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# AUTOMATIC TRANSLATION OF AMHARIC TEXT TO ETHIOPIAN SIGN LANGUAG

MASRESHA, TADESSE ERENSO

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# ADDIS ABABA UNIVERSITY

## SCHOOL OF GRADUATE STUDIES

### FACULTY OF INFORMATICS

### DEPARTMENT OF COMPUTER SCIENCE

# AUTOMATIC TRANSLATION OF AMHARIC TEXT TO ETHIOPIAN SIGN LANGUAGE

**BY**

MASRESHA TADESSE ERENSO

**A THESIS SUBMITTED TO**
**THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY**
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**Members of the Examination Board**

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# Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualifications except as specified.

Masresha Tadesse

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August 9, 2010

The thesis has been submitted for examination with our approval as university advisors.

_____ _____ _____

**Dr. Fistum Admasu**

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## ABBREVIATIONS AND ACRONYMS

**ASL**: American Sign Language

**BSL**: British Sign Language

**CMU**: Carnegie Mellon University

**CV**: Consonant-Vowel

**DGS**: Germany Sign Language

**eSIGN**: Essential Sign Language Information on Government Networks

**ESL**: Ethiopian Sign Language

**HamNoSys**: Hamburg Notation System

**HPSG**: Head-Driven Phrase Structure Grammar

**HTML**: Hyper Text Markup Language

**MESL2T**: Medical Ethiopian Sign Language Learning Tool

**MT**: Machine Translation

**NLP**: Natural Language Processing

**PC**: Personal Computer

**SiGML**: Signing Gesture Markup Language

**SL**: Sign Language

**STAG**: Synchronous Tree-Adjoining Grammar

**TC**: Total Communication

**UML**: Unified Modeling Language

**VGuido**: Virtual Guido

**ViSiCAST**: Virtual Signing: Capture, Animation, Storage and Transmission

**XML**: eXtensible Markup Language

**WWW**: World Wide Web

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# ABSTRACT

*Sign language is a visual-gestural language mainly used by hearing-impaired people to communicate with each other. As in oral language, sign language is not universal; it varies according to the country, or even according to regions. Ethiopian Sign Language (ESL) is the sign language of the deaf in Ethiopia.*

*Hearing-impaired people usually face communication problems when they want to communicate with hearing people without signing skill. At present, sign language interpreters are used to remove the language barriers between people who are deaf and use sign language and people who can hear and speak. However, cost, availability and privacy issues make this an awkward solution at best. A computer application which translates written text into sign language, would better bridge the communication gap between deaf and hearing worlds.*

*This thesis was therefore to contribute in this area by developing translator software, which automatically translates Amharic text into Ethiopian Sign Language (ESL). The developed translator is referred in this thesis as AmESL-T.*

*The system is composed of a text-analysis, mapping and sign animation (using 3D avatar) module. The input for the system is Amharic word, letter and number. The output of the system is avatar animation of Ethiopian sign language. The signs are represented by means of VGuido (the eSIGN 3D avatar) animations. For creating gesture animations, eSIGN editor is used. Amharic has complex morphology which makes complete listing of all words in the database impossible. Hence, a morphological analyzer that reduces morphological variants of a word into a common form is developed and integrated to AmESL-T.*

*AmESL-T is constructed as a web application to allow usage to large population. Using the translator, it is possible to translate Amharic texts into gestures that a hearing impaired can understand. The tool is useful in enabling people who don't know sign language to*

*communicate with deaf individuals. The hearing-impaired can also utilize the software to develop written language skills. Moreover, it may be used as a teaching tool for Ethiopian sign language.*

*AmESL-T was evaluated in terms of quality of signing and subjective opinions. Quality of signing was measured based on intelligibility and acceptability of signs. The evaluation results showed that the quality of signing and the translation accuracy are acceptable, and it satisfies users' need. For better translation results, further research areas are also pointed out.*

# CHAPTER ONE

# INTRODUCTION

## 1.1 Motivation of the Study

Sign language is a common means of communication amongst people suffering from hearing impairment. It takes recourse to visual transmission of gestures to convey meaningful information. Sign language is neither universal nor international. Each country's Deaf community develops its own sign language despite some similarities of grammatical features that are shared by all known-signed languages of the world. Thus, in Ethiopia we have Ethiopian Sign Language (ESL), in the United States there is American Sign Language (ASL).

According to Ethiopian National Association of the Deaf (ENAD), referring to Central Statistics Authority's report on 2007, it is estimated that more than 1.5 million deaf people live in Ethiopia.

The Ethiopian Sign Language (ESL), like other sign languages of the world, has not yet get the opportunity to be developed, standardized and be a medium of instruction in schools. Due to these constraints, the deaf students could not get access to equal educational opportunity as compared to their hearing counterparts. Besides, there is very small number of deaf students who could get access to join higher institution and develop their professional skill [1].

Taking the above issues into consideration, the department of linguistics and philology of Addis Ababa University has recently launched the first Bachelor degree program in Ethiopian Sign Language and Deaf Culture. The program is intended to train sign language teachers, interpreters and sign linguists. It is also aimed to promote collaborative research on Ethiopian Sign Language [1].

Hearing-impaired people usually face communication problems when they want to communicate with hearing people without signing skill in their day to day life. Hearing people reported that they often feel discomfort when communicating with people with hearing loss and this may reflect the lack of sign language skill. With the appropriate sign language skills, hearing people may be able to avoid the frustration and discomfort during their communication with deaf individuals.

Hearing-impaired people often communicate with hearing people without signing skill through a sign language interpreter. However, it is not always possible to find interpreters when needed; in addition to cost and loosing privacy. Therefore, there is an increasing need to develop an automatic translator that is capable of translating text to sign language using computers. Such translators would better bridge the communication gap between deaf and hearing worlds.

This study was therefore to contribute in this area by developing a tool for automatic translation of Amharic text into Ethiopian Sign Language. Using the translator, it is possible to translate Amharic texts into gestures that a hearing impaired can understand. The hearing impaired can also utilize the software to develop written language skills. It can also be used as a tool to learn sign language.

Ethiopian sign language is not standardized among different Deaf communities in Ethiopia. Communities from different geographical locations practice different dialect of ESL [1]. Efforts should be made to establish the sign language used in each region, by trying to standardize the language and spread it among members of the deaf community and those concerned. In this regard, the developed text to sign language translator can be used as a platform for standardizing ESL.

A text to sign language translator applications can also provide a valuable tool for education by being used as instructional and research material in schools, colleges and

universities. There is a sizable body of sign language users in Ethiopia, for whom such tool can provide valuable tools for education and information access.

## 1.2 Statement of the Problem

People are communicating assuming that they can both be understood and understand others. Normally, there is no problem when two deaf persons communicate using their common sign language. The real difficulty arises when a deaf person wants to communicate with a non-deaf person. Usually both will get frustrated in a very short time. In these situations, a sign language interpreter is needed in order to assure that communication and understanding occurs. Sign language interpreters remove language barriers between people who are deaf and use sign language and people who can hear and speak. The role of the interpreter is to solve the communication problem. An interpreter assists in seminars, lectures and other official affairs. However, it is not always possible to find interpreters when needed; in addition to cost and loosing privacy. With this regard, text to sign language translator software could help to facilitate communication between deaf and hearing people and bridge the communication gaps.

As stated earlier, sign language differs from one region to another. A sign for word used in one community may not be accepted and used in other communities. Unless the signs are standardized and spread among members of the deaf community, many more languages will continue to be produced, yet with the same sign alphabets. In this regard, a translation system can be used as a platform to spread various signs among members of the deaf community. It can be used to popularize new signs in ESL.

Traditional education has cared little to address the special requirements and needs of the deaf community. The deaf in regular classes in the whole region of Ethiopia are faced with problems since the available sign language dictionaries and materials are not properly distributed [1]. The development of translator software will partially offset the absence of educational tools that the deaf need for their education and communication. For example, it can assist the dissemination of information on the sign language dictionary. This is the

first step towards wide coverage and distribution of the sign language information for the deaf community.

Due to the importance of interpreters for the community of deaf and hearing-impaired, much emphasis should be given for their training. However, such trainings can be extremely time consuming process unless they are assisted with computer applications like text to sign language translation systems. Such systems can assist interpreters to quickly learn sign language and have a quick reference material.

## 1.3. Objective of the Study

### 1.3.1 General Objective

The general objective of this research is to explore the possibility of developing an automatic translation system that allows users to translate written Amharic text into Ethiopian Sign Language using a virtual human. The intended users of this system are those who can read and write Amharic language.

### 1.3.2 Specific Objective

In order to attain the general objective, the following lists of specific objectives are set:

- Identifying and assessing the extent of communication problem between deaf and hearing people and investigate users requirement
- Reviewing literature and related works
- Studying the grammar and structure of both languages
- Designing the general architecture of the translator (i.e. AmESL-T)
- Developing text to sign matching algorithm
- Developing and Evaluating AmESL-T
- Pointing out further research directions

## 1.4 Scope and Limitation of the Study

The input text for the translation system is limited to Amharic words, letters and numbers to Ethiopian Sign Language. For analyzing Amharic word inputs, a morphological analyzer has been developed and integrated to the translation system. Although morphological analysis can be applied on both inflectional and derivational morphology, we are interested to analyze inflectional morphology of the language. Inflectional morphology manifests primarily in the form of a prefix, suffix, or vowel change. Particularly, we want to analyze Amharic verbs and nouns with personal and possessive pronoun suffixes bound to them.

The scope of the morphological analyzer is limited to analysis of verbs in perfective form (e.g. ሰበረ, ሮጠ) (bound with personal pronoun suffixes) and nouns that are simplex (e.g. ቤት) (bound with possessive pronoun suffixes). The main reason for selecting such categories of words is that the majority of the words in these forms usually correspond to signs in ESL.

Due to time constraint, morphological analysis of other forms of verbs and nouns and other parts of speech were not considered in this work. Moreover, analysis and translation of Amharic phrases, sentences and documents to Ethiopian sign language is out of the scope of this thesis work.

One of the main reasons that AmESL-T is currently not as extensive as would be desired is unavailability of linguistic tools and annotated sign language corpora. The main resource being the natural language processing tools such as morphological analyzer, part of speech tagger, parser and so on. Even although these tools are already developed for Amharic by various researchers, most of them are done by graduate students for academic purpose and they are not publicly available to use it in our system.

On the output part, the sign animation procedure mainly focuses on manual components like handshape, orientation, location and motion of the signs. Non-manual components like facial expression and lip patterns are part of ESL. However, due to time constraint,

they are less considered in this work. The translation system to be constructed with this restriction is enough to aid people who want to know ESL.

## 1.5 Methodology

This section discusses the main methodologies, tools, data collection and evaluation strategies used in this study.

### 1.5.1 Literature Review

In order to attain the objectives of the research, an in-depth literature review on sign language translation systems and related works was done. Books, articles, thesis papers, sign language dictionary, and electronic materials were used to collect the necessary information for this study. Limited literature is available on ESL. Most of the available literatures focus on foreign sign languages like ASL. Based on the information obtained from the reviewed literatures, the input analysis, underlying representation and output representation techniques and tools were selected. The techniques and tools were chosen considering various factors like their effectiveness on similar previous works.

In addition, the distinction between Amharic and ESL in both grammar and vocabulary and various language specific features and properties have been studied thoroughly to ensure the accuracy of translation.

### 1.5.2 Data Collection

Qualitative data collection methods like questionnaires, interview, and observation were conducted to collect primary data from various users. Interview was conducted with Ato Abrham Lilay (Vice President of Ethiopian National Association of Ethiopia (ENAD)). Extensive discussion was made with Ato Eyasu Haile (Sign Language Division Coordinator, Department of Linguistics and Philology, Addis Ababa University) in order to explore the grammar, syntax and structure of ESL. Discussion was also made with linguistic professionals from Addis Ababa University. Two types of questionnaires were used to collect the required data. (See Sample Questionnaire in Appendix I and II). Both

questionnaires were prepared in Amharic language to enable the respondents understand the points in the questionnaire paper. The respondents were asked both general and specific questions with the aim of getting important information for the study. The first questionnaire is intended to assess the communication gap problem between deaf and hearing people. It also addresses issues related to sign language standardization, availability of sign language interpreters and sign dictionary. Moreover, there are questions intended to assess user requirements for the design and development of a text to sign language translator software. The second questionnaire is used during evaluation (after the prototype is fully developed). It is used to evaluate the performance of the translator and to obtain subjective views of the translation system. Deaf people, sign language interpreters, hearing people were the main source of information for this study.

Observation was also used to collect the required data for this study. The researcher has got more important information from the observation about the usage of sign language as a means of communication among signers. The researcher also attended sign language classes at Addis Ababa University.

Ethiopian sign language dictionary is used as the main source for collecting the data that need to be recorded and analyzed. Moreover, recorded sign language videos and images were used to assist the sign transcription process.

### 1.5.3 Tools Used

The tools that were used in this research work are described below:

**Development Environment**: AmESL-T was developed on Window XP Operating System with Intel Pentium IV 3.0 GHz Processor, 512 MB memory and 80 GB hard disk capacity.

**Web Browser:** AmESL-T is developed as a web application in order to benefit from its architecture. Microsoft Internet Explorer (Version 6.0) is used for developing the translation tool. HTML, XML, CSS and JavaScript are used for its development.

**NLP Tool**: A morphological analyzer for analyzing Amharic word inputs has been developed and integrated to the system. A full-fledged text to sign translation system requires other NLP tools like morphological analyzer, par-of-speech tagger, parser and the like. Since AmESL-T currently provides translation at word level, usage of morphological analyzer is only considered in this work.

**Sign Notation**: For sign language transcription, a gesture description language knows as HamNoSys is used. (See Section 4.5.6).This sign notation was chosen because it is currently the most extensive gesture notation system. Since HamNoSys cannot be processed by computers, there is a need to translate them into a language that is amenable to computer processing. For this, an XML encoding of HamNoSys known as SiGML is used. The eSIGN editor was used for translation from HamNoSys to SiGML.

**Sign Editor**: For creating gesture animations, eSIGN editor is used. The eSIGN editor software allows the user to compose signed text to be performed by the eSIGN Avatar.

**Avatar Animation**: The eSIGN avatar (VGuido) is used for playing the signs. The software needs to be installed by the user before virtual signing can be accessed. It is available as a plug-in for Internet Explorer. The avatar plug-in requires Java Runtime Environment (JRE) 1.4 or higher.

