

Review and Comparison of Writing Notations of Sign Language

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Abstract— Sign language is the three dimensional visual spatial language used by hearing impaired people for communication. Unlike spoken languages, sign language can only be expressed using gestures. For creating an automatic translation system from text to sign language, a writing notation for sign language is required. Researchers have developed many writing notations for expressing the three dimensional gestures into the written form. This written form can be used for translation systems. Among many available writing notations, HamNoSys notation is best suitable till date to be used in translation system because this notation system has the provision to add the non-manual component like facial expressions in the sign. This paper analyses and compares the various writing notations of the sign language.

Keywords— Sign Language, Bébian Notation, Stokoe, Gloss, HamNoSys, SignWriting, SignFont, SignScript, Si5s, SLIPA, ASL-phabet

1. Introduction

Sign Language is a language which is used by hearing impaired people using hand shapes, hand fingers, face expressions, gestures and other parts of the body [1]. Sign Language is a visual-spatial language and the signer uses the three dimensional space around his body to describe an event [2]. As Sign Languages do not have well defined structure or grammar therefore there is no or very less acceptability of these signs outside their small world. Sign Languages until the 1960s were not viewed as bona fide languages, but just collections of gestures and mime. Dr. Stokoe's research on American Sign Language proved that it is a full-fledged language with its own grammar, syntax, and other linguistic attributes[3].

There are more than 7105 known living languages in the world which are divided in 136 different language families. Sign Language is one of these 136 families and this is the language which is used by hearing impaired people to communicate with others. This family of the language contains 141 Sign Languages all over the world depending upon the region in the world. For example, Indian Sign Language (ISL), American Sign Language(ASL), British Sign Language(BSL) are few among the list of 141 Sign Languages.

Out of nearly 7 billion people on earth, nearly 72 million are hearing impaired people. Out of such a big number approximately 4.3 million people use Sign Language. Rest of nearly 67 million deaf and hard of hearing people do not use any proper Sign Language to communicate. Thus nearly 90% deaf have a very limited or no access to education and other information [4][5].

In India, situation is worse as there are approximately 5.07 million persons who suffer from hearing disability. Among them, more than 30% persons are below 20 years of age and about 50% are between 20 years and 60 years of age [6]. These persons are generally unable to speak properly because of which they use Sign Language to communicate with others. As Sign Languages do not have well defined structure or grammar, therefore there is no or very less acceptability of these signs outside the small world of these people.

2. Sign Language Hierarchy

Sign Language can be categorized as one handed signs and two handed signs. There exist some signs which may contain only manual components or only non-manual components. Manual signs are those which use hand shapes, hand orientation and hand movements only. The non-manual signs are those which use eye brows, eye lids, facial expressions, head and shoulders movement and sometimes uses the manual signs along with. For example, the sign “Yes” is signed by vertical head nod and it has no manual component. The hierarchy of categorization of various signs is shown in the following figure:

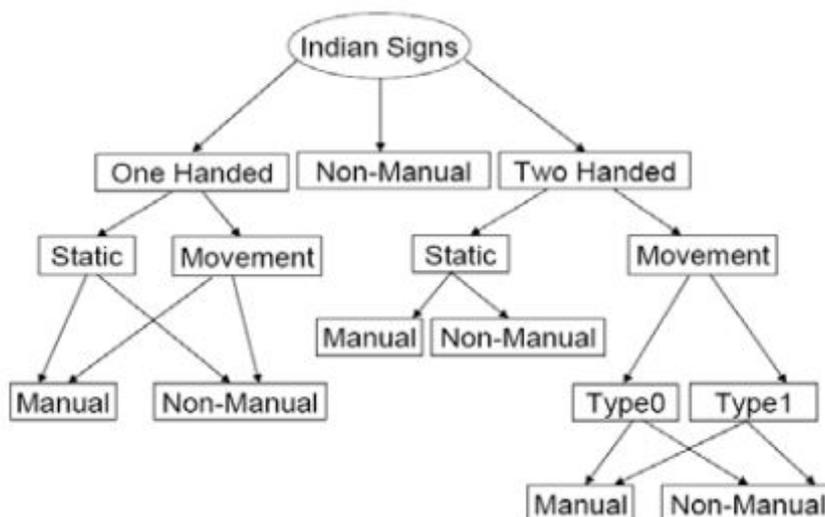


Figure 1. ISL Types Hierarchy

Signs are also categorized as static and dynamic signs. Static signs are those signs which do not have any movement in their signs. The dynamic signs are those which uses the movement of the hands, and the non-manual features of the sign. Most of the signs used in the Sign Language are dynamic signs.

