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Development of Airport Terminology based Synthetic Animated Indian Sign Language Dictionary

Rakesh Kumar Attar*[1], Vishal Goyal[2], and Lalit Goyal[3]

*[1]University College Miranpur, Patiala,rakesh1404@gmail.com
[2]Punjabi University, Patiala, vishal.pup@gmail.com
[3]DAV College, Jalandhar, goyal.aqua@gmail.com

Abstract: **In the current era of computerization, the development of a synthetic animated Indian Sign Language (ISL) dictionary could prove very beneficial for deaf people to share their ideas, views and thoughts with hearing people. Although many human-based video dictionaries are available, no ISL synthetic animated dictionary solely for public places is developed yet. The development of an ISL dictionary of 1200 words using synthetic animation for airports terminology is reported in this article. The most frequently used words at airports in ISL are categorized and then are translated into Signing Gesture Markup Language (SiGML) which generates the signs utilizing synthetic animations through a virtual avatar. The developed ISL dictionary can be used for automatic sign translation systems at airports animating signs from written or spoken announcements. This ISL dictionary is used in the development of airport announcement system for deaf that is capable of displaying spoken airport announcements in ISL using synthetic animations. Moreover, the developed dictionary can prove very beneficial for educating deaf people and for assisting while visiting public places.**

Index Terms: **HamNoSys, Hearing Impairment, Machine Translation, Sign Language, Virtual Avatars**

I. INTRODUCTION

There are approximately 7,139 known living languages in the world categorized in 152 different language families. Sign language is one of these 152 language families, which is the primary communication source of deaf people to convey their ideas, thoughts and messages. This family of the language contains 149 living sign languages worldwide depending upon the different areas of the world. These 149 sign languages are further categorized into 128 specific sign languages, and 21 shared sign languages [1]. Approximately 72 million out of the 7 billion people on earth are deaf. The total number of sign language users is 4.3 million out of these 72 million deaf people. The rest of almost 67 million deaf people do not use any sign language for communication. Thus, 90% of the deaf people have either very restrained or no access to education and other information [2]. Deaf people use sign language involving different hand forms, fingers positions, face expressions, hand gestures and other body postures [3]. It is a visual-gestural-spatial language, as the signer often describes an event or happening using the 3D space around his body [4]. As sign languages are not fully equipped with well-defined structure or grammatical rules leaving sign language not too much acceptable to the outside community of hearing people. Until the 1960s, sign languages were not taken as bona fide languages but merely grouping or collections of gestures and mime. Dr. Stokoe's American Sign Language research was a great boast to render sign language a full-fledged language with its own grammar rules, syntactic and other linguistic rules/attributes [5].

Similar to other spoken languages, Sign languages also have their own grammatical rules, syntactic and linguistic attributes. Therefore, the process of translating between sign and spoken languages is a very cumbersome task, as the translation process is not just an exercise of word-to-word mapping/alignment of text data to signs or vice versa. In this situation, the need for machine translation (MT) methods arises, considering the language models of both spoken and sign language, to find out a proper mapping/alignment between these languages. The main objective of MT is to fill up the gap between two very different language models. It is an intriguing and arduous task as the translation process depends on many factors, like domain knowledge, jargon, culture, variations or differences in proper names etc. [6]. A full-fledged and deep knowledge of the source language is a fundamental requirement. Machine translation of source languages between target languages faces some challenges such as typological diversities like morphological

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nature, syntactical, argument attributes, element dropping etc. and lexical as well as structural divergences [7].

The smooth and effortless translation of spoken language to sign language is necessary to facilitate the easy communication of deaf people with non-deaf communities. For any language translation system, the availability of bilingual or multilingual dictionaries is the fundamental requirement. A dictionary containing 1000 signs of graphical icons was released for the translation of the English language to Indian sign language [8]. Such kind of static dictionary is not fully equipped with phonological characteristics like hand or body movements and facial expressions. Such limitations render this dictionary very difficult for easy understanding of the signs.

