tuniSigner: An Avatar based System to Interpret SignWriting Notations

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Abstract. Virtual Reality is an exciting technology that holds great promise for delivering innovative new ways for people with special needs to deal with information more easily. Signing avatars are virtual human characters capable of performing sign language utterances in a three dimensional environment. They are actually used by deaf community for interpreting television news, teaching school subjects, creating sign language dictionaries, and displaying SMS message content on mobile phone screen. These digital humanoids provide a cost effective and efficient way to make all kind of information accessible to sign language users. In this paper, we present an avatar-based system, named tuniSigner, for synthesizing virtual reality animations from SignWriting notations. The virtual signer will display and interpret the transcribed gestures in natural and comprehensible movements. Certainly, showing how the actual gestures should be performed in visual-gestural modality would be very useful for deaf signers.

Keywords: Virtual avatar, 3D animation, Signwriting, Sign Language

1 Introduction

The Deaf community exists as a cultural and linguistic minority within the wider community. It provides each Deaf person with a sense of belonging, a place where identities can developed, confidence enhanced, skills learnt and friends made. Sign language (SL) is an integral part and an identifying feature of membership in this culture. It is a rich and complex visual-spatial language, with a vocabulary and syntax of its own. It uses both manual and non-manual components, including hand shapes and movements, facial expressions and body movements to convey everything that spoken language can convey. SL still does not have a widely accepted written form, and this makes a large portion of hearing impaired people live in a diglossic environment, where they are forced to use their native language in their face-to-face interactions and another language in all other types of human interaction [1]. But, as they typically have low proficiency in spoken and written language of their country, in comparison to their SL skills, these signers often face multiple challenges in their everyday lives. Based on data collected by the World Federation of the Deaf (WFD), around 80% of deaf people worldwide have an insufficient education, literacy problems and lower verbal skills [2].

Indeed, having a means to represent their own language in a written form can bring to hearing impaired people the same advantage that written systems for spoken languages bring to speakers. For example, young deaf children, who learn a sign language as a first language, will be able to learn to read via a language that is fully accessible to them. This is in contrast to the educational system commonly used today in which the deaf child learns to read a spoken language that does not yet fully mastered [3]. Moreover, such written form can be very useful to improve the ability of these signers to comprehend and acquire the written versions of oral languages [4].

Some attempts have been made to date to devise adequate writing systems for SL, such as American Stokoe notation system and the Hambourg notation system, but these are mainly systems used by researchers rather than ordinary sign language users. SignWriting is another writing formalism based on transcription of manual and also non-manual elements of non-standard signs and complex units through symbols [5]. It is used differently in over 40 countries. Some groups use it for research while others use it in Deaf Education. Despite SignWriting closely visually resembles the concrete signs, a training to learn to interpret their static transcriptions is needed for novice users who are accustomed to the use of their sign language in a visual-gestural modality. The bi-dimensional representation of such notations may inadvertently create confusion and ambiguity to these users since the four-dimensional nature of signing (three-dimensions of space and one of time) cannot be fully reflected into a symbolic transcription. So, in order to make the SW notation content completely accessible to them, we present in this paper an avatar based system, called tuniSigner, to synthesize sign language animations from SignWriting notations. This system, which forms a part of the WebSign project [19], takes as input a formal representation of the SW notation in its XML format and produces the corresponding avatar animation in a virtual world.

2 Written forms for sign languages

Sign languages have been proven to be natural languages, as capable of expressing human thoughts and emotions as traditional languages are. However, the distinct visual and spatial nature of signing seems to be an insurmountable barrier for developing a widely accepted writing form. We will briefly review, in this section, the most popular notations systems that have been created in attempts to write the specific articulations of these dictinct languages.

2.1 Bébian Notation

The first systematic writing system for a sign language seems to be that of Roch-Ambroise Auguste Bébian which was developed in 1825 with a view to facilitate the teaching of signs to deaf children [6]. This system includes less than 200 iconic symbols for representing body articulators (hands, legs, shoulders, head, etc), movements and facial expressions. Examples of Bébian notations are shown in Fig.1. It should be noted that, after the banning of French Sign Language by the Milan Congress in 1880, Bébian system will be partially re-operated by the linguist William Stokoe in 1960.

