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An Avatar based Approach for Automatically Interpreting a Sign Language Notation

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Abstract— **For deaf and hard hearing people, learning any spoken language is not a natural or automatic process, it is rather a long and intensive task. As a matter of fact, the important differences between signed and oral languages significantly affect the ability of these individuals to develop their literacy skills and thus their knowledge and potential. To address that issue, a number of systems for representing SLs in written form have been proposed. Most have become widely used among academics for linguistic research, while a few others have begun to be used as educational tools in some countries. Typically, these notations may inadvertently create confusion for novice readers because of their static nature and the special symbols that they use, so, displaying its contents in the form of video or animation of humanlike character would be beneficial to their users. In this context, we present in this paper a new approach for automatically interpreting a sign language notation using avatar technology. SignWriting will be the focus of our work because it depicts the more suitable method that could satisfy the deaf needs than other notations and which is being taught formally in some schools.**

Keywords-sign languge;deaf; SignWriting; gesture synthesis; signing avatar; animation

I. INTRODUCTION

Sign languages (SLs) have become an increasingly discussed scientific topic, in the last years, given the raising awareness about the Deaf Community and their issues. The acquisition of spoken language and literacy skills is probably the most formidable challenge confronting these hearing impaired, and that has profound implications for their educational and social development. Studies from the World Federation of the Deaf in 2010 reveal that the enrolment rate and literacy achievement of deaf children is far below the average for the population at large, and there are at least 80% of deaf people in developing countries have no education at all. Without a strong educational base, silent people are unable to succeed in today's communities, at work and in the world of technology and information [1].

The salient differences between signed and spoken languages may be the most important factors that make it difficult for signers to decode and understand written words. A spoken language is structured according to how the sounds of speech are produced. This is then formalized into a system of writing also dependent on knowledge of the sounds of the language, whereas, sign language has a structure allowing the production of information simultaneously by using hands, facial expressions, bodily movements and signing space. Everything is adapted to how the eye perceives linguistic information [2].

There is no doubt that learning to read and write in their native language could be of great benefit to deaf learners. Several studies have shown that students are quicker to learn to read and acquire academic skills when first taught in their mother tongue, and this equally applies to sign languages. To this end, a number of systems have been created for representing sign languages in written form, and two of the successful ones were Stokoe notation and SignWriting which is currently being used as educational tool. Nevertheless, the majority of these systems may inadvertently create confusion for novice readers due to their static nature that seems to have lost the dynamicity of signed language, and also their use of special symbols that are not easy to learn.

To support the use of such notations and make their content more accessible, the transcribed gestures should be displayed in visual-gestural modality. An accurate synthesis of these transcriptions would be of paramount importance to their learners. In this context, we present in this paper a new approach for generating 3D animation sequences automatically from SignWriting notation which is provided as input in an XML based format called SWML (SignWrititng Markup Language), using avatar technology. The proposed system aims to help not only the deaf but also the hearing people to read and write with SignWriting.

II. SIGNWRITING

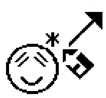
SignWriting is a system developed by Valerie Sutton in 1974, and had its roots in an early form of movement writing called DanceWriting. SW is a pictorial notation system which relies on highly iconic symbols for representing hand shapes, palm orientations, facial expressions, and various indications of motion and contact. These glyphs are combined spatially on two-dimensional canvas to form individual signs as they are visually perceived [3][4].

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. It is now used in more than ten countries to aid literacy. Thanks to its alphabet ISWA (International SignWriting Alphabet) which includes more than 639 base symbols, SW can be used to transcribe any sign language in the world. It can record not only standard signs, but also complex constructions that are very frequent in signed discourse [5]. This script is intuitive for new learners, but nevertheless requires mastery of a set of conventions different from those of the other transcriptions systems to become a proficient reader or writer [6].

III. SWML

SWML (SignWriting Markup Language) is an XML based format which was developed by A. Da Rocha for the storage, indexing and processing of SignWriting notation [7]. Each sign encoded in SWML corresponds to a signbox 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 canvases are also denoted. The representation of the ASL sign “salute” in SignWriting and its SWML translation are given in table 1.

TABLE I. THE SWML ENCODING OF THE SIGN “SALUTE”



```
<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>
```

Indeed, there are two main drawbacks, in the SWML encoding, which make it 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 [3] 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. For example, SignWriting does not use symbols for the hand location, so is SWML.

IV. APPROACH

The objective of our work is to develop a new tool for synthesizing the gestures represented within a sign language written form in SignWriting by using a 3D signing avatar. The provision of transcribed data via a user-friendly interface, make the notation easier to read and understand by deaf and hard of hearing learners.

