Sign Language Multimedia Based Interaction for Aurally Handicapped People

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Abstract. People with hearing disabilities still do not have a satisfactory access to Internet services. Since sign language is the mother tongue of deaf people, and 80% of this social group cannot successfully understand the written content, different ways of using sign language to deliver information via the Internet should be considered. In this paper, we provide a technical overview of solutions to this problem that we have designed and tested in recent years, along with the evaluation results and users' experience reports. The solutions discussed prioritize sign language on the Internet for the deaf and hard of hearing using a multimodal approach to delivering information, including video, audio and captions.

Keywords: deaf, hard of hearing, sign language, VELAP, SLI module, sign language glossary.

1 Introduction

With the growth of the Internet as a mass media, and its great effect on our daily lives, it is incomprehensible that the Internet and its services are still not accessible to everybody, despite numerous disabled end-users who could benefit highly from having access to these services. More than ten percent of our whole world population, i.e. more than 600 million people, is disabled [1] and 71 million have some degree of hearing loss [2]. According to the American National Organization on Disability survey, people with hearing and vision disabilities would highly appreciate being able to use those services at home [3].

However, up to 80% of deaf people cannot successfully understand the written content [4]. The main reason is their lack of education and a low level of literacy, which is a main criterion to benefit from the text-based Internet. Since sign language is the mother tongue of hearing impaired people, and written language is only their

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second language, deaf signer users often become confused when searching for information on Web pages [5 - 7]. It is therefore essential to provide information on the Internet in sign language.

Moreover, legal documents at international, European and national levels, including the United Nation Convention on the Rights of Persons with Disabilities (2006), Riga Declaration (2006), "Disability Action Plan" of European Union (2006) and Brussels Declaration on Sign Languages in the European Union (2010), endow the deaf with the right to use sign language. Consequently, there is an urgent need for research, design and development to provide appropriate, usable and accessible information and communication technology to the deaf and hard of hearing in order to improve their reading ability and education level and prepare them for job competition.

2 Principles and Examples of Good Practices for Deaf and Hard of Hearing

Various technologies have been used to deliver online information in sign language: avatars, streaming videos of sign language interpreters and speech recognition technology. According to research findings, natural videos are currently more accepted by the end users than signing avatars and synthetic gestures [8]. Therefore, our science and engineering approach within the last years has been focused mainly on the development of ways to deliver information to deaf and hard of hearing internet users, applying the technology of sign language interpreter natural video. In this paper, we discuss the following four successful best-practice examples and our experiences with innovative approaches to ensure e-learning accessibility for deaf and hard of hearing people:

- Video-based E-Lectures for All Participants (VELAP);
- Sign Language Interpreter Web Based Video Module (SLI module);
- E-learning Portal for Deaf and Hard of Hearing "How to get a job?";
- On-line Sign Language Glossary for Deaf and Hard of Hearing.

2.1 Video-Based E-Lectures for All Participants (VELAP)

Considering accessibility, a system called Video-based E-Lectures for All Participants (VELAP) was developed. The primary goal was to provide live streaming of lectures on demand for people with disabilities. The main features were:

- Automated recording of lectures with additional materials (presentation slides, video captions, table of contents) for live and on-demand web presentations;
- Inclusion of additional media streams (supplementary video, audio, screen capturing);
- Inclusion of accessibility options for persons with disabilities:
  — a sign language video and captions for deaf and hard of hearing users,

  - audio captions, text enlargements, background/foreground color corrections and JAWS compatibility for visually impaired users;
- Personal customization of the user's view;
- Interactive questions.

In order to evaluate usability and pedagogical effectiveness of the VELAP system, four studies were conducted: a) comparison tests between traditional learning and online learning with Pre-Test/Post-Test experimental control group design, running ANCOVA, b) application of Learning and Study Strategies Inventory (LASSI), which is a 10-scale, 80-item assessment of "students' use of learning and study strategies related to skill, will and self-regulation components of strategic learning", c) application of method System Usability Measurement Inventory (SUMI), d) Question-thinking protocol [9].

In this research, two experiment groups of students were involved. In the first experiment group, 39 electrical engineering students participated and the second group consisted of 36 students of media communications. While the first group participated in face-to-face lectures, the second group watched the VELAP Web-lecture. When discussing results, ANCOVA showed that there was no distinction between the groups in the first lecture in knowledge growth with regard to prior knowledge, whilst in the second a significant difference ($p < 0.05$) was noted. A SUMI test with the value 57 indicated that the usability of the system was above standard. Secondly, 13 deaf or hard of hearing and 7 blind subjects were involved in two experiments. From the results, it was evident that deaf and hard of hearing users did not prefer two different videos, streaming simultaneously (a lecturer and sign language interpreter). However, 77% of the subjects had selected the sign language interpreter video in combination with a PowerPoint presentation as the best mode for the Web lecture. The group of blind subjects was given a Braille keyboard and the JAWS application for performing the tasks. All the subjects were able to control the videos; however, they failed to select different videos.

