Intelligent text recognition when creating audio books for blind people

Reconocimiento inteligente de texto al crear audiolibros para personas ciegas

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Abstract

In the work, two variants of audio input for the children's book using Braille font "Kvasko and Katrusya", which is intended for partially sighted and blind children of primary school age, are investigated. In the first, specialized software is used to create an audiobook and announcers' voices, in the second - text recognition of the prepared original layout and automatic generation of an audio file. In order to determine a more effective technology for the production of audio applications, an expert evaluation of these applications was conducted, and recommendations were developed for the use of multimedia technologies for inclusive editions.

Keywords: inclusive literature, Braille, audiobook, audio editors, expert methods, portfolio method.

Introduction

According to WHO data, there are 180 million people worldwide with visual impairments, approximately 45 million of whom are completely blind, while 135 million have low vision. Annually, the number of blind individuals worldwide increases by 1-2 million. If this trend continues, by 2025, there will be over 100 million people with visual impairments. The issue of blindness and visual impairment is particularly relevant in Ukraine, as it ranks fourth among the main causes of disability (Mylchenko, L., 2021).

In modern society, the e-book industry is gaining momentum. Readers desire access to information and literature, and affordable e-books can meet these needs. Publishers producing e-books are actively implementing various innovations to attract readers. One of the biggest innovations in this field is the development of enhanced e-books. Users can now enjoy not only text but also additional features such as audio, video, interactivity, and more.

Thousands of books in Braille are published worldwide annually, but only a small portion of them are produced in Ukraine. This is primarily due to a lack of funds. The cost of printing one Braille book can reach $50-60, which is quite high for people with disabilities. Print runs in Ukraine usually do not exceed 300 copies (Chebotarova, M., Silchenko, V., & Chebotarova, I., 2020).

With the advent of widespread computerization, alternatives to printed books have emerged, such as audiobooks, speech synthesizers, and DAISY format interactive books — audio with text search capabilities. However, special education teachers and activists unanimously assert that nothing can fully replace printed books. A child who does not read Braille will not be able to learn to write it, and even adults lose their skills without practice. Additionally, we must not forget about deaf-blind individuals: for them, tactile sign language is essentially the only source of information and communication with the outside world.

In 2021, about 80,000 people with visual impairments lived in Ukraine, including almost 10,000 children. Even with the participation of volunteers and patrons, the situation with Braille book publishing in the country is far from satisfying existing needs (Mylchenko, L., 2021).

Therefore, transitioning to e-books or using multimedia applications for regular printed books significantly expands the publishing industry's capabilities to reach a larger audience. By choosing different multimedia features, the same books can be read by people with visual impairments, hearing impairments, and ordinary people alike. Developing optimal technologies for creating multimedia applications and using modern software and technical equipment for this purpose will not only make these books more engaging but also more accessible and affordable. Today, this is the main challenge of inclusive literature.

The article discusses various technologies for developing audiobooks for blind people and considers the features of text recognition technology in creating audiobooks.

Purpose.

The study focuses on the process of developing inclusive publications with audio supplements to enhance the efficiency of this technological process through the utilization of multimedia technologies.To analyze the potential of using multimedia technologies for Braille publications, a popular children's book in hardcover format was selected (see Fig. 1).

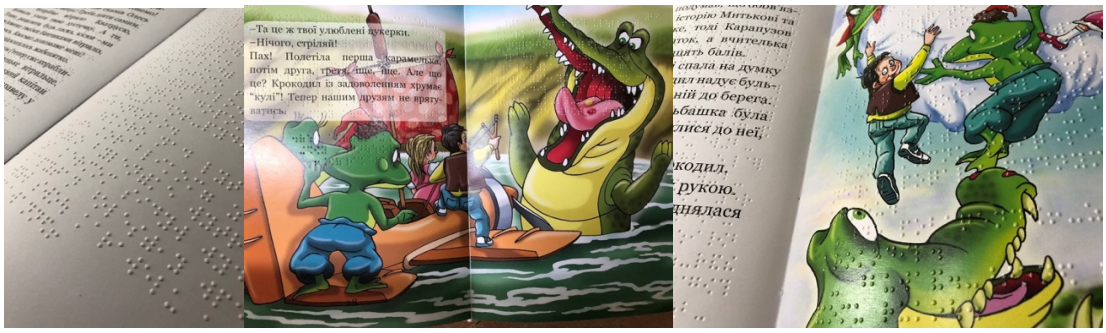

Figure 1. Examples of a page from a children's publication project printed in Braille font.
Source: Author's own elaboration.

