HCI Architecture for Deaf Communities Cultural Inclusion and Citizenship

Laura S. García, Cayley Guimarães, Diego R. Antunes and Sueli Fernandes
Informatics Department, UFPR, Curitiba, Brazil

Keywords: Human-Computer Interaction, Research Architecture, Deaf Culture, Social Inclusion, Computational Tools for Citizenship.

Abstract: There is a lack of adequate support for the Deaf culture, and few researches to inform designers on how to build computational tools to promote inclusion and citizenship for the Deaf. Deaf culture is an expression applied to the social movement that holds deafness to be a difference in human experience – which includes the right to use their natural language: Sign Language (SL) – rather than a disability. The present paper describes an integrated approach through assumptions, methodological strategies and architecture which has been proved so far to be adequate both computationally and socially.

1 INTRODUCTION

Deaf culture is an expression applied to the social movement that holds deafness to be a difference in human experience – which includes the right to use their natural language: Sign Language (SL) – rather than a disability. Available literature and technological products show many limitations towards promoting genuine inclusion and plain citizenship of this population. The present paper describes an integrated approach (assumptions, methodological strategies and architecture) which has been proved so far to be adequate both computationally and socially.

The following sections show and overall of Deaf issues and main problems encountered (2), methodological issues (3), proposed architecture and a few results (4) and conclusions and future work (5).

2 DEAF ISSUES

Fernandes (2006, p.3) tells us the use of Sign Language (SL) by the Deaf is a specific relationship between her and her surrounding world; a different way of being and learning. The traditional oppression of the oral culture negatively affects the development of the Deaf, who are treated as inferior *"[...] because, after all, they lack the essential property for society, that is, the oral and hearing language"*. Oralism (the imposition, by society, of the spoken language) colonized the Deaf by forbidden them to use SL, the natural language for the Deaf for intellectual development, information acquisition, and knowledge creation. This systematic exclusion from society has left in its wake dire consequences (e.g. lack of intellectual development, lack of SL knowledge, social exclusion, among others). Boaventura de Souza Santos (2002) tells us that science should promote inclusion. In that sense, the Deaf communities' specificities (i.e. communication, language, way of understanding the world) must be incorporated into tools to help the Deaf in exercising citizenship.

The responsibilities to explore deeper into more complex features of users (i.e. their culture) is a dear notion to Human-Computer Interaction (HCI) researchers in their task to inform design within people's lives. But there is a lack of research on how these considerations should be incorporated in tools, SL and Deaf issues in general. *"[...] the need is pressing [...]"*, especially when our work extends into differing communities and constituencies other than our own (Winchester, 2011, p.12). This section presents a small picture of the Deaf issues, and some (wrongful) attempts by the computer science field to try to address such issues. Such inadequate attempts prompted the proposed architecture, discussed on Section 3.

S. García L., Guimarães C., R. Antunes D. and Fernandes S..
HCI Architecture for Deaf Communities Cultural Inclusion and Citizenship.
DOI: 10.5220/0004451201260133
In *Proceedings of the 15th International Conference on Enterprise Information Systems* (ICEIS-2013), pages 126-133
ISBN: 978-989-8565-61-7

2.1 Daily Struggles in Deaf Lives

Guimarães et al., (2011b) conducted a series of immersive research with Deaf students of an undergraduate course of Linguistic/Libras (the Brazilian Sign Language). There were 80 students, 35 men, 45 women, ages from 24 to 39 (average of 30 years of age). All of the students chose the television as their source of information; they had no real relationship with their families; they relied on whatever little piece of information in SL they could get; the teacher was their confident for personal matter, among others. **They all suffered prejudices, lack of SL use and late acquisition of Libras**: Most of them were from non-deaf families that imposed the oral culture. They were tossed from school to school, and had no education in SL until their late teens (at the age of 14, in average). The following is a transcript of one of their statements:

> *"[...] my mother didn't know I was Deaf until I was two (2) years old. She forced me to oralize. When I started school, they beat me in the mouth: 'You can't sign'. I didn't understand anything. I got beaten, she pulled my ears, and I was there, helpless [...]"*

Such situation was common among the Deaf students, and show the problems faced by the child, left to their own devices, suffering prejudices, not developing proper social, affective and intellectual skills; and not being exposed to an environment permissive of natural language acquisition.

