Automatic Generation of LIBRAS Signs by Graphic Symbols of SignWriting

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Abstract: The Brazilian Sign Language is the natural language used by Deaf people in Brazil to communicate between themselves and with the society, as well as it is part of culture and tradition. Providing access to communication, information and knowledge (creation) for the Deaf community are just some of the motivations for Brazilian Sign Language writing record. This paper shows some hypotheses for the low usage of computational tools for recording sign languages and proposes a new way to generate the graphic records in Brazilian Sign Language through the SignWriting System for assisting the Deaf individuals in the exercise of their full citizenship.

1 INTRODUCTION

Despite the latest and emerging worldwide social transformations, people with disabilities still suffer from several problems such as prejudice and inaccessibility, among others. Gradually and slowly, transformations in all knowledge areas have started to solve some of these problems. Deaf communities were formerly excluded from society due to the fact of their consideration as not "normal" (clinically originated concept) individuals. Reports show the extreme procedures to which Deaf people used to be submitted in order to "remove their abnormality". Nowadays things have changed. Nevertheless, the above questions are far from having been attended, and social errors and misconceptions about handicapped needs goes on generating (new forms of) exclusion (Fernandes, 2007).

Deaf communities (born Deaf people with proper culture in opposition to people with acquired deafness) in the world still suffer from the lack of opportunities and, in this sense, tools that can help them in communicating with each other and with other members of society are necessary. Plain access to information is one of the research challenges referring to Deaf people, and since information systems help to meet this goal, they are critically important. However, these systems usually impose obstacles to access and use. One of the obstacles is that the human computer interaction is not natural for these populations, because communication via interface is not provided in sign language - in this case LIBRAS (Brazilian Sign Language), considered by linguistic experts the first language of Deaf people, even when it is not chronologically the first one.

From the observation of this reality the need for computational tools that can help Deaf people in communication and access to information becomes clear. In conjunction with all the needs of this communities, there is the difficulty they face with the graphic record of LIBRAS, namely, the problem determined by the lack of a standard writing system and of the corresponding practice of its use by Deaf communities. No language can survive without its writing system, because languages evolve along time. Also, without a proper record, part of them is lost. Deaf communities in Brazil use LIBRAS for communication between their members, but every time they need to use some record of it, they are restricted to use written Portuguese, their second language.

Human beings have different volatile ways of communication, which passed from people to people, with the inherent risk of their meaning modification. Writing systems remain intact. From this the need for the written registration of sign languages arises. According to Dulcineia Azeredo (Azevedo, 2010), "The importance of writing for history and for preservation of the records comes from the fact that it allows for the storage and propagation of information, not only between individuals, but also through generations. Through the writing, it is possible to put the present man in contact with the man from the

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past, rescuing facts to be discussed in a new perspective. This will certainly have benefits for human existence."

In this way, Deaf people who know a sign language should be able to represent and record it through writing. Additionally, one useful type of tool to assist the Deaf in the process of maintaining their culture and recording the knowledge produced by them is a sign writing system. Many different writing systems for sign languages emerged trying to resolve sign representation, but they have produced a new difficulty for Deaf people, since they rarely know which system is more appropriate or, even worse, they are not able to take advantage of the system because of the difficulty of interacting with it.

The most well known sign language writing system is SignWriting, a visual notation whose elements can be easily mapped to sign languages phonological components. Its elements allow for any sign language to be visually represented, ie, the writing system allows to represent the sign phonological structures in graphical form.

SignWriting emerged as an evolution of an spelling system for representing ballet movements created by Valerie Sutton, around the 70s, at the University of Copenhagen in Denmark, the DanceWriting (Sutton, 2005).

Writing systems show interesting alternatives to assist the written record of signs. SignWriting is a complete writing system with all the potentiality to be used in Brazilian Sign Language (LIBRAS) to facilitate the description and the understanding of sign language records. The writing system presents possibilities to express the majority of the sign language resources, as well as its visual spatial modulators incorporated in the signs in context. These characteristics determined our choice of SignWriting for the development of the tool in question (Stumpf, 2005)..

In Brazil, LIBRAS has been used since 1996 in Deaf education and in research by Marianne Rossi Stumpf, who was the first Deaf to write LIBRAS' signs. Then, she started researching about sign writing with Professors Antônio Carlos da Rocha Costa and Marcia Campos at the Pontificial Catholic University in the state of Rio Grande do Sul. From there, Marianne and Antnio translated a children's book "A girl is called Kauana" from Portuguese to SignWriting. This was the first text written in LIBRAS in Brazil (Stumpf, 2000).