**MS Access**: For reasons of maintainability and user friendliness, Microsoft Access was chosen as the storage solution of choice. It is used to store information about the Amharic words, letters and numbers together with the file name of the animation script.

**Digital Camera**: To capture various signs, OLYMPUS digital camera with 12 megapixel resolution was used. Images and videos were used to guide and aid the sign transcription process.

For complete list of software specification and client side requirements of the translator software, refer to Appendix V.

### 1.5.4 Prototyping and Evaluation

A prototype has been developed to test the algorithms and techniques. AmESL-T is used as a working name for the Amharic text to Ethiopian sign language translator software.

The performance and quality of AmESL-T's signing was measured in two ways: intelligibility of signs and acceptability of signs to users. While the first one is objective measurement, the second one is subjective.

While measuring intelligibility, the participants were presented with selected signed words, letters and numbers and asked to write down what they understood. The test data is selected considering their frequency of use in the Deaf community. From most frequently used ESL signs, 30 words, 34 letters and 20 numbers were selected randomly for testing purpose. On the acceptability measurement, the participants were asked to rate how acceptable the words, letters and numbers were as an example of ESL on a 3-point scale (1="Low" 2="Medium", 3="High").

## 1.6 Contribution of the Study

Ethiopian sign language is not well studied. It is still at its infant stage of development. A number of research works need to be done in order to address the special needs of the hearing-impaired community of Ethiopia.

By providing automatic translation of Amharic text into Ethiopian Sign Language, this work has contributed to the existing research domain. This tool combines the advantages of different computer techniques and recent technologies.

AmESL-T has successfully incorporated both the fingerspelling and conceptual expression translations into a single application. The tool is expected to provide various benefits both for the deaf and hearing members of the community. Some of these benefits include:

The developed translator provides an intermediary for communication between the deaf and hearing people. The translation of written text could prove invaluable to both

members of the deaf and hearing community, particularly in areas of low interpreter availability, and for privacy and cost reasons.

AmESL-T can also provide a valuable tool for education by being used as instructional material in sign language schools. Since sign language training is a time consuming process, this tool can assist students to quickly learn sign language and have a quick reference material. Persons who want to learn ESL (e.g. relatives, teachers of deaf children, friends) can take the help of the translator. Moreover, AmESL-T has opened up a platform to work towards the standardization of ESL. It can be used to popularize new signs in ESL. AmESL-T can also assist the dissemination of information on the sign dictionaries in timely and inexpensive way. This is the first step towards wide coverage of ESL to various Deaf communities of the country.

Generally, there is a sizable body of sign language users in Ethiopia, for whom such tool can provide valuable tools for education, communication and information access.

## 1.7 Organization of the Thesis

The thesis is organized as follows: Chapter Two presents an overview of sign language. It also discusses about the Ethiopian Sign Language (ESL) and its grammar. Chapter Three summarizes the studies in the literature on Amharic language, machine translation, web-based application, state of the art for text-to-sign language translation system and sign language notation systems. Summary of related works on sign language is also presented here. In Chapter Four, the development and implementation of Amharic to Ethiopian Sign language translation system (AmESL-T) is explained in detail. Explanation about system architecture, functionalities, database design and the sign animation technology used are also included. The evaluation of the translation system is also presented in this chapter. Finally, Chapter Five concludes the thesis and presents possible future works to improve the translation system by pointing out further research directions.

# CHAPTER TWO

# OVERVIEW OF SIGN LANGUAGE

## 2.1 Deafness

Deafness is mostly defined as 'inability to hear'. It is the complete loss of the ability to hear from one or both ears. Deafness may be inherited, or caused by complications at birth, certain infectious diseases, such as meningitis, use of toxic drugs, and exposure to excessive noise [3]. For many deaf people, particularly those who were deafened before age 3 (pre-lingually); sign language is their primary means of communication. Some deaf people communicate orally, using visual information, including lip movements, to help them understand what is being said. Although speech reading is mostly guesswork, some people are very skilled [3].

The term' hard of hearing' or' hearing-impaired' is usually used to describe deaf people. In Amharic, 'መስማት የተሳነው' is accepted and in use as formal way of calling the deaf people [4].

Following the conventions, the term "deaf" is used in this document to refer to people with a hearing deficit and the term "Deaf" for people that belong to deaf community, that is, people who share Deaf Culture and a sign language.

## 2.2. Sign Language

Sign language is a visual language consisting of various signs, gestures, fingerspelling and facial expressions. Sign Language is developed as a language to meet the need of the deaf to communicate with each other. Unlike verbal languages which are created by using the mouth, tongue and vocal chords and processed by the ears, sign language is a visual language where the use of the hands, face, head and upper torso is processed by the eyes [5].

Despite common misconceptions, sign languages are indigenous, fully accessible languages for Deaf people, with their own unique syntax and grammar. Each country has its own sign

language and these languages can vary slightly from region to region just like the dialects of a spoken language [6].

### 2.2.1 Historical Background

Deafness and Deaf people are as old as humanity itself but the earliest recorded history of the communication and education of deaf people was in the 16th century. Deaf children of very rich parents in Spain were placed under the care of a monk to be taught how to speak. Speech was required in order to acquire wealth. This marked the beginning of the oral vs. Sign Language controversy, which raged on for centuries. The oral method involves teaching or communicating with Deaf people through the medium of spoken language (speech). This method was highly developed in Germany and became known as the "German Method" [7].

The use of Sign Language was highly developed and used in schools for the Deaf in France, hence the name "French Method". In 1880, there was an attempt to eradicate Sign Language from the face of the earth. A conference in Milan (Italy) which was attended by hearing teachers and educationalists but which excluded Deaf people, passed a resolution which banned the use of Sign Language in schools of the Deaf. Sign Language became an underground language. Deaf children used Sign Language outside the classroom situation and so it remained a living and natural language [7].

In 1960 a scientific research report on American Sign Language (ASL) showed that Sign Language was a natural human language with its own grammar, independent of any spoken language. Sign Languages could be analyzed at any of the same levels used for spoken languages in terms of phonology, morphology, syntax, semantics, and pragmatics and discourse analysis [7].

In the 1970s, Simultaneous Communication (Simcom) or Total Communication (TC) was developed. This is a system adapted by the oralists in an attempt to represent English visually. Sim-com/TC involves signing and speaking at the same time. Remember English

or any spoken language has its own grammar, as does Sign Language. When you use both languages at the same time, you violate the grammar of both languages [7].

The 1980s saw the advent of the bilingual-bicultural approach. According to this approach Deaf people use Language and written/read/spoken language e.g. English, Zulu, Afrikaans, etc. It acknowledges that Deaf people live in two cultures, the one being the majority (hearing) and the other being their own culture namely Deaf Culture. Hearing people who come into contact and interact with Deaf people, e.g. parents, siblings, teachers and society in general also learn to function in two cultures [7].

### 2.2.2 The Structure of the Signs

In the production of a sign, there are important aspects that need to be mentioned. The five basic sign language elements are handshape, location, movement, palm orientation and facial expression [8] [22]. Sign language is a very expressive language and understanding these elements will help to better understand how signs are made and what makes them different.

**Handshape**

The handshape is probably the most important component of a sign. It is the configuration the hand assumes when beginning to make a sign. The most frequently used handshapes are the letters of the manual fingerspelling alphabets and the manual numbers. However, linguistics identified a larger number of discrete handshapes [8].

These are a few basic sign language handshapes that are used to form many signs. Practicing to form these handshapes is very helpful for learning ESL vocabulary.

- Open hand: Your hand is flat and your fingers are spread apart (5 hand)
- Flat hand: Your hand is flat and your fingers and thumb are touching
- Curved hand: Your hand is curved and your fingers and thumb are touching

- Bent hand: Your hand is bent at the knuckles and your fingers and thumb are touching and held straight
- Clawed hand: Your hand is curved and your fingers are separated
- And hand: Your hand is formed so that all of your fingertips are touching
- One hand: Your index finger is up with your palm facing forward

**Palm Orientation**

This refers to the direction in which the hand is turned. The direction that the palm of the hand faces (up, down, left, or right) is a useful way of describing the orientation because once the palm is described, the direction of the fingers and the back of the hand is obvious [8] [22].

**Location**

This refers to the place where the signing is performed. Signs are formed on or near only certain areas of the body. For example, it is estimated that about 75% of all the signs in American Sign Language are formed in the head and neck area because they can be easily seen [8]. The location of a sign frequently contributes to its meaning. For example, many signs that denote feelings are formed near the heart, whereas signs related to cognitive concepts are formed near the head [8].

**Movement**

There are a wide variety of movements possible with sign languages. Although hand movement is dominantly used to make the major components of ESL, head movement, eye movement and torso movement may also be applied in ESL.

The movements can be single (e.g. 'አሁን' (now)), double (e.g. 'በር' (door)) or repetitive (e.g. 'ትምህርት ቤት' (school)). Noticing these movements is important because if the movement is not correct, it may be signed inaccurately. The repetition of the movement may indicate

several things: - the frequency of the location, if the noun is plural or singular, or the distinction between a noun or verb. Much of the meanings of signs may be expressed through movement in relation to the body. For example, the sign for 'ትምህርት ቤት' (School) is signed as if someone is a teacher, clapping their hands to get the class's attention [8] [5].

**Facial Expression**

Facial expressions in sign language are very important because they express grammar. They are referred to as non-manual grammatical markers, non-manual behaviors and/or non-manual signals [7]. Facial expressions are rule-governed. Facial expressions for questions that require YES/NO answers are different from facial expressions for WH-question words, e.g. 'ማን ' (WHO), 'ለምን'(WHY), 'መቼ'(WHEN), 'የት'(WHERE), etc.

For YES/NO questions, the eyebrows are raised, eyes are open wide, head and shoulders are forward. On the other hand, for WH-questions: - the eyebrows are lowered, eyes are narrowed, head forward with a slight tilt and shoulders forward. Figure 2.1 shows four different types of facial expressions that convey different meanings.

**Figure 2.1** Examples of facial expressions in sign language [9]

Changing facial expression could convey an entirely different message. There are other facial expressions that mark other sentence types in sign language e.g. topicalisation, conditional sentences, rhetorical questions, commands, etc.

### 2.2.3 Fingerspelling

Fingerspelling is an important component of sign language and is a necessary skill for complete communication in sign .It is useful for spelling proper nouns, technical terms, acronyms, initialized signs, loan signs and words from foreign languages [8]. When finger spelling, people use their dominant hand to create a series of manual symbols, one corresponding to each letter of the word. For instance, if the word has four characters, it will be represented by the combination of four signs, one for each letter.

Fingerspelling is not sign language in itself. It is a technique used to represent the letters of a writing system, and sometimes numeral systems, using only the hands. It is limited to people (deaf or hearing) that have been exposed to written English or any other spoken language. On the other hand, sign language, as the language of Deaf people, can be used to communicate with any Deaf person provided that such a person interacts with and is a member of a Deaf community.

Different countries have developed their own fingerspelling symbols. Among fingerspelling of the world, American fingerspelling is the most widely used and studied. The World Federation of the Deaf has accepted this system to serve as a base for international manual alphabet and used to design fingerspelling for other countries [10]. The American fingerspelling is produced with 26 different handshapes except the letters 'J' and 'Z' that incorporate a motion [11].

## 2.3 Ethiopian Sign Language (ESL)

In different countries, no sign language is the same. Thus in Ethiopia we have Ethiopian Sign Language (ESL), in the United States, there is American Sign Language (ASL) and in United Kingdom there is British Sign Language (BSL). In fact, sign language is a living language with many facets, dialogue and is changing as the need arises.

Ethiopian sign language is believed to have its origin in the American Sign Language with some influence from the Nordic countries [1] [12]. According to a report on a pilot survey conducted by Summer Institute of Linguistics Ethiopia (2005), a comparison was done between 249 signs that are published in American and Ethiopian books. Out of this number 25% of the signs from the ASL that was brought over have been modified to suit Ethiopian culture [1]. This shows that the two languages are closely related languages than other sign languages. Besides, signers of the two countries are seen to communicate at a lesser communication breakdown. Apart from the borrowed signs, there are local signs created and used in specific deaf schools in the country and latter included into Ethiopian Sign Language. For example, 'እንጀራ', 'ሐበሻ', 'ፊሳ' etc [10].

The first Americans who brought with them the signs used in their own country to Addis Ababa were missionaries. The first deaf school in Ethiopia was established by these missionaries. The influence of the graduates of these schools has been clearly seen in the development of the Ethiopian Sign Language [1] [13].

Through sign language, it is possible to manifest the deaf people's culture, sing a song, communicate effectively, and present poetry and anything that a spoken language can do. However, the Ethiopian Sign Language, like other sign languages of the world, has not yet get the opportunity to be developed, standardized and be a medium of instruction in schools [1]. Due to these constraints, the deaf students could not get access to equal educational opportunity as compared to their hearing counterparts. Besides, there is very small number of deaf students who could get access to join higher institution and develop their professional skill [1]. There is also problem in getting qualified sign language interpreters who are familiar with the ethics and conduct of sign language interpretation [1].

Taking the above issues into consideration, the Department of Linguistics and Philology of Addis Ababa University has been giving awareness raising course on Sign Language and

Deaf Culture for the past few years. It has launched the first Bachelor degree program in Ethiopian Sign Language and Deaf Culture in the 2008/9 academic year [1]. The program has the following main objectives [1]:

- To train sign language teachers who can teach sign language courses at secondary and tertiary levels;
- To train sign linguists who can conduct research in Ethiopian Sign Language in order to promote the use, status and functions of the language;
- To train sign language interpreters for governmental and non-governmental organizations;
- To promote collaborative research on Ethiopian Sign Language with other institutions of higher learning both locally and internationally, etc.

## 2.4 Ethiopian Fingerspelling

The Ethiopian fingerspelling was developed in 1971 by the ENAD and later gained acceptance by the Ministry of Education. Currently, it is used in all deaf schools together with the American fingerspelling [1] [13]. The American fingerspelling is used when we want to express words or concepts in English and any local language that is expressed through Latin script like Oromiffa. However, Ethiopian fingerspelling is used when we want to express words or concepts in a language that uses Gee'z alphabet like Amharic and Tigrigna [13] [14].

