# Multimedia Objects Representation in the Digital Knowledge Space [1]

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**Abstract**. The article presents the concept of digital space and its subspaces. Namely the digital libraries and the space of scientific knowledge (SSK). The core of SSK includes formalized knowledge verified by the scientific community and selected according to certain conditions. The paper proposes a number of steps to organize the creation of the SSK, as well as its filling and support. In particular, the digital library (DL) is considered as a means of integrating information resources. DL, in particular, is a complex of technological, technical and organizational solutions that ensures the formation and provision of a wide range of users of information resources in various areas. The paper give some examples of the use of new technological solutions to create tools to transfer images of physical objects into virtual space and introduce virtual content into physical space, for example, museums. In particular, a method is proposed for representing multidisciplinary scientific collections in the form of virtual exhibitions. Virtual exhibitions can effectively solve the problems of presenting information resources, including digital museum collections, integrated by digital library.

**Keywords**: Digital Library, Scientific Heritage of Russia, 3D-model, Museum Object, Virtual Exhibition.

## Introduction

The digital space on the whole is a virtual environment that includes information, entertainment, social resources. These resources can be divided into five main types [1]:

- Multimedia objects. Multimedia objects include photo, video, audio materials, 3D objects (both static and dynamic, including three-dimensional graphics and animation), various audio and visual effects, in addition, online media can be attributed to this type of resource;

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- Guides with open content. This type of digital resource includes the so-called unverified encyclopedias, i.e. freely editable reference resources (for example, Wikipedia), as well as verified online encyclopedias that are in free access [2].
- Digital printed copies. This type of resource by contrast with, for example, a multimedia objects representing scanned pages of a book presented in a pdf-files (a set of pictures), includes, in particular, full-fledged e-books with the ability to search by keywords, etc.
- Social networks;
- Information systems. This type of resource includes information and analytical databases (including state information systems, indexes of persons, bio-bibliographies, expert automated information systems and knowledge bases, etc.).

Inside the digital space "narrowly targeted" subspaces can be formed. For example, digital libraries (DL) which, in turn, can be "wide profiles" or "thematic". The Digital Knowledge Space (DKS) can be a subspace of digital space also. By DKS we will understand the digital environment when accessed by which any user whether a scientist or a high school student will receive answers to questions relating to various fields of science. The DKS should contain reliable science information based on fundamental scientific knowledge. In addition, the DKS should pool the resources of several different resources related to individual areas of science. Generally speaking, these resources must be connected with each other.

Thus, this subspace contains those information objects that are verified by the world scientific community, they are separated from information objects that are ideologically, religiously, and otherwise scientifically controversial [3]. Some formalized characteristics of scientific knowledge should be elements of the DKS. Specific scientific knowledge is specific to particular fields of science. But in almost every field two classes of knowledge can be distinguished - theoretical and experimental. The creation of the DKS content is based on the data already available in the entire digital space, but verified by the scientific community, in addition, this DKS is supplemented with specially created scientific content. A means of integrating information resources, in particular, is a complex of technological, technical and organizational solutions, associated by the concept of a digital library, which provides the formation and provision to general public users the information resources in various fields [4]. At the same time, DL can be part of the CPP (Figure 1).

Providing access to knowledge space objects is provided by the Internet.

