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Dictionary of the Slovenian Sign Language on the WWW

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Abstract. The article describes technical and user-interface issues of transferring the contents and functionality of the CD-ROM version of the Slovenian sing language dictionary to the web. The dictionary of Slovenian sign language consist of video clips showing the demonstration of signs that deaf people use for communication, text description of the words corresponding to the signs and pictures illustrating the same word/sign. A new technical solution—a video sprite—for concatenating subsections of video clips necessary for their smooth display on most available platforms was developed. The contents of the dictionary which were re-edited are combined also with other resources available on the web. Added were also new exercises for learning the sign language.

Keywords: sign language, multimedia dictionary, web application, video player, video sprite.

1 Introduction

The fastest way in which deaf people can communicate is by using sign language using their hands. Facial expressions and body posture which accompany signing can modify the basic meaning of a hand gesture. Sign languages have emerged naturally in deaf communities alongside or among spoken languages already in the ancient past [1]. Like spoken languages different sign languages and dialects evolved around the world.

Only after the year 1500 first attempts were made to formally educate deaf children. First books about signing and attempts to formalize sign languages appeared. An important breakthrough was the realization that hearing is not a prerequisite for understanding ideas. One of the most important early educators of the deaf and the first promoter of sign language was Charles Michel De L'Epée (1712–1789) in France. He founded the fist public school for deaf people. His teachings about sign language quickly spread all over the world.

A gesture in a sign language equals a word in a written language. A sign language is therefore a set of signs or hand gestures. Similarly, a sentence in

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a written language equals a sequence of gestures in a sign language. However, sign language in a given geographical region is not related to the grammar of the spoken language in the same region. For example, in Spain and Mexico they use a totally different sign language although they share the same spoken and written language. On the other hand, in South Africa they use one sign language although they speak eleven different languages [1]. Different sign languages are related mainly due to the influence of formal education and learning of sign languages. Slovenian sign language was derived from the French Sign Language through the Austro-Hungarian sign language in 1840 when the first school for deaf children opened in Slovenia [1]. Sign languages continuously evolve and new signs, such as for example scientific terms are being added to the sign vocabulary [2].

Spoken language is in essence linear—only one sound can be made or received at a time. Sign language, on the other hand, is visual and visual perception allows processing of simultaneous information. Therefore, simultaneous expressions can be used, for example, classifiers which allow a signer to spatially show a referent's type, size, shape, movement, or extent take advantage of the spatial nature of sign language. Gestures in a sign language often emulate the movement or the shape of objects described by the corresponding sign. This principle is called iconicity [1]. Sign languages vary also in word-order typology, for example, Austro-Hungarian Sign Language is of Subject-Object-Verb type while ASL is Subject-Verb-Object. Influence from the surrounding spoken languages is not improbable [1].

To communicate proper nouns and un-common words, sign languages use finger spelling or a manual alphabet [1]. Since the majority of signing employs full words, a signed conversation can proceed with the same pace as a spoken conversation. The Slovenian sign language (SSL), which is used in Slovenia and serves also as the object of this work, consists of approximately 4000 different gestures for common words.

Usually, printed sign language dictionaries, textbooks and manuals relay on illustrations using drawings or photographs which are augmented by text descriptions, for example, such as in the introductory textbook for learning Slovenian sign language [3]. Multimedia technology therefore seems an ideal medium for presentation, reference and learning of such gestural knowledge since it can incorporate also video material. The first multimedia sign language manuals and dictionaries which started to appear in the 90-ties were on CD-ROMs. The American Sign Language Dictionary on CD-ROM was published in 1994 [4]. Our efforts to develop a dictionary of the Slovenian Sign Language started at about the same time [5, 6] and culminated with the publication of the Dictionary of the Slovenian Sign Language on CD-ROM in 2001 [7]. Several other CD-ROM based sign language courses or dictionaries appeared at that time, such as the Czech sign language course [8], British Sign Language [9], etc.

Multimedia CD-ROMs are usually dependent on the type and version of the computer operating system. Due to the fast evolution of operating systems practically all CD-ROMs developed in the not too distant past are therefore practically not usable anymore. The potential users of our dictionary, which worked

perfectly under Windows 7, can not use it on current hardware and software platforms. Our motivation for the work reported in this article was therefore to reuse the contents of the Slovenian Sign Language Dictionary and transfer it to a new technological platform which would make the knowledge even more readily available to potential users. At the same time we wanted to reedit the contents and to expand the functionality of the dictionary. World Wide Web experienced in the past decade a tremendous growth in speed as well as in technical prowess and hence presents the obvious choice as the most appropriate medium for such contents. The decision to transfer the material of the CD-ROM version of the dictionary to the web was therefore clear. Another reason for transferring the dictionary to the web is also the appearance of tablet devices which generally do not support CD-ROMs but offer connectivity to the Internet.