Ethiopian fingerspelling has 33 unique handshapes to represent the first order Amharic alphabet. Later in 2009, additional one handshape was defined for Amharic letter 'ቯ' [10]. By adding six different movements on the first order alphabet, the rest six order alphabets for each first order alphabets are constructed (See Section 4.4.2).

In Figure 2.2, the Ethiopian fingerspelling with the corresponding Gee'z alphabet is depicted.

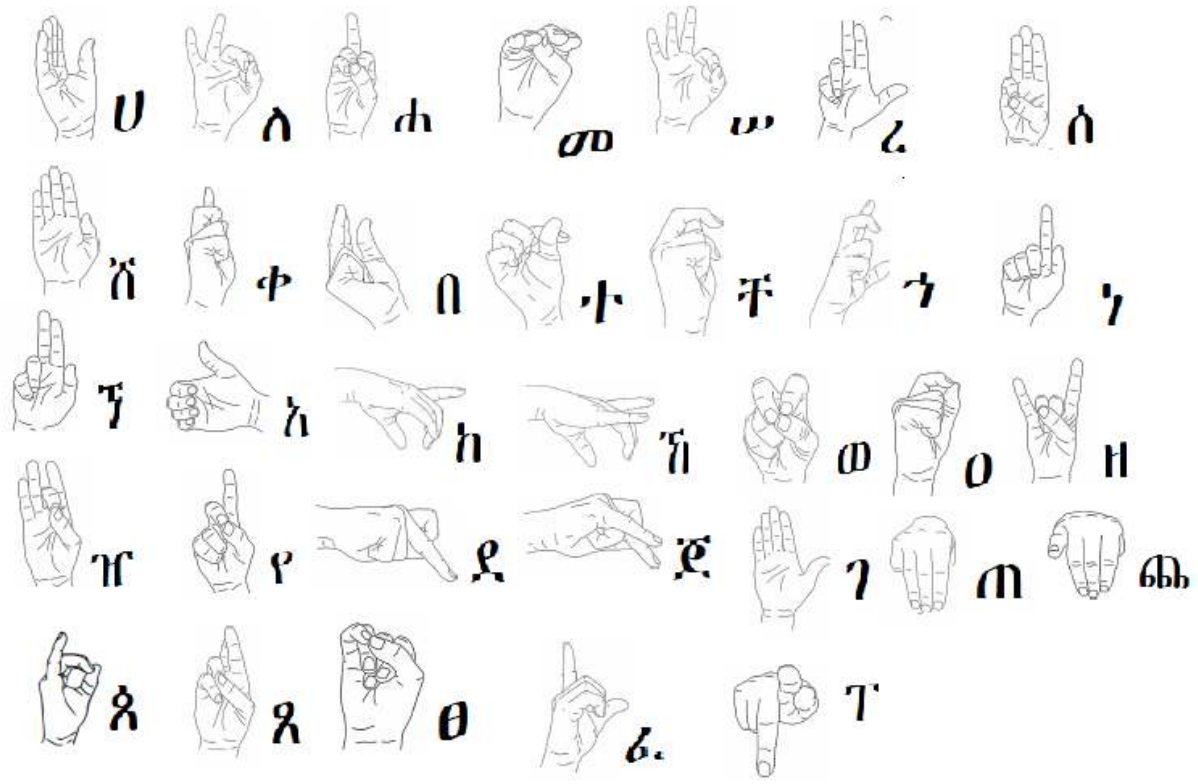

**Figure 2.2** Ethiopian Fingerspelling Representations for Amharic Letters [Source: ENAD]

## 2.5 Explanation of ESL Grammar

### The Five Elements

The five basic sign language elements that make up each sign in ESL are: handshape, movement, palm orientation, location, and facial expression [8].

### Dominant Hand

You have a dominant and non-dominant hand. If you are right-handed, your right hand is your dominant hand. If you are left-handed, your left hand is your dominant hand. Dominant hand is usually used to show signs that are represented with only one hand. Depending on what hand is used, there are three types of signs [8].

- **One-handed signs**: Uses only your dominant hand

- **Two-handed symmetrical signs**: Uses both your dominant and non-dominant hand where they both move the same way
- **Two-handed non-symmetrical signs**: Uses both your dominant and non-dominant hand where the dominant hand moves while the non-dominant hand remains stationary

**Signing Area**

Signing area is the space in front of the signer's body from the top of the head down to the waist and from shoulder to shoulder. Most signs are made in this space during everyday conversation. The signs should not extend beyond this area unless you are signing for a huge audience (where you should sign larger and slower) [8].

**Direction**

Basic sign language direction is very important when it comes to the meaning of signs. A sign can have one meaning when it moves one way and another meaning when it moves the other way. For example, the signs for '**ወስጥ**' (IN) and '**ውጪ**' (OUT) have different directions and different meanings.

Direction can also provide information about the subject and the object of a sentence in basic sign language [8]. For example to signify that you are giving something to some one, you can move the sign '**ማስጠት**' (GIVE) away from you. In contrast, in order to signify that the first person is giving something to the second person, you can move the sign '**ማስጠት**' (Give) from one person to another to. It is also done for many other signs, such as: '**መናገር**' (TELL), '**ጠማየቅ**' (ASK), and '**መላክ**' (SEND).

**Tense**

In Amharic language, words are spelled differently to indicate the past, present, and future. In Ethiopian sign language, you use your body to indicate tense. Signs for the present are signed in front of your body (e.g. 'ዛሬ'(TODAY) and signs for past are signed moving backward (e.g. 'ትላንት' (YESTERDAY) and 'በፊት' (BEFORE), and signs for the future are signed moving forward 'ነገ' (TOMORROW) and 'ወደፊት' (SOMEDAY).

**Intensity**

In Amharic, intensity is usually shown by adding words. In ESL, intensity is shown by varying the intensity or speed with which a sign is made or by incorporating facial expression. For example, the sign for 'መራመድ' (WALK) can be made quickly or slowly to indicate how the person is walking. Signs may change their meaning when their intensity is exaggerated [8].

**Iconic Signs**

When signs look like the word they are representing, these are said to be iconic signs. These signs can often be recognized by people who don't know basic sign language. The sign for 'ዝሆን' (ELEPHANT) is signed like an elephant's trunk. Other examples include signs like 'ግመል' (CAMEL), 'መዋኘት' (SWIMMING) etc. There are many signs like this [8].

**Initialized Signs**

An initialized sign is one that has the handshape of the first letter of the word [8]. There are many of these signs in ESL and some are very helpful for knowing the specificity of the sign. For example, the signs for 'ሰኞ' (MONDAY) and 'ረቡዕ' (WEDNESDAY) look the same except that 'ሰኞ' is signed with a "ሰ" handshape and 'ረቡዕ' is signed with "ረ" handshape.

**The Person Ending**

To show a person's occupation or nationality, the person-ending sign is added after the occupation or nationality [8]. For example, you would sign 'ማስተማር' (TEACH) + person-ending for the sign 'አስተማሪ' (TEACHER). We could also sign 'ኢትዮጵያ' (ETHIOPIA) + person-ending for the sign 'ኢትዮጵያዊ' (ETHIOPIAN). To make the person-ending, point both of your flat hands forward in front of your chest with your palms facing each other. Then, move both of your hands down at the same time [8].

**Gender**

Location is what shows you the gender of some signs. Most male signs are formed on or near the forehead while most female signs are formed on or near the cheek or chin [8]. For example, 'አባት' (FATHER) is signed by touching the tip of your thumb to your head, while 'እናት ' ( MOTHER) is signed by touching the tip of your thumb to your chin [12] [14]. The sign for the words 'አባት' and 'እናት ' is shown in figure 2.3 below.

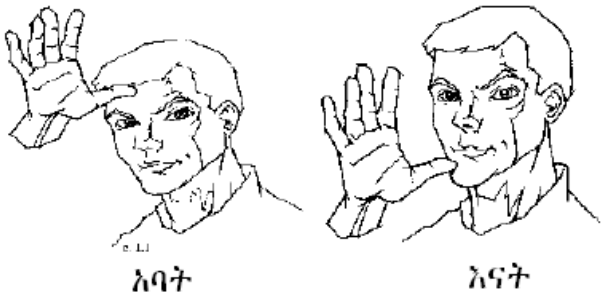


**Figure 2.3** Sign for the words 'አባት'(FATHER) and 'እናት' (MOTHER) from left to right [12]

**Plurals and Possessives**

There are a few different options to form plurals:

The most common way is to repeat the sign several times on either side of the signer's body. Repeating the sign for 'ድመት' (CAT) would mean 'ድመቶች'(multiple cats). A number

or sign that indicates quantity can also be added after the sign. For example, you can sign 'መኪና' (CAR) + 'ብዙ' (MANY) to mean 'መኪናዎች' (many cars).

On the other hand, you can also form the sign and then point with your index finger at a number of locations in your signing area. You can sign 'ቤት' (HOUSE) then point around in your signing area to mean 'ቤቶች' (many houses).

Possessives are rarely used because context is usually used.

**Negatives**

A few options are also available to form a negative:

- Sign the word NOT after the intended word. (e.g. 'ጥሩ' (GOOD) +NOT = 'ጥሩ አይደለም' (Not Good).
- Shake your head back and forth while signing the word ('ማመን' (BELIEVE) + (shake head) = 'አለማመን' (don't believe).

**Punctuation**

Punctuation marks are left out in ESL. They are also unnecessary (facial expression suffices). If adding punctuation mark is needed, the shape of the mark is traced in the air with pointer finger.

**Numbers**

ESL uses signs to represent numbers. Figure 2.4 shows the sign for number '**6**' (Refer to Appendix IV Sign Representation for Numbers)

**Figure 2.4** Sign for the number "6" [7]

**Repeating Signs**

Repeating a sign several times can make that sign plural. Repetition can also add another dimension to ESL. To show a continuous action, you would form the sign with a repeated, slow circular movement. To show a recurrent action, you would form the sign with several quick repeated movements [8] [13]. For example, you can sign the Amharic word 'ማየት' (LOOK) several times with a slow motion to show that you gazed steadily at something, but signing 'ማየት' (LOOK) with a quick repeated motion shows that you glanced at something numerous times [8].

## 2.6 Signed Amharic

Since majority of member of the Deaf community are living with the hearing community, they are influenced by the dominant spoken language and often use this language to express their ideas. The hearing community also gets problem in understanding the structure of the sign language. This is because sign languages are naturally occurring languages with linguistic structures (e.g. grammars, vocabularies, word order, etc.) distinct from spoken languages [10] [14].

In order to address the above problem, a means of manual representation of spoken language called sign-spoken language was designed [14]. It retains spoken language sentence structure and word order and simply encodes a spoken language sentence into a set of signs

performed by the signer's hands. It is most commonly used in educational settings to expose deaf children to the syntax of spoken language

There is a language known as signed English which is a form of manual signing that is distinct from ASL but is not a full natural language. Signed English uses many of the same signs as ASL (and some additional signs of its own) [13].

In Ethiopia, signed Amharic is used to facilitate interaction between the deaf and hearing community [13]. It is basically the same concept as signed English and it essentially a means of producing signs, which correspond to the words in an Amharic sentence, in Amharic order. Currently, it is in use by Ethiopian Television for presenting information for Ethiopian Deaf communities. Moreover, sign language interpreters and other people use it when they sign at the same time as they speak.

# CHAPTER THREE

# LITRATURE REVIEW AND RELATED WORKS

This chapter presents various issues in literature which are relevant to the work presented in this document. Explanation of related works on sign language translation system is also presented.

## 3.1 Literature Review

### 3.1.1. Amharic Overview

Amharic (አማርኛ), the official language of Ethiopia, is a Semitic language that has the greatest number of speakers after Arabic [15]. It is one of the most widely spoken languages in Ethiopia. In spite of the relatively large number of speakers, Amharic is still a language for which very few computational linguistic resources have been developed.

Written Amharic uses a unique non-Latin based syllabic script called "Fidel" or "Abugida" which has originated from the Ge'ez alphabet (the liturgical language of the Ethiopian Orthodox Church)[15] [16]. Written Ge'ez can be traced back to at least the 4$^{th}$ century A.D. The first versions of the language included consonants only, while the characters in later versions represent consonant-vowel (CV) phoneme pairs. In the modern Ethiopic script each syllable pattern comes in seven different forms (called *orders*), reflecting the seven vowel sounds. The first order is the basic form; the other orders are derived from it by more or less regular modifications indicating the different vowels. There are 33 basic forms, giving 7*33 syllable patterns (syllographs), or *fidEls* [17]. Two of the base forms represent vowels in isolation, but the rest are for consonants (or semi-vowels classed as consonants) and thus correspond to CV pairs, with the first order being the base symbol with no explicit vowel indicator. The script also has a unique set of punctuation marks and digits. Unlike Arabic or Hebrew, the language is written from left to right.

Amharic has a complex morphology. Word formation involves prefixation, suffixation, infixation, and reduplication among others. A significant large part of the vocabulary

consists of verbs, and like many other Semitic languages, Amharic has a rich verbal morphology based on triconsonontal roots with vowel variants describing modifications to, or supplementary detail and variants of the root form [18].

Subject, gender, number, etc are also indicated as bound morphemes on the verb, as well as objects and possession markers, mood and tense, beneficative, malfactive, transitive, dative, negative, etc. Amharic nouns (and adjectives) can be inflected for gender, number, definiteness and case, although gender is usually neutral [18].

To demonstrate the applicability of the translation method, the text analysis component of AmESL-T focuses on personal and possessive pronouns as they are bound morphemes on verbs and nouns.

### 3.1.2. Machine Translation

A major area of Natural Language Processing (NLP) research is the design of software that can translate a sentence from one language into another automatically. The process of automatically translating from a sentence in a source language into a sentence in a target language is generally referred to as machine translation or simply translation [19] [21].

There is an architectural spectrum along which most Machine Translation (MT) systems can be classified; loosely they are grouped into three basic designs: direct, transfer, or interlingua [20]. These design choices are often pictured as a pyramid, as in figure 3.1.