Additionally, it is no wonder that they demonstrated **poor Libras skills** due, mostly, to **lack of Standard and dissemination**. The lack of a standard vector for the Deaf implies in several inadequate skills in SL (e.g. errors, lack of knowledge of grammar, several gestures, instead of signs, among others). Tools in Libras (educational or of another nature) to which the students had access were rare, and proved to be detrimental (rather than helpful) to the development of Libras. For example, Capovilla et al., 2009 and Rybená, 2011 are dictionaries, but only present a one-to-one mapping of the oral language to the SL (thus, making it of little use to the Deaf who doesn't know the oral language.

2.2 Lack of Natural Language Acquisition

For Chomsky (1986), the ability to understand, create and transform culture is a human trait that is language-dependent. Kyle (2005) tells that the gaps between the Deaf and her family, due to the lack of communication, are the cause of high levels of mental diseases later in the Deaf's life, in direct relation to life and survival of the Deaf.

Brito, (1993) tells that without SL acquisition, the Deaf has a diminished ability to perform tasks for the development of intelligent action: the Deaf does not learn how to plan and how to overcome impulsive action; the Deaf does not become independent of the visual, concrete situation and the Deaf has difficulties to control herself and to socialize. Consequently, members of the Deaf community are more likely to suffer from: the lack of meaning and knowledge creation; the lack of identity and cultural diversity; the lack of intellectual development, among others, says Finau, (2006). All of these predicaments are dire consequences caused by the lack of affective ties of the human being with language. Due to this language barrier, the non-Deaf parents encounter difficulties to teach their Deaf children even the basics, such as personal hygiene etc.

2.3 Literacy and Sign Language

For Sánchez, (1991), language is more than a way of communication, and it includes a regulation function of thought, according to Vigotsky, (1974). Bilingualism, considered to be more adequate for Deaf education, is the movement that claims the use of, at least, two languages: SL, as a first language, and a second language in its written form – in our case, Portuguese, the oral language of Brazil.

For Lévy, (1999, p.10), society must go beyond the mere use of computers for games and leisure, thus limiting its use. This is a clear call for an innovative, intellectual, interactive use of technologies: to make sense of the world, the child must be able to construct her own mental models of interactions, and, for such, e-learning tools (that scaffold this process) are needed: "*new intellectual technologies*" that are to be used for Literacy.

Literacy is the resulting process of social practices of the use of the written form of the oral language as a symbolic system and as a technology, in specific contexts, for specific goals (in our context, to be acquired by the Deaf by a functional use of the language, where the language assumes a character of real meaning). *"Therefore, Literacy as effective appropriation is pleasurable, is leisure, is access to information, is communication, is a way to exercise citizenship in different social practices"* (Fernandes 2012, p.131).

Since Stokoe, (2000) we have that SL are

considered a legitimate, complete linguistic system, of gestural spatial-visual manner. Languages are social constructs that reflect in the identity of a certain group, and serve many functions and purposes, other than communication (e.g. modelling the world). SL are fully conventionalized, with rules and structure capable of providing the Deaf with an adequate means to realize all of their linguistic potentialities (Fernandes, 2012). They are not universal (i.e. each country has its own SL). They are not mere mimics. They are not gestures. They are independent from the oral language.

Guimarães et al., (2013) surveyed some related work on existing tools for literacy: existing technologies are inadequate to the Deaf specificities (i.e. they are not in SL); they lack usability for the target audience; they do not allow for multiple and full collaboration; they are not designed for Literacy as per the needs of the Deaf. The surveyed works present a lexical approach, without context; simple one-to-one mapping of Portuguese to SL; use of only the hand configuration of signs (out of at least five parameters); the use of restrictive technology (e.g. sensors, gloves etc.). Above all, they do not present stakeholders with a process for computational development of tools and Artifacts, the focus of this paper.

2.4 Natural Language Processing

Most of the related works in Natural Language Processing (NLP), such as Dasgupta et al., (2008) and Marshall and Sáfár (2003) fail to build tools in SL. Huenerfauth, (2004) proposes a translator that goes from written text (of the oral language) to American Sign Language (ASL) animation, but does so by adding complexity creating an interlingua with which to work. El Ghoul and Jemin, (2009) propose a screen reader, from text to SL animation based on avatars; but, as per the publication, their proposal is highly device-dependent, they did not incorporate SL and Deaf users in their work, and it is a one-to-one mapping (i.e. if the word from the text doesn't have a correspondent sign in the system, the system will fail). Such limitations also appear in Buttussi et al., (2007). San-Segundo et al., (2008) incorporate gestures into semantic analysis. But SL are not mere gestures.

