

Assistive computer technologies for people with disabilities

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Abstract. The paper examines modern ways to improve the efficiency of information perception using multimedia technology, thus ensuring the use of a powerful new tool for understanding of information by persons with various forms of nosology. The use of assistive computer technologies for people with disabilities is investigated. The peculiarities of formation of multimedia information content for users with special needs were analyzed. The digital library as a set of information technology services is proposed making multimedia information content accessible to users with various forms of nosology. It was investigated that in spite of rapid development of modern communication means and assistive technologies their use is limited for people with disabilities, in particular for hearing impaired people. Most of available technologies for hearing impaired people translate speech into text. As was shown this approach is not fairly efficient because Sign language turned out to be the most convenient way of communication for the respondents.

Key words: assistive computer technologies, multimedia, user with disabilities, digital library, information content

INTRODUCTION

Today our life is unthinkable without modern information and communication technologies that from year to year are becoming more useful for people with disabilities. Such categories of people are the hearing impaired people, people with visual impairments, etc. According to the statistics of the Ministry of Health, there are more than a million people with hearing impairments in Ukraine, those who speak sign language - 0.2%, there are more than 100 thousand people with visual impairments. Almost every day they have to overcome variety of barriers, because in our country the majority of institutions are designed for those who hear, see and speak well.

Inclusive communication technologies for people with disabilities are discussed in [1]. The paper is focused on technologies that are used in everyday life by people without and with disabilities. The main focus is on

reduction of the "digital divide" in information and communication technologies.

The people with disabilities should use special computerized tools for communication, education and access to information. These tools consist of variety of programs and devices for speech recognition, sign language translation, alternative interaction with the computer, and so on. These tools are called as assistive computer technologies (ACT) – technologies that provide equal opportunities for access to information resources and communicate for people with disabilities [2].

People less use the TV to access information, and increasingly using the Internet, YouTube and social networks.

All the more urgent it is the need to empower comfortable way of accessing information for people with disabilities in various formats tailored for their perception. The information technologies, methods and means that implement aggregation and systematization of electronic libraries' funds are developed and improved by means of specialized information products that integrate multimedia information for the needs of people with different forms of nosology.

The problems of information educational content are discussed in [3]. However, a comprehensive study of the features of information content formation for people with disabilities is not done yet.

Research presented in this article are of great social importance as highlight current scientific and applied problems of communication, education and access to information for people with disabilities in society.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The problem of full understanding speech and written language for people with hearing problems can be solved using the automatic translation system into sign language and vice versa. This problem is relevant in the whole world, as evidenced by the numerous projects in the US (Sign

Smith Studio [4]), the UK (SiSi [5]), France (Artemis [6]), Russia (SLEd [7]), Ukraine (shaped computer [8]).

Today the following systems are known:

- systems for translating text into sign language with articulation of lips (SiSi for the British Sign Language [5]);
- sound recognition and gesture broadcasting (Krown ASL Pocket for the American Sign Language [9]);
- systems of distance learning in sign language (Signing Savvy [10]);
- systems for communicating with sign language at a distance, such as video telephony systems [11].

Ukrainian scientists from V.M. Glushkov Institute of Cybernetics of NAS of Ukraine are actively investigating the sign language as part of the "Shaped computer" project [8]. The means of analysis and synthesis of the Ukrainian sign language, facial expressions and articulation of the Ukrainian spoken language are developed.

Such development has a great social importance and provide an opportunity to people with hearing disabilities for information, communication, training and work.

Research aspects of building assistive technologies is a subject of numerous publications. The paper [12] described the aspects of user interaction with the computer based on fuzzy linguistic variables. In [13] a research of building assistive technologies for the English and Thai languages is described. In [2] a general principles of assistive computer technologies are considered and a new mathematical model of language for assistive computer technologies is described.

The assistive technologies for Ukrainian content are investigated in Information Systems and Networks Department of Lviv Polytechnic National University. Scientists from Information Systems and Networks Department designed recognition system of Sign Language elements [14], software package for sound mathematical formulas [15], means of synthesis of articulation for sound recording language [16], information technology for Ukrainian Sign Language translation based on ontologies [17].

One of another way to make life easier for persons with special needs is digital library. The digital library has become a means of information support to users with special needs. It is defined as a new type of an information system for accumulation, processing and providing access to an array of electronic documents, including distributed and diverse resources [18]. Digital libraries can store and process multimedia content that is not supported by traditional libraries. One of the main advantages of the multimedia library, which is aimed at providing the information needs of people with different forms of nosology, is to provide effective access to information content presented in a convenient format for use.

The special software and hardware of such libraries allow using technologies and methods for digital recording

of information and online access to information resources [19].

Library support to the educational process for people with disabilities facilitates the access to:

- metadata in a convenient way;
- information and library resources that are created for each category of users using special technologies and algorithms.

This approach is based on the use of modern information technologies and innovative development of information technological and library support for the educational process of people with disabilities [3].

