

Sign Language Tutor – Digital improvement for people who are deaf and hard of hearing

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Abstract. This paper is an introduction to the world of deaf and hard of hearing people and their everyday challenges (and opportunities) with technology and computer interaction. The requirements of this focus group in human-computer interaction and the currently available computers tools and technologies in the world, and especially Macedonia will be discussed. An overview of the present research directions and the possibilities of the visualization and 3D technology for this target group will be stated.

In this paper the Sign Language Tutor – sign language interactive e-learning platform will be presented. It represents a collection of modules and games dedicated to ease the learning of the Macedonian Sign Language (MSL), but also to improve the mental and memory capabilities, especially of the younger part of our target group – the deaf children. The central part of this project is 3D simulation – given a 3D model of a girl the subject should sign a chosen letter or object. Computer games to assist with the learning are used: one is a 2D adventure where the hero fights monsters and collects items as rewards – sign of the collected object, the other is memory where the subject should connect a card with a sign of the letter. The platform is built using the Microsoft XNA technology.

Keywords: deaf, hard of hearing, sign language, children, tutorial, human-computer interaction

1 Introduction

The community of deaf and hard of hearing people is not a small community. According to the World Health Organization in 2004 there were over 275 million people globally with moderate-to-profound hearing impairment [1]. Even more, this group of people don't want to be considered as a part of the community of disabled. According to the World Federation of Deaf "*Deaf and hard of hearing people do not identify as having a disability or see themselves as experiencing a limitation. Instead,*

they identify as a member of a cultural and linguistic group.”[2]. However, they live isolated from the rest of the world. The reason for this is the inability for communication with the non-hard of hearing world. Regular world has little knowledge of the challenges that heard of hearing or deaf people experience in everyday activities. For a long time it have been generally accepted that the deaf and hard of hearing people are unintelligent, so that’s why the offensive term “deaf and dumb” has been used. The terms deaf and hard of hearing are voted as an official designation in 1991 by the World Federation of the Deaf (WFD) [2] [3].

In a large study conducted by Conrad [4] it has been discovered that deaf and hard of hearing children attending schools using an oral approach rarely acquire sufficient lip-reading skills. The children with hearing loss greater than 85 dB could only comprehend about 25% to 28% of the words through lip-reading that they could comprehend through reading. The children with hearing loss less than 65 dB could only comprehend about 36% of the words through lip-reading that they could comprehend through reading. Also the studies have shown that many deaf and hard of hearing individuals have difficulty with reading [4][5]. This is explained by the fact that the words and the writings are based on the spoken language, something that the deaf are not truly acquainted to [6].

The language of the deaf and hard of hearing people is called Sign Language (SL). This language can be signed with usage not only of the hands, but also the head, lips or the torso. This is not universal language and the languages differ from country to country. Also the signed languages are not based on the spoken language of the region.

In Macedonia there are around 6000 deaf people [7] and according to the National association of deaf and hard of hearing of Macedonia there are only 12 licensed interpreters of the Macedonian Sign Language (MSL) [8]. The signs of the alphabet together with the terms for mother, father and some basic colors are the only information about MSL that can be, from recently, found online. Until 3 months ago this information was not available. Since then the National association upgraded their web page and published this information online. Unlike the bigger countries that promote their national sign language, there are no e-books, videos or any other type on online content that can help learning the MSL. This community in Macedonia is highly marginalized. Only one television channel (the national channel) offers once a day a MSL interpreted news and a weekly show called “The world of silence”. All the other programs and TV channels don’t offer even subtitles to their contents in Macedonian language. These are the reasons why we started this project. We wanted to enter this world and to offer the possibility of learning MSL to every citizen of our country.

1.1 Macedonian Sign Language

The Macedonian sign language is based on gestures and body gestures, as all the other sign languages. The hands are the basic communication means. The signs are performed with predefined movement and location using one or both hands. Not every hand movement has meaning. There are additional elements that enable more efficient

and understandable communication like head movement, facial expression, mouth or body movement.