Fernades, (2012) proposes some approaches that are paramount to the proposed architecture: center on teaching of SL; the oral language is to be seen and presented in its written form as a set of visual elements; the written system should be used for literacy, with the word as the basic unit (akin to the teaching of Chinese ideograms). Therefore, the word is the minimal element: the oral language for the Deaf is what they see and there is an ideographic relation between the sign and its representation.

2.5 Image Processing/Computer Vision

Antunes et al., (2011) compiled dozens of work from the literature of Image Processing (IP) and Computer Vision (CV) that claimed to be directed at the Deaf issues. The reviewed studies failed to supply real end-use technology. Most studies had some (or combination of some) sort of approach inadequacy: for example, some of them use a restricted set of data (i.e. static images; videos that represent only the alphabet; or only a small set of hand shapes only; or just isolated signs, without a context; or randomly selected signs, among others) that render them inadequate for generalization, for instance. Other approaches use specific, sophisticated devices (e.g. gloves, sensor, accelerometers etc.) that exclude the context of natural signalling by the Deaf.

The authors were able to identify four (4) main categories of problems:

- **Inadequate Framing of the Research Object:** use of restrictive devices; non-natural environments that are difficult to replicate outside lab conditions; the Deaf are not a part of the design process; inadequate use of SL (e.g. one-to-one mapping from the oral language, small sets, gestures, mere alphabets).
- **Inadequate Methodological Approaches:** the studies use two models: a) whole word (isolated signs described in the oral language – one-to-one, no use of the parameters of SL, limited results) and b) the phoneme-base approach as sub-units, but with no computational model.
- **Inadequate Treatment of the SL:** disregard for essential elements of SL (e.g. temporal aspects, quality); data sets limited to static images; limited use of the phonological parameters (e.g. only a few hand shapes or the alphabet, small sets, isolated/random data sets, use of just one hand, no non-manual expressions).
- **Inadequate Use of Technologies:** Two main categories: a) use of devices (e.g. glove, sensors): reduce movement, movements are not natural, limited identification of signs, high costs, availability, technical problems) and b) direct measurement: technical problems.

2.6 Image Synthesis (3D Avatar)

Most of the avatar 3D analysed were mere one-to-one reproduction of a lexical element from the oral language. The avatars are capable of signing only the set of signs that are pre-programed in their database. Most of the avatars lack the SL natural qualities, such as smooth movements, transitions from one sign to the other, speed (the signs are chopped, too fast or too slow, thus making it difficult for the Deaf to understand them).

A correct approach in this process has been found in (Lombardo et al., 2011). Their paper describes an avatar synthesis process embodied in a large research and industrial consortium project, Atlas, which determines a completely different working conditions form our own effort. Never-the-less, we can see that their work adopt the mark-up language strategy to decompose and represent the Italian Sign Language (LIS), often found in the few correct pieces of work available in literature.

2.7 Writing System (Signwriting)

Most of the editors for the writing system are in the oral language. They require an extensive work from the user to compose a written sign. They lack usability: the SignWriting primitives are hidden in several layers of menu choices, overloading the working memory of the user. The positioning of the primitives to form the sign presents several difficulties: precision, speed, and rotation among others. Some editors are a one-to-one mapping from the oral language: you type in the word, and it brings from the data base the completed written form of the sign – highly dependent on the knowledge of the oral language, and whether the word is on the data base.

3 METHODOLOGICAL ISSUES

The genesis of our project can be described as follows. Troubled by the fact that, even if our work was geared towards producing for public education and health, we still produced for the majority of people in Brazil. This research arena was, therefore, excluding of many, which made us turn our research focus to minorities. Our first hypotheses about technology for Deaf was that they did not demand critical changes regarded to non Deaf people; we considered the visual nature of most information in technological artifacts and the presence of non visual information in Portuguese language written form. After reading related literature based on the "clinical view of deaf" (which sees deafness as an illness) for almost a year, we stayed within this first hypothesis.