An innovative concept of digital library is in the context of information needs of users with different forms of nosology. Such library is based on the implementation of requirements of the information society and the improvement of communication processes, providing quick and high-quality access to information for people with disabilities.

One of the lines of development of modern digital libraries is to use web technologies for quick and efficient search of relevant information for users with special needs. The complex of these technologies allows forming semantic annotations of content objects on the basis of ontologies, conducting the clustering of search results, forming models of information needs of users on the basis of an ontological approach. This approach is significantly different from the existing ways of personalizing of user information services. An innovative trend is that such a model of an information object contributes to accelerate and improve the overall results of information search [20].

OBJECTIVES

The main objective of the research is to develop the complex of information technologies that will provide equal opportunities for communication, education and access to information for people with disabilities in society.

THE MAIN RESULTS OF THE RESEARCH

Requirements for information products for people with special needs. Effective library service for users with disabilities involves the creation of library funds with a multimedia component to meet information needs, taking into account nosologies, and convenient access to information resources.

Library collections should include:

- Braille books, as well as "talking" books made by using modern digital formats adopted by the international Daisy consortium for users with visual impairments;
- documents that provide information in the form of visual materials to meet the information needs of people with hearing problems;
- scanned or digitized documents for readers who

cannot directly go to the library [3].

The libraries that use DAISY technology provide blind people with access to large amounts of information, promote their intellectual development, and achieve results on the same level as normal people. All books in this format use a common set of file types that are based on XML. The convenience of using the book in DAISY format is achieved by combining different types of files (batch, text, audio files, and presentations) and technologies (file synchronization, file navigation management, file conversion).

Digital library developers for blind people use the new digital information storage technology known as Digital Talking Books (DTB). They are access technologies for electronic files to provide information through alternative ways of information reproducing: voice synthesizer texts, visual images, dot printing. DTB-compliant files provide quick and flexible navigation, text markup and bookmark use, keyword search, word-of-mouth search, content management, selected by request (e.g., footnotes, page numbers, etc.). The contents of the DTB-compliant files are played using audio signals, combination of audio, text, and images, or only text. The navigation technology used to create the DTB allows blind readers to "flip" the book pages, skip certain chapters and pages, paragraphs, voice synthesized, creating an audio recording [21].

The use of visual information enhances the abilities to perceive information for people with hearing problems.

The library should have several components, such as:

- a simulator of sign language;
- a fund of documents containing information presented in the form of a translation of video sequences of gestures;
- software and hardware for playing video documents.

Specifics of library services for users with reduced mobility require the solution of issues related to the development of remote services:

- providing online access to electronic library collections;
- sending documents in digital format or scanned [3].

In the near future, the synchronized multimedia will be the key information technology for library users with special needs.

Such approach contributes to obtain information in the most convenient form for the users. At the same time, it introduces new requirements for the reorganization of library and information services, based on equipment of modern automated user workplaces, creation of problem-oriented reading rooms, laying of high-speed telecommunication channels of the Internet [22].

The use of assistive technologies for hearing impaired people. Modern information technologies provide people with a wide range of opportunities for information,

communication, education, work. The analysis of the completeness of using modern information technologies and research of factors that limit their full use for hearing impaired people are investigated. The problems of using television, the Internet, social networks and communication facilities are studied.

For this reason, a survey was conducted. Two groups of people were chosen: pupils of 8-11 classes of specialized schools for hearing impaired people and group of people 20-50 years of age.

The survey was attended by men and women, most of the inhabitants of the western regions of Ukraine.

Of the respondents, 91% are constantly using sign language. Questions of the questionnaire were divided into 8 groups: common questions, questions about hearing, use of TV, Internet, social networks, communication means, use of assistive technologies, reading journals and books.

It turned out that among the respondents who do not hear sounds at all, only 41%. Most of the respondents are able to distinguish individual sounds. The distribution of respondents for how well they hear individual sounds is presented in Table 1.

Table 1. Distribution of respondents for the opportunity to hear some sounds

№	How well they hear sounds	Percentage among the respondents
1	Do not hear anything	41%
2	Hear separate sounds	17%
3	Hear separate sounds with the use of a hearing aid	25%
4	Everything is hearing using a hearing aid	17%

The survey showed that students considered that lack of hearing can to be a significant impediment to their careers, 42% of respondents answered positively, indicating the need to develop assistive computer technologies for this category of population (Table 2).

Table 2. Results of the survey on the importance of full hearing in the career

№	Do you consider lack of hearing a significant obstacle in my career?	Percentage among the respondents
1	No, this is just an inconvenience that can be bypassed	58%
2	Yes, this is a significant problem	42%

Most of the respondents think it necessary to watch movies, news and entertainment programs on television have the subtitles (Table 3).

