An Animated Avatar to Interpret SignWriting Transcription

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***Abstract*—People with hearing disability often face multiple barriers when attempting to interact with hearing society. The lower proficiency in reading, writing and understanding the spoken language may be one of the most important reasons. Certainly, if there were a commonly accepted notation system for sign languages, signed information could be provided in written form, but such a system does not exist yet. SignWriting seems at present the best solution to the problem of SL representation as it was intended as a practical writing system for everyday communication, but requires mastery of a set of conventions different from those of the other transcriptions systems to become a proficient reader or writer. To provide additional support for deaf signers to learn and use such notation, we propose in this paper a new tool for displaying SW notation content, automatically, in visual-gestural modality by using a 3D signing avatar. The notation is provided as input in an XML based format called SWML (SignWriting Markup Language). Such tool can help the deaf to grasp and interact with the transcribing data through a more user-friendly environment.**

Keywords—deaf accessibility; sign synthesis; signing avatar; writing system; SignWriting

I. INTRODUCTION

Communication is a central aspect of our daily lives. Our ability to communicate with others through spoken language and written words dictates our access to vital resources such as education, employment, healthcare and other social services.

For deaf and hard of hearing persons who use fluently sign language as their primary means of communication, reading and writing the ambient spoken language can be a laborious process because of their lower levels of educational attainment. The World Federation of Deaf (WFD) recognises that approximately 80% of deaf people do not receive any basic education, especially in developing countries. This means there are over 50 million deaf people in the world are illiterate. Furthermore, the Gallaudet Research Institute indicates that the median reading comprehension score for 17 and 18 year old deaf students, how get education, is approximately equivalent to that of fourth-grade hearing students [1]. These data provide evidence that these members have an extreme difficulty in the acquisition and development of the dominant language and this forms a serious impediment in their access to public information and their full integration in the hearing society.

To address this issue, different methods and technologies geared towards deaf communication have been suggested over the last decades. For instance, the use of sign language interpreters is one of the most common ways to ensure a successful communication between deaf and hearing persons in direct interaction. But according to a WFD survey in 2009, 13 countries out of 93 do not have any sign language interpreters, and in many of those countries where there are interpreters, there are serious problems in finding qualified candidates. The digital technologies, particularly video and avatar-based systems, contribute in turn in bridging the communication gap. Although they are easy to use and can be available in all public facilities, these systems have some limitations. Creating video sequences is a very expensive process in terms of time and expertise, whereas, rendering of high-quality three dimensional animations is still challenging.

Despite the importance and variety of these means, providing information and materials in sign language written form seems to be the most effective alternative for breaking down communication barriers for SL users. Being able to read and write their own language would bring to signers the same advantage that writing systems for spoken languages bring to speakers [2]. However, most attempts at creating writing systems for SLs are not in very widespread use since they were conceived as transcription systems for linguistic researches rather than as practical scripts, with the exception of SignWriting which was proposed for common daily usage.

To provide additional support for deaf signers to learn and use such notations, a great deal of effort has recently been made for displaying their content in natural and comprehensible movements. The visualization of transcribed gestures in visual-gestural modality would be of paramount importance to their learners. In this context, we present in this paper a new tool for automatically generating signing animations from SignWriting notation, by using avatar technology. The SignWriting notation is provided as input in an XML based format called SWML (SignWriting Markup Language).

The remainder of the paper is structured as follows: the next section lists and discusses the well-known writing systems for SLs. Section 3 presents the contribution of this paper to raise the main problems of these systems in order to be more accessible for deaf persons. Section 4 and 5 provides an overview of SWML format and the previous works that based on it to display a SignWriting transcription. The general approach adopted to develop the tool is described in section 5. Finally, a conclusion is drawn.

II. SIGN LANGUAGE NOTATION SYSTEMS

A. Stokoe

Stokoe Notation was the first phonemic script in the history of ASL. It was developed by the linguist William Stokoe [3] in the 60's for proving that ASL sign language was a language by itself, on par with oral languages. This system defines 55 symbols divided in three groups of cheremes, namely tabulation referring to the sign location, designator referring to the hand shape and signation referring to the type of movement articulated. These symbols, which are based on the shapes of Latin letters and numbers, were written linearly from left to right in a strict tab-dez-sig order. An example of Stokoe notation for the ASL sign "don't know" can be seen in Fig. 1.