Our work with an expert with large experience with the Deaf Culture and and deaf communities (a colleague who later became an integral member of our research group), taught us that very few Brazilian Deaf in fact could read and write in Portuguese. The reality was even worse than we had expected. Due to decades of social, political and educational exclusion, which happened throughout the World and also in Brazil up to the last decade, and even considering that Libras, the Brazilian Sign Language was, by law, decreed to be an official language in Brazil, neither Libras nor any "second language" was granted at school. Additionally to the lack of their natural language, which acts as the mediation language for any second language acquisition (in our case Portuguese), the Deaf even suffered from the illness of having to "learn" Portuguese by the oral method. The situation is so severe now that literate and even under-graduating Deaf students cannot write Portuguese following the grammar rules, since their natural language articulates just meaning-full signs.

Secondly, we reached the conscience of the need to work in a genuine multi and interdisciplinary manner, this meaning having as normal interlocutors (from the beginning and during the whole process) experts in Computer Science, Education and Linguistics. Additionally, our posture made Computer Science other subareas from HCI join our view and effort, extending the initial research group to subareas like Algorithms and Formal Structures and Robotics. It is worth mentioning that this approach is not, in fact, a frequent practice so far as Computer Science researchers available work refers.

Finally, our work is characterized also by the join consideration of theoretical and practical knowledge (in this case school practices) and by the crucial strategy of involving the deaf community all over the Project: at beginning, to define correct hypotheses, during design to establish their real principal needs and during developing to test whether our artifacts were appropriate for them. This partnership is to be maintained indefinitely, as it will allow our project to follow the technology cycle (real needs, product developing, limitations and need, new product developing, and so on).

4 PROPOSED ARCHITECTURE

The proposed approach can be described through the

architecture properly considered and by a few pair approved internationally published results.

4.1 The Proper Architecture

The proposed architecture can be described trough two main elements: the abstract four general layers hierarchy (with special relevance of the basic interface structure built) and the integration model, which shows all the modules and their identified interrelations that give support for the execution of the abstract architecture.

Figure 1 presents an abstract of the proposed HCI Architecture, in its four levels.

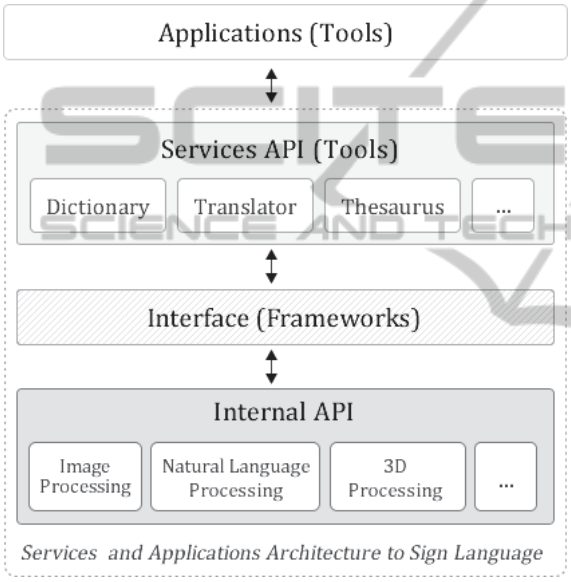

Figure 1: Abstraction of the proposed HCI Architecture to promote inclusion and citizenship for Deaf communities.

The general user environment, as the research emerged initially, is to support Portuguese as well as Libras, the Brazilian Sign Language. In this way, user interfaces must allow user-user dialogues either in Portuguese or in Libras and also mixed ones either between Deaf and non Deaf persons or interactions between Deaf persons and system. In these last cases, interpreters in real time should mediate the interaction. This proposal demanded, of course, a mandatory user profile for the Libras interpreter. The middle layer is to allow for Deaf communities' accessibility to information, to communication and to knowledge creation, through the prism of an inclusive perspective.

The surface layer is responsible for providing adequate applications, mainly in the axes of i) giving adequate support to Deaf natural language (i.e. Sign Language) acquisition and registration (as occurs traditionally in the written codes of any oral language); ii) supporting teaching-learning processes of Libras itself and of written Portuguese as their second language (i.e. literacy); and, what is self-explaining of the situation of real severity level, iii) supporting knowledge acquisition of every other area, considered the hypothesis of the Sign Language acting as the mother language for the Deaf in any interpretation process.

The services needed referred specially to those associated to language itself, starting by dictionaries, thesaurus and translators. Though being themselves applications, they can be seen and even more they are critic as tools to allow for plain applications for Deaf communities.

