 objects of cultural heritage and cultural infrastructure have already been damaged or destroyed in Ukraine. With the beginning of a full-scale war, the need to digitize Ukraine's museum resources became urgent. Along with shelling, looting and destruction, accounting documentation containing information about museum values is

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destroyed. In this regard, Ukraine calls for deepening cooperation between the relevant bodies, including international ones, for the exchange of information, as well as the identification of illegally exported cultural property.

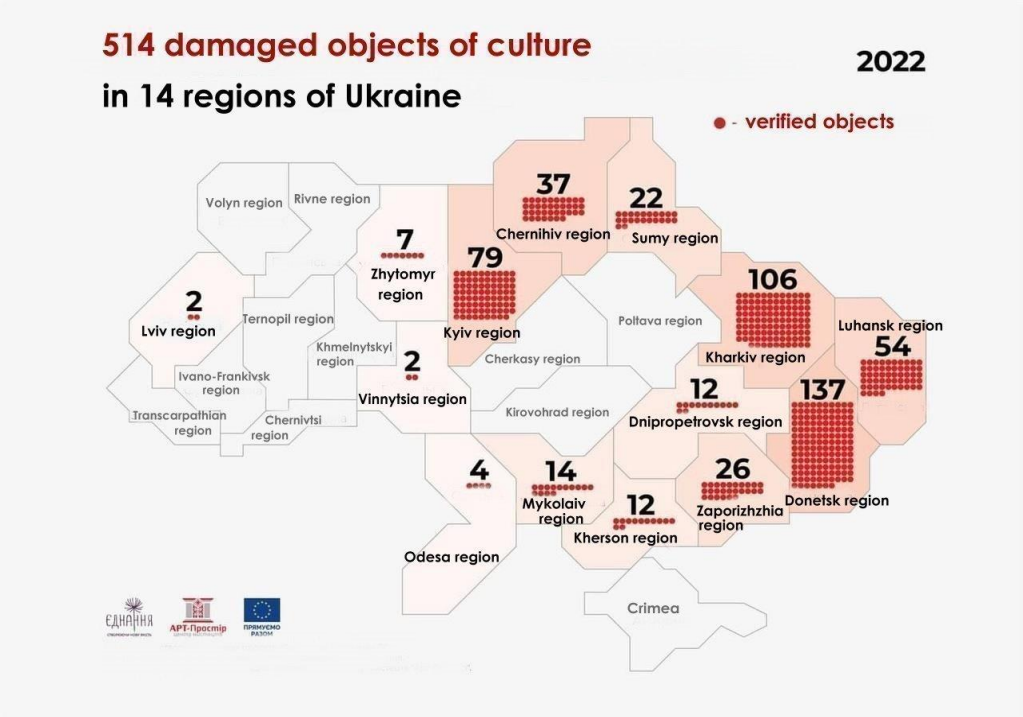

Figure 1: Monitoring of the state of cultural objects during the Russian-Ukrainian war (01.04.2022 - 31.12.2022) carried out by the public organization «Art Centre «Art-Space» [1]

In such conditions, the need for a comprehensive study of the technologies of digitization of museum collections is beyond any doubt.

2. Related Works

Today, the problems of preserving cultural values and their transmission, promotion and development of cultural heritage are issues of national security of Ukraine. Ukrainian culture helps to establish our national identity and the cohesion of citizens, and also contributes to the development of a harmonious society. Historical experience, cultural traditions, language and other cultural aspects determine the identity of the nation and become the basis of Ukraine's development in the future. Cultural «firmware» does play a key role in forming the values that define a country's identity and ability to defend them.

The issue of preserving cultural values, including museum collections, has become the subject of discussion at numerous forums (e.g., International Forum on Cultural Heritage Security «War in Ukraine: Battle for Culture» [2; 3], «Cultural Heritage in Conditions of Armed Conflict» [4], «Digitalization in musical art and education as a requirement of the times» [5]), conferences (e.g., «Rescue of cultural heritage during emergencies. Aid and international cooperation» [6], «Cultural institutions in the line of fire: destruction and reconstruction» [7]) as well as during workshops (e.g., «Digitalization of the Kurbas heritage: challenges and achievements [8], «Kolomyia museum staff are digitizing the cultural heritage» [9], «Lecture-conversation «Digitalization of monuments» [10]), etc.

The scientists began studying these problems in 2014. For example, S.I. Kot, the head of the Centre for the Study of Lost Cultural Property of the Institute of Ukrainian History of the National Academy of Sciences of Ukraine, studied the further whereabouts of cultural values of Crimea and Donbass having been lost during the war [11].