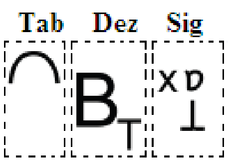


Figure 1. Stokoe Notation of "don't know"

This notation describes a comprehensive analysis of signs articulated using the hands, but it lacks any means for describing non-manual features, such as facial expressions that play a very important role to effectively convey meaning. In addition, it does not have a sufficient number of symbols to cover all the hand-shapes and locations used in SLs. This approach is well suited for notating singular signs in SL dictionaries and not for signs used within a context.

B. HamNoSys

Hamburg Notation System (HamNoSys) is a phonetic transcription system developed by a research team at Hamburg University in 1989 [4][5] to record any sign language in the world. It has its roots in the Stokoe notation but it has attempted to be more accurate and more phonetic. It includes over 210 iconic characters to represent the SL phonemes including NMFs and information about the signing space. Generally, these parameters are recorded in a fixed order, but it is still possible to write the same sign in different ways. In Fig.2, the symbols that denote the sign "house" are shown.

Figure 2. HamNoSys Notation of "house"

The purpose of HamNoSys has never been a usage in everyday communication. It was designed to comply with research requirements, e.g. for corpus annotation, sign generation, machine translation and dictionary construction [6].

C. SignWriting

SignWriting (SW) is a system invented by Valerie Sutton at the University of Copenhagen in 1974 [7]. It was a derivative of a notation developed by Sutton to transcribe choreographic sequences called DanceWriting notation. Unlike the first two writing systems, SW transcribes the signed gestures spatially, in two-dimensional canvas, as they are visually perceived, by using 639 base symbols. These intuitively shaped glyphs are similar to the actual form they are representing. For instance, the circles indicate the head, the squares indicate hands, and the arrows indicate hand motions. The ASL sign "salute" transcribed in SignWriting is shown in Fig. 3

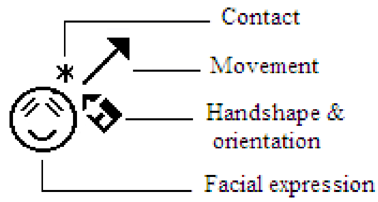


Figure 3. SignWriting Notation of "salute"

Sutton system seems at present the best solution to the problem of SL representation as it was developed for communication purposes rather than linguistic purposes. An important aspect of the benefits of this system could be seen in the production of a set of specialized dictionaries, newspapers and magazines written in SW for the Deaf. Besides, this system is now being taught to deaf children and adults worldwide as a handwriting version of SLs. It can offer to them the exceptionally fantastic possibility of learning foreign sign languages since it represents a bridge between languages [8]. Furthermore, SW can transcribe not only standard signs, but also complex signed constructions that are very frequent in signed discourse [9].

III. OUR CONTRIBUTUION

Currently, there is no a standard form of notation for transcribing signed language data, owing to many reasons. Typically, most proposals record the sign aspects, which are simultaneous during articulation, in a linear order and this could cause problems to signers: the representation of a single sign can be quite long and complex, making it unwieldy for reading of sequences of signs in phrases. Secondly, the different symbols used to encapsulate the phonetics of signs are often difficult to learn and remember like those adopted in Stokoe and HamNoSys systems. Last but not least, the static representation of these notations may inadvertently create confusion for novice readers who have not been trained to read and write in sign language. The three-dimensional depth of signing cannot be shown clearly in the graphical representation.

The main contribution of this paper is to develop an avatar-based system for enhancing the usability and readability of such notations by deaf people. The virtual signer will interpret here the actual gestures that correspond to the sign language notation in visual-gestural modality. We have chosen the SignWriting notation for the input of our system as it represents the more suitable method that could satisfy the deaf needs, than other notations.