Another venue for teaching sign language which was made available by advances in computing is using a virtual human avatar, generated by computer graphics methods, instead of video recordings of an actual human performing signs [10]. This approach, although appealing, has so far not resulted in any large sign language corpus. Namely, besides proper hand movements, the accompanied face expressions are also important for understanding of a sign language. Therefore, any signing avatars should be produced using the highest quality computer graphics which is still too computationally expensive for such applications.

The largest research interest in computing in relation to sign language is oriented towards sign language recognition [11]. Sign language recognition has the well defined goal to translate signs performed by a signing person into text and offers an exciting environment for testing various recognition methods in computer vision.

Sign language support should be incorporated in various communications channels. Using a small window for the signing interpreter is quite common on TV and video material. Now, it is important to include such possibilities also on web pages. Since it is difficult to include this option in the design of web pages from the very beginning and since it can be also distracting to the general public, development of transparent sign language videos which appear only on request were proposed [12]. In this way, the original web page design is preserved but an additional web layer for sign language video is available.

The rest of the article continues as follows: Section 2 is a recapitulation and analysis of the original Slovenian Sign Language Dictionary on CD-ROM that guided us in the design of the enhanced version of the dictionary for the web. The contents and functionality of the new web-based version of the dictionary is described in Section 3. Section 4 presents the technical details of the web-based implementation. In Conclusions we discuss the first user experiences and directions for possible future work.

2 Dictionary of the Slovenian Sign Language on CD-ROM

We developed our first concept of a CD-ROM based multimedia sign language dictionary for the deaf in 1995 [5, 6]. We demonstrated this concept also at

the New Talent Pavilion, MILIA'95, in Cannes, France. The only other similar dictionaries at that time were for the American Sign Language [4, 13]. A pilot application of our sign language dictionary consisting of less than 100 words was made in 1996 [14], while the final application, which included also a method for synthesis of signs from several video clips, was finished in 1999 [15]. This was a well received technical achievement since our CD-ROM-based Dictionary of the Slovenian Sign Language of the deaf was selected among the top 15 products in the Student Europrix'99 MultiMediaArt Competition [16]. The final version of the Slovenian Sign Language Dictionary was eventually officially published on CD-ROM in 2001 [7].

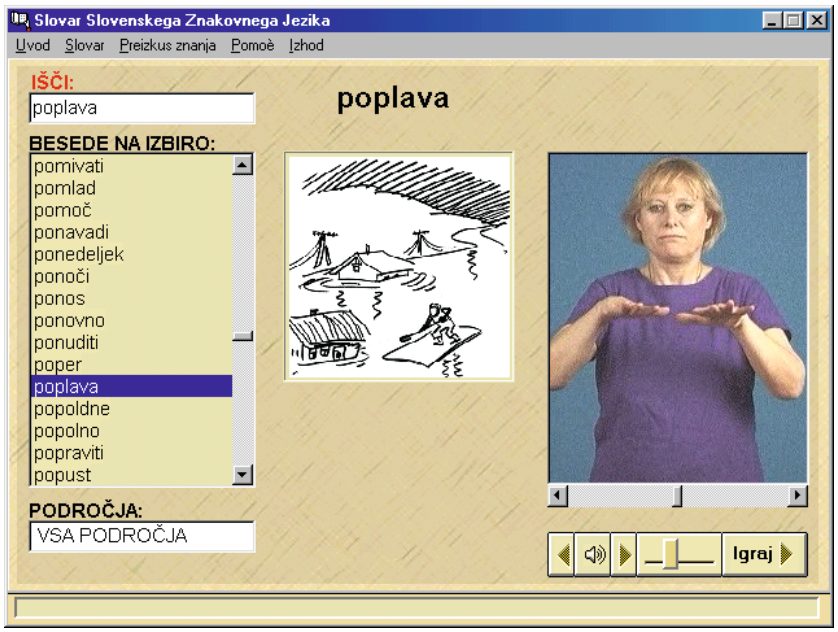

Fig. 1. Word "poplava" ("flood" in English) is on the CD-ROM version of the Slovenian sign language dictionary illustrated with a drawing and a video clip showing the corresponding gesture

The CD-ROM version of the Slovenian Sign Language dictionary includes about 2500 most frequent words or signs. Each word or sign (see Fig. 1) is illustrated with a drawing and the corresponding sign is demonstrated on a video clip. Words are arranged in alphabetical order and also in thematic subgroups so that related words can be found easier. Several signed words are assembled out of two basic signs. For example, the sign for a "farmer" (Slov. "kmet") is assembled out of signs for "rural" (Slov. "kmečki") + "person" (Slov. "oseba"). Similarly, the sign for a "farm" is assembled out of signs for "rural" (Slov. "kmečki") + "landscape" (Slov. "pokrajina"). To save storage space on the CD-ROM and to

include more words in the dictionary, we decided to exploit this feature of assembling signs also by concatenating their corresponding video clips. Therefore, the number of video clips in the dictionary can be smaller than the number of words and space for data storage on the CD-ROM could be saved to include more words in the dictionary. This feature of assembling signs turned out quite useful also now, during the transfer of the dictionary to the web, since we were able to expand the sign language vocabulary just by assembling preexisting signs.