The publication "Kvas'ko and Kvatrusha" belongs to the 2nd age category. Accordingly, there are additional requirements for publications in Braille: the Braille letter size is equivalent to 20 points of the standard Arial font, so it is advisable to use this font and font size for reproducing regular text in Braille; the number of characters per A4 page should be 26; the number of lines per A4 page should be 27; the font should be black on a white or yellow background (this color is perceived).

The layout of the publication "Kvas'ko and Kvatrusha" was developed in accordance with the requirements of state standards for the design of publications for the second age category and the use of Braille font. This book also includes tactile graphics. The use of Braille font, colored and tactile images for children with visual impairments, as well as regular fonts for reading by parents, significantly enhances the learning opportunities provided by this book. Additionally, audio accompaniment is being developed as a multimedia supplement to the book.

Objectives:

- Analysis of the requirements of the target audience.
- Analysis of technologies, materials, and equipment for producing Braille books.
- Analysis of software for developing audio supplements for inclusive publications.
- Development of audio supplements using various technologies.
- Expert evaluation and determination of the most effective technology for developing multimedia audio supplements for inclusive publications.
- Development of recommendations for the application of multimedia technologies for inclusive publications.

Challenges of publishing inclusive literature

The State Standard of Ukraine (Durniak, B.V., Tkachenko, V.P., & Chebotarova, I.B., 2011) does not regulate the definition of publications for the blind. Such publications differ from regular printed publications in terms of the nature of information presentation. According to the literature analysis (Onyshchenko, O.M., 2017), "publications for the blind" are publications intended for independent reading by the blind through touch or auditory perception using sound reproduction equipment. These publications use a special embossed dot matrix Braille font, and reading is done by touch of the fingers.

Most Braille publications in Ukraine were produced by the Republican House of Sound Recording and Printing of the Ukrainian Society of the Blind, which continues to operate, providing specialized libraries in cities across Ukraine with literature.

Private enterprises also help publish books in Braille. For example, LLC "Printing House 'Madrid'," with the help of sponsors, acquired a Braille printer. Since 2018, in addition to regular books, it has been issuing books in Braille through digital printing. In 2020, through cooperation between "Printing House 'Madrid'" and the civil organization "EU Experience," a private social library was opened in Kharkiv. The library features publications in Braille by Ukrainian and European authors (Chebotarova, M., Silchenko, V., & Chebotarova, I., 2020).

Since 2015, the charitable project "Book in Braille" of the Nechitaylo Family Foundation has been operating, which deals with targeted delivery of books and replenishment of library funds.

In many cases in Ukraine, visually impaired people prefer audiobooks, and this segment has its own peculiarities. Publishers pay attention to the quality of the recording, use special effects, and invite famous readers. That's why audiobooks are often very expensive.

And although some private philanthropists and companies send audiobooks to libraries and special schools, this remains the exception rather than the rule. The need for such books is still great.

Innovations in the e-book industry

Innovations in the field of e-books encompass various aspects, including the creation of interactive books for children, the development of software to improve reading and language learning, and the creation of adapted books for people with visual impairments. In the context of widespread use of computers and gadgets, alongside traditional printed books, new alternatives have emerged, including:

Audiobooks - these are audio versions of books that can be listened to instead of read. They provide people with the opportunity to study literature while traveling, exercising, or for those who have difficulty reading.

Speech synthesizers - these are programs that convert text into speech. They are useful for people with visual impairments or those seeking an alternative way to interact with text.

Interactive books in DAISY (Digital Accessible Information System) format - these are audiobooks that contain structured data, allowing users to navigate between sections, search within the text, and interact with the content using voice commands. Such books make content more accessible to people with disabilities (Kriachko, M.O., & Chebotarova, I.B., 2023a, Kriachko, M.O., & Chebotarova, I.B., 2023b).

These innovations help improve learning processes for children and people with special needs.

For example, the company "Pera Technology," with the support of the EU, is developing various technologies to simplify life for people with visual impairments. One of the recent inventions is a Braille display for reading electronic books. "Anagraphs" is a device that needs to be attached to electronic books or a personal computer. Using wax on a resistive touch screen, Braille text will be reproduced. The device was developed by experts from the Fraunhofer Institute for Photonic Microsystems (Germany), as well as companies "CK Productions," "Innora," and "Hobart Lasers." Currently, there are already electronic books for the blind, consisting of separate moving strips with holes for Braille letters. However, "Anagraphs" is easier to manufacture and cheaper (Mylchenko, L., 2021; Kriachko, M.O., & Chebotarova, I.B., 2023). In Ukraine, there are publishers who are dedicated to creating electronic books for people with visual impairments. Special electronic libraries are even being created where necessary books can be found and downloaded.