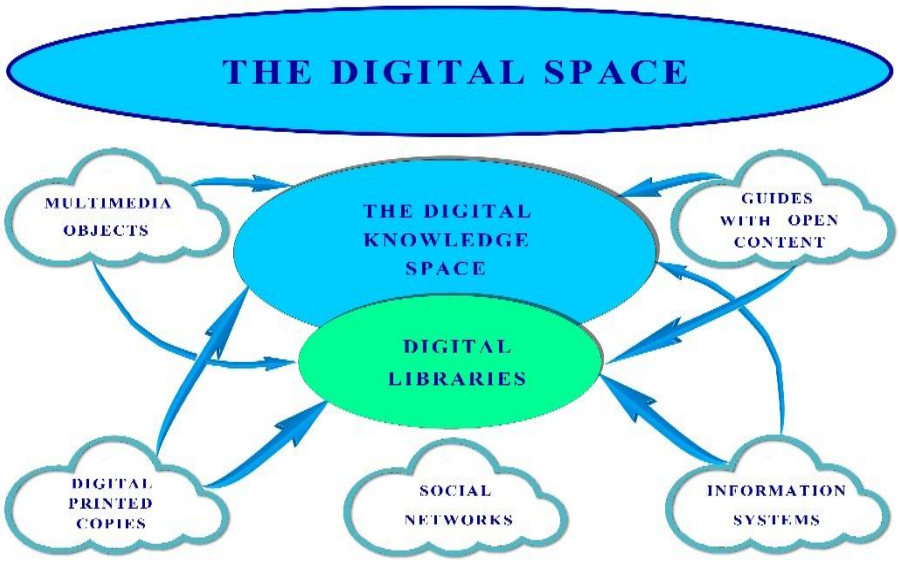


**Fig. 1.** Figure 1 - Representation of digital space

There are several large aggregators of information resources that provide access not only to digital copies of printed publications, but also allow you to view thematic collections or virtual exhibitions [5, 6].

Scientific digital libraries provide such services to a wide range of users as:

- Search in various scientific disciplines and sources in special databases;
- Search in various scientific disciplines and sources in full-text digital editions of major scientific publications of the world;
- Access to found information resources;
- Use of applications that turn digital libraries into a testing platform (virtual observatory, virtual chemical or biological laboratory, etc.);
- Scientific information integrity;
- Prevention of the loss of valuable scientific collections;
- Providing opportunities for scientific cooperation on a regional and international scale.

Thus, when creating a DKS it is necessary not only to solve the problems of generating DKS content, but also to visualize it for educational and scientific purposes. The content visualization of the DKS will effectively provide to the user with information about dynamic processes and volumetric objects (history monuments reconstruction, physical and technological processes modeling, visualization of solutions to equations of the mechanics or chemical reactions), as well as providing popular scientific content, for example, museum tours, etc.

Consequently, the DKS formation involves the development of special approaches and algorithms that are based on new principles. The existing information resources

cannot be its components, but should become sources for filling the central processing center.

## Digital library "Scientific Heritage of Russia"

The multifunctional information resource including various forms, methods and levels of material supply allows to integrate the information funds of various memory institutions. As the development and use of the new technological solutions, tools are created that allow you to transfer images of physical objects into virtual space and introduce virtual content into physical space, for example, museums.
The Digital Library “Scientific Heritage of Russia” (DL SHR) can be a prefigure of the DKS, because it forms the associated metadata of various types objects (persons, organizations, archival record, four corners of scientific publications, etc.).
DL SHR can serve as the DKS, including because it is an information resources integrator of various memory institutes (libraries, archives, museums).
This library is the integrator of memory institutes scientific resources. DL SHR provides the ability to multi-aspect search for objects such as "person", "publication", " museum object "," archival document ", and navigation on found resources [3]. Today DL SHR can act as a means of integrating electronic copies of library, archival and museum storage objects, presented in the form of texts, graphic images, audio-video objects, including three-dimensional objects.
The technology of digitizing library and archival objects has been developed quite well today [4]. However, when digitizing museum objects and integrating them into a single information resource, a number of difficulties arise. Namely:

- Creating high-quality, from the point of view of visual perception, digital 3D-models of museum objects;
- The formation of tools for the description objects information that provide convenient access to them;
- Digital 3D-models of museum objects integration into thematic collections;
- Information objects immersion in a digital library;
- Multidisciplinary multimedia digital collections creation;
- Virtual exhibitions formation.

Virtual exhibitions can effectively solve the problems of presenting information resources, including digital museum collections, integrated by electronic library [7].