Concatenation of video clips presumes a uniform appearance of all video clips so that when we observe an assembled sign, we get the impression that the sign was captured continuously. A uniform appearance of video clips requires that the same person is signing on all video clips. The demonstrator of sign language in the described dictionary was Ms. Ljubica Podgoršek who is the most well known interpreter of sign language in Slovenia and who graciously collaborated also in the redaction of the web version of the dictionary. To achieve the best possible uniformity of video clips it is not enough just to have the same person demonstrating signs. For consistency, the video clips should be captured under exactly the same conditions (i.e. appearance of the demonstrator, lightning, camera setup etc.). We achieved the highest possible consistency of video clips by videotaping the entire sign vocabulary in as few sessions as possible using the same sign demonstrator.

Concatenation of video clips into "natural" looking signing sequences can not be achieved just by concatenating the end of the first clip with the start of the second clip. Namely, in each individual sign video clip, the demonstrator always starts and ends the gesture with the hands in the initial or neutral position at the waist level. "Gluing" together such un-edited video clips would look quite un-natural and in effect similar to trying to synthesize speech just by playing a sequence of prerecorded words. Redundant motions of arms between subsequent signs recorded in individual video clips must therefore be eliminated to assure a smooth transition between the video recordings of individual signs and give an appearance of continuous signing.

For the CD-ROM version of the Slovenian Sign Language Dictionary we developed a new method for concatenating sign video clips which we describe elsewhere [15, 17]. We used computer vision methods to track the position of both hands in all video clips and during entire video sequences. Based on the position of hands we defined four different criteria for concatenation of video clips. Which criteria is used depends on the type of signs (i.e. one-handed or two-handed, general position of the hands etc.) that need to be concatenated. This approach of synthesizing sign language by concatenation of video clips was later used or further developed by several other creators of sign language dictionaries [18–20].

Words which are not in the dictionary or proper names can be shown by spelling and using video clips which contain the signs for individual letters. The complete finger alphabet forms a distinct part of our sign language dictionary showing only still images of gestures for individual letter signs.

2.1 Other Sign Language Initiatives in Slovenia in the Past Ten Years

In 2003 the Association of deaf and hearing impaired people in Slovenia and the Association of interpreters of the Slovenian Sign Language also issued a CD-ROM version containing videos of the most used signs in the Slovenian sign language [21]. However, due to similar issues described above, this CD-ROM is now also technically obsolete.

The Association of interpreters of the Slovenian Sign Language has also developed a light web version of Slovenian sign language dictionary with around a hundred words related to politics [22]. Words are organized alphabetically where for each word a short description is given and a video clip of the performed sign can be played. To play these videos the website uses flowplayer, the HTML5 video player for the web. Unlike the sign video clips that we use, where the demonstrator does not pronounce the corresponding word, the sign language demonstrator on these video clips pronounces the signed word.

On the web page of the Association of deaf and hearing impaired people in Slovenia [23] is available a richer video dictionary of Slovenian sign language, containing signs from the Slovenian and the International sign language. Signs are organized alphabetically and according to selected topics but no other explanation or additional information about the chosen words is available. The website uses jw-player, HTML5 and Flash video player.

2.2 Web-Based Sign Language Dictionaries for Other Languages

The largest web presence has the American sign language (ASL) which is used in more than 50 countries [4]. **Handspeak** [24] is a website with a powerful ASL dictionary which has over 6000 words (glosses) and is still growing. Words are ordered as in a traditional dictionary and the website offers a word search option. One of the more powerful tools on this website is that you can describe a sign with handshape and movement and then search for a word (the dictionary works both ways). When looking for a word, the user of the handspeak dictionary sees only a video and a short word definition, sometimes but only rarely, synonyms and notes would show up. Missing videos can be spotted which makes this dictionary a bit unreliable. The website also includes general information about american sign language such as courses, using sign language with kids, fingerspelling etc.

Signing Savvy [25] is one of the most well known web-based ASL dictionaries. It contains more than 7000 searchable words but is unfortunately payable. It contains also a section for the youngest with 80 basic words.