An example of this is the online library for people with visual impairments called "Lighthouse." The main site includes navigation instructions. A blind person needs to know 10 keys to use the "Lighthouse." All actions are voiced by the Ukrainian language synthesizer "Anatol," and the selected text changes color, so this library can also be used by people with poor vision (figure 2).

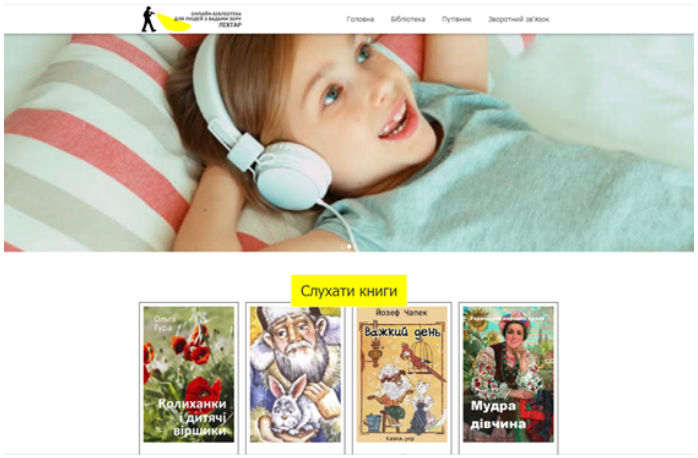

Figure 2. Homepage of the online library "Lighthouse"
Source: Author's own elaboration.

The library has a main website and a special service designed for blind or partially sighted individuals. The website is accessible to all users and can be navigated using a mouse, while the special service is tailored for blind or partially sighted individuals and is also tested by people with visual impairments. It can be operated using a mouse or keyboard, considering that blind individuals rarely use computer mice. The ability to utilize a keyboard is crucial for them. The online audiobook library "Lighthouse" aims to ease the lives of both completely blind and partially sighted individuals (Lihtar, n. d.).

Easy access to various electronic libraries through applications or online services becomes an available alternative to the traditional method of purchasing books. The increase in the number and continuous modernization of portable reading devices, particularly smartphones and tablets, will play a key role in supporting the vibrancy of the global e-publishing market.

The use of advanced technologies and the development of new products define strategic directions in the book publishing market. Publishers and authors actively focus on innovation to increase sales volumes and to modernize and optimize literary and publishing processes. For instance, in January 2020, software for analyzing literary works using artificial intelligence was released, allowing authors to refine their books before submitting them for professional editing. This software can also assess the potential of a work and predict its popularity among readers (Chebotarova, M.R., Sushkova, A.S., Silchenko, V.V., & Chebotarova, I.B., 2022).

To boost book sales, publishing houses are releasing podcasts – a series of discussions or audio episodes of particular books. If the audience enjoys podcasts related to books, they may become more loyal to the author or publisher. If a book is available in the audiobook format, podcasts can provide samples of audio content to attract listeners. This is particularly useful for people who are new to audiobooks. It's also an invaluable format for people with visual impairments to explore content of interest to them.

One of the biggest innovations in this field is the development of enhanced e-books. Now users can enjoy not only text but also additional features such as audio, video, interactivity, and more. Other innovations in the e-book industry include the development of interactive books for children, the development of software for improving reading and language learning, as well as the creation of books for people with visual impairments (Chebotarova, M.R., Sushkova, A.S., Silchenko, V.V., & Chebotarova, I.B., 2022).

Technology for Producing Braille Publications

Main Methods of Braille Printing

A Braille printing machine consists of six primary keys corresponding to the six dots of a Braille cell, as well as a "space" key. Text printed in this manner can be read without flipping the paper. Modern methods of applying Braille font to materials involve various printing technologies. Special paper is typically used, though it's worth noting that cardboard has a shorter lifespan for embossed dots, which shortens the book's lifecycle. The prevalence of different sheet formats for printing Braille depends on national printing traditions.

One method of applying Braille font is embossing, where the matrix and counter die contain the necessary dot combination. A drawback is the need for separate dies for each page, which increases production costs. The Accubraille technology has been developed to apply Braille font during folding and gluing. Thermoforming utilizes materials that expand significantly when heated, such as expandable polystyrene. Fine powder based on them is applied to fresh paint or varnish. During vibratory cutting of the sheet, the powder separates where there is no paint, and then it is heated. Under the influence of heat, the powder adhered to the paint expands or melts, creating relief, and after cooling, it fixes. Special relief varnish that increases in volume when heated can also be used. It is applied by stencil, and under UV radiation, it polymerizes, creating a relief image. Digital printing utilizes special toner, which, when fed into a digital machine, becomes relief. Braille printers print embossed dot characters on paper, outputting text in Braille font.