The Macedonian sign alphabet consists of 31 signs, the same number of letters in Macedonian alphabet. There are two versions of the alphabet: one version is signed using only one hand and the other is using both hands. Figure 1 shows the MSL alphabet signed with two hands.

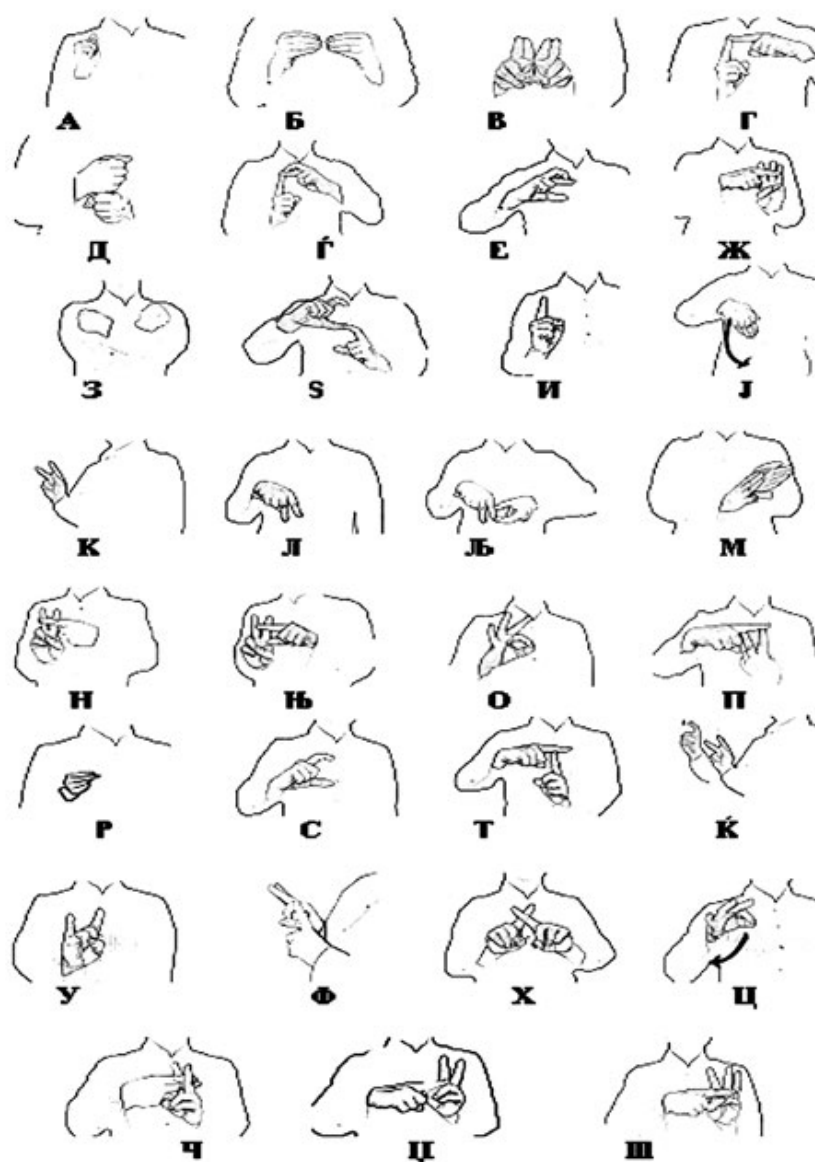


Fig. 1. The Macedonian sign language alphabet signed with two hands [8]

2 The technology possibilities and researches

The digital technology can reduce the gap between the people with physical and mental disabilities and can help the communication of deaf and hard of hearing people with the rest of the population. In the past 10 years there have been efforts in many different directions to improve the quality of life of deaf and hard of hearing.

The inclusion of this community in today's online world has been considered for a long time. General accessibility guidelines for software application are proposed long time ago, in 1994 by Gregg C. Vanderheiden [9]. These are the general recommendations:

- Provide visual form of all auditory information
- Ensure that all visual cues are noticeable
- Offer an operation mode for noisy environments or if sound is turned off;
- Support ShowSounds feature if it exists in the operating system

There have been efforts to produce a general framework to support development of sign language Human-Computer Interaction [10] and to support sign language recognition and interaction. These researches are still in the begging phase.