Despite this first interest, the use of SignWriting is still very restricted, but many authors defend that its use could assist the target population in expanding and documenting their language, LIBRAS. This writing system is still not known by the Deaf communities. One of the arguments raised by the Deaf is that SignWriting is not used mainly because most of information and knowledge legacy is recorded in written oral languages, as Portuguese, and learning SignWriting is in fact an indirection towards written Portuguese domain. Additionally, there are few tools that support LIBRAS recording in SignWriting.

Related literature showed some editors and/or translators that support SignWriting, but these tools have not obtained acceptance (considered as usage practice) of the Deaf communities in Brazil or around the world. From the study of these tools, we have built a complementary hypotheses, namely that this aversion may have been caused by inadequate interfaces and especially by the adoption of incorrect paradigms, which demand high time to generate a single sign, making it extremely difficult to translate extensive text from some country's oral language to SignWriting thus demotivating handouts, books and others translation efforts.

In this context, the development of technological artifacts with appropriate interfaces and interaction models built on paradigms that encourage the use and the legitimacy of SignWriting as a writing system for LIBRAS appears as a sound research route.

In Section 2 describes a Review of Literature (writing systems for Sign Languages and SignWriting, The Computational Architecture to Support the Social Inclusion of Deaf Communities in Brazil and Considerations of Computational Description Model of LIBRAS), Section 3 presentes The Low (or NO) Use of Computational Tools to Support SignWriting by Brazilian Deaf Communitty, Section 4 shows Automatic Generation of LIBRAS Sign by Graphic Symbols of SignWriting. Finally, Section 5 discusses a Conclusion and Future Works.

2 REVIEW OF LITERATURE

In this section the writing systems for Sign Languages and SignWriting (Stumpf, 2005), the Architecture (García et al., 2013) (García et al., 2010a) (García et al., 2010b) and the Phonological Model (Antunes, 2011) for adequate LIBRAS treatment, cornerstones for the present WEB service, are presented.

2.1 Writing Systems for Sign Languages and SignWriting

As it was already mentioned, there are several writing systems for sign languages around the world that address the graphic representation of signs. However, this is seen as an additional problem for Deaf communities that, unable to know which is the most adequate system to use, appeal to the written form of the oral language of their country, not without significative effort. The present section shows some of the available writing systems for sign languages, focusing on SignWriting, which is considered the most complete one.

- **Stokoe's System:** Stokoe (Stokoe, 1978) created a notation to represent sign languages based on their observed parameters: hand configuration (10), location (12 positions), action movements (22) and hand orientation (4). He was also the forerunner of the sign languages linguistic character legitimation. The goal of his notation was to respond to the needs off the registration and the study of sign languages. The use of the written code by the Deafs themselves was not one of his purposes. Stokoes System was the first notation to represent the "phonological" (by the level of equivalence to oral languages analysis) components of the American Sign Language by graphic symbols. The original notation was composed by 55 symbols, but afterwards, researchers modified this set as a consequence of the productivity of living languages (Stokoe, 1978).
- **François Neve's Notation:** François Neve, a researcher at the University of Liége (1996), expanded the Stokoe's notation complemented it. The François Neve's notation made the enumeration and the computational treatment of the signs possible. The written representation is done via columns from the top to the bottom (in a single column when the dominant hand signalizes or in two columns for both hands) (Stumpf, 2005). The phonological aspects specified up to that moment were considered both in Stokoe's and in Neve's notations. Both of them also had the primary elements needed to represent non-manual expressions (face, body and head, among others), significant components of sign languages.
- **HamNoSys:** Hamburg Sign Language Notation System (HamNoSys) (Prillwitz et al., 1989) (R. Elliott and Parsons, 2001) is a phonological linear transcription system with a larger scope than Stokoes. This system defines about 200 symbols for representation of parameters like hand configuration, orientation, locations in the head and in the body and also the movements through iconic representations easily perceived and recognized. This model also brought, as an innovation, the inclusion of the non-manual expressions. A computational system for sign transcription was developed based on HamNoSys model, and it later helped to propose tools for Deaf people. The SiGML (Signing Gesture Markup Language) (Prillwitz et al., 1989) is this transcription model, built by means of XML (the eXtensible Markup Language) and a flexible alternative for representing sign languages signs constituents in a computational way.

