Some Estimates of Labor Contribution for Creating Digital Libraries

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Abstract: One of the main directions of modern technological development is the digitalization of various areas of activity. In the science, this forms integrated digital libraries include various digital objects, including digital copies of printed publications, 3D models of museum items, digitized images, audio and film materials. Scientific digital libraries are characterized by high requirements for the quality of digital copies of printed scientific sources, since any ambiguity or contamination within chemical formulas or mathematical expressions can lead to erroneous perception or misunderstanding of the meaning. Special requirements for digital copies are also imposed when digitizing rare editions and archival documents that are of scientific and historical value not only in their content, and in the notes of scientists in the margins of a book or archival document. Requirements for the quality of digitized materials determine the significant labor intensity of preparation; it is necessary to evaluate it when planning work on filling scientific libraries. This article contains a calculation methodology of span time for creating integrated digital scientific libraries using the example of the technology of forming a digital library "Scientific Heritage of Russia" (DL SHR). DL SHR contains detailed information about scientists, their most important publications (digital copies of full texts), related archival documents, as well as 3D models of museum items related to their activities. The developed methodology includes the decomposition of the entire technological process into a number of operations performed by specialists of a certain profile (librarians, editors, scan-operators, etc.). Each stage is divided into several operations, for each of which the time spent on the execution of works assigned to the unit within this operation is estimated. Such units can be a page of a book, an entire book, a biography of a scientist, etc. Span time estimation is carried out either from the published standards, or, in their absence, from the analysis of the experience of performing this operation. The article provides data on the calculation of time costs for individual operations, the formation of digital objects and their collections in relation to DL SHR based on Russian standards and 10 years of experience.

1 INTRODUCTION

The creation of digital libraries is one of the most rapidly developing field in computer science. In the world today there is a huge collections of scientific information a huge number of collections of scientific information resources called digital libraries. These digital libraries contain different thematic and types of management, use different approaches to the formation of their funds (content). It should be noted that although the term "digital library" is used in a great number of publications, a single clear definition of it has not yet been given. Not referring to the term that was discussed 20 or more years ago, we will give several definitions related to modern times.

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In some publications (Jupp, 1997; Schwartz, 2000) the term "digital library" is defined as an information system that allows you to keep secure and give full play to various types of digital documents (text, visual, audio, video, etc.), localized in the system itself, as well as available to it through telecommunication networks.

Presently scientific publications (Bogdanova, 2017; Parn, 2017) indicate that "Digital libraries" (DL) are forms of complex distributed information systems, providing new opportunities for working with heterogeneous information. DL are considered as the basis for creating a global distributed repository of knowledge. Actually the authors of these articles point out that does not exist a single generally accepted definition of the digital libraries.

Here are some definitions (https://dic.academic.ru/dic.nsf/fin_enc/31885) of the term "digital library":

Digital libraries are organized collections of information resources and associated tools for creating, archiving, sharing, searching, and using information that can be accessed electronically (https://www.encyclopedia.com/literature-and-arts/journalism-and-publishing/libraries-books-and-printing/digital-libraries).

A digital library, digital repository, or digital collection, is an online database of digital objects that can include text, still images, audio, video, digital documents, or other digital media formats. (https://en.wikipedia.org/wiki/Digital_library).

Without going into the discussion of the above definitions, we note that, no matter how the term "digital libraries" is interpreted, a special technology is needed to implement in practice an "access network", "information system" or "ordered collection". Provision of information resources to users is what unites the traditional and digital libraries. Both libraries should create a reference apparatus that allows a user to find what interests him among the resources that the libraries provide. For traditional libraries, these are various kinds of catalogs (including electronic ones) with search elements that have developed in many years of library practice. For digital libraries (in the broad sense of this term) - metadata bases with a search interface of varying complexity (Chen, Lu, 2015). The formation of electronic libraries is often associated with the need for purposeful digitization of certain publications. First of all, this is typical for scientific DL, formed according to narrow thematic or other fixed principles.

Creation and maintenance of digital libraries is labor intensive. Some labor relate to the DL ontology (the choice of the database structure, the definition of classes of objects included in the DL and their relationships, metadata profiles and information presentation formats) or the creation or adaptation of the software shell (Kozlova, 2019).

DL maintenance is constantly required and the amount of work involved in its maintenance is not so much related to technical support, but rather to the creation of content. But with the formation of content, including both digital objects themselves and their metadata, which ensure the quality of search.

The subject of this article is the assessment of permanent labor contributions to support digital libraries using the example of the Digital Library "Scientific Heritage of Russia" (Kalenov, Savin, Serebryakov, Sotnikov, 2012; Kalenov, 2014; Sotnikov, 2015; Zabrovskaya, 2017).