2.1 Visual technologies

The visual technology has evolved. From the previous researches we can conclude that the products with visual interfaces are the most recommendable for communication with SL. A lot of researches are exploiting this technology in different ways.

One research trend is focused on improving *communication* using the visual technologies to translate sign language into text with devices like mobile phones, such as Mobile Motion Gesture Design for Deaf People [11]. Other research groups are working in the opposite direction: converting text [12] or audio into sign languages. Such examples are the applications that translate the audio signal into animated face so the deaf users can use lip-reading, like the Mobile Multimedia Application for Deaf Users [13] and the Lip Assistant [14].

Another direction of research concentrates on the learning process of the sign languages. Examples of this type of research are the System for Sign Language Tutoring [15] which evaluates users' signing and gives multimodal feedback to help improve signing, 3D Animation Editor and Display Sign Language System for Thai Sign Language [16] which exploits the XNA framework in order to train the general person and Deaf person with Thai Sign Language for ability to communicate to each other and SignOn - a Model for Teaching Written Language to Deaf People [17].

An interesting approach is the idea to develop as a prototype an augmented reality book for deaf students [18].

There are also commercial products on the market like the Vcom3D Sign Smith product which use avatar. They offer the products: Illustrated Dictionary - for learning

basic American Sign Language, Studio - to make your content sign language accessible, ASL Animations - to help students to learn English words by adding animated GIFs and MOVs to existing classroom software programs and Signing Science Dictionary - comprehensive science reference for Deaf students in grades 4-8. [19]. Figure 2 shows the signing avatar in the Illustrated Dictionary and generally shows the interface of this product. This product arranges the words both alphabetically and by category. Every word is represented by a picture, used in a sentence and signed. The Illustrated Dictionary includes the 500 signs most commonly included in beginning ASL courses. [19]



Fig. 2. The Vcom3D Illustrated Dictionary [19]

3 Sign Language Tutor

3.1 Sign Language Tutor general information and user interfaces

Sign Language Tutor is an interactive platform for MSL learning that is easily extendible. It represents a collection of games and modules that will ease the learning and increase mental and memory skills of the deaf and hard of hearing children. The central part of this project consists of 3D animations of a girl that signs the chosen alphabet character or some objects. Figure 3 shows our character performing signing.



Fig. 3. 3D animation of the girl signing

The application consists of several modules:

- 3D simulation – this module provides signing of alphabet letters and words. The user chooses the letter or the object and the 3D animation illustrates the chosen sign. The user can rotate the animation in all directions and enables different views to better capture the signing. This is of outmost importance, since the signs and words are actually expressed in 3D, usually with more than just fingers and hands. The animation can be paused and started again.
- Memory – this module represent a standard memory game where the goal is to merge an alphabet letter with the appropriate sign.
- Explore – this module is a 2D game where our hero goes in an adventure against monsters and collects objects. Each of the collected objects is an award – an animated 3D sign of that object in MSL. The game doesn't require high many skills and it is adapted for children. Figure 4 shows the first level of the Explore module.



Fig. 4. The first level of the Explore module

3.2 Sign Language Tutor architecture and technical details

The Sign Language tutor is built from several software modules that are interconnected. This enables easier manipulation and expandability of the project.

The following sections will briefly describe the importance and the management of each of the modules.

3.3 SignLanguageTutor

This module along with the core part is the central part of the software solution and depends of all the other modules. It represents a Windows Game type of project that work on XNA 4.0 framework. It contains the concrete implementations of the games, and respectively the entire user interfaces.

The principle of work of this module is based on manipulation and management of the rendered views of the user interfaces. All the user screens are managed through the global object Screen Manager.