These technologies have their advantages and disadvantages. Thermoforming is affordable but has high labor costs due to a complex processing process. Relief varnish is effective but expensive. Digital printing uses special toner and allows for embossed output on paper. Vacuum forming technology is used in the production of educational materials for the blind, packaging, and advertising, providing high strength and a realistic appearance of the product. For a developed book released in single copies, digital printing is typically used.

Selection of Specialized Software and Equipment for Producing Braille Books

To produce a children's publication, specialized software is required to convert a text file into Braille font, along with two types of printing equipment. First, for printing Braille pages and tactile graphics - in our case, a specialized printer. Second, for printing regular pages with text and graphics - a digital printing machine. A Braille printer is a device designed to print tactile Braille dots and tactile graphics. These printers output textual information by representing it as raised dots on paper. Braille printers can be used to print both textual content and create tactile images. For printing the prepared book project, the Index Braille Everest-D V5 printer was chosen. This is a professional high-speed printer for producing Braille publications on an industrial scale. For printing text pages of the publication, the HP Indigo 7500 digital printing press was selected. The HP Indigo 7600 digital offset machine is ideal for high-volume printing of various commercial works with print runs from one copy to several thousand. Let's also consider the software most commonly used for converting text into Braille font.

An example of software for converting regular text into Braille font is Duxbury Braille Translator (DBT) - a user-friendly software with a graphical interface designed for bidirectional text translation. The main functionality of DBT includes translating regular font into Braille alphabet and vice versa. However, the program is not limited to these capabilities. DBT is a powerful text editor that allows for the preparation of various documents for Braille printing in dozens of languages and different encodings. Additionally, it includes a spell checker with a dictionary of over 300,000 words and a "Quick Find Misspelling" function for quickly identifying and correcting spelling errors. The program can be used with any Braille printer.

ElPicsPrint is software designed for preparing and printing tactile graphics on Index Braille printers. The program automatically converts images into dot images, taking into account the technical capabilities of Index Braille printers and the perception of blind individuals. It's important to note that the most readable tactile images are obtained from black and white images with low resolution.

The application of tactile images includes visual aids for education, cartographic materials, and more. Using *ElPicsPrint* with a Braille printer is more cost-effective compared to other methods of producing tactile graphics. The program has several useful features, such as image conversion for printing on Braille printers, support for floating head printing, printing of finished tactile images on Braille printers in formats such as jpg, png, bmp, and more.

The layout of the publication "*Kvas'ko and Katrusya*" was processed using the Duxbury Braille Translator (DBT) program, which has the ability to create combined documents with text and graphics.

Technological Scheme for Designing and Developing Audiobooks

The distinctive feature of the developed publication is the additional multimedia accompaniment - an audiobook. Two schemes have been developed for Project 1 and Project 2, respectively. The technological scheme for creating the first project is shown in figure 3. It includes not only the stages of voiceover and audio material editing but also the preparation of the textual part.

Initially, the textual part of the book was prepared at the stage of designing the paper version. It underwent necessary editorial and publishing preparation both in terms of text and graphics. Additionally, a part with Braille font was separately prepared.

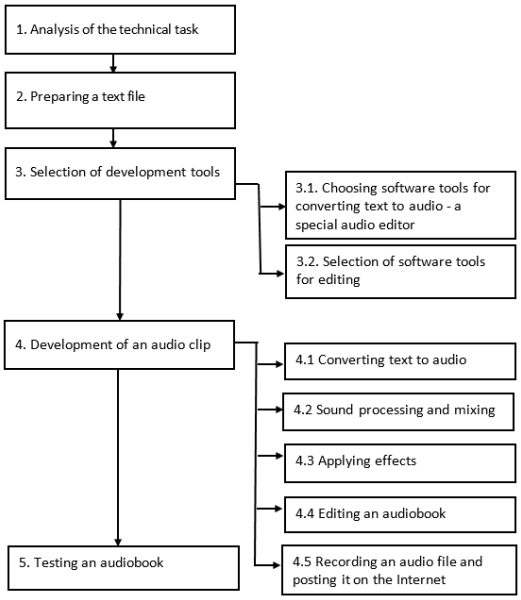

Figure 3. Technological scheme of audiobook production (Project 1).
Source: Author's own elaboration.