2.1.1 SignWriting

SignWriting is a graphic written notation of sign languages. Its components allow for any sign language to be represent visually, or, in other words, the writing system allows for representing the phonological structure of sign languages in a graphic manner. Figure 1 shows examples of SignWriting.

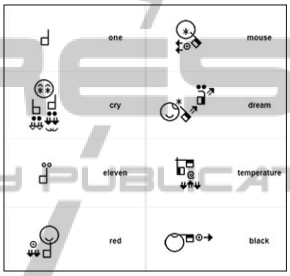

Figure 1: Examples of SignWriting (Stumpf, 2005).

This writing system was developed by Valerie Sutton in 1981 as an extension of a dance movement notation system (Sutton, 2005), the Sutton Movement Writing & Shorthand, that aimed at being able to represent, in a systematic way, any movement of dance, sports, physiology among others.

In Capovilla & Raphael work (2001)(Capovilla and Raphael, 2001), it is possible to perceive that SignWriting has a fundamental role in sign languages in general, since it helps the Deaf people to understand efficiently each detail of the sign composition by means of the written correspondent. Parameters as location, movement, orientation, facial expressions can be easily visualized in SignWriting.

SignWriting has a structure composed of four basic elements: hands, movements, facial expressions and body that other writing systems do not include.

The elements for hand representation are the hands configuration, their orientation and movement. These parameters enable the distinction of types of contact made between one or both hands and the rest of the body. The system has about 900 symbols, which provide more accuracy to the representation of signs (Stumpf, 2005). Facial expressions and body movements are indispensable for the representation of signs. Table 1 presents groups of classification of SignWriting symbols.

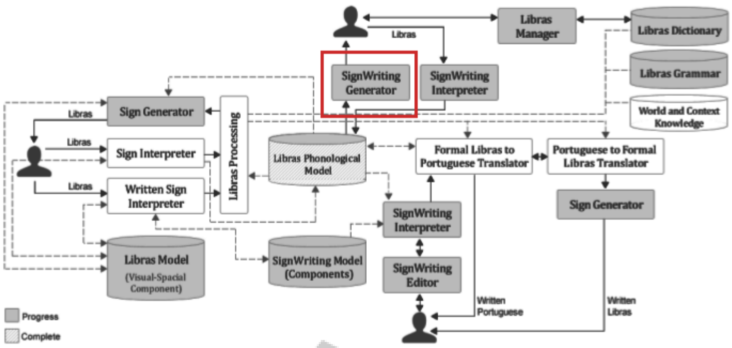

Figure 2: Integration Model of the proposed HCI Architecture with developed and in progress modules and bases. (García et al., 2010a) (García et al., 2010b).

Table 1: Table with groups of SignWriting Symbols (Stumpf, 2000).

<SignWriting Groups>
Orientation and Position of Hands
Contact Types
Hands Configuration
Finger Movements
Arms Movements and appointments (straight, curved, ...)
Facial Expressions
Location of Head Symbols
Head Movements
Orientations of the look
Body Movements
Symbols of Grammatical Points
Dynamic of the Movements

Even being SignWriting a graphic code for signs writing, some important parameters such as velocity, frequency, sequentiality marks, among others, are not available. In socially situated use, these are perceived in a natural and unconscious form by sign language users. Nevertheless, for adequate computational treatment, a more detailed sign phonological components description is needed.

Further differential of SignWriting to other similar systems refers to the fact that this system is the only one that presents clearly characteristics related to simultaneity and that utilizes a precise spacial description.

The writing systems presented here are seen as interesting alternatives for helping in signs registration. SignWriting, mainly, is a proper written system with all the potentiality to be used in LIBRAS, as discussed above. This justifies its choice as the basis for the web service of translating our research group phonological model to the signs writing system in question.

2.2 The Computational Architecture to Support the Social Inclusion of Deaf Communities in Brazil

The architecture proposed by our research group can be described trough two main elements: the abstract four general layers hierarchy and the integration model, which shows all the modules and their interrelations that give support for the execution of the abstract architecture. Figure 2 shows the Integration Model of the Architecture.

The four level hierarchy is show in Figure 4. The surface layer is responsible for providing adequate applications, mainly in the axes of i) giving proper 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); iii) supporting knowledge acquisition of every other area, considering the hypothesis of the Sign Language acting as the mother language for the Deaf in any interpretation process.