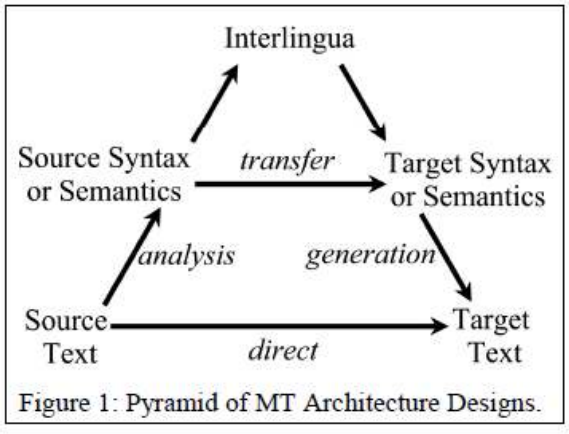


**Figure 3.1** Pyramid of Machine Translation Architecture Design [19]

**Direct Translation Method**

Direct systems were the first generation of MT and they are usually built with one language pair (translation between two languages) in mind. This procedure involves taking a string of words from the source language, removing morphological inflections from the words to obtain the lemmas, i.e. base forms and then looking up the lemmas in a bilingual dictionary between the source and target language [20]. There would be no analysis of syntactic structure or of semantic relationships. After a translation of each word is found, the positions of the words in the string are altered to best match the word order of the target language; these may include Subject-Verb-Object rearrangements, among others [20].

In text to sign language translation system, direct translation approach generates the sign language by direct replacement of the words of input sentence. Also, the system assumes a strong knowledge of both the spoken language as well as the target sign language [20].

**Transfer-based Method**

In a transfer based systems, the source language representation is transformed into a suitable syntactically/semantically correct target language form by applying proper transfer grammar rules [20].

These rules are dependent upon both the source and the target language. However, as the source/target language changes new rules are need to be added. Unlike those in interlingual systems, these representations are language-dependent: the result of analysis is an abstract representation of the source text, the input to generation is an abstract representation of the target text [20]. The transfer based approach is not only used in text-to-text MT systems but also in text to sign language MT systems.

**Interlingua Method**

In this method, the source text is analyzed and semantically processed to produce a typically language independent semantic representation called an “interlingua,” and then a generation component produces the target-language surface form from there [20].

The intermediate representation includes all information necessary for the generation of the target text without 'looking back' to the original text. The representation is thus a

projection from the source text and at the same time acts as the basis for the generation of the target text; it is an abstract representation of the target text as well as a representation of the source text. The method is interlingual in the sense that the representation is neutral between two or more languages [20].

The translation system proposed in this thesis was basically based on direct translation.

But since direct translations have inherent problems, a better approach like statistical or rule based machine translation should be used in the future.

### 3.1.3. Web Application

Web applications are programs designed to be used on the website using a browser [23]. The World Wide Web (WWW) has changed how today's businesses communicate. WWW is not only used to get and disseminate information but now is also employed as a tool for performance. Today's websites are powered by web applications that are capable of responding and interacting with the users.

A web application is accessed over a network such as the Internet or an intranet. It uses a website as a front end and the user can access this website with an application from any computer connected to the Internet. The application is delivered to users from a web server [23] [24]. Web browsers are software applications that allow users to retrieve data and interact with content located on web pages within a website.

Web-based applications have several advantages over their more traditional downloadable software programs. Here are the key ones [24] [25]:

1. **Cross-platform compatibility**. Web-based applications have a much easier path to successful cross-platform compatibility than downloadable software applications.
2. **Updating.** Web-based applications are always updated to the last release, without requiring the user to take pro-active action, and without needing to prompt or interfere with user work habits.

3. **Immediacy of access**. Web-based applications need not to be downloaded, installed and configured.
4. **Ease of trying**. Finally there will be no more obstacles to allow easy and effective try-outs of tools and applications before having to charge users credit card.
5. **Less memory requirements**. Web-based applications have far more reasonable demands on end-user RAM memory than locally installed programs. By residing and running off a provider servers, these web-based applications use in most cases the memory of the computers they run on, leaving more space for running multiple applications at the same time without incurring in frustrating performance hits.
6. **Less Bugs**. Web-based applications should be less prone to crashing and creating technical problems due to software or hardware conflicts with other existing applications, protocols or internal custom software.
7. **Pricing**. Web-based applications do not require the distribution, technical support and marketing infrastructure required by traditional downloadable software. This allows online applications to cost a fraction of their downloadable counterparts.
8. **Data moves online too**. Of course with the move from local applications to web-based ones also the data we create and access will need to undergo some profound changes.
9. **Multiple concurrent users**. Web-based applications can indeed be utilized by multiple users at the same time. No more need to screen share or send a screenshot when multiple users can see and even edit the same document together.
10. **Data is safer**. While hard disk crashes will not disappear, it is likely that users will hear a lot less about them. As companies take over the storage of users data, highly reliable redundant data storage farms will become the norm rather than the exception, and users will have much less of a risk of losing their data due to an unforeseen disk crash or computer virus.
11. **Develop applications in the language you prefer**. Once applications have been severed from local computers and specific operating systems they can be also written

in just about any programming language. Since web-based applications are essentially a collection of programs rather than a single program, these could be written in any programming language out there. While for desktop software you are bound to use the same language as the underlying operating system this is not the case when the software application is independent of the operating system.

Of course, web applications are not without their limitations. They are slower as they run over the Internet. Development is complex and takes longer as they have to work on different browsers and different versions of browsers. They also raise a number of security concerns stemming from improper coding.

In order to allow usage to large population and to benefit from the above advantages, AmESL-T is developed as a web-application.

### 3.1.4 State of the Art for Text to Sign Language Translation

Three main approaches exist in the literature [27]: the first is based on writing or drawing symbols, the second approach is based on video and the third is based on 3D sequences and the animation of a virtual person according to a standard.

#### 3.1.4.1 Writing-based Systems

Drawings were the first transcriptions of sign language and the means generally used to replace writing long time ago [27] [28]. Later on, several transcription systems appeared [28] such as HamNoSys (Hamburg Notation System) and SignWriting in spite of the difficulty to encode sign language in a linear way (See Section 3.1.5).

#### 3.1.4.2 Video-based Systems

The video-based systems consist in the insertion of a video sequence of human sign language interpreter in the original video tape [27]. Much more sophisticated tools exist nowadays on the market.

The use of video sequences to display a signing interpreter is more accepted by the deaf people as it ensures perfect sign performance but is not reusable solution and needs large amount of bandwidth. Some of these current projects based on video are [27]: "The Personal Communicator", "LSF Lexique".

**3.1.4.3 Avatar-based Systems**

Virtual human (avatar) technology has reached a stage where relatively realistic three dimensional human characters can be processed at sufficient frame (image) rates that signed presentations are readable by skilled signers [27] [29] [31]. Some current projects based on video are: "Signeuse Virtuelle 3D", "eSign" and "VSigns".

**3.1.4.4 Virtual Signing compared to Videos of Human Signers**

Virtual signing works by sending commands from a website to animation software installed on a user's PC. This software includes the Avatar [29].

Signed content can be placed on the Internet by recording videos of human signers. However, virtual signing has many advantages when compared to providing videos of human signing [29]. Firstly, the information that is sent from the website to the Avatar is more compact than the information that must be sent when downloading video clips. This means that high quality signing can be provided over low bandwidth Internet connections, something that is not possible when using video. In addition, the Avatar itself is a real 3D system, so not only is the quality of the image high when compared to video systems but the character can be rotated by the user to provide the optimum view [29].

Producing video clips of human signing on websites is expensive, and when any detail of the content changes the clip must be re-recorded. This does not fit well with the normal model of information provision on the web, where the ease and speed of updates is a fundamental feature [29]. Virtual signing technology allows small components of the signed content to be changed without the need to re-create the entire clip. The use of an Avatar also means that output remains consistent (i.e. played through the same virtual

human character) even when many different people work on the creation and modification of content over time. Currently, as the technology is still being developed, the creation of virtual signing content is relatively slow when compared to recording sign language on video [29]. However when virtual signing technology is developed further, content production will be faster and cheaper than video production.

Another key advantage with virtual signing technology is the ability to produce signed output by blending together sequences of signs to make new phrases on demand. This has the potential to integrate into web content management systems, again increasing the viability of including signing on websites [29].

#### 3.1.4.5 Creating Virtual Signed Content

There are two main methods for signed content creation to be used to derive avatar technology: motion capture and synthetic signing [29].

Motion capture works by using a combination of technologies, such as motion capture gloves and position markers, to capture detailed movement of signing components from a human signer [30]. This information can then be stored, manipulated, and sent to the Avatar for playback. This approach has traditionally been used in the production of sign language. However, it still requires that each and every sign occurring in a signed text to be recorded, a time-consuming process when building a lexicon of signs for a given sign language [29].

Synthetic signing works by sending motion commands, in the form of written codes, for the Avatar to animate. It constructs human-like motion from scripted descriptions of signing motions [31]. In eSIGN project, various coding systems are used to describe the different components of signing (manual components, facial expressions, mouth patterns, head and body movements) that are then animated by the Avatar [31]. The animation system has a pre-programmed model of how each signing component should be animated, and these have also been developed and refined during the eSIGN project.

Signs created using the synthetic signing approach generally appear less natural than signs produced from motion capture data. However synthetic signing has some clear advantages over motion capture for use in providing content for websites. The main advantage is the ease with which signs can be blended together. It is possible to blend together 'chunks' of motion captured signing, but with synthetic signing it is possible to create individual signs and automatically blend these together to create phrases of sign language[29] [31].

This means that once an individual sign has been created for one phrase, it can be stored in a lexicon, and reused with little or no modification. As more signs are stored and the lexicon grows in size, more and more signed phrases can be built by simply pulling in signs from the database, meaning that the time needed to create content is reduced [29].

### 3.1.5 Sign Language Notation Systems

There have been a few attempts at developing a standardized notation system specifically for signed languages. Notation systems developed originally for other purposes have also been suggested for use with American Sign Language (ASL) [28].

Several different notations and phonological systems are common in sign language research. When dealing with sign language translation, an appropriate sign language representation is necessary to transfer data from and to the sign recognizer and the presentation avatar [28]. Furthermore, a word or phoneme based notation is needed for the internal alignment with the written words of the spoken language.

The following notation systems are introduced:

**Glosses**

Glosses are written words, where one gloss represents one sign. Additional markings provide further information, e.g. non-manual signs. Unfortunately, no gloss standard exists, which results in inconsistent annotated corpora [28].

**Stokoe's Notation**

The notation system introduced by Stokoe (1960) was the very first phonological symbol system of ASL. It divides signs into movement (sig), hand shape (dez) and location (tab) which occur simultaneously [33]. Figure 3.2 shows the sign for see when written in Stokoe's notation.

As it focuses on ASL, the application on other sign languages is not always possible. An ASCII encoding of the Stokoe system is available. It is an adaptation of Stroke for ASCII character set and a purely linear ordering. Unfortunately, Stroke notation does not cover the full range of expressions that is possible in sign languages, and notably has no way of notating non-manual features [28][ 33].

**Figure 3.2** Stokoe notation for the sign 'see '[28]

**Hamburg Notation System**

The Hamburg Notation System (HamNoSys) is a more general form of the Stokoe system. It is currently the most extensive gesture notation system [28] [34]. It is composed of a large set of mostly iconic symbols, arranged linearly. (See Section 4.5.6) Figure 3.3 shows the sign for 'see' when written in HamNoSys.

**Figure 3.3** Hamburg Notation System for the sign 'see' [28]

**Liddell and Johnson's Notation**

Liddell and Johnson suggest a sequential division of the sign stream into movement and hold segments [28]. This avoids the simultaneous occurrence of phonemes.

**Sutton SignWriting**

This system is based on the combination of conventionalized iconic representations of body parts and movements into stylized drawings of signs. There are several levels of detail with which signs can be transcribed, from a detailed, "phonetic" transcription to shorthand [28]. The fact that detailed phonetic SignWriting conflates a number of distinct symbols into a single drawing would seem to work against its use as a database-friendly transcription system since the distinct symbols, being amalgamated into a whole, lose their autonomy. Software is available for using SignWriting [28].

Hand, arm and body movements and positions, palm orientation, signing space and planes, facial expressions, punctuation, and grammar are all depicted pictorially such that any sign language in the world could be represented by this system. Figure 3.4 shows the sign for 'see' when written in SignWriting.

**Figure 3.4** Sutton SignWriting notation for the sign 'see' [28]

## 3.2 Related Works

There have been several research works that have focused on translating written language input string into sign language. While the majority of these works used computer animation to present sign language, a few others used a pre-recorded video for sign representation.

This section presents review of related works on sign language. The first two research works are on foreign sign languages (ASL and BSL). The remaining are works done on Ethiopian Sign Language. Moreover, while the first four works focus on text-to-sign translation, the last work focuses on hand detection and sign classification.

### 3.2.1 A Machine Translation System from English to American Sign Language (ASL)

In this work the authors, described a prototype machine translation system from English to American Sign Language (ASL), taking into account not only linguistic but also visual and spatial information associated with ASL signs [35].

The authors divided the task into two different steps:

1. Translation from an input English text to an intermediate representation.
2. Produce American Sign Language from an intermediate representation.

To generate an intermediate representation, they have done the following steps

First, analyze the word order and figure out which sign order is more appropriate. Second, generate ASL glosses and embed parameters and use a Synchronous Tree-Adjoining Grammar (STAG) for mapping from English to ASL.

A tree-adjoining is a tree rewriting system, the primitive elements of which are elementary trees [34]. These elementary trees are anchored by lexical items, such as nouns and verbs. The elementary trees also have argument positions for the subjects and objects of verbs, adjectives, and other predicates. Elementary trees are combined by the operations of substitution and adjunction, where substituting elementary trees are attached at the frontier nodes of other elementary trees. Adjoining elementary trees are attached at internal nodes of other elementary trees by removing the part of the host tree below the adjunction site and reattaching it at one of the frontier nodes of the adjoining tree.

As the source-language sentence is parsed, a target-language tree can be simultaneously assembled, using synchronous TAGs, by associating one or more target-language elementary trees with each source-language elementary tree, and associating the nodes at which subsequent substitutions or adjunctions can take place [35].

### 3.2.2 A Prototype Text to British Sign Language (BSL) Translation System

In this work, an attempt was made to demonstrate a text to sign language translation system for investigating sign language structure and assisting in production of sign narratives and informative presentations [36].

The architecture of the English text to British sign language (BSL) system is essentially a pipeline of four main translation stages [36] (See Figure 3.5).

1. English syntactic parsing,
2. Discourse Representation Structure (DRS) generation,
3. Semantic transfer,
4. Generation SL phonetic descriptions.