The new challenges of the day – the artworks of I. Aivazovskyi, taken out from the Feodosia Aivazovskyi Art Gallery; the return of the Ukrainian collection of «Scythian gold», which was exhibited in the Allard Pierson Museum in 2014 – were studied in the work of V. V. Soloshenko [12].

The protection of cultural values in cases of armed conflicts by means of international law was considered by V. Yakoviuk and T. M. Anakina [13].

The process of qualitative transformation of museum communication at the current stage, which is taking place under the influence of the factors of digitalization of information and communication links, transmission and broadcasting of information, was investigated by Zh. Z. Denysiuk [14].

Digital collections dedicated to the preservation and promotion of intangible cultural heritage in the European and Ukrainian web information environments were characterized by T. M. Bilushchak and S. I. Dobrovolska [15].

The economic effect of digitising museum collections was studied in the article of Josh Davis «Digitising a museum collection could contribute over £2 billion to the economy» [16]. The author points out that «The economic benefit of digitising an entire museum collection has been quantified for the first time. Research has found that digitising the Museum's 80 million objects would contribute to biodiversity research, the study of invasive species and the safeguarding of agricultural crops to the tune of billions of pounds».

The official page of the European Commission states:

- «Cultural tourism represents up to 40% of all tourism in Europe.
- Cultural and creative industries contribute 3.95% of total EU value added (€477 billion).
- More than 8 million people are employed by the cultural and creative industries, through 1.2 million firms.
- Europeana currently offers access to 52 million cultural heritage assets, 45% of which can be reused in various sectors.
- Images and text make up 97.5% of Europeana's assets, with only 2.47% audiovisual content and 0.03% in 3D. The collection of 3D assets in particular should see a massive boost, thanks to this latest initiative» [17].

3. Analysis of the world and Ukrainian experience in the digitization of cultural heritage

Today, museum staff, archivists and librarians discuss a digital strategy – a plan or concept that describes how an institution will use digital technologies, platforms, and tools to achieve its goals, improve visitor experience and reach, and expand influence in digital sphere. Such a strategy determines that digitalization is primarily aimed at online presence, that is, digital accessibility allows people from all over the world to get acquainted with museum exhibits, archival documents, and library resources. This, in turn, gives scientists the opportunity to conduct their scientific research. Digitized collections can be integrated into the curricula of university courses, that is, used as teaching materials. Digitized materials can become the basis of virtual exhibitions distributed through social networks. This practice can increase the audience of users several times.

Digitization gives institutions a clear understanding of what resources are most in demand and what forms of their presentation to users are most effective. So, according to the Final report «Digitisation and IPR in European Museums» prepared by the Network of European Museum Organisations Working Group on Digitalisation and Intellectual Property Rights and published on July, 2020, «more than 80% of the responding museums claimed increased visibility as the main objective for digitising their collections, closely followed by 75% of the museums who named increased access and educational use. More than 65% of the museums' objective to digitise their collection is providing metadata for researchers [18] (Figure 2).

European museum professionals acknowledge that Art and Design Museums maintain a digital record of approximately 65% of their collections, while Natural History Museums have made less progress, with only about 15% of their holdings digitised. History and Archaeology Museums fall in between, with around 27% of their collections digitised. This variance in digitisation rates across

museum categories can be attributed to different marketing strategies, as well as the collection size and variety and type of objects [18].

