Assessment of Efforts for Content Creation for the Common Digital Space of Scientific Knowledge

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Abstract: The article presents a labor cost calculation methodology for creating integrated digital content for the Common Digital Space of Scientific Knowledge (CDSSK). This methodology is demonstrated by the example of the content creation technology for the Digital Library "Scientific Heritage of Russia" (DL SHR) content. The content of the CDSSK contains rare (out of print, hard-to find) books and archival documents, which make digital copies of these materials very labour intensive. This needs to be assessed when planning the content filling for CDSSK. The developed technique includes the decomposition of the entire technological process into a number of operations performed by specialists of a certain profile (archivists, librarians, editors, scanners, etc.). Each phase is divided into several operations, and for every operation the time spent on this type of work is estimated. A unit of CDSSK content can be an archival document, a page of a book, a whole book, a biography of a scientist, etc. The assessment of the time period is carried out either according to published standards, or, in their absence, based on analysis of the experience of performing the operation when forming the content of the DL SHR. The article provides data on the calculation of time costs for individual operations of the formation of digital objects and their collections in relation to DL SHR, taking into account Russian standards and 15 years of experience.

1 INTRODUCTION

The Common Digital Space of Scientific Knowledge (CDSSK) is one of the most important objects of the modern information society. The space in its mathematical (formalized) conception is the set of some objects with certain rules for manipulation with them and the sets of axioms that these rules must follow. I.e., it is a set with the structure introduced on it (Antopol'skij et al., 2019). The global information space contains all the information accumulated by mankind in the process of its evolution, that was made available on physical media. It includes various kinds of documents available in printed, handwritten or electronic forms (publications, archival materials, scientific and technical documentation, etc.), photographs, film, video, audio materials, multimedia and 3D models of real-world objects (Abdelali et al., 2019).

The digital information space (DIS) is a part of the global information space. The digital space of scientific knowledge (DSSK) is a part of the DIS containing reliable fundamental scientific, educational and popular science information in various fields of science, presented in various forms. The Common digital space of scientific knowledge (CDSSK) is a computer environment containing the information represented in the DSSK. This information is well organized and provided to users

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according to uniform rules for all sciences. In other words, the CDSSK consists of a set of subspaces related to individual areas of science interconnected on the basis of an unified ontology to the whole space (Antopol'skij et al., 2019). This unified ontology includes a number of subject ontologies that describe individual scientific areas with the help of thesauruses and classification systems.

Each subspace of the CDSSK includes axioms and fundamental results that form the basis of each specific research area, as well as a dynamic part containing information on cutting edge science in this field.

For each separate field of science, specific scientific knowledge is defined for each individual field of science. There are two classes of knowledge in almost all areas of knowledge: ***a priori knowledge*** and ***experimental knowledge*** (Antopol'skij et al., 2019).

The DIS resources are a source of the CDSSK content. These resources should be analyzed for reliability, importance and relevance.

Scientific social networks provide numerous services for share information, posting research results, reviews and comments, search for vacancies, etc. (Kalenov et al., 2012).

The formation of the CDSSK involves the development of special approaches and algorithms that are based on new principles.

2 STRUCTURE OF THE COMMON DIGITAL SPACE OF SCIENTIFIC KNOWLEDGE

The space of scientific knowledge should include two components - static and dynamic. The static component is the fundamental theoretical and experimental data tested by time and practice. The dynamic component is a part of the CDSSK which includes new data and knowledge.

These components can be considered as two parts of the knowledge space. One of which - basis - contains fixed scientific knowledge, and the other - suspension - new scientific information. At the same time, after passing through an expert filter, the second part goes into the first (Sobolevskaya and Sotnikov, 2019).

The connections between the basis and the suspension can be managed at the level of an interdisciplinary scientific ontology. At the same time, the basis and the suspension are a class of subspaces (facets) in various scientific fields.

3 CONTENT OF THE COMMON DIGITAL SPACE OF SCIENTIFIC KNOWLEDGE

Information resources are the sources of scientific knowledge. They contain postulates, theories, experiments description, experimental results and are presented on physical storage media (Kalenov, 2014).

As a rule, the information contained in these resources is reliable and verified (Chen and Lu, 2015). However, an expert examination is required to decide what is to be loaded to the CDSSK. Experts should be qualified representatives of the scientific community in the relevant subspace area.

The basis and superstructure of the CDSSK consist of a ***kernel*** and a ***convex shell*** (Kalenov, Sobolevskaya, Sotnikov, 2019).