## Creating a virtual 3D exposition

Virtual exposition is built not only on intellectual perception but also on emotions [8]. The design decisions that create an attractive exhibition image are important here. The use of texts, graphics, audio and video materials, spatial images (section "Virtual tour") will increase the information availability and will contribute to the new language formation that we speak with our audience [9].

Today, the museum collections objects are being transferred into digital form, which is due to the need to automate the museum collections accounting and the transition to a new level of these funds presentation.

For each collection type is used its own digitization technology. For paintings, large-format contactless scanning systems are used. Book collections are digitized with planetary scanners use. Space eating items, tridimensional objects and museum pieces are photographed. As a rule, many museums offer information about the museum's funds and access to individual digital copies of objects.

Attempts to provide more complete information about the subject than a "flat" photograph began with the stereo imaging technology creation, which is a photograph of an object taken by cameras from different angles. With the computer graphics technology advent, this idea development made a quantum leap. It became possible to store and represent the image of an object not only from 2 fixed points, but also from any point defined by the user. Because of three-dimensional modeling, a visual volumetric image of the object is created. The resulting object image can be seen on the monitor screen in various angles as a result of 3D modeling.

The photogrammetry method is one of the ways to build digital 3D models. It is based on determining the characteristics of objects such as shape, size, position in space, etc., from their photographic images. There are variety of methods for obtaining images today. It can be aerial photography with drone using or manual shooting on a tablet or phone. Let us name the created three-dimensional model of the object using photogrammetry "full-fledged" 3D model. That is, it can be used, for example, to recreate a high-quality copy of the original object on a 3D printer [10].

However, building a 3D model using photogrammetry is a rather time-consuming computational task.

For providing access to 3D models via Internet to general public users, we will use the so-called interactive animation technology. This technology does not imply the construction of a "full-fledged" 3D model, but is based on software changing (scrolling) a fixed set of object types (frames) using specialized interactive display programs that simulate changing the point of view of the original object. To create such an interactive animation, you need a set of previously shot scenes that will be used as separate exposure frames (Figure 2).

**Fig. 2.** A set of previously shot scenes that will be used as separate exposure frames of digital space

## Multidisciplinary collections representation

The organization of specialized virtual exhibitions is one of the ways to represent multidisciplinary collections in a grid environment. A virtual exhibition is an information resource that shows users diverse information (digital copies of printed materials, archival documents museum items, etc.) associated with certain criteria. Due to the fact that various types of materials are being presented in the forming digital science collections process there is a need to create multimedia objects. In particular digital 3D models of museum objects and virtual reality objects.

The following is the sequence of actions of multidisciplinary collections formation and presentation for the digital knowledge space (Figure 3).

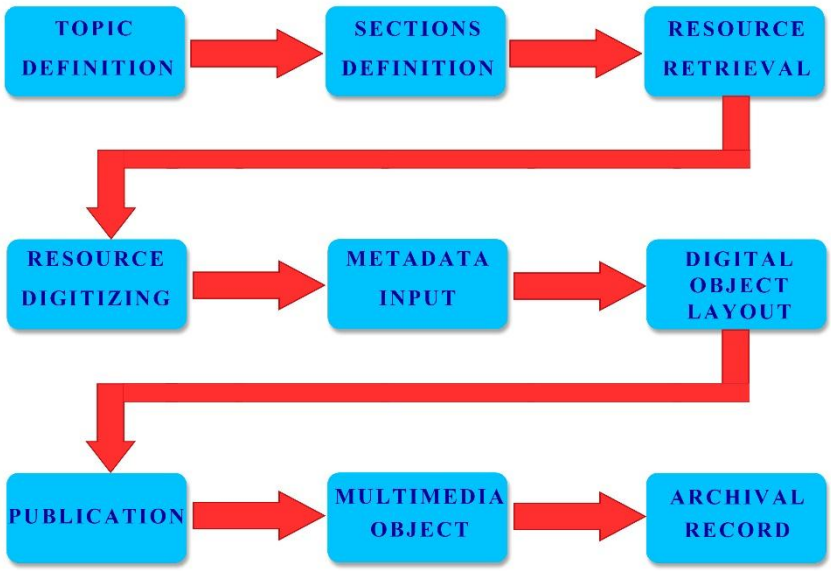


**Fig. 3.** The sequence of actions of multidisciplinary collections formation and presentation for the digital knowledge space

For the correct purpose multidisciplinary collections are divided into three types:

- Research;
- Scientific and educational;
- Teaching and educational.

