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# Technology for supporting web information search and learning in Sign Language

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ABSTRACT

Sign Languages (SL) are underrepresented in the digital world, which contributes to the digital divide for the Deaf Community. In this paper, our goal is twofold: (1) to review the implications of current SL generation technologies for two key user web tasks, information search and learning and (2) to propose a taxonomy of the technical and functional dimensions for categorizing those technologies. The review reveals that although contents can currently be portrayed in SL by means of videos of human signers or avatars, the debate about how bilingual (text and SL) versus SL-only websites affect signers' comprehension of hypertext content emerges as an unresolved issue in need of further empirical research. The taxonomy highlights that videos of human signers are ecological but require a high-cost group of experts to perform text to SL translations, video editing and web uploading. Avatar technology, generally associated with automatic text-SL translators, reduces bandwidth requirements and human resources but it lacks reliability. The insights gained through this review may enable designers, educators or users to select the technology that best suits their goals.



## 1. Introduction

According to the World Health Organization, 278 million people in the world are deaf or hard of hearing (World Health Organization, 2006) and many of them have Sign Language (SL) as their mother language. The diversity of regional variations of SL constitutes a set of minority languages relatively underrepresented in the digital world. Thus, members of the Deaf Community usually face non-native language web sites where accessibility barriers may emerge (e.g. Fajardo et al., 2006; Smith, 2006).

In order to ensure the Deaf Community's social inclusion, SL has to be properly incorporated into Information Technologies. Furthermore, as Kralisch and Berendt (2005) highlight, the web inclusion of minority languages might not be only an ethical but a commercial issue, related, for instance, to financial investment to create bilingual websites. In Spain, there are around 400,000 users of Spanish Sign Language (INE, Instituto Nacional de Estadística, 2006) who use oral and written Spanish as a second language and could benefit from inclusive policies. Spanish and Catalan Sign Languages have held the status of State Official Languages in Spain since 2007, as is also the case in other Member States of the European Union.

The World Wide Web Consortium (W3C) addresses, to some extent, deaf users' issues in the Web Content Accessibility Guidelines, WCAG 1.0 (Chisholm et al., 1999). In particular, Guideline 1.4 recommends that audio and its textual transcription should be synchronized, while guideline 14 states that deaf users would benefit from simple and clear written language. Besides the vagueness of these guidelines, it is important to note that they just deal with the captioning or text transcription of auditory content, leaving out the visual–spatial characteristics of SL, thus causing information loss. In addition, as clear implementation techniques are not provided, non-experts find it difficult to create WCAG-compliant web pages for the Deaf. WCAG 2.0 (Caldwell et al., 2008) became a W3C candidate recommendation in December 2008. As opposed to WCAG 1.0, SL issues are more extensively addressed in this set of guidelines. Guideline 1.2, entitled "Time-based Media: provide alternatives for time-based media", is one of those guidelines whose fulfilment enhances web content *perceivability* by users, including the deaf. Specifically, success criterion 1.2.6 states "*Sign Language interpretation is provided for all prerecorded audio content in synchronized media*". Satisfying success criterion 1.2.6 is necessary in order to meet the most demanding conformance level, the AAA success criteria. Specifically, it claims to provide SL interpretation for synchronized media by means of the following techniques:

- Embedding a SL interpreter in the video stream in order to provide SL transcription of audio content.

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– Techniques and examples of synchronizing video of the SL interpreter in order to display it in a different overlay on the image using SMIL (Michel, 2008) technology.

However, this success criterion just focuses on the transcription of auditory content. Nothing is mentioned about link content or content transcription, which, most of the time, is not auditory but textual.

In order to ensure accessibility of digital resources such as the World Wide Web (WWW), many countries have introduced laws in this regard.[1] Identifying levels of conformance with guidelines is of paramount importance, as most policies rely on standards such as the above-mentioned WCAG or similar. However, the most demanding levels of compliance, including those referring to deafness, are seldom required in order to meet these policies.

In addition, government initiatives and *standardista* contributions cannot be effectively applied if they are not accompanied by research conducted in different areas such as Human–Computer Interaction, Computer Science, Psychology, or Sociology. These scientific disciplines could help to answer questions such as the following, quoted from Cunliffe and Herring (2005, pp. 135–136):

1. How should the impact (whether positive or negative) of technology in minority language use be measured and quantified?
2. How can the linguistic dimensions of the digital divide be measured and how can its significance be assessed?
3. How does interface design influence language behaviour, e.g. how can design be used to promote minority language use in bilingual contexts, or to better support users accessing content in their non-native language?