Digitized publications, archival materials, images of museum exhibits, multimedia materials, and thematic databases supported by scientific organizations form the ***convex shell*** of the CDSSK.

4 SHAPING CONTENT OF THE COMMON DIGITAL SPACE OF SCIENTIFIC KNOWLEDGE

The CDSSK is based on the principle of distributed data with centralized editorial processing, content downloading and technology support.

The digital library "Scientific Heritage of Russia" (DL SHR) (http://e-heritage.1gb.ru/Catalog/IndexL) has been operating since 2010. The DL SHR is based on the principle of distributed data with centralized editorial processing, content downloading and technology support (Sotnikov et al., 2017). More than 20 libraries, institutes and museums prepare information for DL SHR according to uniform rules.

Object-oriented design, data distributed technology, various digital scientific objects as well as the long-standing positive experience in the operating of the DL SHR allow us to consider as a prototype of the Common Digital Space of Scientific Knowledge (CDSSK) (Antopol'skij et al., 2019.).

In accordance with the DL SHR metadata standards bibliographical data related to scientists, their scientific interests in terms of classification, and a bibliography of their main works are entered into the library.

Librarians perform this work. It includes 3 stages:

- the search for sources of scientist biographical data and the compilation of a detailed biography;

- the selection of bibliography;
- the input of data into the DL SHR technological block.

Lets denote the average time spent on the implementation of each stage, respectively, through t_p^1, t_p^2, t_p^3.

Generating information on the scientist that is reflected in the DL SHR includes three times intervals.

The **first stage** (time interval t_p^1).

Analysis of the data of the DL SHR shows that on average, when compiling a biography of a scientist, the time spent on compiling a biography of a scientist from 2 to 3 sources is 15 minutes.

The time spent on library technical operations, related to the issuance and acceptance of items from the library stock, is normalized per item and total 13 minutes. Let us estimate that operations last about 30 minutes (considering that 2 items are to be loaned).

To estimate the time spent on compiling a biography of a scientist, we will use the rule “writing an abstract: studying and analyzing the document for which the abstract is being prepared; writing a text ", equating conditionally compiling a biography to compiling an abstract of selected publications). This rate per one author's sheet (40,000 characters) is 5920 minutes. An analysis of the data reflected in the DL SHR shows that the volume of the text of a scientist's biography ranges from 1000 to 31000 characters and is, on average, about 6000 characters, or 15% of the printed sheet. Thus, the standard time for compiling a biography of a scientist and entering it into the system is 888 minutes, the total time for completing the first stage of forming data about a scientist is $t_p^1 = 15 + 30 + 888 = 933$ minutes.

The span time on the implementation of the **second stage** (the formation of a bibliographic list of the scientist's publications) can be estimated on the time allotted for compiling a bibliographic index, which is 13500 minutes per author's sheet. Analysis of the data entered in the DL SHR shows that the bibliographic list of one scientist, on average, is 2200 characters, or 5.5% of the author's sheet. According to the norms, it takes 742 minutes to compose it.

The total time spent on creating digital library information about one scientist ($T_P = t_p^1 + t_p^2 + t_p^3$) is 1681 minutes or (rounded up) 28 hours of work for a librarian.

5 PREPARING IMAGES OF SCANNED ARCHIVAL RECORDS

Suppose the personal data is entered into the system. Then the technological processes that is carried out in order to prepare the publication for inclusion in the DL SHR are presented in Table 1. We understand an archival document as a paper document. Digitizing a photo and video archive requires much more labor than digitizing paper documents.

Table 1: Technological processes carried out in the preparation of the archival record for inclusion in the DL SHR.

Stage number	Project scope	By whom	Accounting unit	Time
1	Selection and input the archival record proposed for inclusion in the digital library;	registrar	archival record	t_k^1
2	Application consideration	Editorial team member	archival record	t_k^2
3	Getting and introduction the archival record from the Archive;	registrar	archival record	t_k^3
4	Sending for scanning, preparing archival record for scanning	registrar	archival record	t_k^4
5	archival record Scanning	Scanner-Operator	archival record page	t_s^1
6	Image processing	Technical Specialist	archival record page	t_s^2
7	Archival record metadata quality control	Editor	archival record	t_k^5
8	page metadata and navigation system quality control	Editor	archival record page	t_s^3
9	Downloading the digital archival record into the DL SHR	Technical Specialist	archival record	t_k^6

Thus, if an archival record of N pages is entered into the DL SHR then total span time T_A for its inclusion in the Library will be:

$$T_A = \sum_{i=1}^{6} t_k^i + N \cdot \sum_{i=1}^{3} t_s^i \quad (1)$$

When assessing the labor costs of registrars t_k^1, t_k^3 and t_k^4, we will use considered norms for archival documents digitization (42 minutes per document), “indexing (meaningful cataloging)” (7 minutes per document) and “entering computer basic information about the document (author, title, etc.) in a specialized program” (6 minutes). The results are as follows:

$$t_k^1 + t_k^3 + t_k^4 = 55 \text{ min.}$$

We will take the experience in provisioning as a basis for DL SHR database provisioning and the norms for scanning documents in a non-contact method (this is the technology used in the DL SHR), presented in (Burrows, 2018; Bilgaiyan et al., 2019).