Therefore, development or creation of an animated bilingual dictionary that is capable of relating each spoken word to an animated sign is the need of hour. There are two types of animations that can be constructed.In the first type of animation, each spoken or uttered word is related to a video in which a natural human being produces the corresponding sign. In the second type of animation, each spoken or uttered word is related to synthetic animation in which a virtual human being character or Avatar produces the corresponding sign. Between these two approaches, the synthetic animations have much more benefits as compared to real human videos as these animations are more effective in representing signs symmetrically and consume very little memory. A very limited amount of work has been done in which signs are produced using synthetic animations. In 2008, an initiative was taken for the development of a multilingual multimedia ISL dictionary tool in Indian Sign Language [9]. Goyal and Goyal developed an ISL dictionary of 1818 words which are most commonly used by the deaf community in daily life for easy communication [3].

II. Motivation

Deaf people encounters so many problems at the public places like airports, banks, railway stations, museums, postal offices and other government offices in their communication needs with hearing persons. Deaf people are unable to understand any announcement being announced at airport like which flight is going to which place, whether flight is on time, delayed or cancelled, choosing of gate number etc. without the help of any ISL interpreter. So automatic sign language generation systems that can assist them in communication needs at these places, is the need of hour. No full-fledged systems have been developed yet to address these problems. Even though no full-fledged ISL dictionary solely dedicated to public places is available to ease communication between deaf and hearing persons. In this research article, we have reported the development of a synthetic animated ISL dictionary of 1200 words for airports terminology. The developed ISL dictionary is used in our earlier work for the development of “Airport Announcement System for Deaf” that is capable of displaying spoken airport announcements in ISL using synthetic animations [21].

III. Sign Language Dictionaries

A sufficient amount of research work has been carried out for constructing bilingual sign language dictionaries worldwide. In the modern era of computerization, these bilingual dictionaries developed in the form of books are either obsolete or of minimal use in today's world. Researchers in several countries like UK, America, Italy and India have succeeded in developing bilingual video dictionaries for different sign languages. The categorization of these bilingual video dictionaries can be done on the basis of real human beings generating the signs or computer-based virtual characters or virtual Avatars.

- The Ramakrishna Mission started a project to develop a dictionary of sign language in collaboration with CBM International, Germany in January 1999 [10]. The basic objective of this project was to carry our standardization of Indian Sign Language. The first-ever dictionary of Indian Sign Language was unveiled on Nov 24, 2001, which contained more than 2500 signs from 42 cities in 12 States for making available a commonly used sign language all over India. This online dictionary contains signs for different words which were signed and generated in the form of real human videos.
- The European Commission through the "Swedish International Program Office of Education and Training" supported an international project by Leonardo da Vinci named "Spread the Sign". The basic objective of this project is to make available different sign languages of various nations over the Web. The main limitation of this project is that it contains videos signs for the different words as compared to synthetic animations which suffer from delayed time to download or upload in comparison to synthetic animations [11].
- "Hand speak" is another dictionary of American Sign Language developed in [12]. In the year 2000, the release of this ASL dictionary is done over the internet on the website www.handspeak.com. This website www.handspeak.com has American Sign Language signs, different ASL signs variants, several verb inflec-tions, and many more, generation and signing are carried out by native ASL bilinguals.
- Sign Smith [13] is an American Sign Language (ASL) dictionary in the form of 3D illustrative form. It is majorly considered for educational purposes to educate the deaf people residing in the area of America. It is also used as an authoring tool for the creation of American Sign Language material.
- A tool for American Sign Language multimedia

dictionary tool was developed which consisted of prerecorded full-motion digital video using Apple's QuickTime technology [14]. Major functionalities offered by this dictionary tool includes the ability to look out for ASL signs by inputting English words; the ability to look out for ASL signs directly (by specifying formational features); and the ability to search for fuzzy mode (in both ASL and English search modes).

In 2016, an ISL dictionary of 1818 words was developed which contains the most commonly used words by the deaf community in daily life for easy communication [3]. In this ISL dictionary, words were arranged into different categories like nouns, pronouns, adjectives, verbs, prepositions, interrogatives etc. from 1818 words, HamNoSys notations of 1478 words had been constructed perfectly. The fundamental objective of this dictionary was to develop an ISL dictionary of commonly used words by deaf people in the form of synthetic animation rather than human videos. Lip movements are also added with each sign to represent real like speaking of the word itself. Although, the care of non-manual features of all the required words has been taken but it lacks perfections in real lifelike facial expressions. This was the first-ever ISL dictionary using synthetic animations till its reporting time.