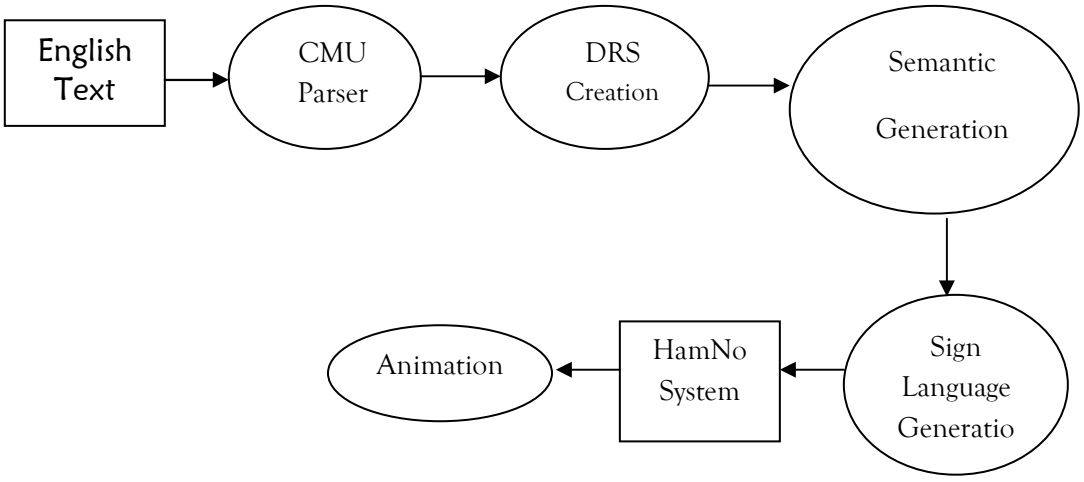


**Figure 3.5** Architecture of the text to British Sign Language translation system[36]

The English text (in Figure 3.5) is syntactically parsed by Carnegie Mellon University (CMU) parser to select appropriate linkage. The DRS is generated to capture the semantic of the text. The DRS is then transformed to an equivalent Head-Driven Phrase Structure Grammar (HPSG) semantic structure which is the starting point for SL generation. The SL produces a collection of signs and Hamburg Notation System (HamNoSys) system must select the appropriate sign [36]**.**

The authors stated that their sign language generation sub-system incorporates a lexicon and grammar whose coverage are representative of a number of interesting sign language phenomena.

However, their current system omits non-manual components of signing (facial expressions, mouth patterns, head and body movements) in the animation. Non-manual

part of signing is as important in signing as the manual part [37]. They stated that their sign language generation has been designed to be extended in this direction in the future.

### 3.2.3 A Machine Translation Approach to Translate Amharic Text to Ethiopian Sign Language

In this work, the author presents a machine translation system to translate Amharic text to an equivalent Ethiopian Sign Language (ESL) by fingerspelling representation with the help of a 2D animating avatar rendering the equivalent ESL manual sign translation [10]. The author used Macromedia Flash software to model and design the avatar (See Figure 3.6).The author stated that the machine translation is adopted to from interlingua system of the three level of the machine translation architecture [10] [38].

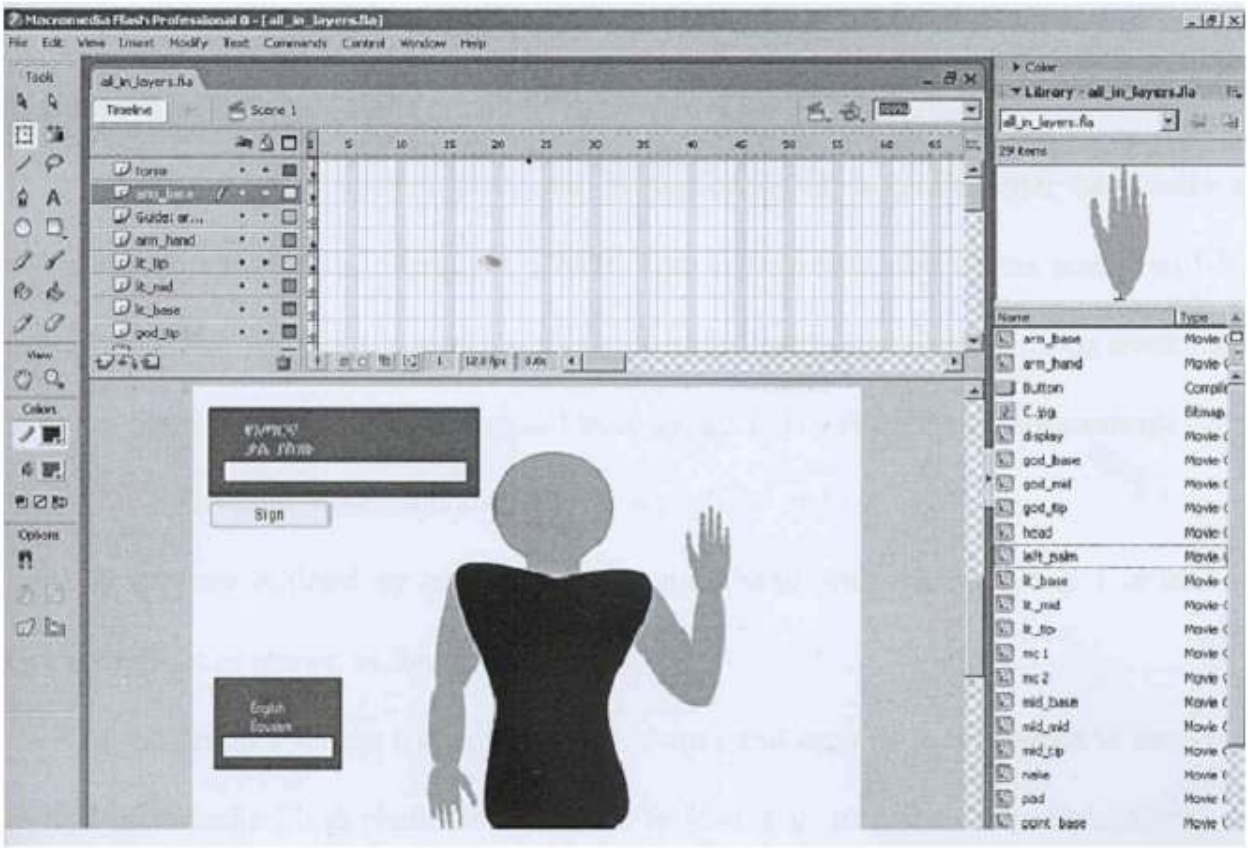


**Figure 3.6** Visual interface of the translator software [10]

However, it can easily be observed that the developed translator has a number of weaknesses and shortcomings that need further improvement.

Firstly, the developed system does not provide full translation functionality. The emphasis of this work is restricted to fingerspelling domain. ESL uses both conceptual signs and fingerspelling for communication in sign. Conceptual signs are dominantly used to convey meaning in ESL. In practical sense, fingerspelling is used if a word cannot be expressed via sign language. Native signers use fingerspelling to convey names, acronyms, technical terms and other words which have no direct sign equivalent. Even though a given word has its own sign representation, the developed system presents it as a sequence of sign alphabets. Apart from fingerspelling, a full signing avatar must also be able to sign the actual (conceptual) signs [37].

Secondly, the developed system is based on a 2D avatar. However, 3D avatar can better convey sign language than 2D avatar. By using three dimensional graphics, signs can be viewed from any position, increasing understanding of the signs in space.

The translation system proposed in this thesis, however, is able to give translation for both conceptual signs and fingerspelling gestures that involve static and motion signs. It is also based on a 3D avatar technology.

### 3.2.4 Design and Development of Learning Tool for Ethiopian Sign Language

In this work, the author developed a hypermedia learning tool considering health environment as a case. Using this tool health professional (who can read and write Amharic) can learn basic health related Ethiopian Sign Language which enable them communicate with their deaf patients. The aim of the thesis work is to minimize the communication gap between hearing and deaf people and helping the deaf in the mentioned area [39].

The system gives translation of Amharic text into ESL with the help of pre-recorded domain specific video set. The system works within some finite samples of Amharic words collected around health centers. The prototype of the translation system was developed using a UML-based hypermedia designing methodology [39]. The author named the tool as Medical Ethiopian Sign Language Learning Tool (MESL2T). The objective of this web-based ESL learning tool was to help health professionals in learning ESL by their own at their own pace [39].The author also stated that the tool can be used by ESL instructors. MESL2T incorporates general communication and medical specific concepts that have terms or signed Amharic phrases and sentences under each category. By clicking on the terms, phrase or sentences, users can view the ESL equivalent in pre-recorded video. This allows users to learn and practice ESL easily. The developed tool also includes instructions on how to use the tool and how to approach and communicate with deaf individuals [39]. Figure 3.7 shows the sample program screenshot of the tool (MESL2T).

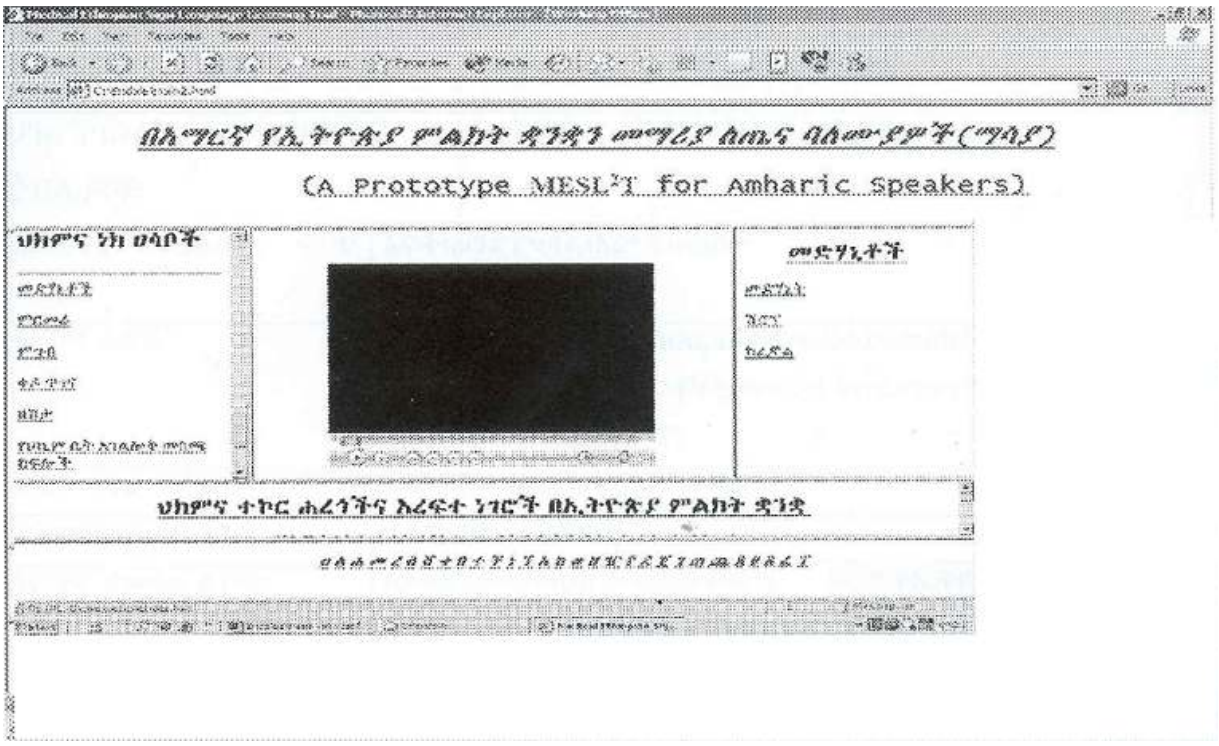


**Figure 3.7** MESL2T's sample prototype program screens [39]

MESL2T is restricted to health domain. It uses a pre-recorded video for this domain. However, presenting signed content using pre-recorded videos is expensive and when the content changes, the clip must be pre-recorded. Moreover, storage and download of these videos can be problematic as video files tend to be large. The author does not discuss any specific effort that need to be done to reduce the size of the video clips so that the system is practical to be downloaded at reasonable time, while at the same time keeping good resolution of the clip to clearly show facial impressions of the sign.

Virtual human signing can be a more effective alternative to videos for presenting signed information. The translation system proposed in this thesis is, however, based on a virtual signing which avoids the aforementioned problems.

### 3.2.5 Ethiopian Fingerspelling Classification: A Study to Automate Ethiopian Sign Language

In this work, an attempt has been made to design Ethiopian fingerspelling classification system. The proposed architecture has components for image capturing, feature extraction, hand detection, region of interest segmentation and sign classification [14]. The system classifies the hand sign of Ethiopian fingerspelling into a class that represents each Amharic alphabet. The system accepts the image of the hand sign as an input and returns the associated Amharic alphabet as output [14]. In figure 3.8, each component of the system is depicted. The rectangular components represent processing components and the circles represent the output of the system.

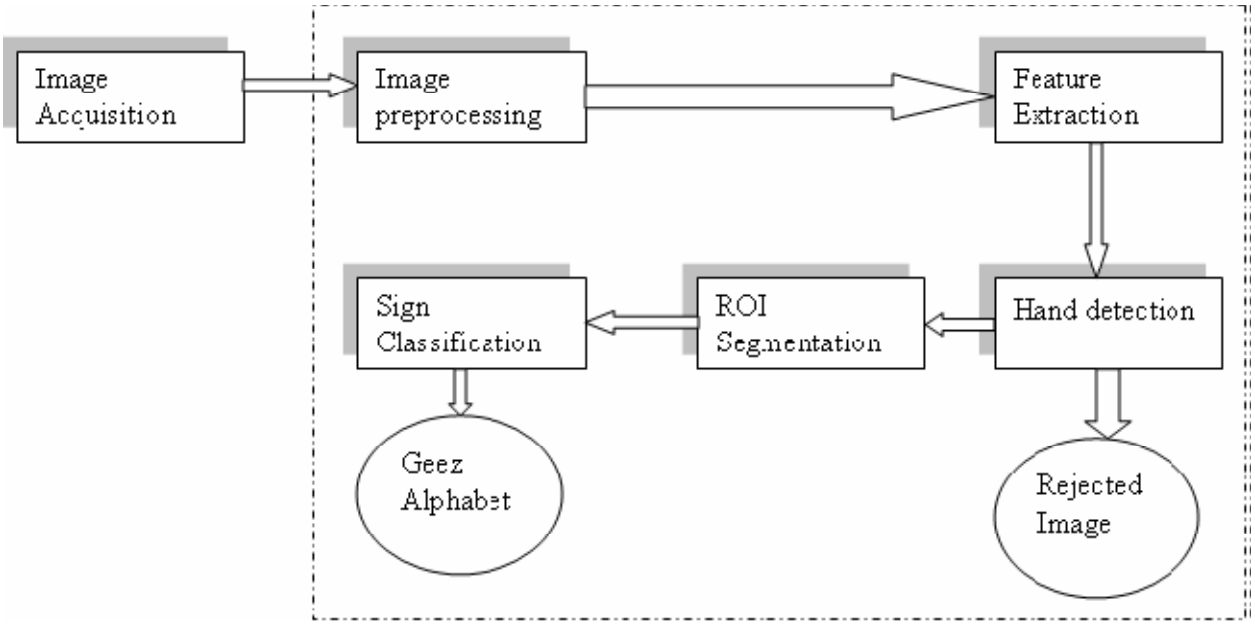


**Figure 3.8** Ethiopian Fingerspelling classification system architecture [14]

For the tasks of hand detection and sign classification, experiments were conducted to select the appropriate pattern classifier and feature. In addition, the capability of the principal component analysis driven and harr-like feature with neural network was tested through experiment [14].