ASLPro [26] is from a web developer's point of view a poorly designed website filled with ads, but has a powerful collection of videos which were poorly converted into flash (the videos still include play, stop, forward buttons inside the video). The dictionary is divided into four major parts: (1) "The main dictionary" with all the words; (2) "Religious Signs" with a lot of words and names used in different religions, churches and holy books; (3) "Conversational Phrases" which include videos of common phrases used in shops, occupations, nature and

similar; and, finally, (3) "ASL for babies" with the most common signs that could be taught to a baby. Every word or phrase is only represented by a video. The website also includes a quiz that is similar to the first of our three quizzes on our website where you have to pick the corresponding word after seeing a sign.

British Sign Language [27] is a web-site that is, such as our web dictionary, also derived from a CD-ROM dictionary. The online dictionary includes 500 words. Every word is presented with an image in gif format (instead of a video) which are not easy for the eyes since only around 2 frames per second are available and hence just a few frames to present a single word. Each word, however, includes a really good description of how it is signed and, if available, related words. The website has also a section for phrases but, unfortunately, only one phrase is shown online, all others are offered only on a CD. The full content of the dictionary is therefore still available only on a payable CD-ROM. Similar to our website, the British Sign Language website offers words grouped by their meaning. A list of several online sign language resources is available [28].

3 Web-Based Dictionary of the Slovenian Sign Language

Our first attempt to move the Slovenian sign language dictionary to the web using the Java programing language goes back to 2000 [29]. This effort was only partially successful. The most severe problems which remained unresolved were with the playback of concatenated video clips. After another decade of intensive development of web technology we believe that the technology is now ripe to transfer the dictionary and its entire functionality to the web, in particular, since due to technical obsolescence, the original CD-ROM version is practically not usable anymore.

At the same time we decided to redesign also the graphical user interface, to combine the original information contained in the dictionary with other resources available on the web and, finally, we had to solve the problem of smooth playback of concatenated video clips.

We used this opportunity also to correct some mistakes and to add new words to the dictionary whose sign could be assembled out of two or more existing video clips. Since many words in the sign dictionary are assembled out of two or more basic signs, it was possible to add new words into the dictionary without the need to record new video clips. Ms. Ljubica Podgoršek selected more than 100 new words for the web-based dictionary that we could assemble out of existing sign video clips.

Currently, the web version of the sign dictionary includes 2514 words and 1801 video clips. The difference is due to sign synonyms when the same sign can have different meanings (486 words) and because some words are assembled out of two or more video clips (245 words).

Fig. 2. On the left side of all web pages of the dictionary are links for navigation: (1) link to the Computer vision laboratory where the dictionary was implemented, link to other resources for the deaf, and email contact of the administrator of the dictionary; (2) five links to the main parts of the dictionary: home page, alphabetical list of words, thematic groups of words, signs for individual letters, exercises. On the right side are the contents of the web pages. On the right side of the home page shown here are: (3) some general information about sign language, about the sign dictionary and acknowledgements to all contributors, (4) a player for video clips used for showing the demonstration of all signs included in the dictionary which was developed specially for this purpose.

3.1 Graphical User Interface

We aimed for a rather minimalistic design of the whole web dictionary so that the video player would clearly stand out of the pages. The new home page of the dictionary is shown in Fig. 2. On the left side of all pages are links for navigating the dictionary, while on the right side are the contents of web pages.

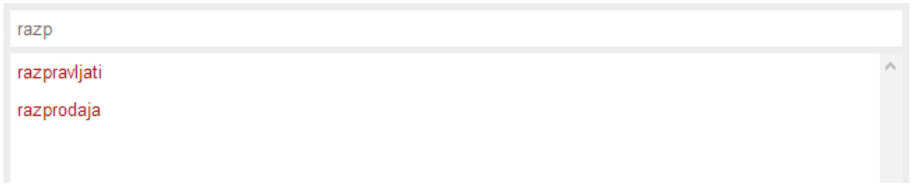

Fig. 3. An AJAX powered search field for words from the alphabetical list offers an autocomplete function

The core functionality for searching the alphabetical word list is the ajax powered search field (Fig. 3) which offers an autocomplete function. This makes the search of words easier since it instantly shows the user all the remaining words from the dictionary which share a common begining.

The description of each individual word in the dictionary is structured as follows (see Fig. 4): (1) the thematic group into which the word belongs and the number of basic signs needed to show that word, (2) the description of the word from the web dictionary of slovenian language [30], (3) the video player showing the corresponding demonstration of the sign, (4) images acquired through search for the word with google images, and (5) permanent link to the web page giving the users the possibility to directly link to it.

There are currently 38 thematic groups of words in the dictionary (Fig. 5). Thematic grouping of words makes the searching for related words much faster. The most common words in each thematic group are presented with their corresponding sign videos visually organized into a grid (Fig. 6).