The interface between the services and the internal APIs has as its principal function providing correct frameworks for both tools layers being built scientifically sound. Rescuing oral natural languages analytical hierarchy for the traditionally so called "natural languages" processing when Sign Languages were still not recognized in this way, we could quote the phonological level (surface level: phonemes), the lexical one (words), the syntactic level (grammar rules), the semantic level (underlying meaning), and, last but not least, the pragmatic level (language in context).

As for Sign Languages, the surface level is the signal production one, the first structure of our approach applied for the Libras phonological level: the level that describes sign production (articulation). Though not being of an audio nature, the sign's elementary components level of the Sign Languages is called phonological by analogy to oral languages. The choice of this structure as the basic one in the whole architecture has proved productive after four or five years' work, as the following section shows. Our hypothesis for this to happen is that it captures the correct approach of Natural Language Processing, together with the correct understanding of the Libras itself, which, for communication purposes, takes advantage of the Portuguese Language alphabet mapping signs only to denote words with no corresponding sign in Libras and to refer to Brazilian proper names.

Finally, the internal level is responsible for the Computer Science subareas knowledge and technology necessary for the several tools and applications.

After presenting the overall architecture, we proceed to describe the integrating model. This representation makes explicit all the modules and bases involved, and their necessary interrelations.

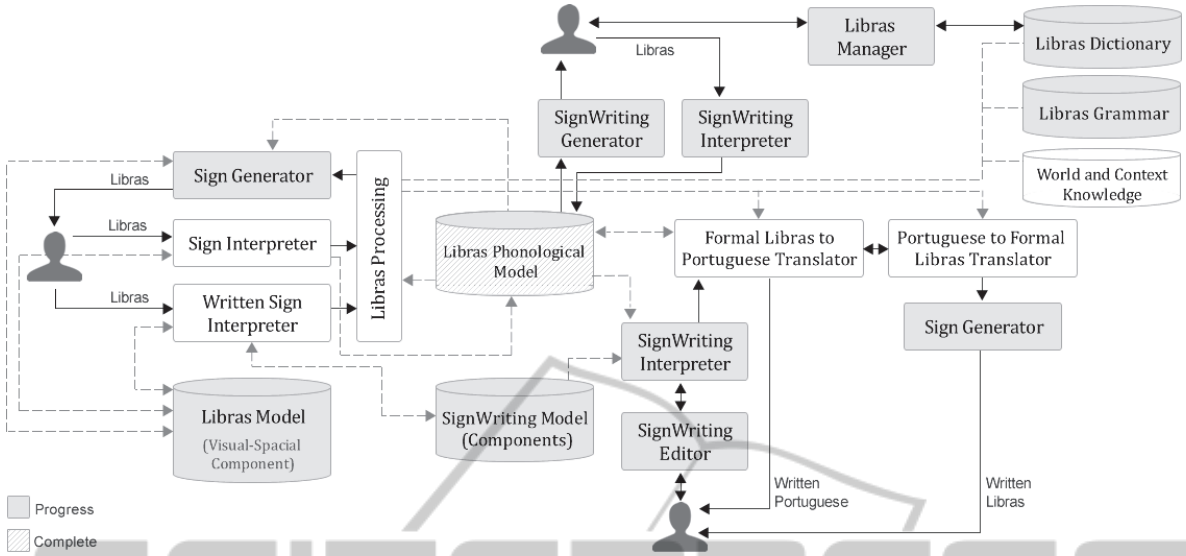

Figure 2: Proposed HCI Architecture with developed and in progress modules and bases.

Figure 2 shows it, together with the modules instantiated (developed/in progress) up to the present moment.

Libras processing, considered as Natural Language Processing, requires several modules shown in a general way in Figure 3. The precise logic of the modules execution is not yet defined.

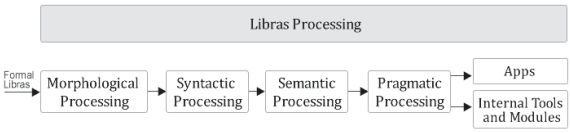

Figure 3: Libras processing steps (in a general way).

In order to complete the overall description of our work, we show the applications already addressed (Figure 4). It is pertinent to note that these applications priority was determined by the deaf community always present (both as a design actor and as potential user) during our research.

Figure 4: External applications (take advantage of internal and tools architecture).

4.2 Results so Far

As the foundations stone of the architecture, the Libras Phonological Model was first designed and developed. The Model describes the sign production components by a hierarchical structure whose most abstract levels are shown in Figure 5. This model was described in some international events published papers, namely: Antunes et al., (2011), Guimarães et al., (2010a,b), Guimarães et al., (2011a, b, c), Guimarães et al., (2012a,b), Guimarães et al., (2013), Trindade et al., (2012).