The digital library "Scientific Heritage of Russia" (DL SHR) (http://e-heritage.1gb.ru/Catalog/IndexL) has been operating in Ethernet mode since 2010. The main goal of the DL SHR is to create, preserve, and provide access to accurate and reliable information about outstanding scientists who have contributed to the development of Russian science and scientific achievements. The DL SHR contains biographical information about scientists, the major publications (bibliography and scanned full texts), archival information and museum objects related to them. The library includes text information, digitized prints, archival documents, photographs and films, 3D models of museum items.

To date, the DL SHR provides information on more than 6100 scientists who worked in Russia from the 18th to the first quarter of the 20th centuries; about 25,000 books published during this period have been digitized and available to users.

The DL SHR is based on the principle of distributed data with centralized editorial processing, content downloading and technology support. More than 20 libraries, institutes and museums prepare information for DL SHR according to uniform rules.

The task of content providers the selection of materials in accordance with the principles, the formation of metadata about the inclusion of objects in the DL SHR (personalities, publications, archival documents, museum items, photographs, multimedia materials), the digitization of publications and information processing in accordance with the rules of the system (for DL SHR adopted, according to which the scanned text is not recognized, with the exception of the table of contents, the transfer of processed materials to the editorial group.

The editorial team performs the following functions:

- makes the final decision on the inclusion of publications proposed by providers in the digital library;
- metadata validation;
- prepares the editions that have passed the control for loading into the software shell of the demo part of the digital library.

The object-oriented approach chosen in the design of the DL SHR, the use of distributed data preparation technology, the reflection in the DL SHR of various digital objects of scientific purpose and positive experience of many years of its operation allows to consider the DL SHR as a prototype of the Common Digital Space of Scientific Knowledge (CDSSK) (Antopol'skij, Kalenov, Serebryakov, Sotnikov, 2019.). The creation of the CDSSK is the most important challenge for the development of a system (that will provide scientific, educational and cultural informational support and preserve scientific data and knowledge) for scientific educational and cultural (informational) support and preservation of scientific data and knowledge.

In this regard it is important to build a labor input model for the CDSK on the basis of the DLSHR operating experience. The model is built on examples of the most labor-intensive processes, which are the digitization of printed publications (the formation of electronic books) and the creation of 3D models of museum objects.

2 THE DIGITAL COPIES OF BOOKS PREPARING

The DL SHR content is determined according to the principle "from person to publication". Therefore, to include a book in the DL SHR content, it is necessary to enter information about its author first (first stage).

To determine the scientific interests of the selected person, a universal hierarchical classification (K) of knowledge areas is used. This classification is adopted to systematize the entire flow of scientific and technical information.

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 four stages:

- the search for sources of scientist biographical data;
- 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.

Suppose he information is entered into the system, then the scientific technological processes carried out in the preparation of the publication for inclusion in the DL SHR are presented Table 1.

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

Stage number	Project scope	By whom	Accounting unit	Time
1	Selection of the publication; Input into the technological block of primary metadata of the publication including connections with persons	librarian (organization - participant of the project)	Book	t_k^1
2	Application consideration	Editorial team member	Book	t_k^2
3	Getting the book from the library stock; the introduction of extended metadata of publications (including the serialization of the book to classification K)	librarian (organization - participant of the project)	Book	t_k^3
4	Sending for scanning, preparing a book for scanning	librarian (organization - participant of the project)	Book	t_k^4
5	Page Scanning	Scanner-Operator	Page	t_s^1
6	Image processing	Technical Specialist	Page	t_s^2
7	Table of contents processing; digital book build	Technical Specialist	Book	t_k^5
8	Book metadata quality control	Editor	Book	t_k^6
9	Page metadata and navigation system quality control	Editor	Page	t_s^3
10	Downloading the digital book into the DL SHR (link start-up between the book layout and metadata)	Technical Specialist	Book	t_k^7

Thus, if a book of N pages is entered into the DL SHR the total span time T_B for its inclusion in the Library will be:

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

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

To implement the **first stage** (time interval t_p^1), it is necessary to perform the following operations:

- selection of authoritative publications (primary documents);
- obtaining information about the scientist, ordering Items from a library;
- delivery from storage;
- issuing to the user (in this case, to the employee compiling the biography of the scientist);
- compiling a biography of the scientist based on information from the publications received;
- returning the publications to the funds.

The time spent on the selection of publications can be estimated using the norm “Implementation of thematic information; search and selection of documents ". Analysis of the data of the DL SHR shows that on average, when compiling a biography of a scientist, from 2 to 3 sources are used) is 15 minutes.