Or, added by us:

4. What kind of technology is available and how appropriate is it to include SL on the web?
5. How do SL technologies affect the information scent (assessment of the semantic similarity between searching goals and hyperlink choices) and knowledge acquisition on the web?

Although it is vital to find the answers to all of these questions, the objective of this article is principally to answer the last two. Therefore, the aim of the following sections is to shed some light on how current SL technologies can provide deaf users with a satisfactory user experience while interacting with the WWW. Note that some of the prototypes presented were not intended for the WWW but they are mentioned in this paper as their foundations are sound and can be deployed in web environments.

Section 2 describes the most relevant SL generation systems for the web, emphasizing their strengths and weaknesses with regard to their usefulness for web information search. Similarly, the same procedure has been followed in Section 3, focusing on web learning. In Section 4, based on the previous systems review, we propose a taxonomy that classifies SL generation systems according to a set of relevant dimensions which are not only functional but also technical, such as location rendering, underlying technology (programming language, mark-up, etc.) or dimensionality. The purpose of the taxonomy is to help in the selection of the system or set of functionalities that best suits the goals of designers, educators or users while considering the availability of resources.

[1] Available at http://www.w3.org/WAI/Policy/.

## 2. Information search on the WWW by means of Sign Language

A web document or hypertext system is composed of a set of information nodes connected by links or hyperlinks. Information search refers to the user's behaviour when looking for pieces of information within or between web pages or hypertexts by means of queries in search engines and/or by following hyperlinks. Whatever the mechanism used, one of the most influential theories of information search, the Information Foraging Theory (Pirolli and Card, 1999), predicts that a particular hyperlink will be followed when the trade-off between information gained and cost of access is low. Therefore, in order to calculate such trade-offs, individuals have to assess the semantic similarity between the search goals and hyperlink choices (called information scents) presented on a web page or in a hypertext node. As Pirolli (2004) found, users seem to use semantic scents for judging not only when visiting a website but also when leaving it.

The obvious problem for SL users is that semantic cues are commonly only available in a non-native language (link words) in which they present low levels of reading proficiency (e.g. Leybaert et al., 1982; Alegría, 1999; Asensio, 1989; Goldin-Meadow and Mayberry, 2001). Consequently, deaf signers find it difficult to use a scent following strategy with textual cues as some empirical studies seem to indicate (Fajardo et al., 2009). Apparently, an easy solution to increase information search for deaf signer users is the use of graphical hyperlinks or icons, since they facilitate the process of semantic decision-making according to the classical Picture Superiority Effect (Nelson et al., 1976; Paivio, 1991). In addition, Namatame et al. (2007) observed that deaf participants were even more accurate than hearing participants in a simple visual search and match task where participants were asked to pair directory names, typically used in representative web sites, with pictograms (Experiment 2). In contrast, Fajardo et al. (2006) did not observe accuracy differences between deaf and hearing users with using graphical material. Across two experiments, users were asked to find targets in a hypertext system with several layers of nodes (a more complex search task than in Namatame et al.). Although deaf users were faster in a graphical than in a textual hypertext, deaf and hearing participants were equally accurate when very familiar and frequent pictures were used as hyperlinks (Fajardo et al., 2008a). When unfamiliar pictures were used as hyperlinks, both types of users found less targets, were slower and became more disoriented in the graphic hypertext than in the textual hypertext (Fajardo et al., 2006). Therefore, it seems reasonable to assume that SL scent cues could be a more appropriate solution for improving deaf signers' information searching than text or icons, but here we find a technological issue: is there any technology available to provide SL scent cues? As described in the following sections, we distinguish between mechanisms for making it possible to follow hyperlinks in SL and mechanisms for supporting queries in SL (for an extended description of this functional dimension for SL generation techniques, see the dimension *Task* in the taxonomy proposed in Section 4).

### 2.1. Hyperlinking by means of Sign Language

To enable not only content access but link-following in SL, a number of research projects have developed a set of more or less sophisticated techniques. Starting with an apparently simple idea, the Cogniweb project (Fajardo et al., 2008b,c) developed two alternatives consisting of videos embedded in small frames which contain SL translation (performed by human signers) of each textual hyperlink in the menu. This mechanism is called *Sign Language Scent* (SLS) here. In the first approach, when the cursor hovers over a link, the embedded video located at the left-bottom of the page