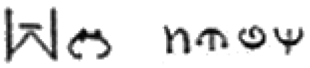

Fig. 1. Bébian notations for the signs "Book" and "Take"

2.2 Stokoe Notation

William Stokoe, a hearing Gallaudet College professor, was the leading pioneer of Sign Language research. He invented a method that made it possible to transcribe the internal structure of the American Sign Language (ASL) signs. The method showed signs as being morphological units composed of three formal features or cheremes: the handshape (called Designator, or dez for short), location (called Tabula, or tab for short), and movement (called Signation, or sig for short) [7]. These cheremes were written in a strict order with meaning dependent on placement within the string. The Location and Movement symbols were iconic while Hand Shape symbols were represented by units taken from Latin letters and Arabic numerals (Fig.2). The original Stokoe system has been taken and expanded by several other SLs including British Sign Language, Italian Sign Language and Signed Swedish.

Fig. 2. Stokoe notation for the sign "Number"

The development of the Stokoe system advanced the field of sign linguistics significantly, but it is now outdated [8]. This system is seen actually as inadequate to represent sign language for regular use, because it has no way of indicating non manual features such as facial expressions. It was created essentially as a tool for linguists to transcribe single, decontextualised and standard signs.

2.3 HamNoSys Notation

The Hamburg Notation System (HamNoSys) was invented in 1989 at the University of Hamburg in Germany as a phonetic transcription notation for sign language. Its alphabet includes over 200 iconic symbols which are sufficient to cover all hand configurations and movement combinations [9]. The order of the symbols within a string is fixed, but still it is possible to write down one and the same sign in lots of different ways. An example of HamNoSys notation is shown in Fig.3.

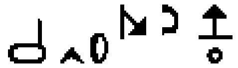

Fig. 3. HamNoSys notation for the sign "Where did you go?"

HamNoSys notations are very precise, but also very long and cumbersome to decipher. It is possible to transcribe facial expressions, but their development is not quite finished yet. HamNoSys is still being improved and extended all the time as the need arises. It has undergone four revisions and continues to be popular for academic purposes.

2.4 SignFont

SignFont is a notation system created, in 1987 at the Salk Institute in California, for writing down American Sign Language. The symbols used are partially iconic and can be divided in two main groups: full-size symbols to represent the handshape, location, motion or non-manual marker, and shorter symbols, which used somewhat like diacritics, to provide additional specificity for the preceding full-size symbol. In general, each sign can be written in this order: Handshape, Action Area, Location and Movement. Action Area is distinctive to this system; it describes which surface or side of the hand is the focus of the action [10].

Fig. 4. SignFont notation for the sign "All of them"

Signfont notation has been praised for having a much smaller symbol inventory than other sign language scripts, making it easier to learn. However, this means that not all the contrasts in ASL can be written using the script. In addition, the small symbol set makes it difficult to extend the script to signed languages other than ASL. Perhaps due to these disadvantages, it has found limited acceptance among the deaf.

2.5 SignWriting Notation

SignWriting was created in 1974 by Valerie Sutton, a ballet dancer who had two years earlier developed DanceWriting, MimeWriting, SprotsWriting and ScienceWriting. SW was conceived to be used by deaf people in their daily lives, for the same purposes hearing people commonly use written oral languages, such as taking notes, reading books, writing emails, learning at school, etc [11]. It was developed not only for one language, but was built to be appropriate for any sign language. A vast number of sign languages are already making use of the script.

SW has incredible flexibility to depict the phonetic or phonemic details of signing gestures. Compared to HamNoSys, SignFont, or Stokoe, SignWriting's flexibility is very handy and especially useful when it comes to record SL stories and poetry [12].

The International SignWriting Alphabet ISWA defines 30 groups of highly iconic symbols containing 639 basic symbols similar to real world objects. It is possible for each basic symbol to have 96 variations (up to 6 different fills and 16 rotations). Such combinations yield a total of 35,023 valid symbols to describe the configuration, movement and location of hands, fingers, facial expressions, punctuation and others.

SW signs can be written in a full body form using a stick person, a 'stacked' form which removes the stick figure for placing the iconic symbols above and below each other, or in a short hand form [13].