The page dedicated to the alphabet and spelling (Fig. 7) contains a link to the thematic group “alphabet”, where video clips for each letter sign can be seen, and a link to the still images of hands signs for the letters in the alphabet. On the bottom of the page words can be spelled out with the help of these hand signs.

Exercises for learning the slovene sign language were substantionally expanded. There are three types of exercises (see Fig. 8):

- after seeing a video clip with a sign, select the correct word among five choices,
- after seeing a video clip with a sign, write down the interpreted word,
- for the given word, demonstrate the sign yourself and then compare you sign with the correct sign in the video clip.

For each exercise you can limit the selection of words to selected thematic groups and select the number of repetitions.

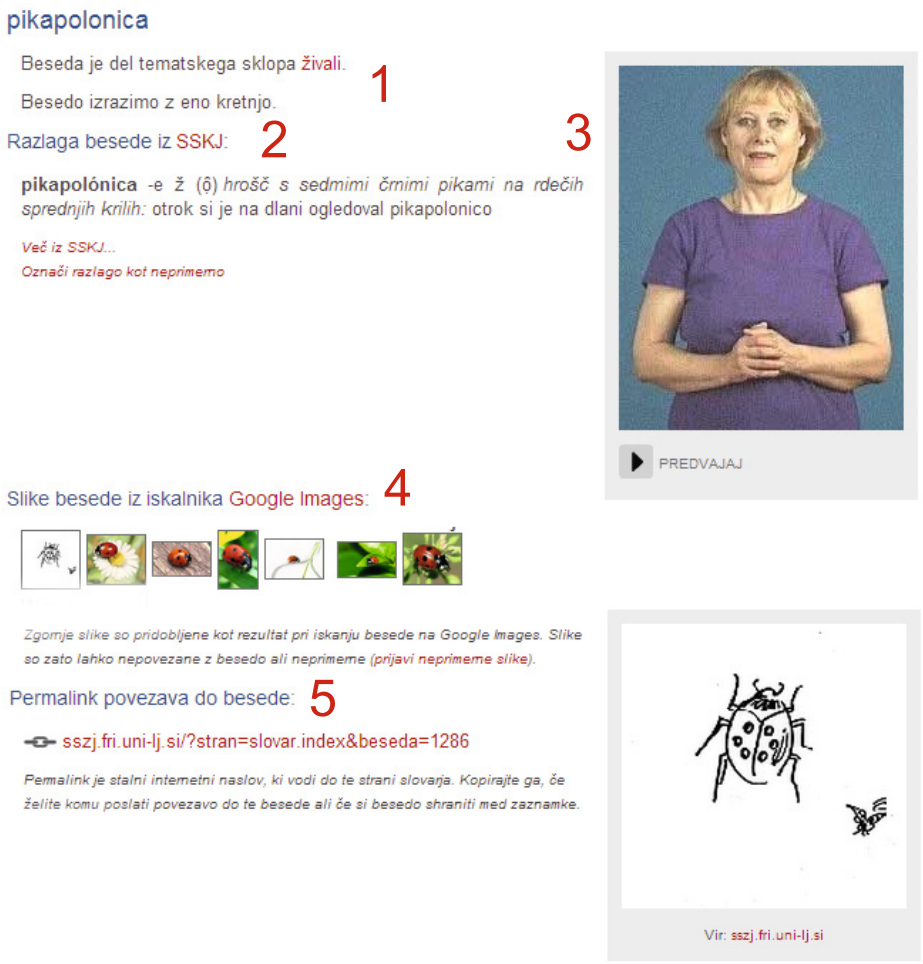

Fig. 4. Description of the word "pikapolonica" ("ladybird" in English). (1) In which thematic group belongs the word—animals and how many signs are needed for demonstration—one. (2) description of the word, (3) window for the video demonstration, (4) pictures found with Google Images, (5) permalink to the word, on bottom right is the selected picture, the illustration of the word by artist Marjan Bregar in this case.