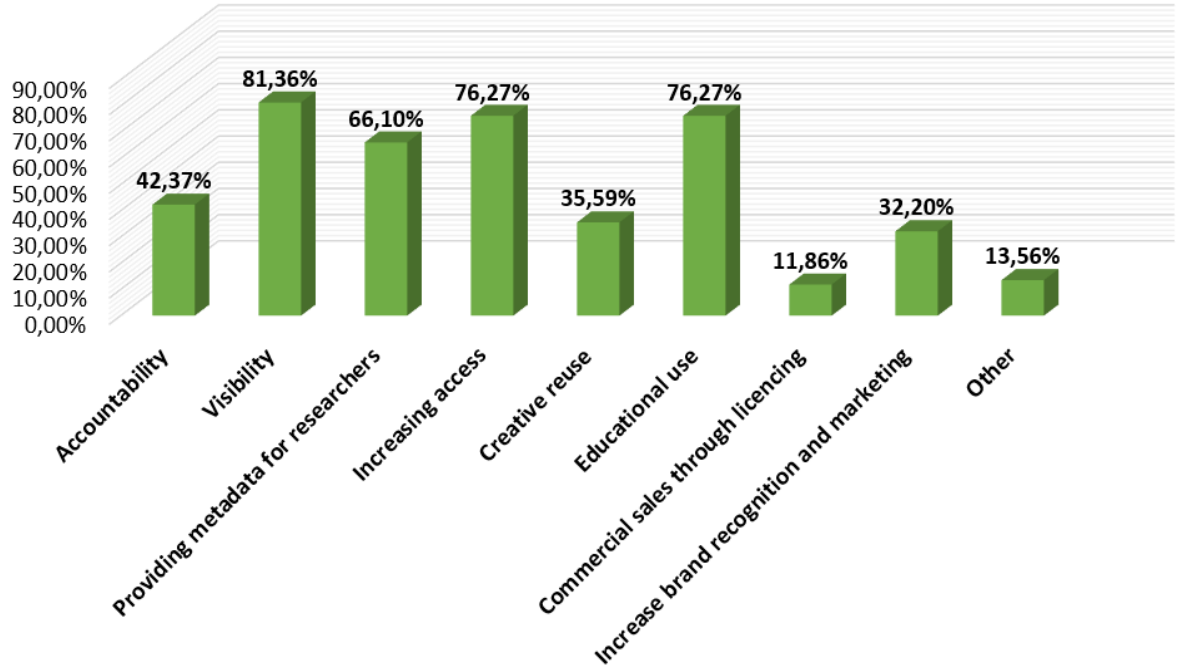

Figure 2: Objectives of digitization of collections [18]

80% of the museums that have their collection online publish their digital collection on their own online platform. It is worth noting that archival funds and library collections have a similar trend. They often present their digital collections on social media. More than 35% of responded museums point out that they are publishing their digital collection on Europeana. In addition, most museums having their collections online publish them simultaneously on 3-5 platforms [18] (Figure 3).

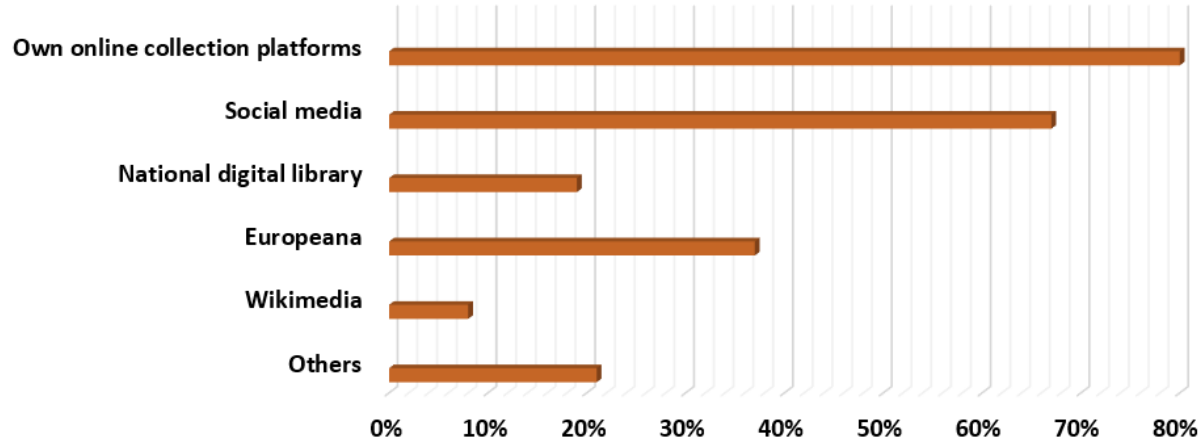

Figure 3: Presentation of digitized collections [18]

According to the recommendation of the European Commission of 10.11.2021 on a common European data space for cultural heritage, «The development of advanced digital technologies, such as 3D, artificial intelligence, machine learning, cloud computing, data technologies, virtual reality and augmented reality, has brought unprecedented opportunities for digitization, online access and digital preservation. Advanced digital technologies lead to more efficient processes (e.g., automated

generation of metadata, knowledge extraction, automated translation, text recognition by optical character recognition systems) and higher quality content. They allow innovative forms of artistic creation, while opening up new ways of digitally engaging with and enjoying cultural content through co-curation, co-design and crowdsourcing, empowering public participation. Artificial intelligence, blockchain and other advanced technologies can also be explored for automatically identifying cultural goods that are illicitly trafficked. The uptake of such advanced technologies has a significant impact on European recovery and growth following the COVID-19 pandemic, and Member States should support it by taking appropriate measures» [19]. These recommendations give an important role to Europeana. The European digital cultural platform will be at the basis for building the common data space for cultural heritage. It will allow museums, galleries, libraries, archives across Europe to share and reuse the digitized cultural heritage images such as 3D models of historical sites and high-quality scans of paintings.