For developing an audiobook with narrators' voices, the textual part needs to be divided into several parts according to roles. This will serve as the source information for the narrators. Then, voice recordings are conducted in the studio using selected software – a music editor. Next comes the sound processing and mixing, as well as the addition of effects where necessary. The final step is recording and placing the file on Google Drive and forming a link for the QR code. This code is placed on the book, allowing readers to download the audiobook version via this link. The second option for the book is based on text file recognition and automatic audiobook generation (see figure 4).

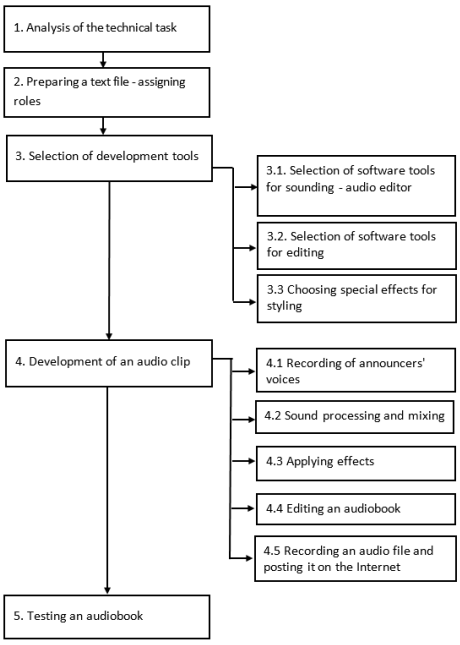

Figure 4. Technological scheme of audiobook production (Project 2).
Source: Author's own elaboration.

To achieve this, the prepared text part of the book is used, and text recognition and sound generation are carried out in a specialized program. Then, necessary effects are applied to the finished audio track (these could be filters to alter the voice, such as for children's stories, adding intonation, pauses, etc.). The final step, as in the previous project, involves recording and placing the file on Google Drive or YouTube and generating a link for the QR code. These links can also be placed in specialized electronic libraries for free (or conditionally free) access to audiobooks. Final editing in both cases is done in Adobe Premiere Pro, which allows adding an illustrative "cover" to the audiobook, making these projects more appealing to consumers. Before placing the files, they need to be minimized to ensure quick access to them. The final stage is testing, which was conducted on various devices to check download speed, sound quality, and sound effects.

Experimental Section

Experiment Planning

In the experimental part, two audio versions of the children's book "Kvas'ko and Katrusia" for visually impaired and blind children of primary school age using Braille font were developed for a more detailed study. Developments were carried out using different audio processing technologies and various software selected based on expert analysis.

The following stages were defined for the implementation of the research tasks: Identification and analysis of the target audience; Analysis of audio processing software; Development of audio applications using different technologies; Selection of an expert group and criteria for evaluating audio applications; Conducting expert evaluations and determining the most effective technology for developing multimedia audio applications for inclusive publications; Development of recommendations for the application of multimedia technologies for inclusive publications.

Analysis of the Target Audience

In Ukraine, people with visual impairments, including the blind, have faced difficulties in accessing educational literature since childhood. Currently, there is a serious shortage of textbooks and books for this category of citizens. Domestic schools have only 15% to 42% of the necessary special literature. Teachers remain attached to textbooks printed as far back as 2014, while the school curriculum is regularly updated.

There is a shortage not only of educational manuals but also of literature of scientific and artistic orientation. The paradox is that people with visual impairments read significantly more on average than those with normal vision. According to monitoring results, the average Ukrainian reads about 12 books per year, while blind people read almost 50. In particular, the older generation lacks access to fiction and popular science literature. As already noted, nearly 60% of people with visual impairments listen to audiobooks. In this situation, the development of technologies for quickly creating audio applications for books can at least partially solve the problem of book shortages.

For the study, two versions of audio applications for the children's book in Braille font "Kvas'ko and Katrusia" for visually impaired and blind children were developed. 1st version - specialized software is used to create an audiobook and voice actors for narration. 2nd version - for creating an audiobook, the original layout in text format, prepared for printing, was used, and text recognition and automatic generation of the audio file were performed.

Justification of Software Selection for Recording and Processing Audio Application

A comparative analysis of audio processing applications can be useful in determining the best choice depending on the specific task and needs of the customers. Depending on the needs (whether it is audio recording, audio processing for video, music composition, etc.), as well as budget and experience, a specific program is chosen that best meets the requirements of the task. For the first version of the audiobook, we chose the free audio editor FL Studio.

Many books that are available in libraries for the visually impaired have text parts already prepared on a computer. Therefore, to simplify the technology of preparing audio annexes to books, special software can be used to convert text to sound. We have analysed Google Text-to-Speech, Narakeet, and Voiser Voiceover Transcription. Each of these tools has its own advantages and disadvantages, but based on the requirements of our task, the free version of Voiser was chosen to develop an audiobook according to the second option.