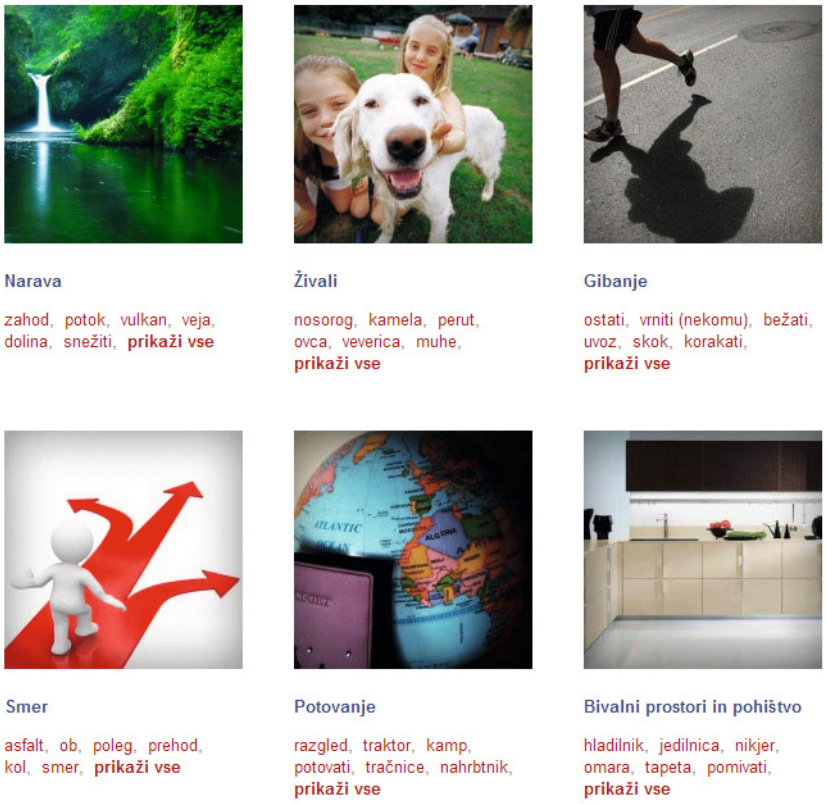

Fig. 5. Words in the dictionary are organized into 38 thematic groups to make the searching and learning of related words easier. Themes from left to right and from top to bottom are: nature, animals, movement, direction, travel, living areas and furniture.

4 Technical Details of the Web-Based Implementation

4.1 Technology Used

Prior knowledge, experience, ease of use and programming speed lead us to the decision to implement the web-based dictionary on the PHP platform. A development server running Apache HTTP service was set up. For the main data storage we used the MySQL database management system and we took great care to design a well organized database scheme. When the application's back-end was ready, we focused on how the dictionary's proper front-end should be structured and what its platform dependancies would be.

Since one of our main goals was to make the web-based implementation of the dictionary accessible to as many users as possible, this consideration lead to the conclusion that platform dependancies should be minimized. The first step towards achieving this goal was to avoid the use of rich multimedia browser

Fig. 6. Words on pages dedicated to individual thematic groups are organized alphabetically into a rectangular grid of sign videos

Fig. 7. Page dedicated to the hand alphabet and spelling. The word "članek" (Engl. "article") is spelled with the help of one hand signs for letters.

Fig. 8. There are three types of exercises: (1) on the left: after seeing a video clip of a sign, select the correct word among five choices, (2) in the center: after seeing a video clip of a sign, write down the correct word, (3) on the left: for the given word, demonstrate the sign and compare it with the correct demonstration of that sign.

plugins such as Flash or Java which are not included or even available on some popular platforms. We ended up limiting ourselves to using only the universally supported CSS syntax for page design and JavaScript code for the interactive parts of the dictionary.

4.2 Implementation of a Custom JavaScript Video Player

Video clips with a sign language demonstrator showing the appropriate sign is an integral part of a sign language dictionary. Since we decided to illustrate signs assembled out of two or more basic signs also by concatenating their corresponding video sign clips and at the same time eliminating redundant motions of hands, a very tight control over the video playback is required. Namely, to play a video clip from a predetermined arbitrary start point till a predetermined arbitrary end point and then continue with the playback of the next video clip in the same way without any interruption.

Restricting ourselves to using only CSS and JavaScript raised an important issue which had to be considered carefully. A video player for playback of sign videos had to be chosen. We considered and studied several available options and came to the following conclusions:

– players implemented as web browser plugins (Flash, Java, JavaFX, etc.) cannot be used, as they would make the dictionary platform dependent since some mobile platforms, tablet PCs and other handheld devices are not provided with these plugins.

- HTML5 is nowadays almost universally supported, making it a potentially good option. However, HTML5 video players are not fully controllable by JavaScript, making it impossible to implement the playback of compound words, which are concatenated out of two or more basic sign video clips which need to start and end playing at arbitrary points.
- Converting the videos to Animated GIF format was also considered. However, compared to the HTML5 option, the playback is even less controllable.
- A custom video player should be implemented, which would be fully controllable using JavaScript functions and would further provide JavaScript with the information about which video frame is currently being played. This would allow the playback of assembled words which are concatenated out of two or more basic video clips.

The last conclusion lead us to the idea of converting video files to a custom format which could be controlled by JavaScript. After some brainstorming, discussion with other developers and testing a series of prototypes we were able to develop a working JavaScript controllable video player.