The Annexes to the European Commission Recommendations on a common European data space for cultural heritage set out Indicative targets for content contribution to Europeana and the data space by 2030 per Member State, in proportion to each Member State's population, adjusted to the Member State's GDP per capita. The leaders among the countries are as follows (Table 1).

Table 1

Indicative targets for content contribution to Europeana and the data space by 2030 per Member State [19]

	Number of records on 1 February 2021	Number of high-quality records on 1 February 2021	New high-quality records by 2030	Total number of records by 2030	Total number of high-quality records by 2030	3D digital assets by 2030
Austria	2.372.357	1.106.942	1.002.892	3.375.249	2.109.834	401.157
Belgium	2.499.646	2.247.432	1.215.817	3.715.463	3.463.249	486.327
France	3.860.232	1.779.567	6.381.064	10.241.296	8.160.631	2.552.426
Germany	5.536.786	4.107.742	8.924.266	14.461.052	13.032.008	3.569.707
Italy	2.150.207	687.421	5.119.900	7.270.107	5.807.321	2.047.960
Netherlands	9.126.499	7.554.003	1.992.463	11.118.962	9.546.466	796.985
Poland	3.040.221	936.996	2.477.819	5.518.040	3.414.815	991.127
Spain	2.960.596	1.228.351	3.851.622	6.812.218	5.079.973	1.540.649
Sweden	4.307.321	3.047.430	1.098.975	5.406.296	4.146.404	439.590

As we can see, Germany is the undisputed leader in the digitization of cultural values in Europe. In 2009, on the initiative of the Digitization Working Group of the Saxony-Anhalt Museum Association, the Museum-Digital project was founded to help museums place their collections online. Today, the Museum-Digital project is an initiative, software package and platform that offers tools for both publishing and indexing information about objects. The Museum-Digital project consists of various portals, including international museum digital portals of Germany, Hungary, Brazil, Indonesia, Austria, Switzerland, and Ukraine. The Museum-Digital Ukrainian portal contains information on 4,609 objects in 207 collections of 29 museums (Figure 4) [20].

Among them are the National Reserve «Zamky Ternopilya» (Castles of Ternopil), which includes 33 objects in 2 collections, and the National Museum-Reserve of Ukrainian Pottery in Opishne, which include 1 object. Museums publish and manage their collection data mainly in regional digital museum instances. However, published data is also aggregated in larger instances such as Museum-digital: global, which allows searching of all collections published on the Museum-Digital portal. Museum-Digital has developed a set of software solutions to facilitate an easy and inclusive process

of digitization in museums. Originally, Museum-Digital was founded to publish object information online, so the development of a public interface for viewing object information began.

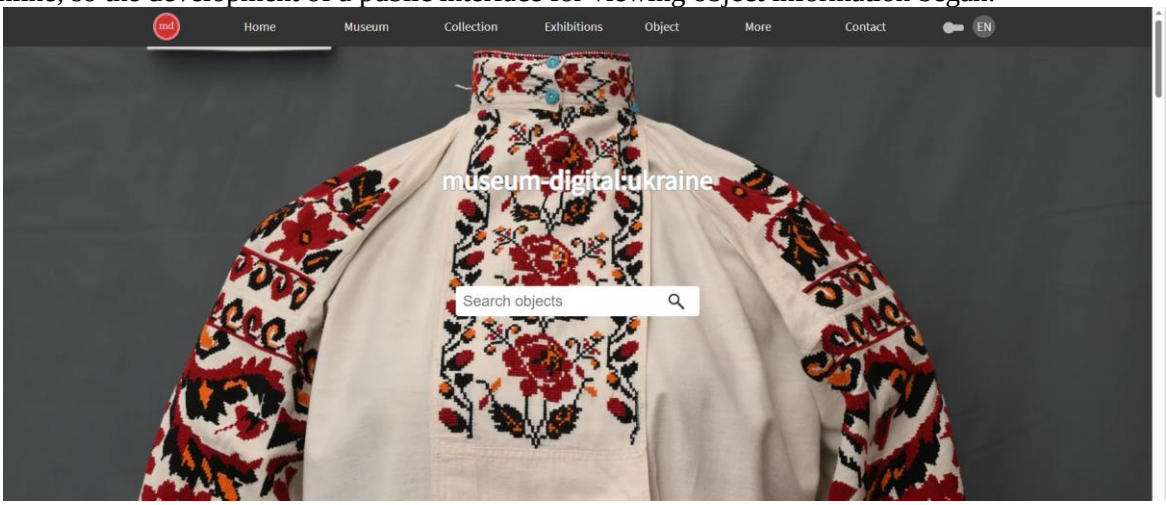

Figure 4: Museum-Digital: Ukraine [20]