This work mainly focuses on hand detection and sign classification that will be used as input for Ethiopian fingerspelling recognition. This work is limited to the detection and classification of static signs of Ethiopian fingerspelling. Apart from static signs, the Ethiopian fingerspelling has dynamic signs. These signs constitute the majority of the signs in Ethiopian fingerspelling. The system should be expanded to give detection and classification capability for dynamic signs as well. This requires a tool for capturing and detecting hand motion.

# CHAPTER FOUR

# DESIGN, DEVELOPMENT AND EVALUATION OF AMHARIC TO ETHIOPIAN SIGN LANGUAGE TRANSLATOR (AmESL-T)

## 4.1 AmESL-T Overview

AmESL-T is a prototype Amharic text to Ethiopian Sign Language translation system. AmESL-T's main prospective is to promote communication between the deaf, their parents and people around them by presenting Amharic text into Ethiopian Sign Language (ESL) translation tool. The signs are shown using a 3D animation avatar technology.

The main design objectives of AmESL-Tare:

- Friendly and easy-to-use interface
- Good results in text analysis
- Clear and realistic animations
- Extendible dictionary

## 4.2 Amharic and ESL Pronouns and Person Features

### 4.2.1 Amharic Pronouns

Pronouns are symbols in a language that are used in place of nouns and function as simple noun phrases. Languages may use these parts of speech in place of a noun that has already been established earlier in the text in order to refer back to that noun. Pronouns may also be used to describe referents that do not have an antecedent [41].

As to their forms, they are classed, as in other Semitic languages, into separable and inseparable pronouns. We begin with the separable pronouns. They are personal, possessive, demonstrative, Interrogative and reflexive.

Since this study focuses on Amharic personal and possessive pronouns as they are bound morphemes on verbs and nouns, they are discussed as follows.

**I. Separable pronouns**

**Separable Personal Pronouns**

They are three for the singular and three for the plural. The singular has some peculiarities. The first person has not the gender expressed: the second person and third have distinct forms for the masculine and for the feminine gender.

**Table 4.1** Amharic Personal Pronouns

| Singular | Plural |
|---|---|
| እኔ : I | እኛ : We |
| አንተ: m. አንቺ: f. You | እናንተ : You |
| እርሱ: m. He እርሷ: f. She | እነርሱ : They |

**Separable Possessive Pronouns**

For possessive pronouns (mine, yours, etc), Amharic adds the independent pronouns to the preposition yä- 'of'. For example: የእኔ 'mine'. They are formed by the genitive of the personal pronouns, and are as follows

**Table 4.2** Amharic Possessive Pronouns

| Singular | Plural |
|---|---|
| የእኔ : my, mine | የእኛ : our, ours |
| የአንተ: m. የአንቺ: f. your, yours | የእናንተ : your, yours |
| የእርሱ: m. his የእርሷ: f. her, hers | የእነርሱ : their, theirs |

**II. Inseparable Pronouns**

They are, with regard to their character, personal, possessive, relative and distributive and with regard to their position, they are either prefixes or suffixes.

**Personal suffixes to verbs**

They consist partly in modifications of the personal pronoun and are annexed to the end of the verb. The suffixes shown in table 4.3 below are subject pronoun suffixes bound to verbs.

**Table 4.3** Amharic personal pronoun suffixes bound to verbs

| Singular | Plural |
|---|---|
| ሁ,ሁኝ, ኩኝ: I (እኔ) | ን : We (እኛ) |
| ህ ,ክ : m. You (አንተ) ሽ :f. You(አንቺ) | ችሁ: You(እናንተ) |
| ል :He(እርሱ) ች:She (እርሷ) | ሱ : They (እነርሱ) |

*Example*: ሞሮጥ : "to run"

| Singular | Plural |
|---|---|
| ሮጥሁ : I ran | ሮጥን : We ran |
| ሮጥህ : m. ሮጥሽ : f. you ran | ሮጣችሁ : You run |
| ሮጠ: He ran | ሮጡ: They ran |
| ሮጠች : She ran | |

**Possessive Suffixes to Nouns**

Amharic has a further set of morphemes which are suffixed to nouns, signaling possession. They are, to a certain degree, similar to the preceding.

**Table 4.4** Possessive Suffixes to Nouns

| Singular | Plural |
|---|---|
| ê:my (የ እኔ ) | ãችን : our (የ እኛ) |
| ህ : m. your (የ አንተ) ሽ: f.your (የ አንቺ) | ãች ሁ: your (የ እናንተ ) |
| û,or ãው:his (የ እርሱ) wã : her (የ እርሷ) | ãቸው: their (የ እነ ርሱ) |

*Example*: ቤት : "House" with possession suffixes

| Singular | Plural |
|---|---|
| ቤቴ : my house | ቤታችን : our house |
| ቤትህ : (m), ቤትሽ: (f) your house | ቤታችሁ : your house |
| ቤቱ: his house | ቤታቸው: their house |
| ቤቷ: her house | |

### 4.2.2 ESL Pronouns

ESL pronouns refer to nouns that have already been established earlier in the text. ESL personal pronouns can be used to refer to three classes of referent, the speaker (1st person), the person being addressed (2nd person), and other nouns that are not the speaker or the addressee (3rd person).

If the person or object is present, you can just point at him, her, or it to mean "HE/HIM," "SHE/HER," or "IT." If the person or object is not present, you would first need to identify the person or object. Then, you can "index" the person or object to a point in

space. Once you have set up this referent, you can refer back to that same point every time you want to talk about that person or object.

To refer to referents, some types of signs used are:

- Personal Pronouns
- Possessive Pronouns

**Personal Pronouns**

Personal pronouns are signed by pointing with your index finger toward a person, object, or referent [42]. A referent is used when a person or object is not present. If the person or object is present, you can just point at him, her, or it to mean "HE/HIM," "SHE/HER," or "IT."

If the person or object is not present, you would first need to identify the person or object. Then, you can "index" the person or object to a point in space. Once you have set up this referent, you can refer back to that same point every time you want to talk about that person or object [42].

Here are the signs used for personal pronouns:

- "me" = point at yourself, touching your chest
- "you" = point at the person you are talking to
- "he/she/it" = point to the person or object you are talking about (or to the spot you are using to reference the person or object)
- "you/they/them" = point to the group or point and sweep your hand to the side toward the people you are referencing (to the right or left)
- "we/us" = use index finger starting on your chest near the shoulder of your dominant hand and moving it near the shoulder of your non-dominant hand

**Possessive Pronouns**

In ESL, personal pronouns can indicate possession simply by changing the handshape from an index finger to a flat hand. The palm should face toward the person or thing that is doing the possessing [42]. For example, to sign "YOUR," you would sign "YOU" with a flat hand, fingertips up, and your palm facing toward the person.

Here are the basic possession signs:

- "my/mine" = flat hand on your chest
- "your/yours" = flat hand toward the person (in front of you)
- "his/hers/its" = flat hand toward the person or object
- "our/ours" = flat hand starting on your chest near the shoulder of dominant hand (palm facing in) and moving in a half-circle to near the shoulder of your non-dominant hand (palm facing in)
- "theirs" = flat hand making a sweeping motion toward the people you are referring to

**Figure 4.1** shows a list of pronouns that refer to people, and it also gives you the signs for personal and the possessive pronouns.

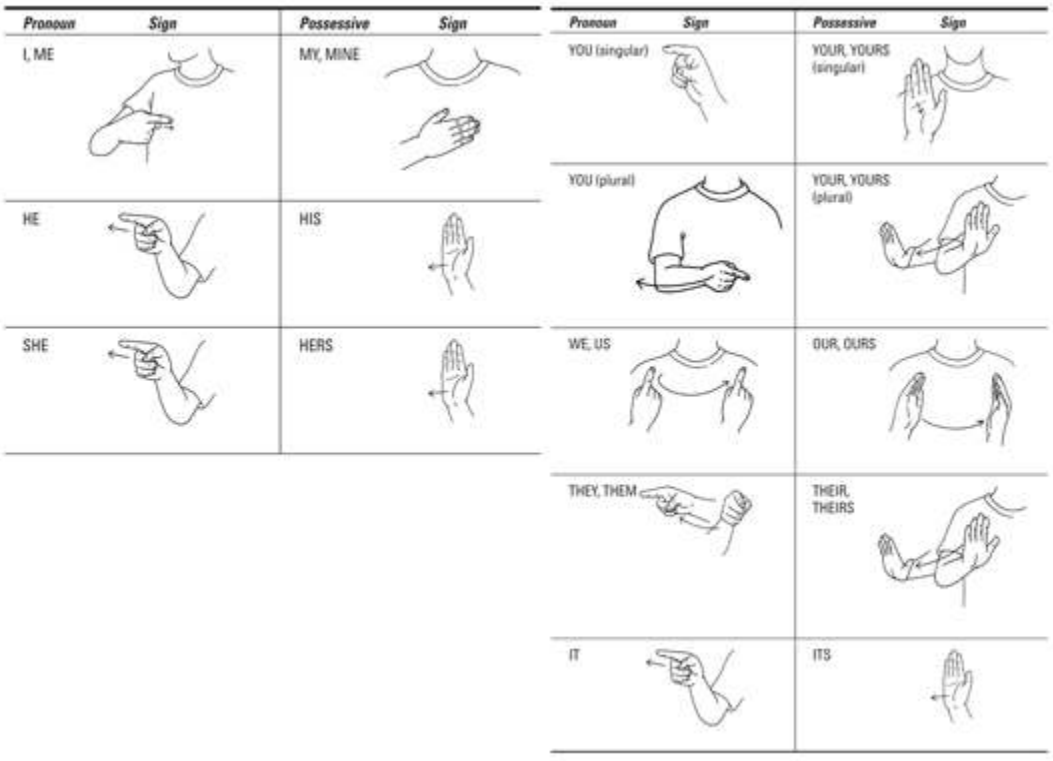


**Figure 4.1** List of ESL sign for personal and possessive pronouns [42]

Pointing for second and third person singular for masculine and feminine is towards the same place. In order to differentiate them, gender marker sign is shown before the actual pointing. In ESL, location of the sign shows the gender. Most male signs are formed on or near the forehead while most female signs are formed on or near the cheek or chin. For example, to sign that the referent is second person singular feminine (i.e. 'አንቺ'), the signer first shows the sign for female gender marker sign followed by the sign for the pronoun you. Figure 4.2 shows the sign for the pronoun "አንቺ".

**Figure 4.2** Sign for pronoun "እንቺ"

In pronouns, plural number is mostly marked by sweeping or circular movement, such as 'THEY'. Possessive pronoun signs are usually shown after the person or thing you are signing. For example, you sign "የእኔ ወሻ "as "ወሻ የእኔ".

### 4.3 System Architecture

The system architecture of the proposed Amharic Text into ESL translation system is composed of the following three essential modules.

I. Input Text Analysis

II. Text to Sign Mapping

III. Sign Synthesis/Generation

The translation system takes Amharic text as input and generates virtual avatar animations of Ethiopian sign language. The general architecture of the translation system (i.e. AmESL-T) is illustrated in figure 4.3.

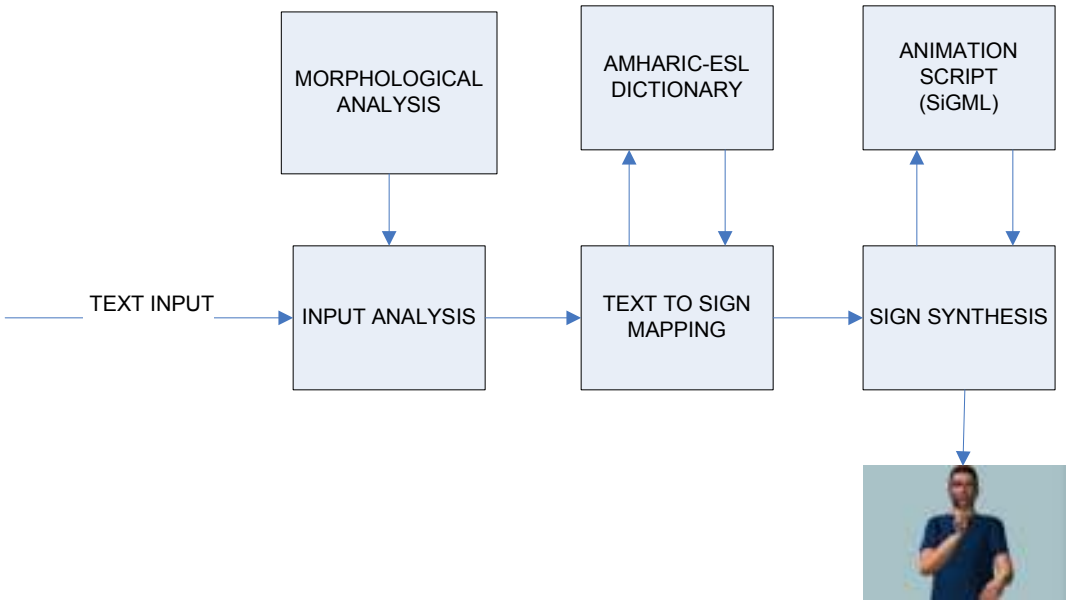


**Figure 4.3** General architecture of AmESL-T

### 4.3.1 Input Text Analysis

The input for the translation system is one of the following: Amharic word, letter or number. The input text is acted on by some analysis routines before passing it to the mapping module. The type of analysis performed on the input depends on the nature and type of the input.