The needed services refer specially to those associated to the language itself, starting by dictionaries, lexicon and translators. Although being themselves applications, they are critic as tools as well, allowing for plain applications for Deaf communities. The interface between the services and the internal APIs has as its main function providing correct frameworks for both uppermost layers from sound different specialities bases Finally, the internal level is responsible for the Computer Science sub-areas knowledge and technology needed to support the several tools and applications.

After presenting the overall architecture, we proceed to describe the integrating model. This representation exposes all the modules and bases involved, and their interrelations. Figure 3 shows it, together

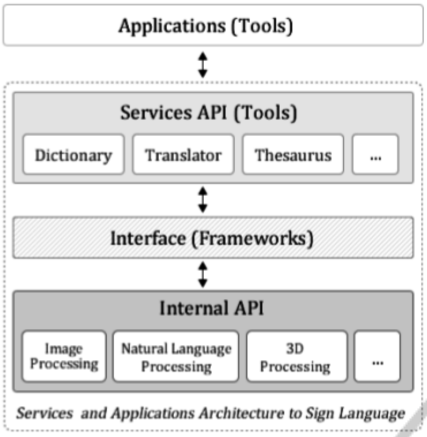

Figure 3: Abstraction of the proposed HCI Architecture to promote inclusion and citizenship for Deaf communities. (García et al., 2010a) (García et al., 2010b).

with the modules instantiated (developed/in progress) up to the present moment.

The work described in the present paper - the WEB service for the interpretation of the sign descriptions by means of the computational model of LIBRAS phonology to SignWriting symbols - is situated within the described architecture as indicated in Figure 3, as part of the SignWriting Generator, since it receives the computational phonological description of a sign components and produces, for the user, the graphic representation components of the sign in SignWriting.

2.3 Considerations on the LIBRAS Phonology Description Computational Model

Other participant of the research group in which the present work is situated developed a computational representation model based on a compilation and adaptation of phonological models that aggregates a high degree of details for sign description. Such finesse in describing the signs render the model presented adequate for computational treatment of SL. Figure 4 shows an adaptation of the basic structure of the model with some of its main parameters, one can see a Sign is composed by a Hold, a Non-Manual Expression and a Movement (that may be combined in different levels to represent simultaneity and sequentiality). Each element, by turn, is the roots of the tree that expands down to the leaf level, where the actual values of the required parameters are enumerated (e.g. the element of quality may be defined by the extension, tension, velocity and other temporal aspects of the movement). The proposed structure (its use and

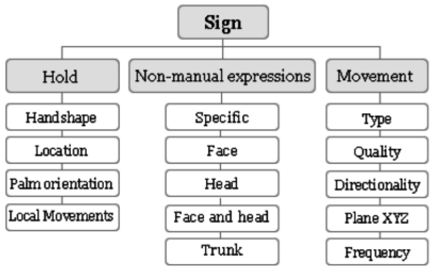

Figure 4: Conceptual Structure of Sign Computational Representation (Antunes, 2011).

the degree of computational details of signs) is important to solve a series of problems thus far encountered in SL recognition, building signs (3D), written signs, among others.

The proposed model is a compilation of several phonological models existing in the literature, and it extends these models in various aspects: it allows for simultaneity, sequentiality; non-manual expressions etc. The model has a high degree of detailed parameters and values that could be attributed to such parameters. Additionally, it allows for adoption of new expressions, parameters and values, which is a powerful feature in the model to support new signs in SL.

The model is critical as a proper support for image recognition, translation, 3D avatars generation and so on. Additionally, the proposed model includes the non-manual expressions, that may be used in the intensity, sentence formation, semantics and in the singular characterization of a sign. This singular characterization often occurs in disguised signs. These signs aggregate facial expressions. The proposed model is an important element of the conceptual HCI architecture previously cited that takes several aspects of Deaf needs into consideration.

Figure 5 shows the sign of Brazilian Sign Language that represents "tree". In this sign, the dominant-hand takes the form of the specific configuration 56 used at the point of articulation. Note the need contact attribute, because the signal is articulated on the back of the non-dominant hand contact with the elbow. Still to make the sign it is necessary to use the local movement of rotation (counterclockwise). Table 2 describes this sign by the Computational Description Model of the Phonology of LIBRAS.