The «frontend» of museum-digital is primarily designed to always offer a clear focus on whichever information is central to a given page or section. This allows for easy understanding. A lot of additional options exist for power users – from visualizations to a command line menu embedded into the website. As much as possible, the «frontend» provides information in open standards as well: object information can be accessed in LIDO, information about museums can be downloaded as electronic business cards (vCard), and calendar information such as exhibitions can be integrated with calendar tools using the iCalendar standard [21].

Since the original method of data input – the museums entered their data into their local database, sent it to the programmers, the programmers entered it to museum-digital – did not scale well, a simple online input interface, musdb, was developed. Some museums, that did not yet have a dedicated database for inventoried data, but knew musdb well, began to ask additional inventory functionalities. And thus, the approach of musdb changed: instead of being an input interface to a publication platform, it turned into an inventory tool with the option to publish. Musdb is museum-digital's tool for indexing and creating inventories. Originally developed for recording objects to be published only, it has since developed into a full-featured inventory and museum management solution. Central to the development of musdb are: musdb is developed based on requests by and communication with the museums using it; musdb is made with collaboration in mind: New features and fixes are available to all museums; using musdb means working collaboratively: the controlled vocabularies, that are used for linking people, times, places, and tags, are used together by all museums of a given language; working with musdb should be as easy and intuitive as possible; Tips and warnings are given not to just enter data, but to create high quality data [22].

Soon after, requests for options to more thoroughly present digital narratives and stories became more frequent. While museum objects may be interesting by themselves, it is also a central task of museums to contextualize them. As a reaction to these requests, the Themator as an independent tool for writing and publishing stories online was developed. The Themator is museum-digital's solution for digital story-telling. The Themator is structured around topics, which can be super- or subordinate to other topics and which can be associated with objects (both those entered only in the Themator and those published in any of the main portals of museum-digital), literature entries, and more. This focus on topics provides for a broad range of possible uses in the field of digital storytelling, especially where it relates to museum objects. On the one hand, the Themator can be used for creating digital exhibitions. On the other hand, it has been used to create learning materials (e.g., for teaching in German minority schools in Hungary). This, combined with the need to be able to embed objects from the different instances in the same topic, has led to design the Themator as a tool completely independent from the main instances [23].

Early on, when developing the main frontend and musdb, it was decided to use controlled vocabularies for all databases of a given language. Internally, «norm data control tool» nodac is used for curating these. Nodac is museum-digital's tool for curating controlled vocabularies. That means labeling, describing, translating, creating hierarchies of concepts and linking concepts to the corresponding entries in external repositories like Wikidata, GND, AAT, geonames, etc. As the primary management tool behind museum-digital's vocabularies it is essential for nodac to be trainable. In nodac, one can blacklist terms altogether, set up the automatic transfer of terms from one vocabulary to another and store permanent rewrites of terms to their canonical forms. Thus, it is built to facilitate not only a precise editing process, but also a sustainable one despite limited resources. Nodac is able to work with multiple polyhierarchical thesauri and follows the SKOS 2 standard. From the start, nodac has been written with linked open data in mind. It not only helps curating such links but also enables the automatic retrieval of data recorded at Wikidata, the Common Authority File [24].

Since the vocabularies have grown considerably since, and have become a useful resource on their own by now, a searchable frontend – md:term – has also been developed for these. Md:term is a browser for controlled vocabularies. Using it, one can navigate through hierarchies of keywords and places, view the description and translations of labels and concepts. Most importantly, the controlled vocabularies are made searchable and provided in a machine-readable format as much as in a human readable way [25].

As of August 10, 2023, the Museum-digital database contains records of 966,706 objects in 9,049 collections of 1,051 museums [26]. Therefore, Ukrainian museums have a real opportunity to join the European and international museum communities.