One Handed Signs

The one handed signs are represented by a single dominating hand. One handed signs can be either static or movement. Each of the static and movement sign is further classified into manual and non-manual signs. Figure 2 shows the sign of ear which is one handed static manual sign and Figure 3 shows the sign of headache which is static non manual sign.



Figure 2. One Handed Static Manual Sign (Ear)



Figure 3. One Handed Non-Manual Sign (Headache)

Two Handed Signs

The two handed signs are represented by both the hands of the signer. As in the case of one handed signs, similar classification can be applied to two handed signs. However, two handed signs with movements can be further distinguished as: Type0 and Type1 signs.

Type0 signs are those signs in which both the hands are active i.e. both the hands are in motion.

Type1 signs are those signs in which one hand (dominant) is more active as compared to the other hand (non-dominant).

Figure 4 shows the sign “Long” which is two handed sign of type0 as both the hands are in motion. Figure 5 shows the sign “Flag” which is two handed sign of type1 as one hand (dominant hand) is actively in motion whereas the other hand (non-dominant) hand is stable.



Figure 4 Two Handed Sign "Long" (Type0)



Figure 5 Two handed Sign “Flag” (Type0)

3. Sign Writing Notations

Sign Language is a three dimensional language which cannot be written just like the other spoken languages like English, Hindi, Punjabi etc. But, researchers have created some methods/notations for writing the Sign Language. Though these writing notations are not familiar to the hearing impaired community but these are very important for synthetic dictionary generation and translation systems. The invention of writing notations is only for the research purpose and is not standard notation system. A standard written form/notation of 3D sign is useful in Sign Language translation to enable easy distribution of data and to make the translation system scalable. Use of a writing notation of sign language is an intermediary step that will be an aid for making systems more scalable, although it may depend on the notation used. There are a number of written forms of the Sign Language but there is no standard written form for Sign Languages till now.

If a standard notation system emerges, it can aid in data sharing and new projects can be built on older projects, thereby enabling the projects and hence field to progress more rapidly. A lot of notations are being used by different researchers. Among them, a few are described below.

3.1 Bébian Notation

The first ever known writing system of a Sign Language is Bebian Notation [7]. This notation system was developed in 1825 by Roch Ambroise Auguste Bébian and was created for the use of signs of America. It was supposed to be the systematic writing system for a sign language created in a view to facilitate the teaching of signs to deaf children. Total number of symbols included in Bebian notation were less than 200 which represented body articulators (hands, legs, shoulders, head etc.), movements and facial expressions. Below is the example of Bebian notation of word “Book” and “Take”.

Figure 6. Bébian Notations for the Sign “Book” Figure 7. Bébian Notations for the Sign “Take”

3.2 Stokoe Notation

The Stokoe notation system was developed by William Stokoe in 1960 [8] which is the well-known oldest written form to express the signs in written form. Stokoe notation is phonetically based which uses the concept of segmenting signs into phonemes. Stokoe notation was developed for American Sign Language. Stokoe describes signs with the following aspects:

Hand configuration determined by the active hand, and denoted designator (dez)

Place of articulation denoted tabula (tab)

Movement the action of the sign, denoted signation (sig)

Figure 8. Stokoe Notation for Word “Good Morning”

Figure 9. Stokoe Notation for Word “Number”

The development of the Stokoe system advanced the field of sign linguistics significantly, but it is now obsolete. The Stokoe system seems to be inadequate to represent Sign Language because this notation does not support the non-manual component of the sign language. For example, Stokoe notation could not produce facial expressions. Stokoe Notation is not equipped to handle ASL pronouns. Some of the symbols used in Stokoe notation are:

Figure 10. Symbol Set used in Stokoe Notation System

3.3 Gloss Notation

When a person signs and one write/type what is being signed and add some notation for non-manual facial expressions or body movements, we call it glossing. Glossing is not interpretation but it is the transcription of sign language to textual form, word for word. Glossing of a language is different from writing in a language as in case of glossing the target language may not have equivalent words to represent the source language. Thus Gloss notation represents the sign using a word available in a

spoken language [1]. Gloss notation is particularly useful for describing non manual component of signs, emphasis, classifier predicates.