Methodology for Analyzing the Strengths and Weaknesses of Projects

To determine the most effective technology for creating audio supplements, an expert group and criteria for evaluating audiobooks are chosen, followed by expert evaluation.

Comparing the two audiobook projects requires identifying their strengths and weaknesses. Since all books are ultimately assessed by the customer who votes with their money, it's crucial to quickly identify the relative quality of the final projects. Conducting sociological surveys on the target audience requires a lot of time and additional financial costs. Moreover, it's challenging to obtain a clear understanding of the objective advantages and disadvantages of books because respondents need to be chosen quite diversely for such specific publications. This group must include both printing specialists, users with visual impairments, and managers or marketers involved in promoting inclusive book products. Assembling such a group is quite difficult. Therefore, a more dynamic and reasonably objective assessment of the competitive situation oriented towards the subjective evaluation of developed projects by a group of experts - representatives of the target audience under study - will be assumed (Silchenko, V., 2024).

This can be achieved by using the method of analyzing the strengths and weaknesses of competitive projects. The essence of this method lies in plotting dots on a scale, giving a rating to the product according to different features, and then determining the relative advantages or disadvantages of the projects.

The basis of this method is a list of features that can describe competitive projects. By comparing the projects on each feature, dots (ratings) are plotted on the scale. Then, all the ratings are connected, forming a profile of ratings. Comparing the rating values for each feature between the compared projects allows constructing profiles of the strengths and weaknesses of the product - the developed audio supplement.

To build such a profile, the following tasks need to be addressed: Define a set of features that characterize the project - a book made in Braille font with an audio supplement (an analogue of this book). Evaluate each of the projects (construct corresponding profiles). Construct a relative assessment (difference profile) of the strengths and weaknesses of the project.

Let's determine the set of features for describing the situation.

During the analysis, it is necessary to consider not only the quality of the obtained products but also other features - for example, the time spent on project preparation and implementation, implementation complexity, financial component, ease of execution, etc.

Based on the literature analysis and previous practical experience, the following list of features for analysis has been chosen:

1 – Sound quality;
2 – Diction quality;
3 – Presence of multiple voices;
4 – Material perception (considering emotional impact on children);
5 – Project implementation time (the shorter, the better);
6 – Cost of text conversion and audio processing software (the lower, the better);
7 – Financial costs for voice acting considering the number of performers (the lower, the better);
8 – Project implementation complexity (considering all stages);
9 – Use of the developed project production technology as a standard for similar products.

Four of the chosen evaluation criteria are reverse. That is, the higher this feature, the better the result. This is explained to experts at the beginning of the evaluation. These are the criteria: project implementation time, cost of software, financial costs for voice acting, project implementation complexity.

When constructing graphs, scales that are most familiar to users can be applied. However, when working with objects that are difficult to describe, it can be challenging to explain the difference between close ratings, for example, between ratings of 6 and 7 on a ten-point scale, so it is recommended to continue using the nine-point scale. In this scale, it is quite simple to distinguish three zones: good, bad, satisfactory, and their shades can be distinguished. For example: not quite good - 7; good - 8; more than good - 9. Similarly, other groups can be evaluated: not quite bad - 3; bad - 2; very bad - 1. Thus, the nine-point scale allows logically justifying ratings. Before experts start giving their ratings, the boundary values for positioning on each characteristic are agreed upon. When establishing boundary values, it is necessary to take into account the following requirements for ratings: They reflect the position of the consumer - the reader of this book, taking into account their specificity (absence or visual impairments); The ratings should be as complete and understandable as possible. To compare the two developed audiobook projects, a construction of an assessment profile will be made. For constructing the assessment profile of each project separately, a rating is given for each characteristic. To increase the reliability of the assessment and reduce the influence of the subjective opinion of each expert, the construction of the assessment profile of the developed book projects is carried out by a group of experts. A group of 5 people was selected: the deputy director for production at the digital printing house, a representative of the society of the blind, a manager, a multimedia publications development expert, and a parent of a visually impaired child. Individual ratings are averaged. The obtained final ratings are entered into the table. It consists of three parts:

- fields for constructing profiles of strengths and weaknesses;
- feature fields;
- project ratings fields.

Project 1 - an audio supplement voiced by two narrators, developed using FL Studio and Adobe Premiere Pro.
Project 2 - an audio supplement developed through text conversion, using Voiser and Adobe Premiere Pro.