4.3 A New Format for Video Clips

First, we extracted all picture frames from the original video files script and saved them internally as a series of JPEG images using a Python script. Because the original videos are not of the best quality we did not want to degrade them even further and have therefore used the highest JPEG quality (Q=100) that uses a compression rate 2.6:1. The quality of the new video format from the viewer's perspective remained almost the same and any differences are barely noticeable. Since the original video files were recorded with a frame frequency of 15 frames per second we obtained 15 JPEG files for each second of the original video. Next, we merged the individual JPEG images of each video clip into a single larger (actually only wider) JPEG image. In this way, all the original video clips were converted into corresponding JPEG images which were assembled out of video frames of the original video clip. An example of such an image can be seen on Fig. 9. To differentiate this format from the original video clip we decided to name this type of images a *video sprite*.

In addition to the original aim of the new format for video clips, to gain a more precise control of video playback, another beneficial effect turned up—the resulting images or video sprites were considerably smaller than the original videos. On average, the new file size was reduced to 60% of the original file. This reduction in size is especially important since our application runs on the web and video clips can be downloaded from our server much faster.

Our JavaScript video sprite player creates an HTML element with a fixed size (which is the same as the size of a single video frame) and attaches it as a CSS directive, which determines the element's background image. The selected background image is the video sprite version of the target video. Due to the fixed HTML element size, only the first frame from the video sprite is seen.

Fig. 9. Each original video clip was converted into a single JPEG image file which contains all video frames of the original clip. We named this format a *video sprite*.

Using JavaScript we can wait until the video sprite is fully downloaded (because the video sprite is actually a single JPEG image) and react afterwards. Next, the JavaScript code starts shifting the HTML element's background image to the left 15 times per second, creating the illusion of video playback.

The described implementation makes it possible to fully control video playback from JavaScript. By loading two more video sprites and using them as background images for the same HTML element at appropriate times, it becomes possible to stack basic sign videos together at preselected points to sign a compound word. The solution that we implemented has been tested on different software and hardware platforms. The results of the playback of a single and merged videos have been satisfying and to an observer look almost the same as the ones from the CD-ROM version of dictionary on almost all platforms. Video playback was tested on PC laptops and PC desktop computers on most widely used browsers including Google Chrome, Mozilla Firefox, Internet Explorer and Opera running on the operating systems Microsoft Windows XP, 7 and 8 and Linux Ubuntu (with the exception of Internet Explorer). Video playback was tested also on an Apple MacBook Pro using the Safari browser running under OSX. The final testing was performed also on tablets and mobile devices where video performed as expected on Apple iPad and iPhone running the Safari browser under iOS operating system, on Android Samsung Galaxy Tab under Android browser, on a "low budget" Android tablet MpMAN MP824 under Opera and on mobile device HTC Desire Z, running Android 4.0, using a 3G network connection to the Internet. A slower performance of the video playback was noticeable only on a LG KC910i most likely due to a much slower hardware, but signs in the video clips were still recognizable.

4.4 How Images That Illustrate the Dictionary Words Are Found

The original CD-ROM version of the dictionary includes a large set of images for illustrating the meaning of words included in the dictionary (as seen on Fig. 1). These images make the learning process faster and easier, especially for younger learners, considering also that deaf people in general are not as proficient readers as the hearing population. Taking into consideration the fact that the spoken and written language is not their primary language. These original illustrations which were drawn expressly for the dictionary by Marjan Bregar[1] were included also in the current web version of the dictionary. However, not every word in

[1] Marjan Bregar is a renowned slovenian cartoonist and illustrator, best known for his series of cartoons in the 1950s and 1960s featuring Peter Mozolc in the weekly satirical newspaper *Pavliha*.

the CD-ROM version was illustrated and also new words were added to the web version of the dictionary. How could we fill the missing illustrations? Employing a professional illustrator for a self contained dictionary made sense but on the web exist so many public repositories with rich collections of multimedia that creating new material for that purpose would be unnecessary and superfluous. How could we combine the words from our dictionary with this vast collection of images on the web?

We decided to test a simple and straightforward approach by using Google Image Search API. When a user selects a word in the dictionary, the API is used to perform an image search query using the selected word and the first five resulting images are shown. The results are generally relevant, but there are cases in which the resulting images do not appropriately illustrate the word's meaning. To eliminate such cases we created a simple tool that allows the dictionary's editors to manualy remove inappropriate results. We also created a way in which the users can report image inconsistencies that the editors may have missed.

This simple approach enlarged the initial set of illustrations significantly and demonstrated its usefulness, but almost a third of all search queries produced inappropriate results. Based on these initial and encouraging results we are in the process of improving our search for illustrations:

- replacing Google Image Search API (which is deprecated since of 26 May 2011) with the new and improved Google Custom Search API,
- using beside Slovenian words also their English translation as search queries,
- enabling the users of the dictionary in a crowd sourcing manner to vote on the appropriateness of illustrations so that gradually the best illustrations for the selected words would emerge, and
- giving the users the option to manually enter new image sources.