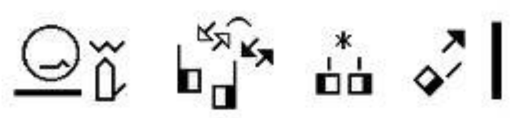

Fig. 5. A SignWriting representation for the sentence "Before talk with him"

Despite Sutton system is closely visually resembles the concrete signs, a deaf user requires a training to master the different symbols and rules governing the notation for becoming a proficient reader or writer.

3 Contribution

During the last decades, the three-dimensional animated characters called virtual avatars have been designed to provide increased accessibility for deaf people on a range of computing devices. A great deal of research has focused their interest on the automatic translation of written text to 3D signing animations but this is not the focus of our work. Rather, the focus here is to develop an avatar based system for synthesizing sign language utterances from sign language notations. Rendering SL notations in the form of 3D avatar animations can make a major difference in the usability and readability of such transcriptions since deaf users could visualize how the actual gestures should be articulated in virtual worlds.

At first glance, it might seem that recording a signer with a video camera would be a reasonable approach, but video lacks the flexibility of avatar animation systems. In fact, 3D animation systems provide a low-cost and effective means for adding sign language translation to any type of media because animation is actually a much easier type of data than video to store. Furthermore, 3D animation can be easily manipulated by users: the point of view of the virtual camera that renders the signing character and the location of the character in relation to the background can be optimized to enhance clarity. In contrast, the point of view in a video sequence is limited to the original positioning of the camera. Last but not least, video recordings imply considerable production cost and their content cannot be modified after production.

4 System Description

As shown in Fig. 6, our system architecture is divided mainly into three parts. The first one is devoted to parse and process the SignWriting notations which are provided in an XML format. The second part is dedicated to provide a linguistic representation for each notation in order to specify how correspondent signs are articulated. Finally, the third part is devoted to convert the obtained linguistic representations to SML (Sign Modeling Language) [17] for rendering avatar animations.

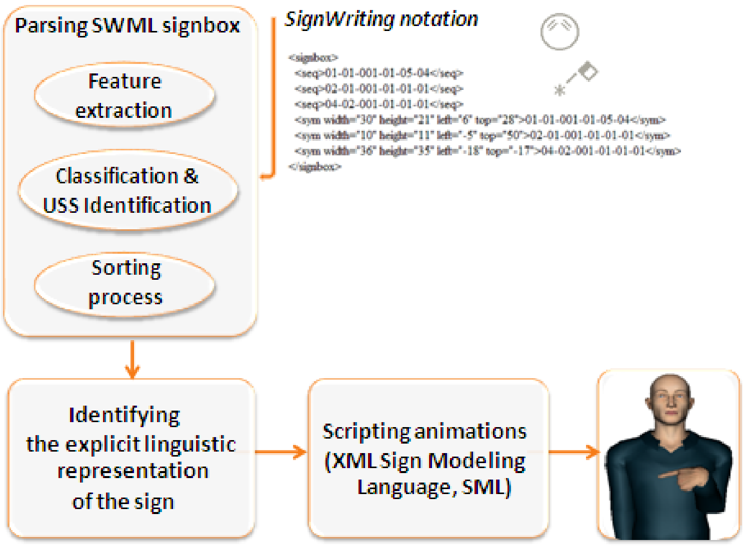

Fig. 6. An overview of the system architecture

4.1 Parsing SWML Sign-Box

SignWriting Markup Language or SWML is an XML-based encoding of SignWriting, developed by [14] for the storage and processing of SW texts. Each sign encoded in SWML corresponds to a signbox comprising the set of symbols that together represent the notation. Each signbox can include two types of elements: "sym" as spatial symbol and "seq" as sequential symbol. The spatial symbols include 2-dimensional positioning and are considered unordered, while sequential ones form an optional ordered list of symbols IDs organized by the SignSpelling rules [5].

To process an SWML sign-box, we must firstly extract the associated information with each spatial symbol which can capture an articulator or some aspect of its movement. Secondly, define the set of spatial tokens representing manual features (hand configuration, directional movement, finger movement and contact) as an underlying structure of the sign (USS). The USS is used to identify the type of the written sign which can be static or dynamic, produced with one-hand or with both hands, symmetrical or not symmetrical, in unit (both hands move as a group to the same direction) or not in unit, simple or compound. We assume here that a compound sign comprises at least two hand symbols and two movement symbols for each articulator (right or left). Our proposed taxonomy for SW notations is given in Fig. 7.