Due to the study, we were able to conclude the following facts:

- Requirements for switching media windows are different for deaf and blind users;
- When attending the lectures, deaf users prefer one video for a sign language interpreter without the lecturer;
- Video control bar for deaf users should be above the video window.

2.2 Sign Language Interpreter Web Based Video Module (SLI Module)

Sign Language Interpreter Web based Video Module (SLI module) is a technology that enables deaf and hard of hearing people to rapidly access information in their first language – sign language, with sign language interpreter videos together with captions. They are displayed over the existing web page with a transparent background, without altering the structure of web page and disturbing the learning process (see Fig. 1).

SLI modules provide multimodal information retrieval (video, audio and captions), Timed-Text Authoring Format is used for captioning and cross browser Flash player

(SLI player) is applied. Integration of an SLI module is enabled with a hyperlink button placed at a specific location of the web page, and the web address for the video is set to the server where the video is located.

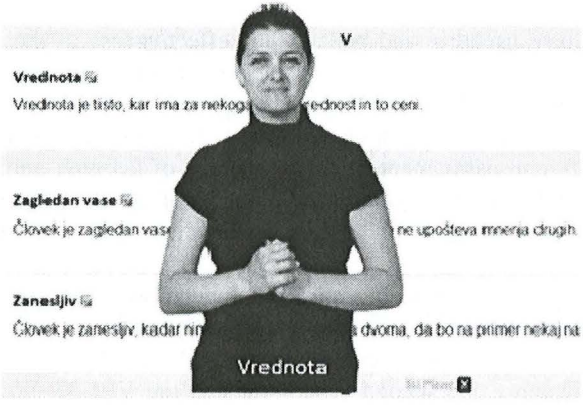

Fig. 1. Sign Language Interpreter Module

Two evaluation studies with deaf and hard of hearing users were conducted [10]. In the first group, there were 14 participants, aged from 18 to 72. In the second evaluation, 31 deaf and hard of hearing subjects, aged between 15 and 21, participated. In the first evaluation, the gestural thinking method was applied. After using the system, users had to fill out a questionnaire with three basic questions about their experience. The results revealed that 92% of the users were satisfied with the system. In the second evaluation, we conducted a pre-test questionnaire for the participant's demographic profile, a post-test questionnaire for evaluating usability with 5-point Likert scale, and an open debate to determine positive/negative or missing functionalities of the prototype. The evaluation results showed a high degree of evaluated usability metrics, such as satisfaction (80%), ease of use (77%) and comprehension (83%).

Due to the study, we were able to conclude the following facts:

- SLI module is acceptable among deaf and hard of hearing users;
- SLI module is easy to use, comprehensible and makes users satisfied.

2.3 E-Learning Portal for Deaf and Hard of Hearing "How to Get a Job?"

The E-learning portal is an e-learning system, based on a custom modified version of Moodle. The system comprises of three parts: contextual, communicative and collaborative. Users are familiarized with advice on how to look for a job. The whole content is in written form and it is translated into the Slovenian sign language in fixed videos with captions. The video that presents the interpreter is located on the left side of a screen window and the text, which is translated in the video, is on the right (see Fig. 2). The glossary of potentially unknown words is provided with a transparent SLI module, where the words are explained in sign language and supported with captions.

The video is displayed when activated by the user on the website. The communication parts of the e-learning system are videoconference communication and collaboration tool, videoforum and chat room. Videoconference provides communication among deaf: hard of hearing and sign language interpreters with live video, text messages and interactive whiteboard. Videoforum enables the posting of messages in the form of a video recording, along with text message, or just text without a video recording. In terms of collaboration, users can do exercises, quizzes and assignments.

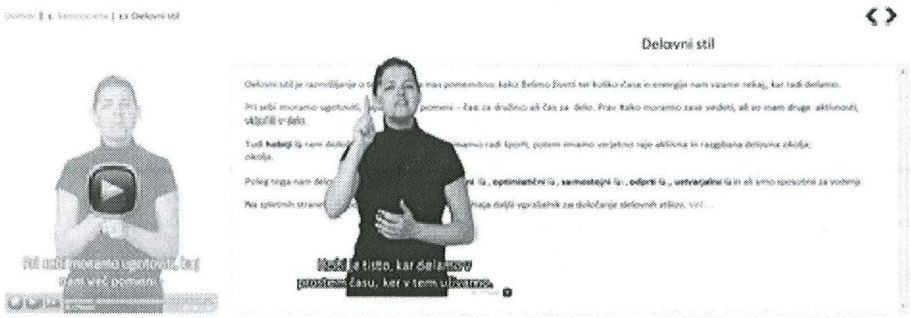

Fig. 2. E-learning Portal for Deaf and Hard of Hearing "How to get a job?" with fixed and transparent video (SLI module)