#### Word Analysis

Morphological analysis is important for morphologically complex languages like Amharic because it is practically impossible to store all possible words in a lexicon, and many words have close to 0 probability of occurrence in any given corpus [40]. This becomes obvious in the context of machine translation from Amharic to sign language (considered morphologically simple language) where the correspondence between words in Amharic and the sign language will often be many-to-one.

An Amharic word consists of a lexical part, or stem (Amharic አምድ), and one or more grammatical parts [40]. This is easy to see with a noun, for example, the Amharic noun

አገራቸው: The lexical part is the stem አገር; this conveys most of the important content in the noun. Since the stem cannot be broken into smaller meaningful units, it is a **morpheme** (Amharic ምዕላድ), a primitive unit of meaning. This is followed by a grammatical suffix (አቸው) , which provides information about possession.

For the purpose of this study, a morphological analyzer that analyses simple Amharic verbs (perfective form) and nouns into their stem and a set of suffixes is developed and integrated to the translation system. The analysis depends highly on the data provided in the suffix list. In this work, we are interested in inflectional morphology of the word. Inflectional morphology manifests primarily in the form of a prefix, suffix, or vowel change. In particularly, we want to stem Amharic verbs and nouns with personal and possessive pronoun suffixes bound to them. We carefully selected a set of personal and possessive pronoun suffixes for the different combinations of person, number, and gender (excluding the second person polite suffix –wo (t)) (See Section 4.2.1).

Instead of direct table look up for word-sign pairs, AmESL-T performs a set of analysis on the input word. Since only the stem word is stored, the size of the database is dramatically reduced. Then taking the output of the analysis, the basic sign corresponding to the stem is retrieved and modified based on the analysis result.

For example, for the Amharic word ‘ጨረሰች’ (She finished), the morphological analyzer returns ‘ጨረሰ’ + ‘ች’ (morphological marker for singular feminine) where ‘ጨረሰ’ is the stem. Then, the system retrieves the sign corresponding to ‘ጨረሰ’ from the database and modify (or add new sign to it) according to the analysis, in this case singular feminine.

**Letter Analysis**

AmESL-T also performs a set of analysis on the input letter/word before its ESL fingerspelling equivalent is shown. Although the seven orders of each Amharic letter have the same handshape, they are differentiated by the movement of the hand. The direction of the handshape movement for Amharic letters is shown in Table 4.5. For the

fingerspelling functionality, each letter is analyzed separately. The following algorithm is used by AmESL-T for fingerspelling.

*For each letter in the input text*

*Identify order of the letter ($1^{st}$, $2^{nd}$ ...$7^{th}$)*

*Read the handshape animation code and write to file*

*If letter is from $2^{nd}$ to $7^{th}$*

*Identify the corresponding movement*

*Append movement code to the file*

*End if*

*End for*

*Feed the file, containing the animation code, to the avatar for signing*

**Figure 4.4** AmESL-T's Fingerspelling algorithm

**Number Analysis**

A number input is also analyzed by AmESL-T. For simplicity reasons, numbers in AmESL-T are considered as basic and derived. Basic numbers have their own sign representation in ESL where as derived numbers are shown by combining signs of basic numbers. Only the sign for basic numbers are stored in the database. For example, the number 6 has its own sign representation in ESL. But the number 106 is considered as derived number as it can be expressed in terms of basic numbers 100 and 6. The sign for 106 is shown by concatenating the sign for 100 and 6. AmESL-T performs a serious of such analysis to split the derived number into its basic forms before passing it to the mapping module. The

animation code for all basic forms are then read from file and concatenated based on their order.

### 4.3.2 Text to Sign Mapping

After appropriate analysis is done on the input text, word, letters or number is produced. These form the input for the text to ESL mapping module.

The text to sign mapping module transfers the written Amharic text to equivalent sign structures and aligns input words (after analysis) with corresponding signs. This module uses ESL dictionary which stores a set of commonly used Amharic words, letters and numbers. These words are mainly taken from ESL dictionary and various text books. Along with the words, letters and numbers, the file name and the path of the animation script is stored in the database.

It is this module that looks up the text (word, letter, and number) in the sign dictionary. If the text is found in the dictionary, it will send the text along with the file name of the animation script to the sign synthesis module.

### 4.3.3. Sign Synthesis/Generation

This module is responsible for converting the script of the animation into ESL animation. Based on the information obtained from the mapping module, animation scripts corresponding to each word, letter or number are retrieved from a file and fed to the avatar by the sign synthesis module. The individual animation scripts are concatenated one after the other, in the correct sequence to generate ESL animation that represents the sign language output corresponding to the input text. Finally, the concatenated animation script is fed to the sign avatar for signing.

### 4.4 Description of the functionalities of AmESL-T

This section presents the functionalities of the developed translator, AmESL-T. The system is designed in such a way to provide translation functionality for words, letters and numbers. The translation system currently provides the following groups of tasks:

**I. Amharic Word to ESL Translation:** This feature allows users to enter Amharic word and view the ESL signs that correspond to the entered text.

**II. Amharic Letter to ESL Translation (Fingerspelling):** This feature allows users to enter Amharic letter/word and view its ESL fingerspelling representation.

**III. Number to ESL Translation:** This feature allows users to input numeric values and view the ESL sign representation.

**IV. Addition of New Signs**: This feature allows a user to propose new words and their corresponding sign using a gesture description language known as HamNoSys (See Section 4.5.6).

#### 4.4.1 Amharic Word to ESL Translation

The current version of AmESL-T provides translations for commonly used Amharic words, letters and numbers into ESL. These words are mainly collected from ESL dictionary and sign language text books.

The sign dictionary consists of a number of word-sign lexicons. For the purpose of this prototype, 50 Amharic words, 34 letters and 30 numbers were selected and their sign representation is transcribed using HamNoSys and stored. For more information about the AmESL-T database, refer to Section 4.6.

When Amharic word is typed from the keyboard, the text box uses JavaScript (Amharic Phonetic Typing JavaScript) to allow the user to type Amharic automatically. For this to work, the JavaScript in a web browser must be enabled.

The system first looks up the word in the ESL dictionary. If a match is found, the file name of the animation script is retrieved from the database. It then reads the animation script from file and fed it to the avatar for signing. Remember that in order to make an avatar sign, pre-specified animation sequences must be sent to the avatar.

However, if the sign is not found in the ESL dictionary, morphological analysis is performed in order to find the stem word (See Section 4.3.1). It then looks up the stem word in the dictionary. If a match is found, the basic sign corresponding to the stem is retrieved and modified (for example sign for personal or possessive pronoun may be appended).

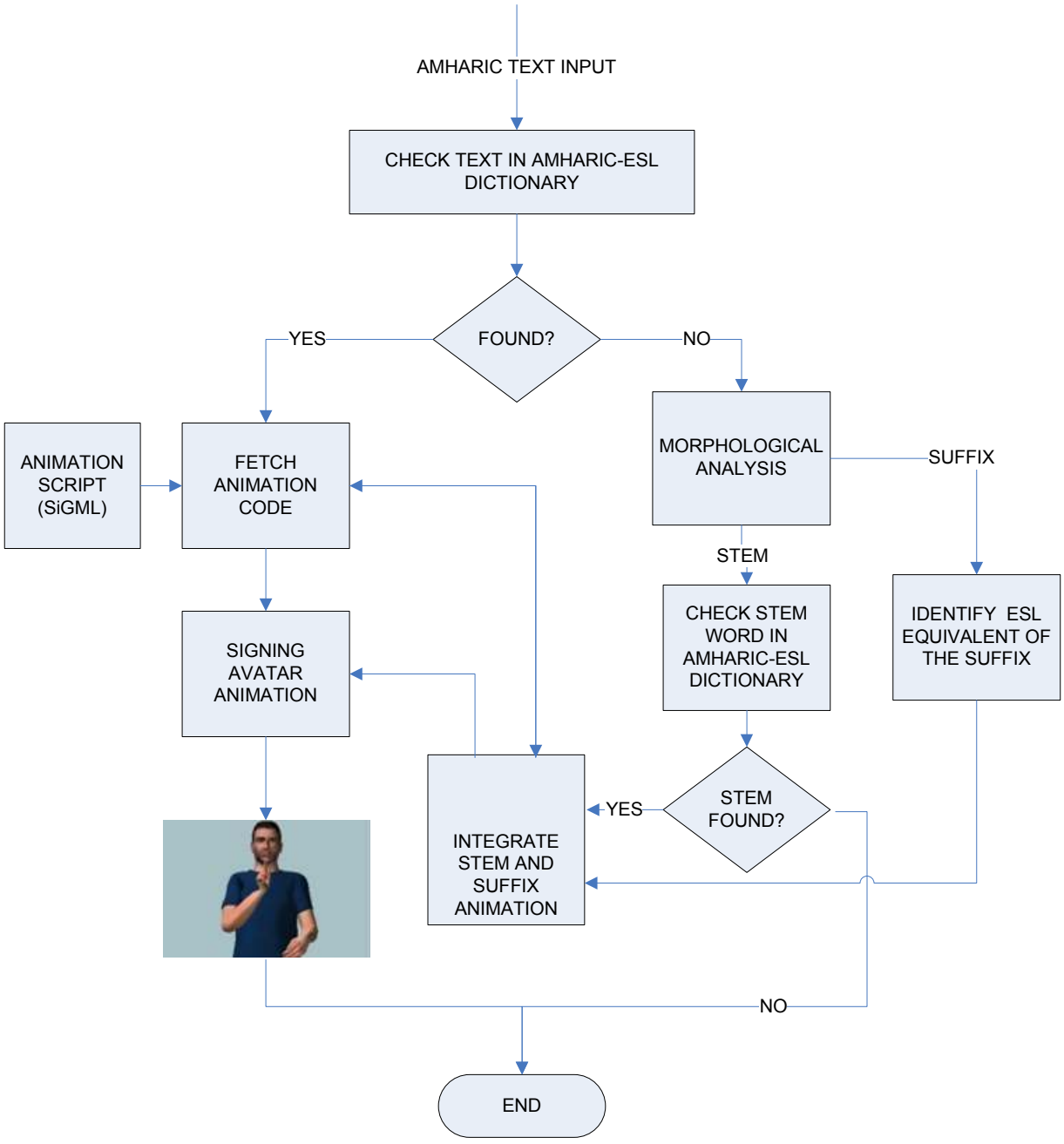


**Figure 4.5** Data flow sequence for Amharic word to ESL translation

The above figure shows the data flow sequence diagram for translating Amharic word to ESL. The module for translating Amharic text into ESL has a visual interface shown in Figure 4.6.

For Amharic word input, the system first looks up in the Amharic-ESL dictionary. If the word is found in the dictionary, the system fetches the animation script (SiGML code) from file and feed it to the signing avatar.

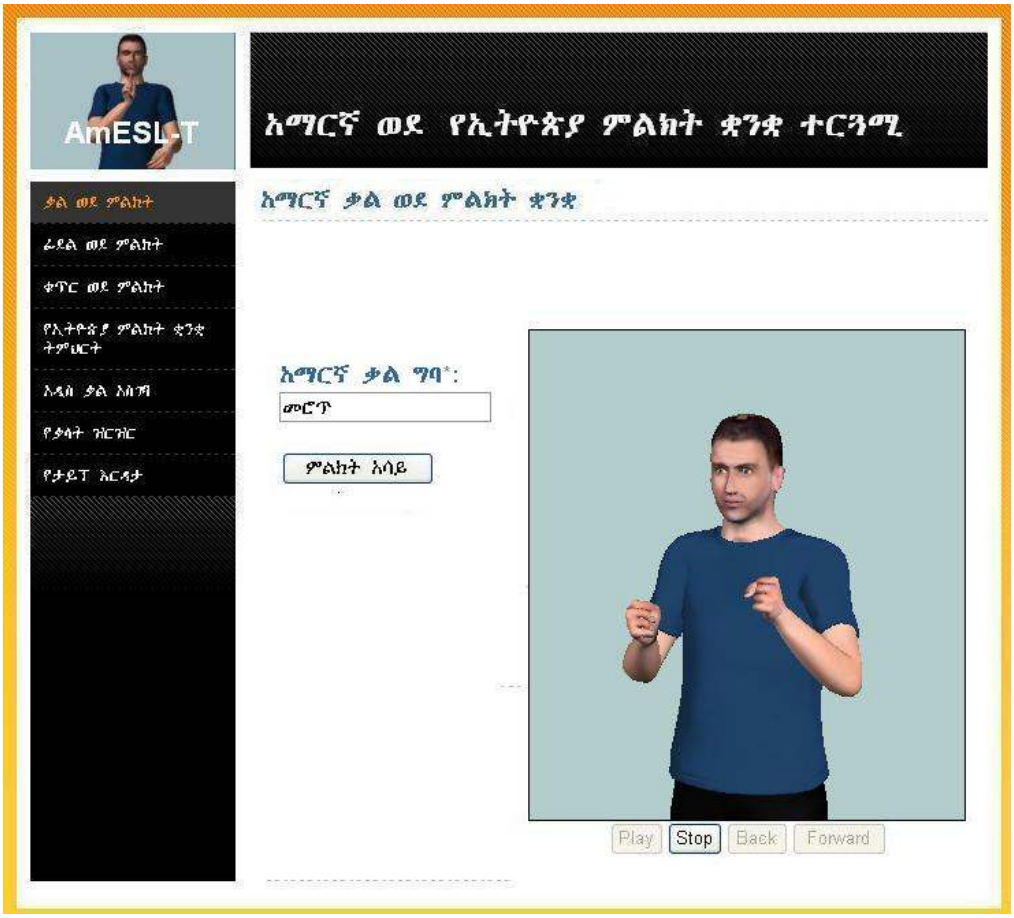


**Figure 4.6** Visual interface of the Amharic text into ESL translation module

In contrast, if a match for the word is not found in the dictionary, the morphological analysis is performed to reduce the word into its stem and a set of suffixes.