The rate for one employee is 45 archival records per shift. Based on this, we get

$$t_k^2 = 10 \text{ min}$$

The rate per operator for page scanning (step 5) is 200 pages per shift. It means that

$$t_s^1 = 0.15 \text{ min}$$

The main task of the **6th stage** (image processing) is to check and edit the graphic images of the digital pages.

The rate per operator during this stage is 200 pages per shift. Thus

$$t_s^2 = 0.15 \text{ min}$$

Stage 7 (archival record metadata quality control).

The day's work for one specialist is 10 archival records per shift, it therefore follows:

$$t_k^6 = 32 \text{ min.}$$

At **stage 8** (page with metadata and navigation system quality control), the issuing editor checks the layout of the archival record on the production server.

When certain defects are identified, the corresponding information is transmitted to the operator of the 6th stage. The norm for these works is 800 pages per shift, based on this, we get

$$t_s^3 = 0.3 \text{ min.}$$

At the **final stage**, the issuing editor publishes the archival record and metadata on the e-library portal and checks the availability of the downloaded information. The production rate for one specialist is 100 archival records per shift,

$$t_k = 19.2 \text{ min.}$$

Substituting the obtained values into formula (1), we find that the average time spent on digitizing and including one archival record of N pages in the digital library will be (in minutes)

$$T_A = 116.2 + 0.6 \cdot N$$

Registrar workers from this time spend

$$T_R = 55 \text{ min}$$

Editors

$$T_E = 57 + 0.3 \cdot N$$

Technical specialists

$$T_T = 87.5 + 0.15 \cdot N$$

Scanning operators

$$T_0 = 0.15 \cdot N$$

To prepare and enter into Digital Library (DL) the archival record of a scientist that was not previously presented in the DL, 100 archival in volume will take about 27 hours, including ~ 20.5 hours of work of registrar specialists, ~ 2 hours of work of an editor, ~ 1.5 hours of work of an operator- scanner, ~ 3 hours of work of a technical specialist. By introducing another archival record by the same person, the processing time will be reduced the work needs of registrars will be reduced to one hour, and the total preparation time for a archival record will be about 7 hours.

6 PREPARING IMAGES OF SCANNED BOOKS

If a book of M pages is entered into the DL SHR then total span time T_B for its inclusion in the Library will be:

$$T_B = \sum_{i=1}^{7} t_k^i + M \cdot \sum_{i=1}^{3} t_s^i \quad (2)$$

When assessing the labor costs of librarians t_k^1, t_k^3 and t_k^4, we will use, together with the already considered norms for the selection of literature, the norms for "forming a bibliographic record for documents in a language (descriptive cataloging)" (18 minutes per document), "indexing (meaningful cataloging)” (18) and “entering computer basic information about the document (author, title) in a specialized program” (5 minutes), “preparing documents for microfilming and scanning documents” (5 minutes), “transferring documents for microfilming and scanning” (16 min.). The results are as follows:

$$t_k^1 + t_k^3 + t_k^4 = 75 \text{ min.}$$

Consider the processes (indicated as stages in Table 1) performed by the staff of the editorial team, scanners and technicians. As a basis. We will take the experience in provisioning as a basis for scanning documents in a non-contact method (this is the technology used in the DL SHR), presented in (Ali and Gravino, 2019; YUmasheva YU.YU., 2012).

The rate for one employee is 30 books per shift. Based on this, we get

$$t_k^2 = 16 \text{ min}$$

The rate per operator for page scanning (step 5) is 800 pages per shift. It means that

$$t_s^1 = 0.6 \text{ min}$$

The main task of the **6th stage** (image processing) is to check and edit the graphic images of the digital pages.

The rate per operator during this stage is 800 pages per shift. Thus

$$t_s^2 = 0.6 \text{ min}$$

The main tasks of the **7th stage** are:

- formation of the table of contents of the book (recognition and editing of text or its manual input);
- layout of an e-book in a special program based on prepared high-quality graphic formed pages and a generated table of contents;
- creation of the most accurate navigation system of the digital book.