5 Discussion

A multimedia sign language dictionary can serve multiple functions. Primarily, it supports the learning process of sign language in special educational institutions for the deaf as well as enables normal hearing people who are in daily contact with deaf people to learn to communicate with them in sign language. Another goal of a sign language dictionary is to standardize a given sign language. Since communities of deaf people are often isolated from each other there is a great tendency to develop local dialects which are then not easily understood by other communities of deaf people. A dictionary can unify the meaning of signs and at the same time define a standard way of performing a sign. A dictionary can also partially fill the lack of qualified sign language instructors. The web version of the multimedia dictionary of the Slovenian Sign Language addresses these needs in Slovenia. The dictionary of the Slovenian sign language can now be freely accessed over the Internet from different computing platforms, including tablet computers.

Statistics for the web based Slovenian Sign Language dictionary usage which have been tracked since its opening on 25 June 2012 are encouraging. After the

initial buzz the web dictionary was receiving direct traffic and referral traffic from the Facebook page of the dictionary [31] and emails that had been sent to different associations for impaired hearing. In the first month the website was receiving around 5 to 20 unique daily visitors, 70% of which were new and 30% returning. All together 240 unique visits were tracked in July most of which were either referred to the website or came to it by entering the url address directly. 16% of the traffic came to dictionary through a search engine such as Google, Yahoo, Najdi.si etc. Since then, the statistics have gone up because of the increased ranking on major search engines. Our website has been ranking first for the main phrase "slovar slovenskega znakovnega jezika" (Engl. "Dictionary of the Slovenian sign language") on Google. In November 2012 almost 900 unique visitors have seen our website with the Slovenian sign language, half of which have been referred to it via search engines. About 50% of the visitors were returning and an average visit duration was 7 minutes. It should be mentioned that the population of Slovenia is about two million which gives a rough estimate of the total number of speakers of Slovenian language and at the same time the corresponding number of users of the Slovenian sign language.

In the future, we would like to improve the learning experience of the dictionary users. We are cooperating with instructors of deaf children to find better ways of designing the exercises offered with the dictionary. We would like to enable registration of individual users so that the system could track their progress and suggest the next best exercises that they should take for faster learning.

Although a full usability study of the Slovenian sign language dictionary is still missing we received valuable feedback from instructors in schools for deaf children. As a result of this feedback, a distinctive dictionary interface for children who can not read yet is in preparation. In general, we would like to make the user interface more visual and less dependent on text. Pre-lingually deaf children, whose familiarity with their local spoken language is that of a second language learner, written text is in general much less useful than is commonly thought. As is the use of computers in learning of the alphabet by hearing children now common due to their easy accessibility, we would like find a way how to systematically and interactively teach deaf children new signs by expanding the functionality and improving the user interface of the dictionary. Combining several signs into sign sentences brings up also the problem of generation of sign language from written text [10]. Since the grammar of sign languages in general differs from the corresponding natural language, for example Slovenian sign language versus written Slovenian language, the synthesis of sign language from text must be tackled in the context of language translation.

Another desirable feature that we would like to implement is to make the dictionary two-way, so that the user could describe a sign and get the corresponding word. A simple way of describing a sign is just to repeat or demonstrate it. This brings us again to the problem of sign language recognition and interpretation [11].

Since the community of users who regularly use the dictionary is rather stable we would like to engage them also in some type of crowd sourcing to improve

the dictionary. As the first step in that direction, the users will be able to vote which of the images selected with the help of Google image search offers the best illustration of the currently selected word.

6 Conclusions

The Slovenian sign language on the WWW project started with the rather humble goal: to make the contents of the original, more than 10 years old CD-ROM version of the sign dictionary accessible again, primarily to children in the school for deaf. Due to technical obsolescence the original CD-ROM version was not usable anymore. However, during the project we realized that we could use the Internet not only as the medium for distribution of the dictionary contents but to also to combine the original contents of the sign dictionary with other sources of information available on the Internet. For the textual description of meaning of individual signs/words we use the Dictionary of the Slovenian language on the web. For pictures that illustrate the words we use Google image search.

At the same time we decided to make a redaction of the dictionary contents. The nature of the sign language where new words can be included by combining existing signs (videos) allowed us to expand the dictionary contents with new words without making new video clips. The user interface is very important, in particular for deaf children. We would like to make a specific interface for children with less stress on text and the possibility to manipulate and combine video clips into whole sentences.

Since the sign dictionary constructs some words/signs by merging two or even three signs/words, concatenating of video clips from arbitrary start and end points on all possible platforms is necessary. To achieve this goal we devised our own method for playing video clips on the web which is based on a new format for video clips that we named video sprite.

We hope that the solutions and experiences that we gained during this project will help other developers of web-based sign dictionaries for other sign languages.

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