The word chosen to represent each sign might be the "name" of the sign and typically represents one meaning of the sign, though not necessarily the meaning of the sign in context. To indicate simultaneous elements of ASL, a horizontal line is placed over the gloss and non-manual features are described above the line. Gloss notation was created for discussion and analysis of American Sign Language grammar. This notation is independent of the hand shape, hand orientation, and hand location of each sign.

Advantage part of the Gloss notation is its support to non-manual component of the signs. Secondly, the transcribed signs are already in words from the target language which makes it easier to map between the two languages. However, this mapping will be easier for a particular language pair. To have this close match using the same Sign Language and a different spoken language would require the data to be transcribed again. We can say that the Gloss notation is language dependant. The limitation of this notation system is that it is not standard notation as data described/transcribed using gloss notation is variable. Different people may transcribe the signs differently.

3.4 Hamburg Notation System (HamNoSys)

The Hamburg Notation System (HamNoSys) is a phonetically based notation system that was developed by Siegmund Prillwitz in 1984 [9]. HamNoSys notation is rooted in the Stokoe notation with more detail handling the non-manual component of the sign also. Around 200 symbols are available in this notation system to describe any sign. The structure of this notation contains mainly four components: Symmetry operator (in case both the hands are used), NMF (to describe the non-manual features), Initial Configuration (contains in sequence the hand shape, hand orientation, and hand location), and Action/Movement (the dynamic part or movement of the hands)

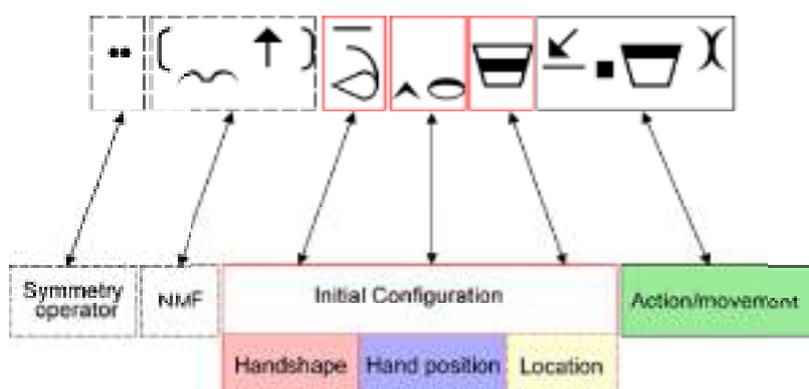


Figure 11. Structure of the HamNoSys

⊙ ^ 0 † \ ∪ → ⊙ < 0 ^ ∪ → ⊙ ^ 0 \ 0 ⊙ \ ⊙ ⊕ +

Figure 12. HamNoSys Notation for word "Beautiful"

An advantage of HamNoSys is that it is international and can be used to write any Sign Language. This notation system was initially handwritten, but a machine readable Unicode is now available from

the University of Hamburg. This notation is iconic, has a formal syntax as shown above and can be stored in a computer database. The limiting part of this notation is that it does not provide an easy way to describe non-manual features, such as facial expressions and body movements.

An XML encoding of HamNoSys called Signing Gesture Markup Language (SiGML) is also available. SiGML encoding is used to produce the animation of the sign. It was developed for the ViSiCast project by Richard Kennaway [10]. Some of the symbols used in HamNoSys notation are:



Figure 13. Symbol Set used in HamNoSys Notation System

3.5 SignWriting (SW) [11]

SignWriting (SW) is another writing notation of any sign language. The beauty of this notation is that it uses the visual symbols to represent the hand shapes, face expressions, and hand movements of the sign language. SignWriting notation is developed by a dancer Valerie Sutton in 1974. Two years before he developed SignWriting, he developed DanceWriting. The goal of SignWriting notation was for communication purposes rather than linguistic purposes. It was developed to enable signers to be literate in their first language. SignWriting notation contains 672 graphical symbols which are written in two dimensional layout. Below is the example of SignWriting notation.