The system was proposed as a model for the evaluation of e-learning systems for the deaf and hard of hearing and used as a basis for the development of a common evaluation method for measuring both pedagogical richness and usability (PRU method) [11]. A starting point for the development of PRU method was Sonwalkar's method for measuring pedagogical effectiveness of e-material. He proposes 16 factors within three dimensions in relation to learning styles, media used in e-material and interaction. In the PRU method, we expanded Sonwalkar's method with the integration of new interaction factors (videoconference, videoforum and chat). Additionally, captions were added among the media factor (see Table 1), so that the method is appropriate for an evaluation of e-learning systems for deaf and hard of hearing users. On the basis of the PRU method, users' response is measured with a 5-point Likert scale questionnaire. A final result of the calculation is the value of the PRU index, which varies between 0 and 1. A value greater than 0.5, signifies an e-learning system that is pedagogically rich and user friendly.

The e-learning portal was evaluated by The System Usability Scale (SUS). Two experiments measuring usability were conducted [12]. In the first experiment group, 16 participants were involved, 7 males and 9 females, aged from 24 to 57 and with the mean age of 41. The majority (11) was deaf and 5 were hard of hearing. 12 were signers and 4 had no knowledge of sign language. There were 11 with little or no Internet skills, and 5 were average Internet users. In the second experiment group, 12 males and 7 females were included. The age varied between 16 and 24 with a mean age of 19. The majority (11) was deaf, 5 were hard of hearing and 3 subjects had no hearing loss. The majority had excellent Internet skills. Both groups used the system for one hour and the results showed that the SUS score correlated with Internet usage skills.

The first group evaluated the system with the final SUS score 57, which indicated low marginal acceptability of the e-learning portal. The SUS score of the second group was 70. It indicates that the e-learning portal was acceptable.

Table 1. Factors considered in the evaluation with the PRU method. (Source: Kožuh et al., 2011)

Learning styles	Media	Interaction
incidental learning	graphics	revision
inductive learning	audio	bulletin
deductive learning	video	videoconference
discovery	animation	videoforum
	simulation	chat
	captions	

In the study the following has been concluded:

- An e-learning system, comprised of contextual (content supported by sign language), communicative (videoconference, videoforum, chat room) and collaborative part (exercises, quizzes, assignments) can serve as a model for e-learning systems for deaf and hard of hearing;
- PRU method can serve as a universal method for measuring both usability and pedagogical richness of e-learning systems for deaf and hard of hearing users.

2.4 On-Line Sign Language Glossary for Deaf and Hard of Hearing

The system presents a unified web dictionary of sign language translations with the aim of providing accessibility to the original website and an initiative as a starting point for the development of official Slovenian sign language recognition. When the user selects the text in the browser and triggers the spacebar key stroke, the selected text is sent, using JavaScript, to the SLI Flash Glossary. The Flash player loads an HTTP request with a string parameter added to the URL. On the server side, the parameter from the URL is retrieved by the website and the asp.net logic checks against the records stored in the database in order to find the denominator of the term. If the data matches, the video URL is retrieved by the server-side web application and is returned to the Flash player. The Flash player with JavaScript dynamically creates the Flash HTML container for the signed video on the original website and the transparent signed video with captions is played automatically. When the video playback ends, the signed video is automatically closed. On the other hand, if the selected text does not exist in the database, the asp.net website inserts a new record.

Due to the study, we were able to conclude the following facts:

- On-line Sign Language glossary is a unified web dictionary of sign language translations that can serve as a base for the development of official Slovenian sign language recognition.

3 Conclusion

In this paper, we provided a technical overview along with lessons learned from several systems, their evaluation results and user experience. The discussed systems present a combination of multimodal information including video, audio and captions, and offer the option of prioritizing the sign language on the Web for deaf and hard of hearing users. The interaction is mainly managed with transparent and movable videos of a sign language interpreter. The videoforum for deaf people, for example, presents an asynchronous communication tool for the exchange of ideas among students and tutors in two languages: sign language and written text. The tools presented could have a stimulating effect for the deaf and hard of hearing since they can choose their own communication model.

We are of the opinion that the systems presented will thoroughly change the method of information transmission for the deaf and hard of hearing on the Web. The systems discussed have already been accepted at a large scale national level in Slovenia and tend to be positively accepted in countries where sign language is recognized as an official language for the deaf and hard of hearing. In Slovenia, official websites are meanwhile supported with sign language translations. Moreover, a majority of television programmes and movies are captioned. Amongst the weaknesses, one cause of indignation for the deaf is the absence of captions in live television programmes and in sign language interpreter videos on the Web. Thus, our future research will be aimed at proving that the captions integrated into sign language interpreter videos are required.

With the expansion of the discussed technologies, we could contribute to literacy improvement, rising education levels and improvement of competitiveness in job market. This will also enable them to get better opportunities for easier integration into the social network and, at the same time, it will preserve their identity and self-esteem.

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