The input of our sign synthesis system is the SWML signbox of the SW notation to be visualized. To render its content in signed 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. 1. 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 movements of the avatar. 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 (Sign Modeling Language) which is interpreted then automatically by the WebSign player [8] to animate the virtual avatar.

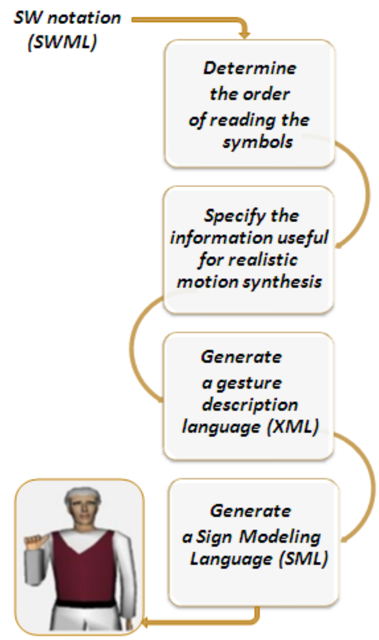


Figure 1. Proposed system process.

A. Sorting Procedure

For the sorting process, we define the set of symbols representing hands, directional movement, finger movement and contact as an underlying structure to the sign through which we can identify its type: static or dynamic, one-handed or two-handed, symmetrical (in which both hands have the same shape, orientation, location and movement) or not symmetrical, in unit (both hands move as a group to the same direction) or not in unit, simple or compound.

According to the type and the underlying structure of a sign, a series of rules will be applied appropriately to arrange the list symbols. For example, the sign ”salute” mentioned above, is a simple sign articulated with one hand, it includes one configuration, a directional movement symbol and a touch contact. In this case, a rule based on the direction of movement arrow is used to determine if the touch contact occurs before or after the motion.

B. Identifying the Missing Information

Animating a 3D avatar in SL 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 avatar performance. The hand position is a key feature that was not explicitly defined in SW and thereby in SWML. It is rather deduced by the reader from the pictograph. To define this feature, we must always consider the most symbols' placements within the sign, especially those representing the head, shoulders, torso and limbs. But, sometimes when the hand touches different body parts (e.g. in the ASL sign "we"), it will be more suitable to use detailed location symbols. These tokens are not used to write SignWriting for everyday use, but for programming an avatar in order to give the computer information about exact locations.

C. Gesture Description

The purpose of the gesture description is to support the representation of signs at the phonetic level, and this by representing phonetically the significant features 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 surrounding the signer's body. 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. The definition of non-manual components is also provided in the gesture description to specify the behavior of facial articulators such as raised eyebrows, puffed cheeks, eyes blinking, and bodily movements such as tilting the head body and shoulders.

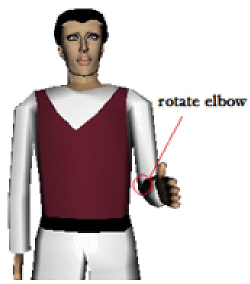
Fig. 2 illustrates the description of the sign "salute" in which the tip of the right index moves to contact the upper right side of the face and then moves forward to the right in straight movement. The eyebrows of the signer are straight up and his mouth smiles. It is important to note here that the definition of all these features is based on the corresponding definition in the SignWriting alphabet (ISWA 2010).

```
<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 2. The description of the sign "salute"

D. Animating the Avatar

For rendering animations in real time, an XML based descriptive language (Sign Modeling Language or SML) [9] is used to codify the obtained gesture description. SML was developed to provide an extra layer around X3D for facilitating the 3D virtual agent manipulation. The SML language is a successive movement of a group of joins. Every movement has a fixed time during it the rotation of every joint in the group is done. The armature design is compliant to the H|Anim specifications, in which each joint have a specific name and specific initial orientation. Fig. 3 shows how left elbow joint can be rotated using SML.




```
<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 3. Rotation of elbow joint int SML

A 3D rendering module will interpret then the SML script and convert it into 3D animation using a virtual agent.

V. Conclusion

We have presented in this paper a new system for automatically interpreting a SignWriting notation by using avatar technology, and this in order to make it easy to learn for deaf people. Unlike the previous works, VSign [10] and SASL that generate MPEG-4 BAP sequences directly from the SWML signbox to drive a virtual signer, this system has proposed a simple gesture description to reformulate the different features of the sign and convert it then into SML for rendering the corresponding signing animations.

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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