IV. SWML

SWML (SignWriting Markup Language) is an XML-based format that was developed for the storage and processing of SW texts and dictionaries, allowing thus the interoperability of SW applications and promoting web accessibility to deaf people in their own natural languages [10].

Each sign encoded in SWML corresponds to a signbox tag comprising the set of symbols that together represent the notation. To identify the aspect of sign language to which it corresponds and the variation to which was subjected, each symbol is specified by a unique ID. Further, the coordinates concerning the relative position of each symbol in the bi-dimensional canvas are also denoted. The representation of the sign “salute” and its SWML translation are given in Fig. 4.

```
<signbox>
  <seq>01-04-004-01-05-02</seq>
  <seq>02-05-001-03-01-08</seq>
  <seq>02-01-001-01-01-01</seq>
  <seq>04-01-002-01-01-08</seq>
  <seq>04-04-002-01-01-01</seq>
  <seq>04-02-001-01-01-01</seq>
  <sym width="36" height="35" left="-18" top="-17">04-04-002-01-01-01</sym>
  <sym width="36" height="35" left="-18" top="-17">04-02-001-01-01-01</sym>
  <sym width="36" height="35" left="-18" top="-17">04-01-002-01-01-08</sym>
  <sym width="21" height="21" left="16" top="-18">01-04-004-01-05-02</sym>
  <sym width="31" height="31" left="25" top="-54">02-05-001-03-01-08</sym>
  <sym width="10" height="11" left="7" top="-29">02-01-001-01-01-01</sym>
</signbox>
```

Figure 4. SWML encoding of the sign salute

Indeed, there are two main drawbacks, in the SWML encoding, which make difficult to drive automatically a signing avatar. On the one hand, there is no temporal order in which symbols are written to interpret correctly the sign. A SignSpelling Sequence [11] can be proposed by the creator of each sign for internal ordering its symbols, but it should be notated that this sequence is an optional prefix, it cannot be found in all signboxes. For this reason, it is not possible to adopt this possible solution in our approach for arranging the notation elements. In other hand, the SWML format encodes just the original glyphs and this means that a certain amount of information may be omitted: they are deduced, rather, from the image. For example, SignWriting does not denote symbols for the hand location, so is SWML. SignWriting places the hand shape and movement symbols in the sign box with a symbol for the head to encode locative parameters.

V. PREVIOUS WORKS

VSign is one of the first projects that perform animation sequences from SW notation. It is a Greek project developed by Maria Papadogiorgaki and al.[12] at the Informatics and Telematics Institute in Greece. This project has adapted the original version of SWML for the synthesis of virtual reality animations using Body Animation Parameters of the standard MPEG-4. It converts all individual symbols found in the sign box to sequences of BAPs, which are then used to animate any H-anim compliant avatar using MPEG-4 BAP player. This system can render about 3200 words, but torso and shoulder movements are not implemented. Moreover, some problems may occur when contacts and complex movements are involved. Fig. 5 shows an overlap of hands that could happen when the inclinations of the hand joints are not accurate enough for the exact description of bimanual movements. The touch between the hands or the hand and the face is also difficult to be achieved.

Figure 5. Example of VSign’s problem

South African Sign Language (SASL) Project [13] at the University of the Western Cape was concerned also to render an animated avatar endowed with expressive gestures, from SW notation, using MPEG-4 BAPs. This system has tested only 8 signs.

VI. OUR APPROACH

The input of our sign synthesis system is the SWML signbox of the SW notation to be visualized. To render its content in sign language, the set of symbols found in the signbox will be processed and converted into 3D animation sequences by implementing four steps, as shown in Fig. 6.