Table 3. Results of the survey on the importance of spelling on television

№	How important the spelling on television?	Percentage among the respondents
1	It is important for the program to have a subtitles	56%
2	Sufficient subtitles for understanding	44%

Most of the respondents are constantly communicating with people who do not speak a sign language (Table 4). At the same time, the greatest difficulty lies not in the inconvenience of using the pen and the paper for communication, but in the complexity of understanding the person who is hearing (Table 5). It was also a significant problem that deaf people cannot understand what people are talking with each other, creating significant barriers to communication and trust.

Table 4. Communication with people who do not speak a sign language

№	How often do you have to face-to-face conversations with people who do not speak a sign language?	Percentage among the respondents
1	Continuously	64%
2	Several times a day	26%
3	Times a day or less	10%

Table 5. The biggest problems arise when working with people who do not speak sign language

№	Problems that arise when talking with the audiences	Percentage of respondents for whom this problem is significant
1	I cannot understand what they want to tell me	63%
2	I cannot explain them to my opinion	51%
3	I do not understand complex sentences	52%
4	I cannot understand what they say among themselves	28%
5	I spend a lot of time writing a text	26%

Despite large communication problems, only a small percentage of respondents use voice recognition tools to communicate with people who do not know the sign language. This can be explained by the imperfection of modern speech recognition devices, which practically

cannot correctly recognize speech in the text in the presence of other sounds.

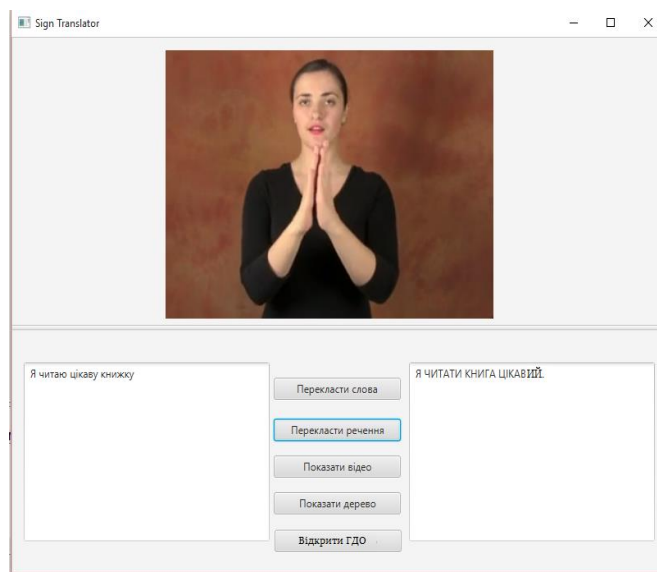
Translation system of Ukrainian Sign Language. Studies of the Ukrainian Sign Language (UKL) translation into the text and vice versa are also held at the Lviv Polytechnic National University. Researchers [17] developed a Ukrainian sign language dictionary containing 2176 words, 13 dialogues and 7 monologues. Authors developed software and algorithmic complex “SignTranslator” for bidirectional translation Ukrainian sign language based on grammatically augmented ontology using modern approaches to the creation of computer systems for the translation of sign languages.

Researchers designed the structure of the software and algorithmic complex, built a system of rules for the translation of the annotated Ukrainian sign language using grammatically augmented ontology and developed the algorithms on the basis of the investigated methods of translation of the Ukrainian sign language.

The interface of the software and algorithmic complex is convenient and accessible to both in-ear and hard-of-hearing users with computer skills, and allows to comfortably implement the bidirectional translation of the Ukrainian sign language.

The user with hearing disabilities uses the keyboard to enter the sentence that must be translated, the monitor, the mouse to select the translation, etc.

The translation process of the annotated Ukrainian sign language is performed by the user who selects the language of the input sentences and the language for the output sentences (see Fig. 1). After that, the user clicks on the “Перекласти речення” (“Translate sentence”) button.

**Fig. 1.** The interface of “SignTranslator”

The translation is performed involving the semantic and syntactic parsing procedure of the input sentence, the procedure of transforming the constituency tree into the dependency tree, transfer rules database, which consists of rules for sign language translation and reordering rules that are used to generate the text in UKL. By clicking on the button “Показати відео” (“Show vide”), the user can view the sentences in the Ukrainian language in the form of video gesture recording.

The Ukrainian sign language translation system “SignTranslator” shown high efficiency (93 % correct sentences translated).

CONCLUSIONS

The survey allows determining the direction of further research in creating new assistive computer technologies and software applications to improve the living conditions for people with disabilities. The survey showed that sign language translation is important for the perception of information by people who communicate in sign language and not sufficiently taken into account in the development of assistive computer technologies.

The software and algorithmic complex “SignTranslator” for bidirectional translation Ukrainian sign language was developed. This software provides new communication opportunities for people with hearing impairments and can be used in digital libraries.

The research in this paper have a great social importance, because it covers the actual scientific and applied problem of creating a complex of information technologies that will provide equal conditions for communication, perception and acquisition of information to people with disabilities in society.

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