IV. Sign Language Notations

To study the linguistic structure of the sign languages on a deeper level, a sign notation system is a primitive requirement. Therefore, it is a need to adopt notation system for describing the signs or signed sentences for daily communication purpose. Two well-known pioneers towards developing sign notations, William C. Stokoe, who first coined the proposal of a sign notation system for American Sign Language (ASL), and Lynn Friedman, who further carried out a deep analysis of American Sign Language taking into account phonological structure of ASL had contributed a lot.

A. Stokoe Notation

William Stokoe, the pioneer of the notation system, designed a sign notation system for writing American Sign Language (ASL) at Gallaudet University [5]. In the year 1965, he presented an ASL dictionary for the American deaf community in published form. He utilized several characters to perform various hand movements, hand locations, and the formation of various hand shapes to develop a signwriting system for the signs used by the deaf community. However, this writing notation was built only for the representation of manual components and there was a lack of any written notation for the representation of non-manual components. In addition, this notation was built only for words and lacked the capability of writing full-fledged sentences. Each sign follows hand location, hand shape and hand movement sequentially in Stoke notation. However, too many technicalities similar to phonetical alphabets in speaking languages in a designed notation system made it impractical for general users.

B. SignWriting

In 1974, Valerie Sutton, a dancer, designed a "SignWriting" notation system for the representation of signs in written form. "SignWriting" notation is visually iconic as images like icons of hands, body parts and facial expressions are utilized to represent the signs. Non-manual components along with manual components are included in this notation to better represent any signs used by the deaf community. The use of Unicode characters was made to write up this notation. Her system was used to write Japanese Sign Language (JSL) and the outcomes revealed that the system had much efficacy to represent JSL in written form [15].

C. Gloss Notation

This notation is used to represent a sign using a word stem from a spoken language [16]. This notation is specifically designed for describing non-manual components, emphasis, classifier predicates, etc. Gloss notation does not have any standards for transcribing data and without any guidelines, different people transcribe each data set differently.

D. Si5s

In 2003, Si5s was developed by Robert Arnold as a writing system for American Sign Language (ASL). The primary components of si5s notation are the digibet (hand shapes), diacritics (movement of hand), movement marks (movements of words), locatives (indicates when a word is bounded to the body) and extra-manual marks (facial configurations and body movements) making it distinct from other writing notations [17].

E. SLIPA

David J. Peterson developed SLIPA to provide an International Phonetic Alphabet (IPA) for sign languages (Sign Language IPA or SLIPA) [18]. It is a phonetic transcription system for signing that uses an ASCII character set and it consists of location, movement and hand shape with the absence of orientation. Basically, it is an international phonetic alphabet, with the lines of the IPA (used for spoken languages which transcribe speech sounds).

F. *SignPhon*

SignPhon is a database that describes signs phonologically and in isolation. The database uses encoding to describe signs, rather than developing a new script, to keep it notation-neutral [19].

G. Hamburg Notation System (HamNoSys)

In 1984, a writing notation named "Hamburg Notation System (HamNoSys)" was designed by a team of research scholars to write sign languages at the University of Hamburg [20]. The HamNoSys notation has a phonetic structure to represent the signs. In the initial phases of its development, this notation was written by hands like other writing notations, but then the University of Hamburg succeeded in providing a machine-readable Unicode form. The Signing Gesture Markup Language (SiGML), an XML encoding of HamNoSys, is also available these days. The Signing Gesture Markup Language (SiGML) was designed for the "ViSiCast project". HamNoSys can be used to represent the written form of any signed language. The facility of representing non-manual features along with manual features is also included in the HamNoSys notation system. Nowadays, most researchers are widely adopting the HamNoSys notation system for the writing of sign languages in their systems.

V. Material and Methods

The deaf community encounters so many problems at public places like airports, railway stations, banks, post offices, museums and other public offices in communication due to their hearing disability. Although, some researchers showed their interest in the development of sign language dictionaries for commonly used words but none of them has tried to develop a sign dictionary specifically designed for public places. In this article, we are reporting the development of an ISL dictionary specifically made for airports to ease the commination barriers between the deaf and non-deaf communities. This ISL dictionary can provide great help to the deaf community at airports and having smooth and effortless communication while travelling. To create the bilingual ISL dictionary of words and terms used at airports following methodology is used as shown in Fig. 1.