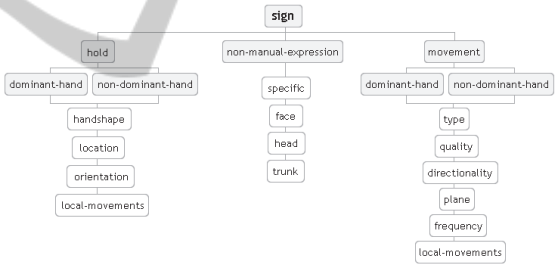

Figure 5: Abstraction of the proposed HCI Architecture to inform design of effective otols for Deaf inclusion.

As previously shown in Figure 2, several other component modules and bases had been addressed so far.

Regarding the internal and tools levels, we can quote the Libras dictionary and grammar and the Libras model - this one by (Gonçalves, 2013). All this work is in progress and has not been published.

Still within the main architecture and as far as the addressed communities are concerned, we can mention the SignWriting generator, the SignWriting interpreter – themselves complementar compilers, the Libras manager - who aims to allow for Libras dictionary queries by written Libras signs, the SignWriting editor – that focuses on usability and communicability issues in order to facilitate task completion by deaf and non deaf.

Considered as the most relevant applications by the deaf community itself, the three applications built have been already approved by peer review when presented at international events.

The interactive artifact to support bilingual culture (Libras and written Portuguese) is an innovator conceptual environment which, in fact, supports the teaching-learning binomial in virtually any knowledge discipline. Guimarães et al., (2012; 2013). It is a doctoral theses work to be presented soon.

The Interactive artifact to support written Portuguese acquisition by deaf children has been designed having as a premise the literacy concept and as its methodological strategy a totally interdisciplinary work (Computer Science, Education – theories and practices, and Linguistics). It is also a theses work, to be presented within a year effort. The results reached so far have not been published.

Last but not least, the Collaborative artifact for knowledge building was designed having in mind the critical deaf necessity of the Libras interpreter in order to grant not only communication processes but also knowledge building ones.

5 CONCLUSIONS AND FUTURE WORK

Available theoretical results and technological products for deaf communities have several limitations, as far as our studies have revealed. The present paper described a HCI architecture – or, better, an approach that aims at treating deaf communities in an adequate manner, regarding the computing field interests. It implies, in the authors view, differential premises and strategies synthesized as follows: 1) deaf considered as culturally bilingual citizens (in opposition to not normal clinical ones); 2) multi and interdisciplinary work both with external areas (Education and Linguistics) and with internal ones (in our case, so far, Algorithms and Formal Structures and Robotics); 3) join consideration of theoretical and practical knowledge (School practices); and 4) involving the deaf community all over the Project: at beginning, to define correct hypotheses, during design to establish their real needs and during developing to test whether our artifacts were appropriate for them.

The differential factors just mentioned lead naturally to our Libras Computational Phonological Model and, from it, to all the bases and modules themselves now in progress. The present paper showed the architecture that integrates them, as well as described briefly (since they are unpublished results) the group main partial results.

At close future work, the group will give priority to the Libras dictionary, together with the Natural Language Processing tools, necessary to the Translator, which is another critically desired product.

The authors thank Fundação Araucária and CAPES for the financial support.

REFERENCES

Antunes, D.R. et al., 2011. A framework to support development of Sign Language Human-Computer Interaction: Building Tools for Effective Information Access and Inclusion of the Deaf. *V IEEE RCIS'11. Guadaloupe. P. 126—137.*

Brito, L.F., 1993. *Social integration and Deaf education. Rio de Janeiro:* Babel.

Buttussi, et al., 2007. Using Web3D technologies for visualization and search of signs in an international sign language dictionary. In: *Proceedings of the 12th I. Conf. on 3D Web tech. Perugia, Italy. 61—70.*

Capovilla, F.C., Raphael, W.D., Maurício, A.C.L., 2009. *Novo Deit-Libras: Dicionário Enciclopédico Ilustrado Trilíngue.* São Paulo: Edusp.

Chomsky, N., 1986. *Knowledge of language: its nature, origin and use.* New York: Praeger Publishers.

Dasgupta et al., 2008. A multilingual multimedia Indian Sign Language dictionary tool. *6th workshop on Asian Language Resources.* Indian School of Business. Hyderabad, 57—64.