Technological operations of library related to the issuance and acceptance of editions of the funds are normalized per edition 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 basis of the norm for compiling a bibliographic index, which is 13500 minutes per author's sheet. The volume of the bibliography of the first year of his activity - the average number of publications by one scientist has increased several times over the last century in his scientific activity. 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.

Entering structured data about a scientist can be interpreted as the operation “typing on the keyboard information about the reader: last name, first name, patronymic, characterizing his characteristics (education, specialty, other information.” According to the norms, 6 minutes are given for this operation.

Thus, 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 of a librarian.

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: $t_k^1 + t_k^3 + t_k^4 = 75$ 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 of the 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 (YUmasheva YU.YU., 2012).

The results are as follows (stage 2 in Table 1), an employee of the editorial group decides to enter the input into the digital library of books proposed by the project participants. To do so an item is checked according to the following parameters:

- compliance with the system journal of the library;
- compliance with copyright rules;
- detection of duplication of bibliographic record rules. Then a unique number is then assigned to the e-book (ID). If the item (book) cannot be registered, a note is made a mark is made indicating the reason for such a decision. The rate for one employee is 30 books per shift. Based on this, we get $t_k^2 = 16$ min.

The rate per operator for page scanning (step 5) is 800 pages per shift. It means that $t_s^1 = 0.6$ min.

The main task of the **6th stage** (image processing) is to check and edit the graphic images of the digital pages. It includes three technological processes:

- automatic scan processing by a special program - automatic processing;
- manual correction.

As a result of the first process, typical scanning defects are corrected to an acceptable level.

The second process involves:

- checking the sequential display of pages (page numbering should be sequential, search for pages missed during scanning);
- checking the quality of scanning (the degree of readability of the text, at least 98% of the information presented on the page must be readable);
- Checking the quality of automatic processing of scanned pages (correct page cropping, geometric correction of text, text bends and distortions);
- the simplest editing of scanned pages (cropping, removing extraneous elements).

As part of the third process, the pages are manually processed in one of the graphic editors. This stage is provided for the most complex editions, many formulas, tables, illustrations, etc. It includes:

- geometric correction of text, text bends and distortions;
- removal of extraneous elements on the pages of electronic books (operator's fingers, stripes, shadows, and other extraneous elements);
- color correction.

The rate per operator during this stage is 800 pages per shift. Thus $t_s^2 = 0.6$ 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: $t_k^5 = 96$ 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: $t_k^6 = 48$ 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 shortcomings 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 $t_s^3 = 0.4$ 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. The production rate for one specialist is 50 e-books per shift, $t_k = 9.6$ min.

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

$$T_B = 244.6 + 1.6 \cdot N \quad (2)$$

Library workers from this time spend $T_L = 75$ min.

Editors $T_R = 64 + 0.4 \cdot N$. Technical specialists $T_c = 105.6 + 0.6 \cdot N$.
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. By introducing another book by the same author the processing time will be reduced the work needs of librarians will be reduced to one and a half hours, and the total preparation time for a book will be about 10 hours.

3 LAYOUT 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. The estimated staff time required for creation of 3D-model (one object) and of digitals collections that include several objects will be discussed below.

Various methods are used to visualize a three-dimensional object (Kalenov, 2020; Scopigno, 2017; Garstki, 2017; Guidi, 2020; Medina, 2020; Hipsle, 2020).

The photogrammetry method (Lobanov, 1984; Carstensen, 1991) allows you to build a high-quality 3D-model with the transfer of the texture and color of the object. However, computationally, building 3D-models from a set of images using the photogrammetry method is a rather laborious task. For example, the processing of 124 photographs on one of the nodes of the MVS-10P cluster (http://new.jscc.ru/resources/hpc/#item1587) installed at the MSC RAS took 41 hours of calculations (Sobolevskaya, 2019).

For the formation of digital 3D-models in the DL SHR there was a model of interactive animation technology (Sobolevskaya, 2019). This technology does imply the construction of a 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 be separate exposition frames.

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

This work includes:

- Selection of an object for digitization with the documentation preparation;
- Inspection of the object for preservation with the preparation of a protocol of inspection or entry into the register of museum items;
- Issuance of an object for digitization.

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

After these preparatory work 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. Preparing for digitizing. It means setting up an object at the shooting location, adjusting lighting, etc.
2. Digitization of the object. To carry out this work, a special complex based on a specialized rotary platform and a digital camera. 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 did 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 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.

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 the 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: $T_{Ger} = 415 \cdot 50 + 180 = 28\,180$ min. That's about 470 hours.

4 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 methods 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 obtained can be further extended to create copies of other types of institutions for planning work on the formation of a single digital space of scientific knowledge.

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