Such model is appropriate, for example, to aid Computer Vision (CV) to better train algorithms for sign recognition, with the correct set of representative signs and descriptions. Most CV studies rely on the use of gloves for recognition. A glove limits the natural signing of the SL and systems of this kind do not consider, in most cases, very important aspects as

Figure 5: Sign Tree “árvore” (Antunes, 2011).

Table 2: Table with the XML Description of the Movement of the Sign Yellow “amarelo” in LIBRAS.

```
<sign name=“arvore”>
 <hold sequence=“1”>
  <dominantHand>
   <handshape specific=“28” arm=“vertical” >
   <location bodySide=“dominant hand” >
    <hand >dorse </hand >
   </location >
   <orientation >
    <palm hand=“vertical”>upward, forward </palm >
    <floorParallel>hand base </floorParallel>
   </orientation>
  </dominantHand>
  <nonDominantHand>
   <handshape specific=“56” arm=“horizontal” >
   <location bodySide=“dominant hand” >
    <space >
     <proximity distance=“proximal”>
                      <spatialRelationship        loca-
tion=“stomach”i=“shoulder” >
    </space >
    <trunk >elbow </trunk >
   </location >
   <orientation >
    <palm hand=“vertical”>upward, forward </palm >
    <floorParallel>hand base </floorParallel>
   </orientation >
  </nonDdominantHand>
 </hold >
</sign >
```

non- manual expressions, locations, among others.

To assist CV in the recognition process, the creation of an adequate sign base (not random or isolated) with descriptions of the signs according to phonology is important. Thus, CV will receive a representative sets of signs and their recognition will determine elements of phonology. In this way it is possible to retrospectively identify any other signs not present at the base, by recognition of their parameters. Thus, it is possible to create tools that allow for searching signs by the signs' phonological components and will support translation process.

This model is a core feature in the work in question, since from its rules for sign components description in a high level of detail, it permits the automatic generation of the graphic symbols.

3 THE LOW (OR NO) USE OF COMPUTATIONAL TOOLS TO SUPPORT SIGNWRITING BY BRAZILIAN DEAF COMMUNITTY

Some results found represent the state of art for the development of information systems for members of Deaf communities in Brazil and worldwide. There are some initiatives that aim to assist these communities by the learning of sign languages and registering of language through SignWriting.

Recent developed tools, although with the purpose of helping the Deaf, are produced to a very specific audience (those Deafs that are able to read and write the official language of their country) and in this way, they are not adopted in everyday activity by Deaf people as communication resources, interaction or learning. Many of these artifacts do not attend in general to the needs of Deaf people, among which reasons we can mention language issues (i.e. the information is presented mostly in the written language of the country, assuming that all the Deaf can read it) and interaction (i.e. most of the tools for users to interact with the interface are not mediated by LIBRAS).

By analysing related work, it has been concluded that most available tools have several problems which can be inferred by the low usage reported. One of the common problems is that, in general, the use of symbols trees to edit a sign is a paradigm that should be abandoned, because in order to edit a sign in a software that uses this technique, it is necessary to drag primitive by primitive and positioning it in the corresponding place. This takes a long time, since the number of existing primitive symbols is extremely high, being, then, unsuitable to write a long texts.

Another point that causes this low use of tools by the community is the poor interfaces quality, some of them still being developed in MS-DOS environment, together with a high number of accessibility problems, hardening the user-tool interaction.

Also, the development of a new way to generate the graphical form of the signs of LIBRAS on SignWriting tools is necessary, firstly in order to provide the Deaf community with viable edition processes to allow for information accessing and knowledge creation and, secondly, to written the components that will be the base for LIBRAS sign generation sign generation to provide Human-Computer interfaces written outputs.

4 AUTOMATIC GENERATION OF LIBRAS SIGNS BY GRAPHIC SYMBOLS OF SIGNWRITING

This automatic generation is situated within the architecture as described in Figure 3. It can be used for the automatic interpretation of XML to the SignWriting graphic symbols, and, also, for intelligent search for graphic symbols.

The system reads the LIBRAS sign description in the Phonological Model in XML and provides as output the graphic symbols of SignWriting that correspond to the input sign.

Figure 6 shows the automatic generation process. The main difference in relation to other tools available comes from the fact that it does not make a conversion from a sign to a unique pre-existent SignWriting correspondent symbol sequence but, instead, converts each piece of XML describing the primitives that compose the sign (dominant hand, movement,...) to the correspondent SignWriting sign component.