Archival Information Systems (AIS) is the first company in Ukraine that professionally and systematically works in the field of mass digitization of archival and library funds, and also implements information technologies in these areas. AIS provides high-quality mass digitization, data entry and content conversion services, as well as software solutions for content presentation and automation of internal workflows in Ukrainian archives and libraries. By creating electronic resources, AIS not only promotes the availability of unique Ukrainian documentary and book collections, but also ensures the safety of these materials, limiting the circulation of originals, supplying archives and libraries with modern scanning equipment, technologies and materials for the restoration and conservation of funds. AIS is the Ukrainian representative of the German company Zeutschel (scanning, microfilming and conversion systems); Czech EMBA (acid-free cardboard and products made from it like archival folders, boxes, etc.); the Dutch NESCHEN (materials for repair and restoration); German CCS GmbH (leading content conversion and metadata creation technologies); Czech Ceiba (the best technologies, equipment, tools and materials for restoration and conservation), and of many other companies [27]. ARCHIUM – a platform for creating a digital archive; its software complex allows you to create and present online separate document collections, as well as to form comprehensive electronic resources of state archives of a significant volume. LIBRARIA is a platform for creation, management and online (offline) presentation of library collections, including periodicals (newspapers and magazines) and books.

The full-scale war in Ukraine exposed problems in the field of preserving the cultural heritage, which included more than 140,000 monuments of architecture (of national and local importance), archaeology and monumental art; more than 12 million items of the Museum Fund of Ukraine; more than 4,500 museums (national, local, university, etc.). As of June 15, 2022, about 30 museums have been damaged, some of them completely destroyed [28]. And since almost all registration cards of exhibits were in paper form (according to tentative estimates, only 10-15% of museums keep their accounting documentation in electronic form), there is a threat of losing both the exhibits themselves and information about them [28]. Therefore, the core of the state's cultural policy is the creation of the National Cultural Heritage Platform, which will make it possible to implement projects for the creation of online registers of architectural and archaeological heritage and the electronic register of the Museum Fund of Ukraine, where museums will be able to independently integrate data on art objects that are stored, restored, transported etc. Such a digital transformation, in particular the creation of a unified state electronic monitoring and accounting system for the state museum fund, will allow you to quickly navigate the number, movement and condition of art works in each museum, as well as integrate into the global space through data exchange. It is envisaged that key public

registries will interact with each other to provide electronic services, so the trust in public electronic services will grow due to the creation of a secure infrastructure, in particular a digital identity system, secure data exchange and data quality. In addition, digitalization can provide an anti-corruption effect.

As part of the cooperation of the Ministry of Culture and Information Policy of Ukraine with the Ministry of Culture and National Heritage of Poland and Solidarity Fund PL, in 2022, the project «Implementation of the electronic system of the register of the Museum Fund of Ukraine» was launched. To date, work is underway to develop the basic software for the electronic system of the register of the Museum Fund of Ukraine. For effective work, a working group was created. It included representatives of 12 leading museums of Ukraine of various profiles such as historical, natural, archaeological, artistic, etc. The experience of the members of the working group allows us to take into account all the needs of modern museum staff and create a convenient and useful electronic system for recording valuables. These cultural institutions will take part in testing the prototype, analyse the required functionality, recommend changes and be the first to test future software. The next stage of system implementation involves an analysis of the level of computerization of museum institutions and already existing electronic accounting systems used in Ukraine. Based on the results of the first stage and feedback from the museums, the software developers will analyse the business processes implemented in the electronic system and finalize it. In the future, the task of the Ministry of Culture and Information Policy of Ukraine will be to ensure the registration in the system of all institutions authorized to store objects of the Museum Fund of Ukraine, and ultimately to abandon paper records. The project is implemented by the Representative Office of the Fund of International Solidarity in Ukraine and is financed by the Office of the Prime Minister of the Republic of Poland within the framework of the public task entitled «Implementation of the electronic system of the register of the Museum Fund of Ukraine».

Already in May 2022, the Ministry of Culture and Information Policy of Ukraine initiated the launch of the United Platform of Culture and Media during the War [29]. The platform contains evidence of the Russian Federation's war crimes, evidence of the destruction of the cultural heritage of Ukraine, unique photos and videos, examples of combating disinformation, military creativity, and much more. One of the projects posted on the platform – DESTROYED CULTURAL HERITAGE OF UKRAINE – records damaged and destroyed objects of cultural heritage and cultural institutions of Ukraine in the database.