In the process of creating a navigation system, the technician must ensure:

- the correctness of typing, titles, notes and other parts of the navigation system;
- the correctness of the electronic links and the navigation system;
- completeness of the e-book: sequential number of pages, order of sections.

The day's work for one specialist is 5 e-books per shift.

$$t_k^5 = 96 \text{ min}$$

Stage 8 (book metadata quality control) includes:

- checking the correspondence of the author name, the title, the output data to those on the cove page;
- checking the formatting of records - spelling, punctuation, accepted word abbreviations in bibliographic data;
- checking the compliance of the information entered in the fields "type of publication", "language", "pages", the original. The "pages" field is verified strictly according to the electronic version of the book and includes the total number of files in the digital version, prepared for uploading to the site, checking for the presence of appropriate indexes;
- checking the formatting of the bibliographic description (according to standards).

The day's work for one specialist is 10 e-books per shift, from which follows:

$$t_k^6 = 48 \text{ min.}$$

At **stage 9** (page metadata and navigation system quality control), the issuing editor checks the layout of the e-book on the production server. The work of the editor includes the analysis of graphic images of the pages and checking the navigation system. It includes:

- checking the sequential display of pages;
- checking the quality of scanning (the degree of readability of the text, at least 99% of the information presented on the page must be readable);
- checking the quality of processing of scanned pages (correct page cropping, geometric text correction, absence of text bends and other distortions, absence of "extraneous elements" - stripes, shadows, operator fingerprints, etc.);
- checking links for their opening;
- checking links for compliance with the chapters and contents of the book.

When certain defects are identified, the corresponding information is transmitted to the operator of the 6th stage. The norm for these works is 1200 pages per shift, based on this, we get

$$t_s^3 = 0.4 \text{ min.}$$

At the **final stage**, the issuing editor publishes the book and metadata on the e-library portal and checks the availability of the downloaded information (Kozlova et al., 2019). The production rate for one specialist is 50 e-books per shift,

$$t_k = 9.6 \text{ min.}$$

Substituting the obtained values into formula (2), we find that the average time spent on digitizing and including one book of N pages in the digital library will be (in minutes)

$$T_B = 244.6 + 1.6 \cdot N \text{ (4)}$$

Library workers from this time spend

$$T_L = 75 \text{ min}$$

Editors

$$T_E = 64 + 0.4 \cdot N$$

Technical specialists

$$T_T = 105.6 + 0.6 \cdot N$$

Scanning operators

$$T_0 = 0.6 \cdot N$$

To prepare and enter into DL the first book of a scientist that was not previously presented in the DL, 200 pages in volume will take about 38 hours, including ~ 29.5 hours of work of library specialists, ~ 2.5 hours of work of an editor, ~ 2 hours of work of an operator- scanner, ~ 4 hours of work of a technical specialist (Kirillov S.A., 2009). By introducing a book by the same author the processing time will be reduced to one and a half hours, and the total preparation time for a book will be about 10 hours.

7 PREPARATION OF 3D DIGITAL MODELS OF MUSEUM OBJECTS

Along with digital publications DL SHR contains multimedia content and, in particular, 3D-models of museum objects. These objects can be associated with a specific person (or several persons) or they can be combined into an independent collection dedicated, among other things, to a certain research area or event. Estimated staff time required to create a 3D model and digital collections that include several objects will be discussed below.

Various methods are used to visualize a three-dimensional object (Kalenovet al., 2020). These methods can be based on SfM-technologies (Sotnikov et al., 2017; Wróżyński et al., 2017; Scopigno, 2017; Garstki, 2017), software and technological solutions used, in particular, in laser and optical 3D-scanning, photogrammetry methods (Guidi et al., 2020; Hosni and Idri, 2018).

For the formation of digital 3D-models in the DL SHR there was a model of interactive animation technology (Sobolevskaya and Sotnikov, 2019). This technology does not imply the construction of a full-fledged 3D-model based on a programmatic change (scrolling) of a fixed view of an object (frames) using standard interactive display programs that simulate a change in the point of view of the original object. To create such an interactive cartoon, you need a set of pre-prepared scenes that will separate exposition frames.

Before proceeding with the formation of digital 3D-models of museum objects in order to include them in the electronic library, it is necessary to carry out certain preparatory work performed by the staff of the museum, which owns the modeled object.

The standard time T_0, desired for preparatory work is, on average, 130 minutes per object.