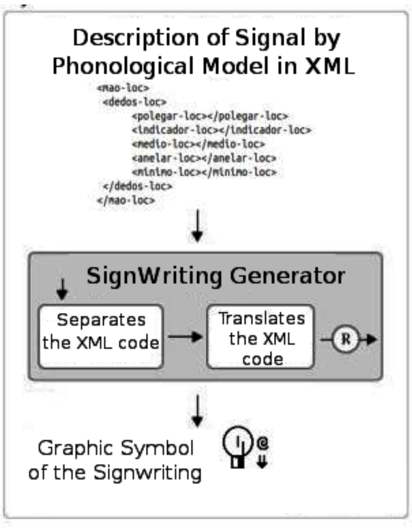

Figure 6: Abstraction of the proposed system (Iatskiu, 2014).

Figure 7 displays the LIBRAS graphic sign for the Portuguese word "pai" (father). Table I should be observed in order to understand the way in which the system interprets each piece of XML code and how it forms the written symbols. It shows the movement in LIBRAS Phonological Model of Figure 4.

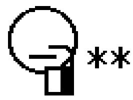

Figure 7: Graphic sign of "pai" father in SignWriting.

As we can observe in Table 3, the service reads each described XML chunk in an independent manner for the SignWriting symbols generation. In this way, every existent (or yet non-existent, if represented in the Model) LIBRAS sign can be generated from its primitives description. The systems databases storage every elementary component described by the LIBRAS Phonological Model, instead of the correspondence sign-SignWriting symbols like other available tools do.

Table 3: Table with the XML description of the movement of the sign "pai" in LIBRAS.

```
<movement sequence="1">
 <dominantHand>
  <type>
   <contour>rectilinear</contour>
   <unidirectional>sideways</unidirectional>
   <contact>touch</contact>
  </type>
  <quality>
   <velocity>normal</velocity>
  </quality>
  <frequency>double</frequency>
 </dominantHand>
</movement>
```

The tool is relatively simple, it shows the user the structure of the descriptive XML for him to enter the LIBRAS signal information, which can also have the clean interface shown in Figure 9, if the XML is ready for automatic conversion. Thus, the system reads the user input, corrects any mistakes and eliminates not required information saving each description in a vector.

After this stage, the main vector is separated into 7 other vectors respectively connected to each SignWriting primitive: dominant-hand configuration, local movement of dominant-hand, non-dominant hand configuration, local movement of non-dominant hand, no manual expression, movement of dominant-hand and non-dominant hand. A scan occurs to verify if the information is primitive, because in a sign it is not necessary to have all of these primitives and each primitive does not need to have all the descriptions recorded.

The final stage of the process is to check if the vector has the description of the primitive. If so, several searches in the database are performed to find some primitive that has the similar characteristics to the one inserted into the XML and if it finds it the

Service shows to the user the primitives forming the corresponding signal. Figure 9, shows a screen of the tool for Automatic Generation of LIBRAS Signs by Graphic Symbols of SignWriting.

This makes the system's managing possible and innovative, since along the language evolution in course, it will not be necessary to enter each new sign created, because its elementary components will be already storage.

The second functionality of the service presented here acts in a similar way as other available tools do, with the difference that it uses as input the same XML code with the sign description in the first capacity or use of the service described above. The output for the user consists on the set of all the signs that have that chunk as a component. The service is all being developed for the WEB platform in order to be available for Deaf communities. It has been declared especially useful as a tool for LIBRAS learning. Also, it will be integrated to the whole working architecture within a non-distant future.

5 CONCLUSIONS AND FUTURE WORK

The need of any natural language writing is critical, so that the language is not lost along time. Deaf communities needs are clear, mainly concerning access to information without the country's official language indirection. In this sense, the work presented here potentiality represents a step towards solving a relevant technical problem, also having clear future social results. The service presented here is a relevant part of an alternative output to 3D LIBRAS avatars within the Portuguese - LIBRAS translator module under development.

The main question to be treated in future work is the generation of SignWriting symbols of a certain sign in the correct arrangement (in columns, from up to down, from left to right). This will be the last step after the conversion of the written Portuguese version into the corresponding XML LIBRAS description by the Phonological Model built within the research group.

This capacity will be one of the bases for automatic translation from written Portuguese to LIBRAS, giving Brazilian Deaf communities the possibility of having access (in graphic written form) to books, classroom notes, films and any other academic or cultural content and, last but not least, to knowledge creation in their natural language.

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