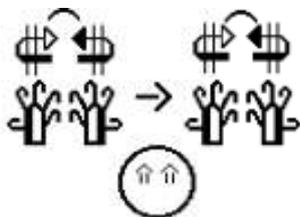


Figure 14. SignWriting Notation for “Clouds”



Figure 15. SignWriting Notation for “Cat”

Advantage part of SignWriting notation is its iconicity which makes it easy to learn, to read, as it is written in two dimensions as compared to other notation systems which are written in one dimension. SignWriting notation system has a detailed mechanism to represent the facial expressions and other

non-manual components of the sign. This notation can be used to describe any sign language of the world. A Unicode with 672 symbols is available for this notation. Because of two dimensional spatial layout of this notation, a special software is required to write the graphical symbols of this notation. Some of the symbols used in SignWriting notation are:

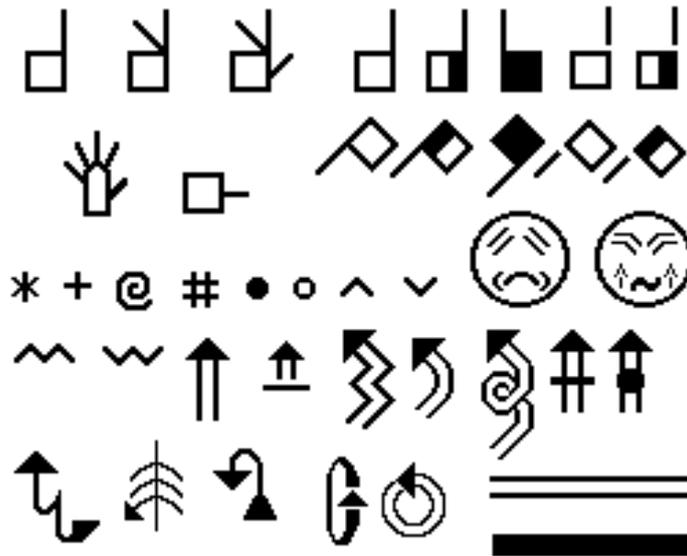


Figure 16. Symbol Set used in SignWriting Notation System

3.6 Si5s [12]

Si5s is the sign writing notation for American Sign Language which is developed by Deaf Linguist Robert Arnold Augustus. si5s notation system was formally announced at the Deaf Nation World Expo, Las Vegas, Nevada in year 2010. si5s includes the symbols for non-manual features of the sign to allow the full grammar of American Sign Language. si5s is the collection of 80 characters and a collection of grammatical symbols which can express the signs of American Sign Language. Some of the symbols used in si5s writing notation are shown in the following symbol set of si5s:



Figure 17. Symbol Set used in si5s Notation System

3.7 SignFont

SignFont [13] notation system was developed by the linguist named Don Newkirk at Salk Institute in California. This notation system was developed for American Sign Language. SignFont is collection of 272 symbols which include the symbols for non-manual features. The sign is written using the symbol in sequence of symbols of hand shape, contact region, non-dominant hand shape, non-dominant contact region, location, non-dominant location, and movements. SignFont notation does not have much acceptance and is not commonly used. Some of the symbols used in SignFont notation are:



Figure 18. Symbol Set used in SignFont Notation System

3.8 SignScript

SignScript [14] notation is developed by a deaf educator Donald Grushkin in year 2010. SignScript uses 46 hand shapes, 12 locations, 29 symbols to represent the non-manual features of the signs and 39 symbols to create the movement of the hands. A total of 5 palm orientations are added in its symbol set. SignScript notation has been developed to write the American Signs Language. The sign is written using the symbol in sequence of symbols of hand shape, hand orientation, hand location, and hand movement. Some of the symbols used in SignScript notation are:



Figure 19. Symbol Set used in SignScript Notation System

3.9 SLIPA

SLIPA [15] sign writing notation system was developed in 2005 by a linguist David J. Peterson. David J. Peterson named his writing notation as Sign Language IPA. Where IPA is International Phonetic Alphabet which allows the precise writing of spoken languages. SLIPA adds the support for non-manual features but is not intended to be used for writing full sentences. The symbols used in this notation system are available in Unicode. Symbols are written from left to right and uses superscripts and diacritics in Unicode form. Some of the symbols used in SLIPA notation are:

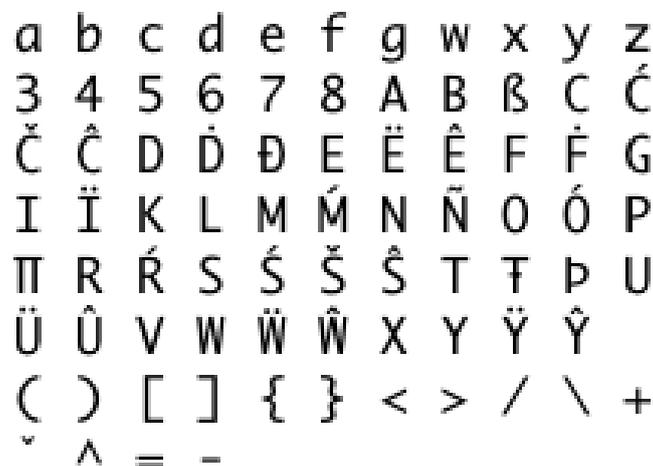


Figure 20. Symbol Set used in SLIPA Notation System

3.10 ASL-phabet [16]

Samuel Supalla, a deaf linguist started working on writing American Sign Language in 1990's. He developed the simplified sign writing system based on SignFont writing system at the Salk Institute in California. He worked with the Canadian Cultural Society of the Deaf and launched sign language dictionary for kids using his writing notations, ASL-phabet.

ASL-phabet does not include non-manual features and is not intended for writing full sentences. A total of 22 hand shapes, 5 locations, and 5 movement types are used in his writing notation. The order of symbols in this notation system is symbols of hand shape, hand location, and hand movement in sequence. Some of the symbols used in ASL-phabet notation are:

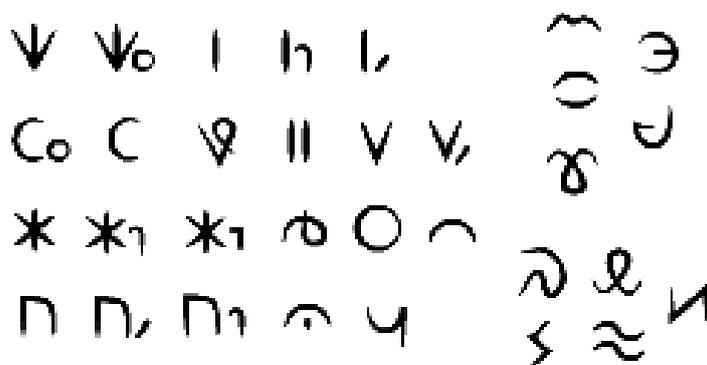


Figure 21. Symbol Set used in ASL-phabet Notation System

4. Comparison of Sign Writing Notations

Though various sign writing notations are available from various researchers, only a few are famous which are used in practical translation work. In the previous sections, the various writing notations are presented with their pros and cons. A comparison of features of various sign writing notations is presented here:

Table 1. A comparison of Various Sign Language Notations

Writing System	Universal	Non-manual Support	Intent	Arrangement	Coding
Stokoe	Yes	No	Dictionary / Academic	Linear	Custom Font, or ASCII
Gloss	yes	Yes	Public use	Linear	Language Dependant
SignWriting	Yes	Yes	Public Use	Pictorial	ASCII, Unicode
HamNoSys	Yes	Some	Academic	Linear	Unicode
SignFont	ASL	Some	Academic	Linear	Custom Font
ASL-phabet	ASL	No	Dictionary	Linear	Online only
si5s	ASL	Yes	Public Use	Pictorial	Unknown
SLIPA	Yes	Yes	Recreational / Academic	Linear	Unicode or ASCII

5. Conclusion

Researchers have put their efforts to develop the writing notations for the sign language so that this three dimensional non-spoken language can be expressed in writing. The writing notation of any sign

language is very important for the development of the translation system. The important aspects for any writing notation for the sign language are non-manual support and universality. Because the facial expressions are very important in any sign language so the non-manual component is the crucial component of the sign language. Though the non-manual support is available in many writing notations still the HamNoSys notation is better than other notations because it provides versatility for production of the facial expressions in the sign. Also, the lips movements are possible using HamNoSys notation. Because of the features available in HamNoSys Notation, this notation is better over the other notations to produce the synthetic signs using Avatar.

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