After these preparatory works is completed, the main cycle of work begins on the creation of a digital 3D-model of the museum object.

This cycle of work includes the following main stages:

1. Preparation for digitization. It means setting up an object at the shooting location, adjusting lighting, etc.
2. Digitization of the object. The end result of this stage is an array of data, files with photographs of the object taken from 120 angles;
3. Processing of the data set obtained at the first stage. At this stage, the background on which the image was taken is removed from each photo. This is done using a software module specially designed for this stage;
4. Layout and quality control of the digital resource image. The result of this phase is digital 3D-images of museum items.
5. Description of the museum item, the digital 3D-model of which is included in the digital library. The museum staff does this work.
6. Loading the generated model into the DL SHR.

Lets $T_1, T_2, T_3, T_4, T_5, T_6$ - time intervals required for processing one museum object at stages 1-6, respectively.

Table 2 shows the technological processes carried out in the creation of museum 3D-objects for inclusion in the DL SHR.

Table 2: The technological processes carried out in the creation of museum 3D-objects for inclusion in the DL SHR.

Stage number	Project scope	By whom	Accounting unit	Time
1	Preparing for digitizing	Museum employee	Museum object	T_1
2	Digitization of the object	Technical Specialist	Folder containing 120 jpg files for each object photographed	T_2
3	Processing of the data set obtained at the first stage	Technical Specialist	obtained files	T_3
4	Layout and quality control of the digital resource image	Technical Specialist	Digital 3D-object	T_4
5	Description of the museum item, the digital 3D-model of which is included in the digital library	Museum employee	Digital 3D-object	T_5
6	Loading the generated model into the DL SHR	Technical Specialist	Digital 3D-object	T_6

Thus, if there are M digital museum 3D-objects are introduced into the DL SHR then the average time T_{av} for the inclusion of this volume of digital resources in the DL SHR is:

$$T_{av} = M \cdot \sum_{i=0}^{6} T_i$$

After several objects have been digitized, they can be combined into one or more collections. Let T_k be the average time required to form and describe a collection. Then the total time T is the total for the formation of a digital collection of museum 3D objects is:

$$T = T_{av} + T_k$$

The following are the numerical values of the average time spent on the formation of digital 3D-models of museum items based on the experience of creating content in the DL SHR. In the process of replenishing the digital library content, more than 100 3D-models of museum items were prepared, combined into several collections. Among them is a digital 3D-collection of models of fruits by I.V. Michurin, stored in the State Biological Museum named after K. A. Timiryazev (GBMT), digital 3D-collection of anthropological reconstructions by M.M. Gerasimov, stored in the GBMT and the State Darwin Museums (http://acadlib.ru/; http://vim.benran.ru/).

The average time values $T_1, T_2, T_3, T_4, T_5, T_6$ are given below, based on the experience of formation, including these collections.

To implement the first stage (preparation of an object for digitization, interval T_1), an average of 45 minutes is required.

To implement the second stage (digitization of the selected content, interval T_2), on average, 20 minutes per object.

To implement the third stage (processing the files obtained as a result of digitization, time interval T_3), an average of 290 minutes per object is required.

To implement the fourth stage (layout and quality control of the image of a digital resource, time interval T_4), on average, 25 minutes per object is required.

To implement the fifth stage (description of a digital 3D-object, time interval T_5), an average of 15 minutes is required per object.

To implement the sixth stage (loading a 3D-object into the DL SHR, time interval T_6), on average, 35 minutes are required per object.

Thus, the total time spent on presenting one digital 3D-model of a museum object in the DL SHR is:

$$T = 45 + 20 + 290 + 25 + 15 + 35 + 130 = \\ = 560 \text{ min.}$$

To generate at least 40 digital 3D-models of museum objects (time T_k), an average of 180 minutes is required.

When forming a digital 3D-collection of anthropological reconstructions, M.M. Gerasimov was created and uploaded to the site http://acadlib.ru/, integrated with the DL SHR, 50 works by M.M. Gerasimov. The total time taken to create this collection was:

$$T_{Ger} = 415 \cdot 50 + 180 = 28\,180 \text{ min.}$$

That is approximately 470 hour.

8 CONCLUSIONS

Using the results obtained, it is possible to solve the problem of optimizing the time spent on creating digital copies of printed materials and museum objects by paralleling "technological processes performed by library or museum specialists (preparation of object metadata) and technical specialists (digitization of materials and quality control).

The estimates can be further extended for the digital copies creations of the other types of objects and to be used for work planning on the formation of the Single Digital Space of Scientific Knowledge.

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