To develop the bilingual ISL dictionary, HamNoSys notation for writing sign languages is adopted. Due to its facility of providing representation of both manual and non-manual features of signs, HamNoSys is widely accepted and used worldwide. For the generation of animated signs, an XML encoding of HamNoSys named "Signing Gesture Markup Language (SiGML)" is utilized. For smooth and effortless conversion of the HamNoSys notation to SiGML code, a third-party tool, e-Sign Editor has been utilized. The generated SiGML code is then passed to a SiGML (JASigning) [22] player for producing the animations of signs. The SiGML code of word ”Airport” is shown in Fig. 2.

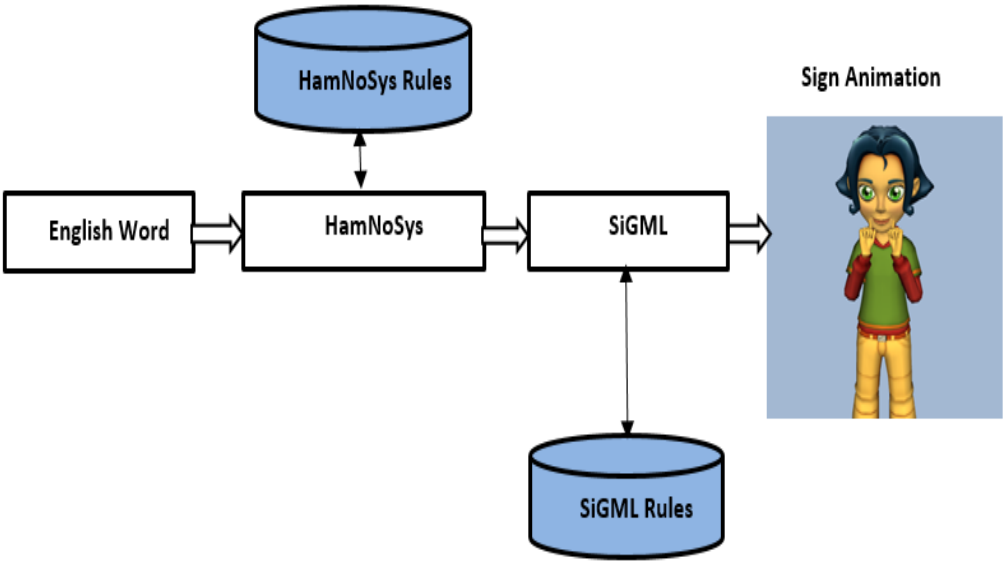

Fig 1. The methodology used to generate sign animations from the English word

For the creation of a bilingual English-ISL dictionary specifically designed for airports, a list of airports announcements is obtained and then these announcements are broadly categorized into static as well as dynamic announcements with their corresponding ISL part as shown in Table 1. To generate corresponding Indian Sign Language Sentence of these airport announcements, ISL grammar rules are developed with the help of an ISL Interpreter. Then all the announcements are translated into corresponding ISL announcements with the help of ISL Interpreter. Dynamic announcements are those announcements that contains some

dynamic part that is replaced at the time of announcement is being done.