Multidisciplinary collections combine the results and provide information support for basic and applied research.

Scientific and educational multidisciplinary collections are designed to disseminate scientific knowledge.

Educational or instructional multidisciplinary collections are created for various types of classes related, for example, to the programs of educational institutions, and contain lectures, audio and video materials, and other educational content.

The multidisciplinary collections include the following main types:

- A personal collection dedicated to the scientific heritage of a particular scientist;
- A thematic collection dedicated to any scientific field or scientific problem;
- A digest dedicated to especially important events in the history of science (for example, history of conquest of space);
- A corporate collection cross-sectional the history of scientific institutions and societies, scientific schools;

A referral collection containing encyclopedic and bibliographic information, archival guides, inventories and museum catalogs.

In spite of the fact that each multidisciplinary collection is unique in its content, the following main types of sections can be distinguished when forming such collections:

- The main topical section;
- Interactive section;
- Biographical section;
- Video materials section;
- Photo documents section;
- The digital library;
- "Collection of 3D objects" section;
- Feedback section;
- Contacts.

*The main topical section*. This section contains an information kit that reveal the main theme of the multidisciplinary collection. As a rule, these are articles (including opinion piece, written specifically to reveal the themes of the collection), rare photographs and images collections, excerpts from journalistic and periodicals.

*Interactive section*. The control elements of the section interface should enable the user to interact with the elements of the virtual exposure. The objective of this section is to increase the users interest (virtual exhibition visitors), the transition from an information susception to an active collection understanding. The main elements of the interactive section are scientific quizzes, intellectual games, 3D animations.

*Biographical section*. This section contains biographical details and scientists portraits.

*Video section*. The video materials in this section are documentaries, archival videos, and / or popular science films. Video viewing is implemented both in preview mode and in full-screen mode. It also implements all the necessary controls for watching videos. If there are any links to video materials that are freely available on the Internet, they are formed in this section too.

*Photo documents section*. The section, as a rule, contains unique photo documents provided by the project participants.

*The digital library*. The section presents publications on a given topic from the funds of the DL SHR. The section is arranged in interactive list of authors and publications, using which the user gets directly to the page dedicated to the scientist or his publication on the DL SHR website. Additionally, links to the publications that are freely available on the Internet are provided. If there are any publications haven't been digitized for some reasons, bibliographic lists are created in a format that allows to users to find these printings.

*"3D Collection" section*. The section is a gallery consists digitized 3D models of archival or museum objects. The items are digitized so that the user can examine each item in detail from all angles.

*Feedback section*. This section is created for feedback with site visitors. Here you can (after mandatory registration) exchange opinions, make various messages on the subject of the exhibition.

*Section "contacts"*. This section indicates the contacts of the administrator of the virtual exhibition for communication with him.

Sources of objects for presentation in the multidisciplinary collection are collections of library, archival, museum storage objects presented as digital copies of prints, manuscripts, audio-video objects or 3D models of archival or museum objects, biographical information and other information resources. Selected objects are united by a certain common set of properties and have a certain thematic relatedness [11].
To select the sources presented in the multidisciplinary collection, it is necessary to comply with the provisions of a copyright law. The multidisciplinary collection contains publications copies that are not fall within the purview of copyright law. Publications protected by copyright law require the letter of consent of the copyright holders.