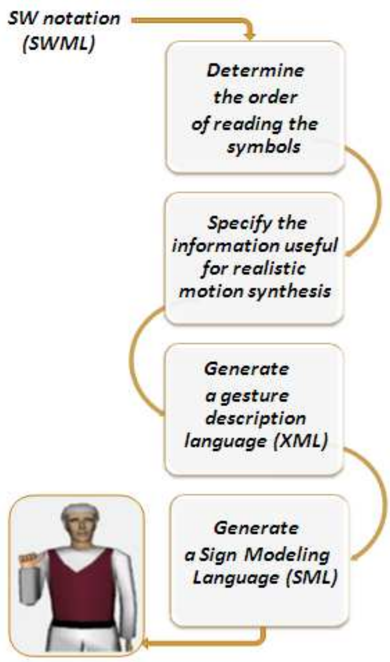


Figure 6. The architecture of the proposed tool

The first step is dedicated to determine the correct order of symbols in the sign, while the second is devoted to provide the missing information needed to describe the avatar movements. The third step ensures the automatic generation of a gesture description language which explicitly specifies how sign is articulated. Finally, the last step is devoted to transform the obtained sign description to SML, a Sign Modeling Language [14], for rendering an animated avatar.

A. Ordering the Symbol List

The sorting process starts by parsing the associated information with each symbol contained within the input signbox. Each one captures an articulator or some aspect of its movement: it can indicate hand, contact, movement, finger-movement, a head circle with a set of modifiers, torso, limb, dynamics or timing of movement.

To determine the order of reading of these symbols, we have realized the following steps: first, we define the set of symbols representing hand, directional movement, finger movement and contact as an underlying structure to the sign through which we can identify its type. An SW sign can either be static or dynamic, articulated with one hand or both hands, symmetrical (in which both hands have the same shape, place, orientation and movement) or not symmetrical, in unit (both hands move as a group to the same direction) or not in unit, simple or composite. The composite sign includes at least two hand symbols and two movement symbols for each articulator (right or left). Our proposed taxonomy for SW signs is given in Fig. 7.

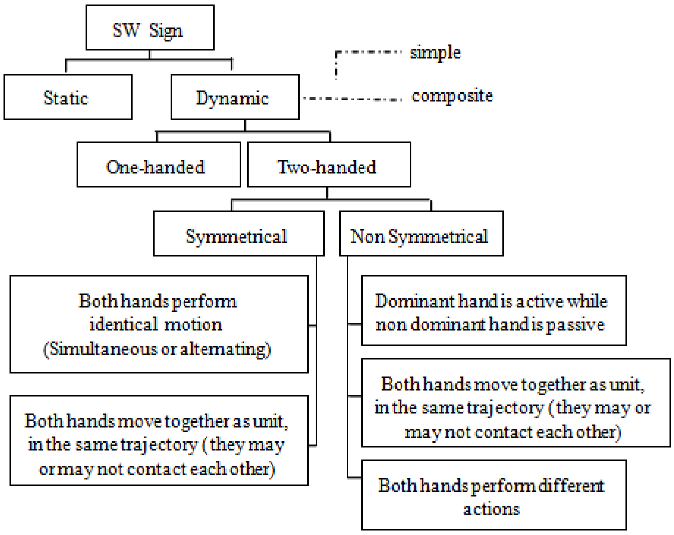


Figure 7. A taxoomy for SignWriting signs

Second, according to the type and the underlying structure of the sign (USS), a set of precedence rules will be applied appropriately to arrange the symbol list. For example, the sign "salute" mentioned above, is a simple sign articulated with one hand, its USS includes one configuration, a directional movement and a touch contact. In this case, a precedence rule based on the direction of the movement arrow is used to determine if the touch contact occurs before or after the motion. Such rules serve to identify the predecessors of a directional movement that are located at the tail of the arrow, and its successors that are located at the arrow head.

If there was another type of movement (instead of directional arrow) in this USS, we should need to adopt another series of precedence rules, for example:

- if the movement symbol describes an arm circle or wrist circle (e.g. the sign "politics"), the movement occurs always before the touch contact.
- if the movement symbol is an axial arrow or indicates a wrist flex (e.g. the sign "suffer") , the movement occurs always after the touch contact
- if the movement symbol describes a finger movement (e.g. the sign "bird"), the finger movement occurs always after the touch contact.

The use of such rules is needed to have a correct interpretation of signing animations especially that there is no obvious method by which users might order the symbol list [15].