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<!--□□□□□□□□□□□□□□ □□□-->    ←→ HamNoSys Notation
<sigml>
<hns_sign gloss="airport" >
<hamnosys_nonmanual>          ← Non-Manual Features
<hnm_head tag="NF"></hnm_head></hamnosys_nonmanual>
<hamnosys_manual>             ← Manual Features
<hamfinger23/><hamindexfinger/><hampinky/><hamextfingerl/>
<hampalmd/><hamstomach/><hamlrbeside/><hammoveul/><hammoveul/>
<hammoveul/><hamplus/><hamfinger2345/><hamthumboutmod/>
<hamfingerbendmod/><hamextfingero/><hampalmd/>
</hamnosys_manual>
</hns_sign>
</sigml>
```

Fig. 2**.** SiGML Code of "Airport"

Table 1 Some of Static and Dynamic Airports Announcements

English Sentence	**Indian Sign Language Sentence**
Static Airport Announcements	
Please have your boarding pass and identity card ready Smoking is prohibited on the entire aircraft, including the lavatories.	Please your boarding pass and identity card ready Aircraft entire smoking prohibited, lavatories including.
Dynamic Airport Announcements	
This is the pre-boarding announcement for flight _____ (No.) to _____. Regular boarding will begin in approximately _____ minutes time	Boarding pre announcement flight _________ to ________. Boarding regular begin approximately time _______ minutes

Table 2 Statistics of words

Word Category	**No. of Words**
Adjective	176
Adverb	60
Article	1
Conjunction	4
Interjection	1
Noun	656
Prefix	1
Preposition	15
Pronoun	21
Verb	211

	1146
Airport Names and Places	54
Total No. of Words	**1200**

VI. Results and Discussions

A list of 1146 distinct words used at airports is prepared from collected announcements. These words are categorized according to their POS tags as shown in Table 2 and the percentage of words is demonstrated in Fig. 3. This list is then translated into Indian Sign Language and a video of all distinct words is obtained. In addition, a list of 54 words containing airports names and the names of their respective locations is also generated. Then HamNoSys notations of these words are prepared one by one to construct the SiGML code of these words. Each sign contains facial expressions and mouth movements to represent the sign like speaking the word itself. Special care has been given to include all non-manual components into corresponding signs of each word. Finally, a bilingual English-ISL dictionary of 1200 distinct words used at airports is prepared. Table 3 shows some dictionary words along with corresponding HamNoSys notations and animations screenshots. For some words such as person names, places etc. which do not have proper signs, the combinations of alphabets are used to create the animated signs. To handle such kind of situation, all the alphabets are signed individually. Also for the numbers, signs of all the numerals from 0 to 9 are created. The rest of the numerals can be generated using the different combinations of these ten coded signs. For purpose of the accuracy, these animated signs respective to all distinct words have been prepared and matched with videos of Indian signs created and released by the Indian Sign Language Research and Training Centre (ISLRTC), New Delhi, India. The generated signs have been demonstrated to the ISL interpreters and various deaf people. The signs of the words demonstrated to them were easily comprehended and the effort in developing a bilingual ISL dictionary for airports was very well applauded. The developed Synthetic Animated Indian Sign Language Dictionary can be used for automatic sign translation systems at airports animating signs from spoken or written announcements for easy understanding of deaf people. The developed dictionary can prove very beneficial for educating deaf people and for assisting while visiting airports as well as other public places.

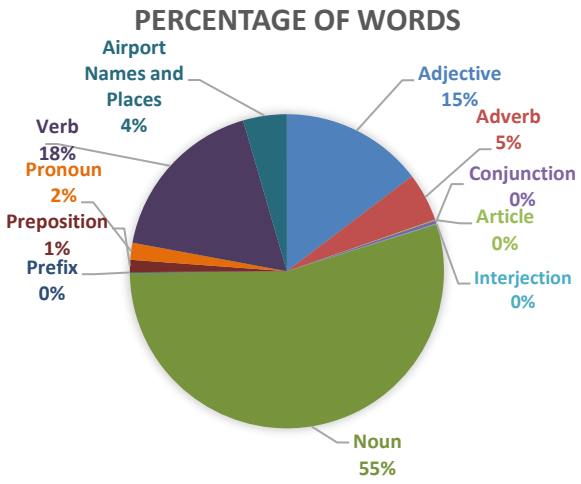

Fig. 3 Percentage of Airport Dictionary Words

VII. Conclusion and Future Directions

The non-standardization of sign languages renders translation of spoken languages to sign languages an arduous task. The absence of proper grammatical and linguistic rules of sign language also pose an obstacle to translation task. This article reports the development of an ISL dictionary containing 1200 words for airports using synthetic animations. This is the first ISL dictionary of its kind in the public domain. Synthetic animations are better in memory consumption and conversion time as compared to human videos but lack naturally displaying expressions. These synthetic animations are very easy for uploading/downloading over the network without any delay in generating the signs from English words in real-time. In future, the developed ISL dictionary can be enhanced by adding more words to it. This proposed research methodology can be utilized to develop more dictionaries for different public places like railway stations, bus stands, banks, hospitals etc.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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