Fernandes, S., 2006. Avaliação em Língua Portuguesa para Alunos Surdos. *SEED/SUED/DEE*, CURITIBA.

Fernandes, S. 2012. Educação dos Surdos. Curitiba: IBPEX.

Finau, R., 2006. Possible encounters: Deaf culture, education and linguistics. In: *R. Quadros (Org.) Deaf Studies I. Petrópolis:* Arara Azul.

el Ghoul, O., Jemni, M. 2009. A sign language screen reader for Deaf. *USAB'09. A. Hozinger, K. Miesenberger (Eds.).* Springer, Berlin Heideber, 476—483.

Gonçalves, D. A., 2013. *Avatar 3d para Síntese Automática de Sinais da Língua de Sinais Brasileira*. M.Sc. Dissertation. Informatics Dept. UFPR.

Guimarães et al., 2010a. Structure of the Brazilian Sign Language (Libras) for computational tools: citizenship and social inclusion. *WSKS'2010*, v.111, p. 365—370.

Guimarães et al., 2010b. Technological artifacts for social inclusion: structure of the Brazilian Sign Language (Libras), Gestures for Citizenship. IADIS WWW/Internet, v.1, p.267—271.

Guimarães et al., 2011a. Evaluation of a computational description model of Libras (Brazilian sign Language). Guadaloupe: *V IEEE RCIS'11*. P.485—494.

Guimarães et al., 2011b. Collaborative Consensus and Knowledge Creation: Computer-Mediated Methodology for Sign Language Studies. Mykonos: *WSKS'11*. P. 278—292.

Guimarães et al., 2011c. Empowering collaboration among the Deaf: Internet-based knowledge creation system. IADIS WWW/Internet, p. 137—144.

Guimarães et al., 2012a. Conceptual meta-environment for Deaf children Literacy challenge: How to design effective Artifacts for bilingualism. *VI IEEE RCIS*. CFP1240D-ART, v.6, p.1—12.

Guimarães et al., 2012b. Deaf Literacy: A computational process to design Sign Language/Portuguese Artifacts for Internet. IADIS WWW/Internet, Madrid, p. 250—259.

Guimarães et al., 2013. Pedagogical Architecture – Internet Artifacts for Bilingualism of the Deaf (Sign Language Portuguese). 46th HICSS. *IEEE CPS*, v. 46. 40—49.

Huenerfauth, M., 2004. A multi-path architecture for machine translation of English text into ASL animation. *ACL, Morristown,* 25—30.

Kyle, J.G., 2005. Beginning Bilingualism. *Ibero-American Congress on Bilingual Education. Lisbon.*

Lévy, P., 1999. *Cyberculture*. Paris: Odile Jacob.

Lombardo, V., Battaglino, C., Damiano, R., Nunnari, F., "An Avatar-based Interface for the Italian Sign Language", *International Conference on Complex, Intelligent and Software Intensive Systems (CISIS)*, pp.589, 594, 2011.

Marshall, I., Sáfár, E., 2003. A prototype text to BSL translation system. *ACL'03,* v.2, 113-116.

Rybená, 2011. Available at http://rybena.com.br accessed in 05/05/11.

Sánchez, C., 1991. *La educación de los sordos en um modelo bilíngue.* Mérida: Diakonia.

Santos, Boaventura de Souza, 2002. *Um discurso sobre as ciências*. Porto: Apontamentos.

San-Segundo et al., 2008. Proposing a speech to gesture translation architecture for Spanish Deaf people. *Journal of Vis. Lang. Comput*., 19, 5. 523—538.

Stokoe, W.C., 2000. Models, signs and universal rules. *SLS,* v.1, n.1, p. 10—16.

Trindade et al., 2011. Communication and cooperation: an analysis of a community of practice by non-Deaf and Deaf to study sign language. *WSKS'2011*. P. 191—205.

Trindade et al., 2012. Challenges of knowledge management and creation in communities of practice organizations of Deaf and non-Deaf members: requirements for a Web plataform. *Behaviour & Information Technology*, v,31, p.1—12.

Vigotsky, L.S., 1974. *Mind in society: the development of higher psychological processes*. MA: Harvard University Press.

Winchester, W.W., 2011. III REALizing our messy future: Towards culturally responsive design tools in engaging our deeper dives. *ACM Interactions,* V.XVII (6). New York: MIT Press. 12—19.