## Creating virtual exhibitions examples

The described scheme for the multidisciplinary thematic projects formation was implemented in virtual exhibitions dedicated to the 160-th birthday of I.V. Michurin and the genetics development in the USSR [12] and the scientific heritage of M.M. Gerasimov [13].
The virtual exhibition "Forensic sculpture" dedicated to the M.M. Gerasimov's scientific heritage, created on the DL SHR platform in conjunction with the K.Timiryazev State Biological Museum (TSBM), the State Darwin Museum and the Russian State Archives of Film and Photo Documents (RSAFPD).
The exhibition deals with the scientific achievements of an anthropologist, archaeologist and sculptor Mikhail Mikhailovich Gerasimov (1907 - 1970).
Gerasimov's method is still used not only by anthropologists but also by criminologists. Gerasimov's heritage is kept in the museums collections and scientific organization.
In the course of work with the exhibition was created the digital 3D models of M.M. Gerasimov's anthropological reconstructions. Then this collection was integrated in the DL SHR environment. This virtual exhibition is an example of using the integration of information resources of libraries, archives and museums into a single thematic project [14, 15].
The logic of constructing a virtual exhibition "Forensic sculpture" is based on the construction of the person's connections (M.M. Gerasimov) with all elements of the DL SHR, including museum objects and collections.
The exhibition is divided thematically into seven sections.
*The first section is "About the project"*. Here is a summary of the exhibition as a whole, i.e. who M.M. Gerasimov is and his scientific interests and achievements.
*The second section is "Biography"*. This section is dedicated to the biography of the scientist. In this part is suggested an active list of memoirs and biographical articles about M.M. Gerasimov.
*The third section is "M. M. Gerasimov's personalia"*. Here the printings about M.M. Gerasimov and his scientific school.
*The fourth section is "M.M. Gerasimov's academic papers"*. This section presents the M.M. Gerasimov's print media included into the DL SHR.

*The fifth section is "Retrospect the Past. Reconstruction methods"*. This section is about the anthropological reconstruction methods, about the history of the anthropology development in Russia, and in this section the works of some M.M. Gerasimov's students also.
*The sixth section is "M.M. Gerasimov's works catalog"*. This section contains digital 3D-models of M.M. Gerasimov's sculptural works and attribution to them.
*The seventh section is "Documents of epoch"*. This section presents archival documents, newsreels and photo documents related to M.M. Gerasimov and his students.

## Conclusion

The described scheme for the multidisciplinary thematic projects formation was implemented in virtual exhibitions dedicated to the 160th I.V. Michurin's birthday and the genetics development in the USSR (http://vim.benran.ru/) and the scientific heritage of M.M. Gerasimov (http://acadlib.ru/).
The virtual exhibitions described above are examples of a fundamentally new effective solution to the problem of presenting museum objects virtual collections including 3D models integrated by digital library.
Researches and analysis of approaches to the formation and presentation of multidisciplinary digital collections revealed a number of problems associated with the visualization of 3D models museum objects. Namely, when constructing a 3D model by photogrammetry, the so-called "blind spots" of an object may appear, which leads to the formation of "artifacts" on the object itself during its visualization. This leads to the need for "manual" each model refinement.
The development of method to the presentation of interdisciplinary digital collections involves the formation of a method for constructing digital 3D models of museum objects, which allows removing or easing restrictions on limitations of the scanning device resolution and increases modeling accuracy. This method will allow increasing the image formation speed also. Along with this, such a method should provide the opportunity to create a unified methodology for integrating virtual thematic collections into a digital library environment.
Currently, there is a certain deficit in the methods of digitizing museum objects, primarily for 3D digital models building, their integration into a single thematic resource, and providing a general public users with modern multimedia technologies. Therefore, the technology for creating interdisciplinary thematic collections based on the collections of archives, libraries and museums needs to develop a unified approach to the formation of such collections and providing access to them. However, the technology for creating virtual exhibitions is a fundamentally new effective solution to the problem of presenting digital 3D collections of museum objects integrated by digital library.

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