According to the type and the underlying structure of the sign, a set of rules will be applied appropriately to determine the order of reading of symbols [15][16].

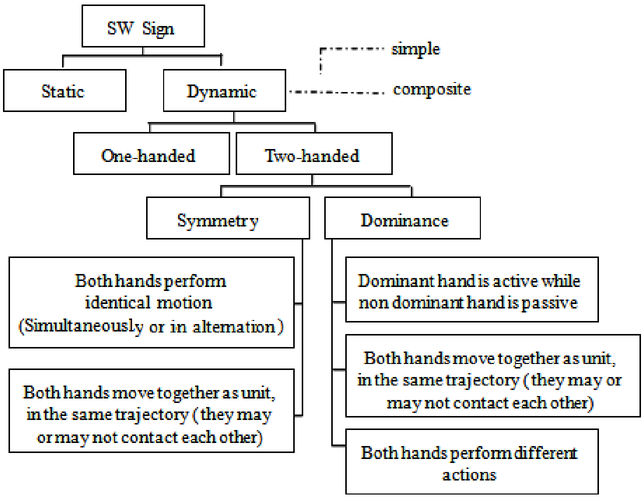

Fig. 7. A proposed taxonomy for SW signs

4.2 Identifying the explicit linguistic representation of the sign

Rendering sign language, in the form of 3D animations, requires the definition of all relevant features of signing gestures (or phonemes). Nevertheless, SWML is not complete enough and phonologically-based enough to be used for the underlying linguistic representation of a sign. It is merely an XML adaptation of SignWriting which can provide information about the relative position of each basic symbol in the notation. For instance, the hand location is a salient phonological aspect in SL that was not explicitly defined in SignWriting and thereby in SWML. It can only be extracted from symbols by considering their spatial positions. For this reason, using an appropriate phonological representation that explicitly specifies the different linguistic features is a prerequisite for the correct performance of a sign.

4.3 Scripting and Generating 3D animations

Thanks to the real time animation engine integrated into the Websign kernel, an H-Anim compliant avatar can be used to render any sign language gestures annotated with a scripting language named SML [17]. The Sign Modeling Language provides an extra layer around X3D for facilitating the control and manipulation of the virtual agent. It can describe the signed utterance in terms of translation or Euler rotation of a group of joints, such as the neck, wrist, eyebrows, and so on. The main objective of the current phase is to achieve the automatic conversion of the linguistic representation of the SignWriting notation into SML before sending it to the WebSign player and generating the corresponding animations (Fig. 8).

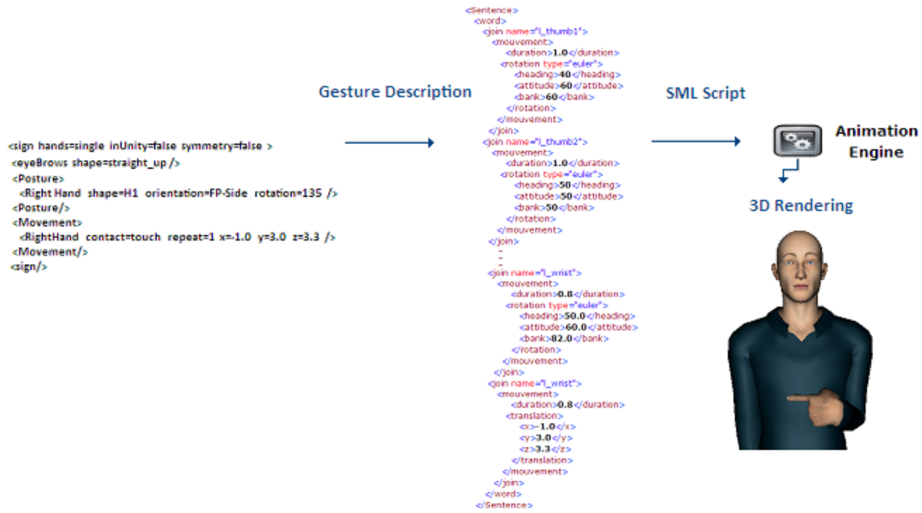

Fig. 8. Rendering 3D animation from SML script

Handshape and Orientation . The motions of the fingers and thumb are represented as various rotations at hand joints around specific joint axes. So, in order to produce the desired hand shape, the suitable Euler angles rotation must be applied to the different finger joints. The process is about the same for the hand orientation which is seen as a simple rotation at the wrist (Fig. 9).