The expert assessments of the project profiles are provided in table 1.

***Table 1**. Expert assessment of audiobook projects*

№	Features	Expert evaluation of the project 1						Expert evaluation of the project 2					
		1	2	3	4	5	Generalised assessment	1	2	3	4	5	Generalised assessment
1	Sound quality	9	9	9	9	9	9	8	7	9	9	7	8
2	Diction quality	9	9	9	9	9	9	9	6	8	8	6	7
3	Availability of multiple votes	9	9	9	9	9	9	6	6	7	8	5	6
4	Perception of the material	8	9	9	9	8	9	8	7	8	8	6	7
5	Project production time	5	6	5	4	7	5	9	9	9	9	8	9
6	Cost of software for text conversion and audio processing	6	6	3	3	5	5	8	8	7	8	9	8
7	Financial costs for voice-over	7	5	3	5	4	5	9	9	9	9	8	9
8	Complexity of project implementation	7	8	6	6	7	7	9	8	9	9	7	8
9	Using the developed technology as a standard	8	8	7	6	8	7	9	8	9	9	8	9
							64,6						**71,8**

The profile of strengths and weaknesses of the two audiobook projects is presented in figure 5.

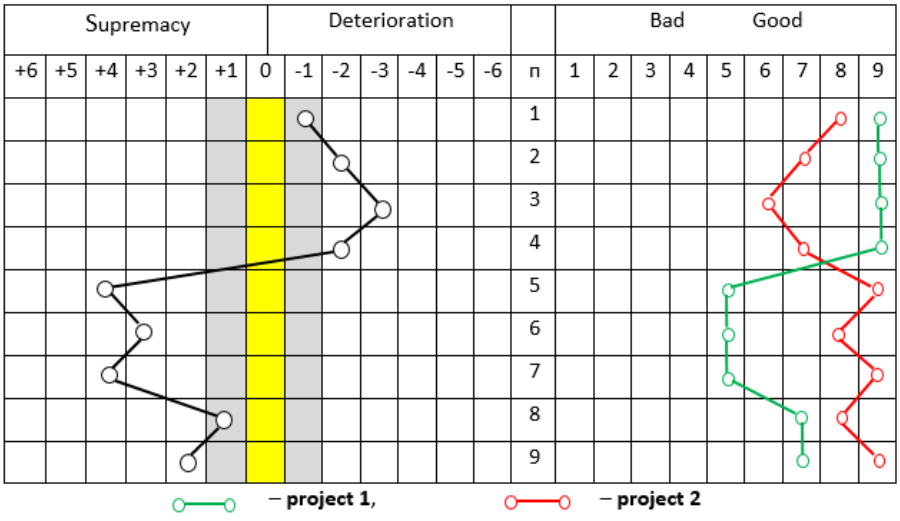

Figure 5. Construction of the profile of strengths and weaknesses of the developed audiobook projects.
Source: Author's own elaboration.

On the next stage, we will determine the consensus rating of the experts' opinions. For this purpose, coefficients of variation will be calculated for each criterion and overall according to the following formula:

$$V = \frac{\sum \sigma}{\sum \bar{x}}. \quad (1)$$

The results of the calculations were carried out for each project according to 9 criteria (Tables 2 and 3).

***Table 2**. Results of coefficient of variation calculations for Project 1*

Evaluation characteristics (criteria)	The average value of the ratings	Standard deviation	Variation range	Dispersion	Coefficients of variation
1. Sound quality	0,140	0,00036305	0,00000013	1	0,002596362
2. Diction quality	0,140	0,00036305	0,00000013	1	0,002596362
3. The presence of multiple votes	0,140	0,00036305	0,00000013	1	0,002596362
4. Perception of the material	0,134	0,00095556	0,00000091	1	0,007138564
5. Project production time	0,083	0,00090355	0,00000082	1	0,010845705
6. Cost of software for text conversion and audio processing	0,070	0,00145302	0,00000211	1	0,020701261
7. Financial costs for voice-over	0,074	0,00168237	0,00000283	2	0,022775149
8. Complexity of the project implementation	0,105	0,00017509	0,00000003	1	0,001667712
9. Using the developed technology as a standard	0,114	0,00027177	0,00000007	2	0,002377801