The international community continues to help Ukraine preserve its cultural heritage. Saving Ukrainian Cultural Heritage Online (SUCHO) is an international volunteer initiative to safeguard the digital cultural heritage of Ukraine amidst the ongoing Russian invasion. Anna Kijas (Tufts University, US), Quinn Dombrowski (Stanford University, US) and Sebastian Majstorovic (European University Institute, Italy) launched the initiative on 1st March, 2022. SUCHO quickly garnered the support of approximately 1,000 volunteers within the first week of its launch. While the preservation of physical cultural heritage in Ukraine received considerable media attention, the vulnerability of digital cultural heritage became increasingly apparent. Digitized content and born-digital materials, including photographs and other files stored on servers, faced the risk of destruction or corruption during attacks or power outages. Even websites hosted outside of Ukraine were in jeopardy, if the websites owners were unable to meet their hosting expenses. Hence, the primary objective of SUCHO from the outset was to safeguard Ukraine's digital cultural heritage, with the intention of restoring the preserved files and data to their original institutions after the war. By June 2022, SUCHO volunteers successfully web archived over 50TB of data encompassing more than 5,000 websites. This vast collection offers a rich and diverse representation of Ukraine's tangible and intangible cultural heritage. The archived websites span a wide range of institutions, from local museums, music academies and theatres to monasteries, archives, libraries and programmes dedicated to children's and local history.

In addition, SUCHO curated selected materials into a publicly accessible gallery, while also amassing a collection of war-related memes enriched with metadata for future historical research. Digital repatriation is a core value for SUCHO. The goal is not to create an archive of Ukrainian culture that can be studied safely in the west, but to return this data to Ukrainian cultural heritage organizations in Ukraine when they are in a position to rebuild. SUCHO is only «data-sitting» for now while the war is ongoing. SUCHO is in touch with UNESCO and have been involved in early

conversations around a future National Digital Library of Ukraine, which may be a good long-term steward for the data, if desired by the organizations whose websites SUCHO archived [30].

SUCHO offers Ukrainian libraries, archives and museums free and unlimited file storage space through the NextCloud platform (Figure 5). This is possible thanks to the NextCloud's support and SUCHO's cooperation with the Wasabi server centre based in Europe.

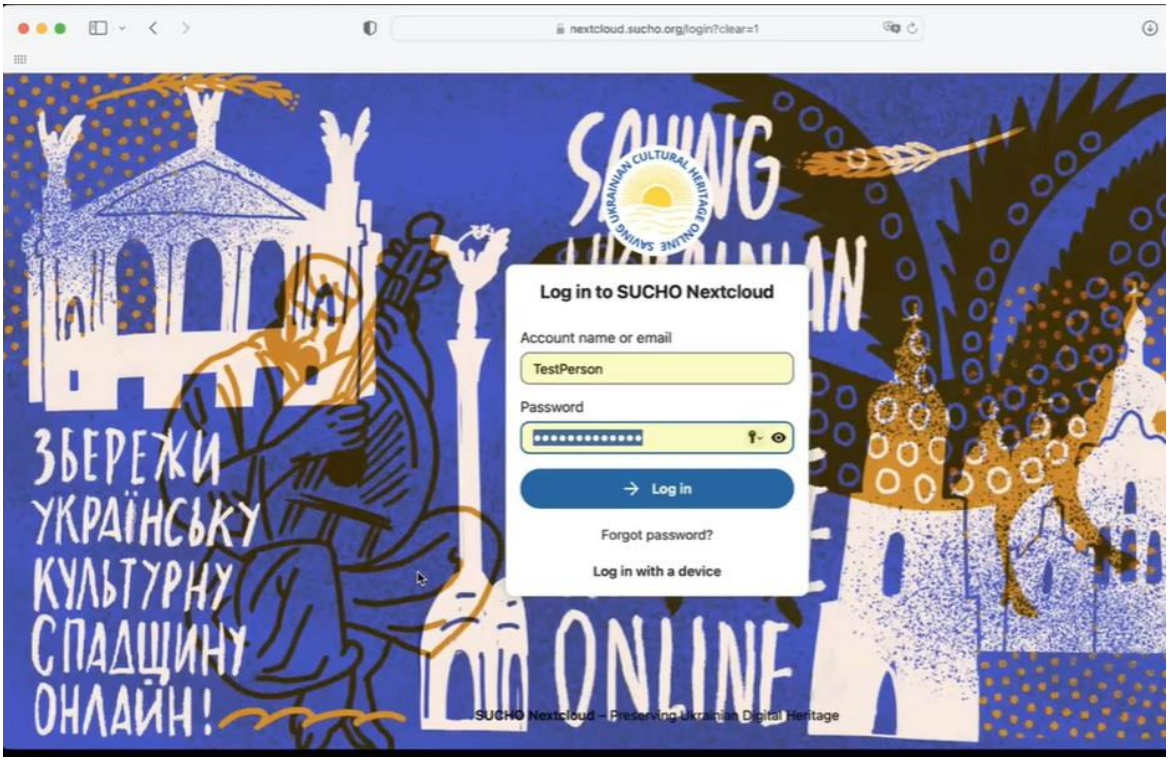

Figure 5: Login/registration form in SUCHO NextCloud

NextCloud is a cloud solution where you can store files, work with them, share them, etc. NextCloud can be used as an additional storage, as well as a place of operational work for institutions and organizations where employees work together by sharing files. Besides, SUCHO provided Ukrainian museum institutions with the opportunity to store an unlimited number of downloaded files (Figure 6).