B. Specifying Misssing Information

Animating a 3D avatar in sign language requires explicit enough information in order to be close to reality. As we have seen, SWML encoding may omit some interesting details that are implicitly present in the notation, and can affect the avatar performance. The hand location is an important aspect in SL that was not defined explicitly in SWML. To determine this feature, we have considered the relative position of each hand symbol from other symbols placements, especially those representing the head, shoulders, torso and limbs, and this by relying on the horizontal and vertical coordinates of the upper left corner of their glyphs, as well as on their predefined sizes (width and height). But, sometimes when the hand touches different body parts (e.g. the ASL sign "we"), it will be more suitable to use detailed location symbols that are not used to write SignWriting for everyday use. They are conceived rather to give the computer information about the exact location when programming an avatar.

C. Gesture Description

SignWriting decompose a sign into body-parts, movements and facial expressions and assigns a representation to each of them. To support the sign representation at the phonetic level, we have proposed a simple gesture description language that captures the important phonetic details of signing.

The gesture description we present includes essentially two segments: posture and movement. The hand posture is defined by the shape of the hand, its orientation, its degree of rotation, and also, where necessary, its position in the signing space. In contrast, segment movement is used to specify the relevant features of any type of movements which could be a global movement, local movement or contact. Local movements refer here to small repeated movements of the fingers, wrist or forearm which accompany the major movement of the hand (e.g. the ASL sign "language").

Non-manual components are also defined in the gesture description to specify the behavior of facial articulators such as raised eyebrows, puffed cheeks, eyes blinking, and non-manual bodily movements such as tilting the head and shoulders. It is important to note here that the definition of features is based on the corresponding definition in the International SignWriting alphabet (ISWA 2010).

Fig. 8 gives the description of the sign “salute” in which the tip of the right index moves to contact the upper right side of the face and then moves forward to the right in straight movement. The eyebrows of the signer are straight up and his mouth smiles.

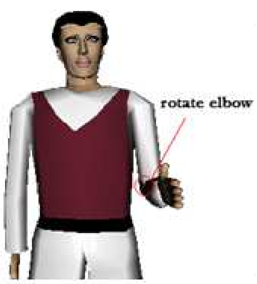
```
<sign hands=single inUnity=false symmetry=false >
  <mouth shape=smile />
  <eyebrows shape= straight_up />
 <Posture>
  <Right-hand shape=H72 orientation=FP-Side rotation=45 />
 <Posture/>
 <Movement>
  <Right-hand contact= touch repeat=1 part= r_index_tip_outside
                loc=r_upper_face />
 <Movement/>
 <Movement>
  <Right-hand globalMovement=FP_straight joint=elbow
   repeat=1 size=small direction=forward_right speed=normal />
 <Movement/>
<sign/>
```

Figure 8. The description of the sign “for”

D. Animation

The WebSign kernel [14][16][17] developed by our research laboratory LaTICE, integrates a 3D rendering module for generating 3D animations from an SML description of the sign to be visualized.

The SML (Sign Modeling Language) is an XML based language designed to provide an extra layer around X3D for facilitating the manipulation of the virtual avatar. The SML animations are stored as a successive movement or rotation of groups of joints. Every movement has a fixed time during it the rotation of every joint in the group is done. Fig. 9 shows how left elbow joint can be rotated using SML. Thus, what we need to do in this phase is to convert the obtained gesture description script into SML in order to be interpreted automatically by the WebSign player.




```
<Sentence>
   <word>
      <mouvement>
         <duration>0.5</duration>
         <join name="l_elbow">
            <rotation type="euler">
               <heading>80</heading>
               <attitude>50</attitude>
               <bank>50</bank>
            </rotation>
         </join>
      </mouvement>
   </word>
</Sentence>
```

Figure 9. Rotation of elbow joint int SML

VII. CONCLUSION

We have described in this paper a new avatar-based system for automatically synthesizing 3D signing animations from SignWriting notation. Interpreting the transcribed gestures with virtual signer will certainly help deaf and hard of hearing people to understand and learn the sign language notation, and thus providing them the opportunity to communicate through the medium of writing their preferred language.

It should be noted that our system is under development. The evaluation phase has not yet been achieved and remains a work in progress on animation phase.

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