***Table 3**. Results of coefficient of variation calculations for Project 2*

Evaluation characteristics (criteria)	The average value of the ratings	Standard deviation	Variation range	Dispersion	Coefficients of variation
1. Sound quality	0,125	0,0022174	0,00000492	1	0,017734731
2. Diction quality	0,115	0,00233944	0,00000547	1	0,020276517
3. The presence of multiple votes	0,100	0,00228494	0,00000522	1	0,02280614
4. Perception of the material	0,115	0,00144266	0,00000208	1	0,01250853
5. Project production time	0,137	0,00065175	0,00000042	1	0,004764287
6. Cost of software for text conversion and audio processing	0,124	0,00039904	0,00000016	1	0,003218299
7. Financial costs for voice-over	0,137	0,00065175	0,00000042	2	0,004764287
8. Complexity of the project implementation	0,131	0,00157246	0,00000247	1	0,012015358
9. Using the developed technology as a standard	0,134	0,00100428	0,00000101	2	0,007500177

All obtained coefficients of variation are less than 0.2. This indicates that the experts' opinions are consistent for each criterion.

To assess the average degree of agreement among all experts, the coefficient of concordance is used:

$$W = \frac{S}{\frac{1}{12} * m^2(n^3 - n) - m * \sum T_i}, \quad (2)$$

where m=5 – is the number of experts,

n=9 – is the number of alternatives,

s – is the standard deviation of all rank assessments for each alternative from the mean value.

Let's determine the coefficient of concordance for each of the projects.

Project 1:

$$W = \frac{1294}{\frac{1}{12} * 5^2(9^3 - 9) - 5 * 23} = 0{,}93,$$

S = 1294, n = 9, m = 5.

The obtained coefficient of concordance W = 0.93 indicates a high degree of consensus among the experts in the conducted research.

Project 2:

$$W = \frac{867}{\frac{1}{12} * 5^2(9^3 - 9) - 5 * 44{,}5} = 0{,}68,$$

S = 867, n = 9, m = 5.

The obtained coefficient of concordance W = 0.68 indicates a moderate degree of consensus among the experts in the conducted research.

Let's proceed with evaluating the importance of the coefficient of concordance. For this purpose, we'll calculate the

$$x^2 = \frac{S}{\frac{1}{12} * mn(n+1) + \frac{1}{n-1} * \sum T_i}, \quad (3)$$

$$x^2 = \frac{867}{\frac{1}{12} 5 * 9(9+1) + \frac{1}{9-1} * 44{,}5} = 27{,}15.$$

The obtained χ^2 is compared with the tabulated value for the degrees of freedom K = n-1 = 9-1 = 8 at the given significance level alpha = 0.05.

The calculated χ^2 = 27.15 is greater than the tabulated value (15.50731). Consequently, W = 0.68, indicating that the magnitude is not random. Therefore, the results obtained make sense and can be used in further research.

Next, let's analyze the strengths and weaknesses graph of the developed audiobook projects.

The analysis of the constructed profiles shows that these two projects have both advantages and disadvantages across different criteria. Therefore, it's better to analyze them based on relative characteristics as competitors. There is a significant gap in the following aspects: quality of diction, presence of multiple voices, and material perception. The second project lags behind the first in these aspects due to the technology used for its preparation – voiceover narration, which consumers prefer. However, this also affects the price and production time of the audiobook (criteria 5-7). Therefore, the second project surpasses in these criteria. This is an interesting result. According to the experts, the second project is chosen based on the criterion "Use of developed technology as standard". This technology is recommended for further use, largely due to its financial component and the simplicity and speed of audiobook production. Perhaps for children's books, voiceover narration will remain more attractive, but for mass production of cheaper books, the second technology can be recommended. This is confirmed by the summarized ratings of expert evaluation – the first project scored 64.6 points, while the second scored 71.8.

The conducted research and the obtained results can be used for further development of similar projects. This is very relevant for publishing houses that produce Braille books and already have layouts for these publications. The set of selected software and the developed technology can be recommended as standard.

Conclusions

In the modern information environment, it is extremely difficult for visually impaired people. It is currently crucial to implement projects aimed at inclusion so that everyone has the opportunity to enjoy leisure activities or study in a convenient format. Reading is an important means of socialization and adaptation for people with visual impairments.

Researching the possibilities of using multimedia technologies for Braille publications is of great importance for improving the accessibility of information for people with visual impairments. Multimedia technologies can provide new ways of distributing and perceiving textual and audiovisual information for this audience.

Braille books require the presence of special equipment and software at the enterprise; therefore they have a rather high price. This is the reason for the low production of such books. Therefore, the technologies for developing audiobooks, which are complementary to Braille books, are relevant. They can also be used separately when a person is unable to buy a paper version of the book.

This is confirmed by the research conducted in this work. Multimedia audio supplements increase the interest of readers of Braille books. And the audiobook development technology, which allows reducing the time and cost of producing audiobooks, is more efficient and appealing to users.

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