3.4 SignLanguageTutorContent

This module is responsible for the management of the resources. It represents a ContentProject type of project and it is used for resources compilation, storage and preparation for use during the execution. It is divided in parts responsible for management of models, backgrounds, textures, maps etc...

The part that manages modules contains all the 3D animation models. We use Autodesk FBX XNA importer as a specific resource to import the 3D models. The em-

bedded resource processor in XNA cannot be used because of the complexity of the 3D models (existence of animations based on skeleton movement attached to the model). That is why we have extended the embedded resource processor in XNA. The extension is represented in the `SignLanguageTutor.AnimationProcessor` module, described in the next section.

3.5 `SignLanguageTutor.AnimationPipeline`

This module is compiled to a dynamic link library. It contains the `AnimationProcessor` class that extends `ModelProcessor`. The processor contains two parts needed for texture processing: skeleton processing and animation processing part. This actions are called through the function `Process` that is inherited and replaced from the `ModelProcessor`.

First we process the skeleton attached to the model. In this process we track the skeleton bones and then we create a hierarchy of dependent bones. This is required for the movement of one animation. In this phase we transformed the model into parts that are included in one coordinate system. After that we import the model which represents the skin attached to the skeleton. For better and more real appearance we use material and textures. Finally, we process the animation. In this phase first we create a search table that will enable index-based search of the bone names in the model. After that we create an array of matrices to save the transformations of the bones. We recursively process the whole module graph of the scene and extract the data that contains animation. For each animation we process the keyframes and we define grouping of the keyframe bones. In the keyframe filtering we perform linear interpolation.

3.6 `SignLanguageTutor.AnimationAux`

The `AnimationAux` is an auxiliary module that includes animation processor connection. It contains entities for animation model storage, helpers for animation and models' binary formats loading directly in the source code.

3.7 `SignLanguageTutor.TileEngine`, `LevelEditor` and `LevelEditorContent`

This `TileEngine` module is used in the 2D game `Explore`. It represents a framework that defines all the basic 2D game functionalities like movement physics, game map and view. This is also popularly called game engine.

The `LevelEditor` and `LevelEditorContent` modules are in charge for game maps creation and storage. The map editor is also XNA Windows Game application.

4 Current work: application testing and improvement

At this moment we are working on getting more standard subjects in their natural environment in order to test the usability of the system. In Macedonia, since the

community of deaf and hard of hearing is much marginalized, it is very difficult to get to the children of this group. At this moment we are negotiating with the specialized institution for deaf and hard of hearing “Partenija Zografski” in order to test the system on a referent number of children

Our work on this project doesn’t stop here. We have few goals for the future. Our first goal is to enrich the dictionary with more words and phrases. Another goal is to create a mobile version of our application for the popular platforms like Android and iPhone, and make the application closer to the users: the ones who are heard of hearing impairment and the ones that have no problems of this kind. We believe that it will enable the ordinary users to get more acquainted with the Macedonian Sign Language.

We would also like to explore the possibilities of automatically signing text in Macedonian language with usage of software patterns. For that purpose we have to get more acquainted to the MSL grammar.

5 Conclusion

We have seen that the scientists all around the world are working on the goal to improve the communication between the deaf and hearing people and they are trying to find out innovating approaches to reach their goal like signing tutorials, automatic convertors and avatars. In most of the develop countries the community of deaf and hard of hearing people are open to the society. They have material about their native signing language and the society pays attention to their inclusion by offering accessibility features.

Unfortunately in Macedonia the situation is far from the ideal. Poor information about MSL can be found only on the site of the National association of deaf and hard of hearing and the deaf children are isolated in only few schools. Our project offers bigger inclusion and increases the awareness of this social group by helping the deaf and hearing people to learn MSL.

The software is developed using the XNA framework which has proven to be a good platform for video games, offering wide spectrum of possibilities and fast export of the solution to any platform that supports XNA and .NET framework.

We have followed the recommendations given by research human-computer interaction with deaf children [20][21] about deaf children psychology and abilities and we created a product that deaf children will easily use and will offer education and fun combined. It will help the children or their non-deaf parent to improve SL communication skills.

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