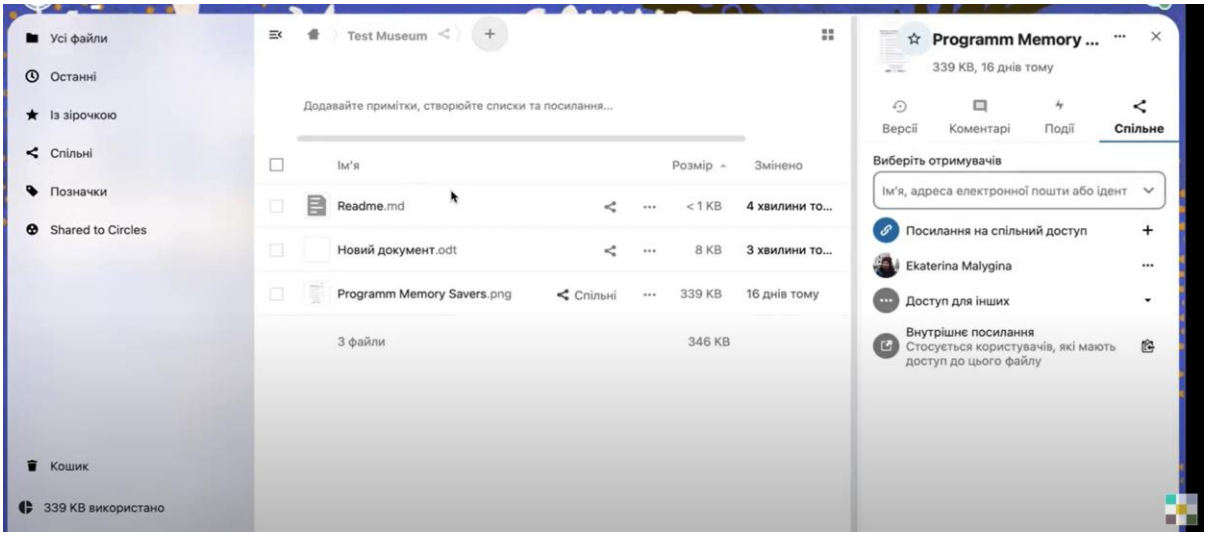

Figure 6: NextCloud home page in Ukrainian

4. Conclusions

Undoubtedly, the introduction of information technologies and large-scale digitization are becoming necessary steps for modern museums. These activities aim to ensure accessibility, preservation and dissemination of knowledge and cultural heritage. Large-scale digitization and implementation of information technologies in the museum industry are of great importance and provide numerous benefits, such as preservation and protection of cultural heritage (digitized documents and cultural relics become available online, which helps to preserve them from damage, loss or wear and tear over time.

So, in such a way important information and cultural heritage can be preserved for future generations); convenient access to information (digital resources become available to any user with Internet access. This makes it easy to search, obtain and use information without the need to visit institutions directly); dissemination of knowledge and education (digitized documents and resources are available to a wide audience, including students, researchers, teachers and the public. This contributes to the dissemination of knowledge, improvement of education and raising the cultural level of society); space conservation (digital collections reduce the need for large spaces to store exhibits. This is especially important for organizations with limited resources or in locations with limited space); increasing the efficiency (the use of information technologies allows automating the processes of digitization, indexing and data storage, which increases the efficiency of museums); quick access to information (searching for information in digitized databases takes less time than searching in paper archives or catalogues; this facilitates the work of researchers and users); ensuring long-term storage (the use of special data storage systems allows for long-term preservation of digital archives and resources, reducing the risk of data loss over time).

The powerful work of museum staff abroad, in particular in European countries, is a reference point for their Ukrainian colleagues. Numerous foreign organizations and foundations provide Ukrainian specialists with comprehensive theoretical, methodological and financial assistance. With their help, Ukraine has the opportunity to preserve the national cultural heritage for posterity.

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