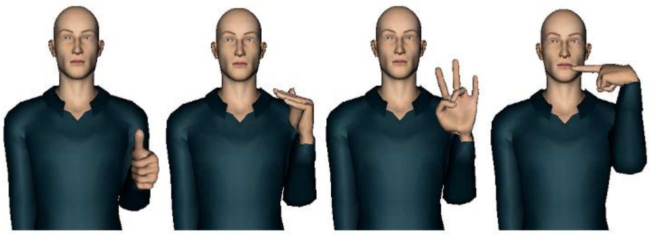

Fig. 9. Examples of hand shapes and orientations

Location and Signing Space. The location of the hand is described by a set of positions in the signing space or on the signer’s body. The signing space in front of the avatar is represented by three-dimensional grid of discrete points, resulting from the intersection of three planes (horizontal, parallel to the frontal plane, parallel to the sagittal plane). The particular positions on the signer's face and body refer here to the SignWriting symbols that are used to depict sign location on torso, face and limbs.

Movement . the hand movement is defined in SML as a translation of the wrist joint toward a specific position in the signing space or on the body signer in case of contact. Basing on the initial position of the hand, the trajectory form of the movement symbol (straight, curved, circular, etc) as well as the articulation size (short, medium, large), the intermediate positions can be calculated automatically. It is important to stress here that an animation solver based on inverse kinematics [18] is employed to perform the analytic computation in the real time. Rotations for shoulder, elbow, and wrist joints are commutated by inverse kinematics in accordance with 3D positions of wrist joint in the space.

Finger Movement. According to the hand shape used, the given finger movement (finger opening, closing, bending, wiggling) will be transformed into a sequence of rotations at the appropriate finger knuckles.

Non Manual Gestures. Facial expressions and body postures are a key component in all sign languages. The signing avatar developed within the WebSign project can produce the important non manual gestures basing on: a Rigging method [19] to simulate, for example, the head swinging, gaze changes, tongue movement, and a physics based muscle method [20] for emulating facial mimics like eyebrows, cheeks and mouth motions (Fig. 10). The control of such articulators is done via SML.

Fig. 10. Examples of non manual gestures

Time line. To control the timing of the animation, a fixed time interval, expressed in seconds, was assigned for each movement, during which a rotation or translation of a joint is performed.

5 Results

The proposed system has been evaluated with more than 1200 SignWriting notations, from different sign languages (Tunisian Sign Language, French Sign Language, Brazilian Sign Language, American Sign Language and Egyptian Sign Language).

The results we have obtained, so far, are valuable and very promising (Fig. 11). However, in order to achieve an objective evaluation, we have provided a simple web user interface for our system. The user can search the sign he want to learn, click and the virtual agent will demonstrate the 3D signing animation that corresponds to its SignWriting notation. The user can also evaluate the accuracy of signing animations and give feedback. tuniSigner is accessible online at http://www.tunisigner.com/.

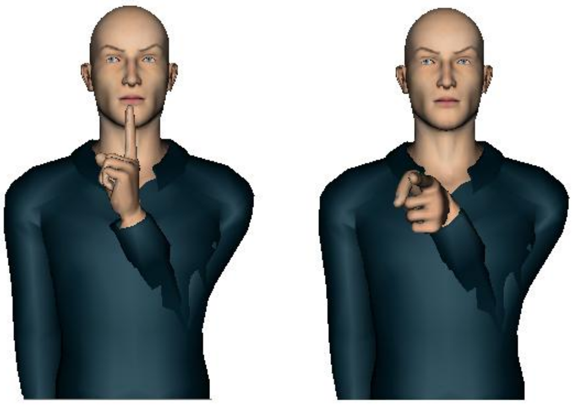

Fig. 11. The interpretation of the TSL sign "Ordonner"

6 Conclusion

An avatar-based system to render sign language animations automatically from SignWriting notations has been presented in this paper. Showing how the actual gestures should be performed in virtual reality would be of paramount importance not only for deaf and hard of hearing users but also for all interested in learning SW.

In our future works, we plan to extend our multilingual dictionary to include more individual signs and sentences from different sign languages. Besides, we aim to provide online games for deaf children to motivate them to learn SignWriting.

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