For example, for Amharic word 'ሩጦች', the morphological analyzer returns the stem word 'ሩጠ' and third person singular feminine suffix. Then the system looks up the stem word 'ሮጠ' in the dictionary. If a match is found, the file name of the animation is retrieved and the animation code is read and concatenated with the suffix's sign equivalent. The suffix in the above example is represented by the sign for 'እርሷ' (SHE) which in this example

represents the subject of the action. Then the concatenated sign code is feed to the avatar for signing. Figure 4.7 shows the sign for the Amharic word 'ሮጦ'.

**Figure 4.7** Example of AmESL-T's output for Amharic word "ሮጦ"

### 4.4.2 Amharic Letter to ESL Translation (Fingerspelling)

Fingerspelling in sign language is the way in which letters of alphabet are made on the hands [5] [7] (See section 2.2.3). Avatar animation fingerspelling every word of Amharic sentence would generally not be understandable to a deaf user with low levels of written language literacy (since it is merely an encoding of the original text) [7].

However, sign languages sometimes use fingerspelling for proper names, titles, acronyms, technical terms and other specific words which have no direct sign equivalence. Hence, fingerspelling software is an important sub-component of a complete written language to sign language translation system.

Much of this component has not been used for communicative purpose but rather for sign language education. People learning to interpret fingerspelling at more fluent speeds can use these educational systems to automatically produce an animation to practice with.

AmESL-T incorporates a module for translation of Amharic letter to fingerspelling animation. Ethiopian fingerspelling has 34 unique handshapes that represent each Amharic first order alphabet. The sign of the rest six order alphabets is constructed from the handshape of its first order and by incorporating six different hand motions that correspond to each Amharic alphabet order. In the figure 4.8, the Ethiopian fingerspelling

representation for the Gee'z alphabet '**ሀ**' is depicted. The sign is shown without handshape movement.

**Figure 4.8** Sign for the letter "**ሀ**"

In order to show the sign representation for the remaining six order alphabets of the letter 'ሀ' (i.e. ('ሁ','ሂ','ሃ','ሄ','ህ', 'ሆ') , different hand movements are added to the above handshape. The direction of the movement for the six order alphabets is depicted in Table 4.5.

**Table 4.5** Handshape movement for Amharic letter '**ሀ** ' and its derivatives

| **Order** | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
|---|---|---|---|---|---|---|---|
| | ግዕዝ | ካዕብ | ሳልስ | ራብዕ | ኃምስ | ሳድስ | ሳብዕ |
| **Geez Alphabet** | **ሀ** | **ሁ** | **ሂ** | **ሃ** | **ሄ** | **ህ** | **ሆ** |
| **Movment direction** | No movement |  |  |  |  |  |  |

The above movement direction is also applicable to other Amharic letters.

AmESL-T translates Amharic letters or words to ESL fingerspelling. In figure 4.9 the data flow sequence for Amharic letter to ESL fingerspelling translation is depicted.

Whenever the user enters Amharic letter to be fingerspelled, the system analyzes the letter to identify its order and the movement associated with it. It starts by checking whether the

letter is 1st order or not based on the above classification. If the letter is 1st order, it reads the handshape representation (without a specific movement) from handshape library and feeds it to the avatar for signing.

On the other hand, if the letter is in one of the orders from 2nd to 7th, it reads the handshape representation from the handshape library and the corresponding motion representation from the handshape movement library. It then combines the handshape and movement representations (animation codes) and produces signed output by feeding it to the signing avatar.

If the user enters Amharic word, the system splits the word into individual letter and performs the above analysis for each letter. Here, before a shape and movement representations are feed to the avatar, they are concatenated one after the other and finally sent to the avatar for signing.

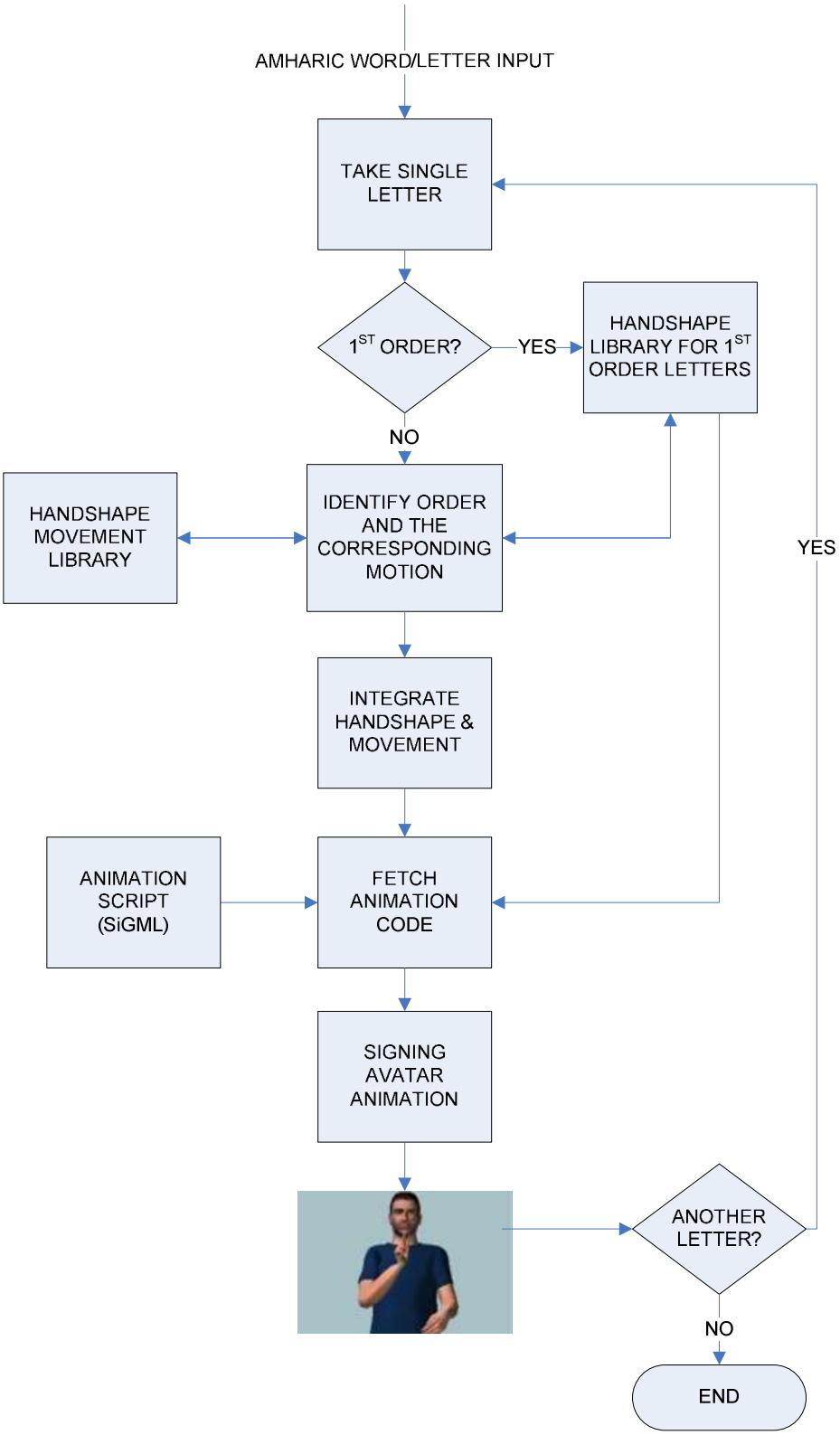


**Figure 4.9** Data flow sequence for Amharic letter to ESL translation

For example, for Amharic letter 'ሸ' the system looks up the sign in the dictionary and displays its representation as shown in Figure 4.10. Since the letter is first order, it is shown without a handshape movement.

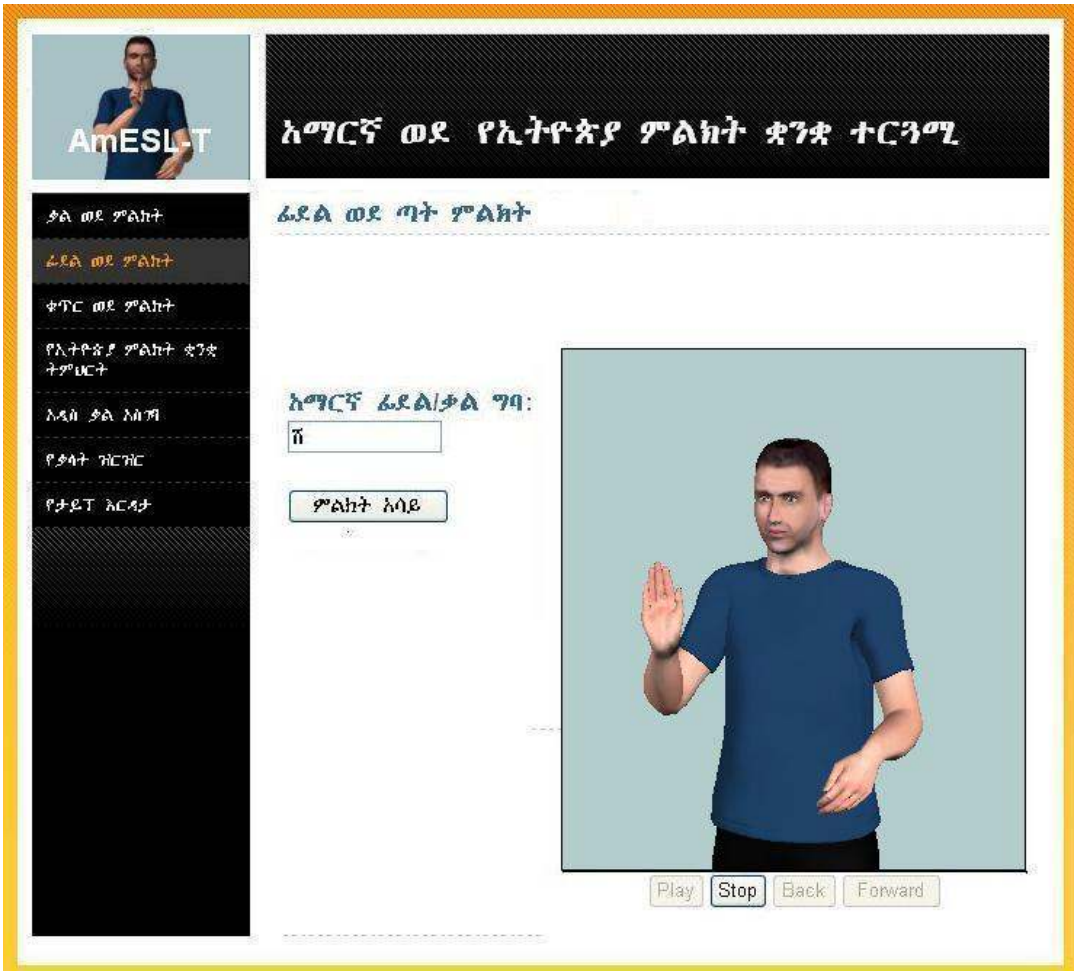


**Figure 4.10** Visual interface of the Amharic letter into ESL translation module

### 4.4.3 Number to ESL Translation

This module takes number as input and shows its representation in ESL. After the system takes numeric input, it performs a serious of analysis to transfer the number into its basic forms. It then looks up the dictionary for the file name of the animation script for each individual basic numbers and fed the animation script to the signing avatar. Signs for

derived numbers are created by concatenating the signs of each of the basic number representations. Figure 4.11 shows the data flow sequence for number to ESL translation.

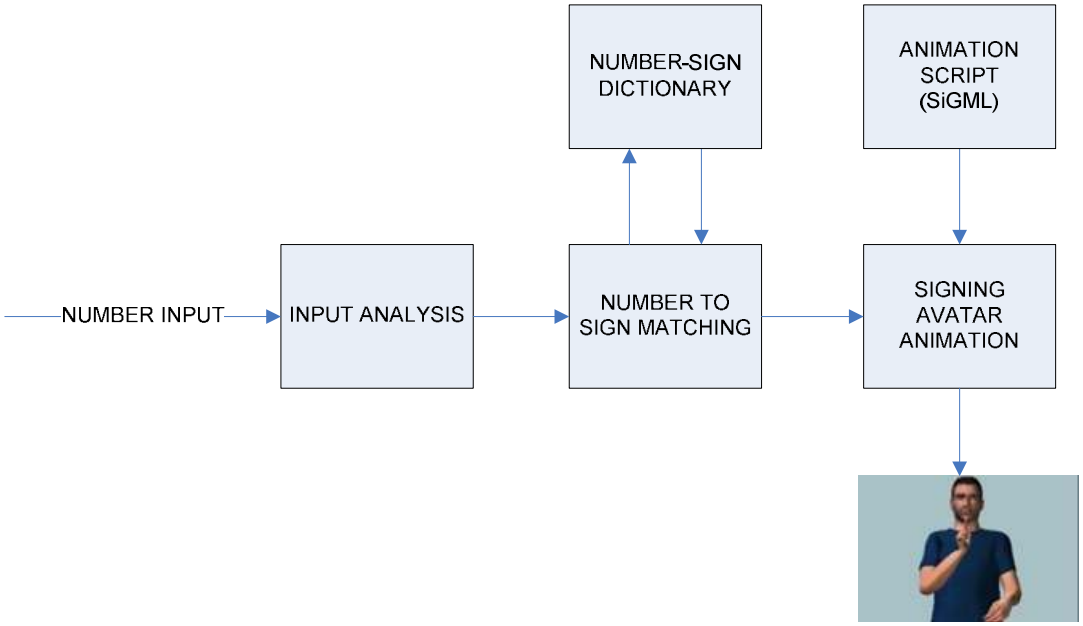


**Figure 4.11**Data flow sequence for number to ESL translation

The visual interface for the subsystem of AmESL-T which performs number translation is shown in figure 4.12. If the user enters basic number, the system looks up the number in sign dictionary and displays its sign representation. On the other hand, if the number is derived, the system decomposes the number into its basic forms. It then reads the animation code for each number and concatenates them according to the rules of ESL. For example, if the user enters '137', the number is converted to '100', '30' and '7'. The sign animation code corresponding to these numbers is read from file and concatenated based on the rule. Finally, it is fed to the avatar for signing. ESL uses distinct signs to represent the numbers '7', '30', and '100'.

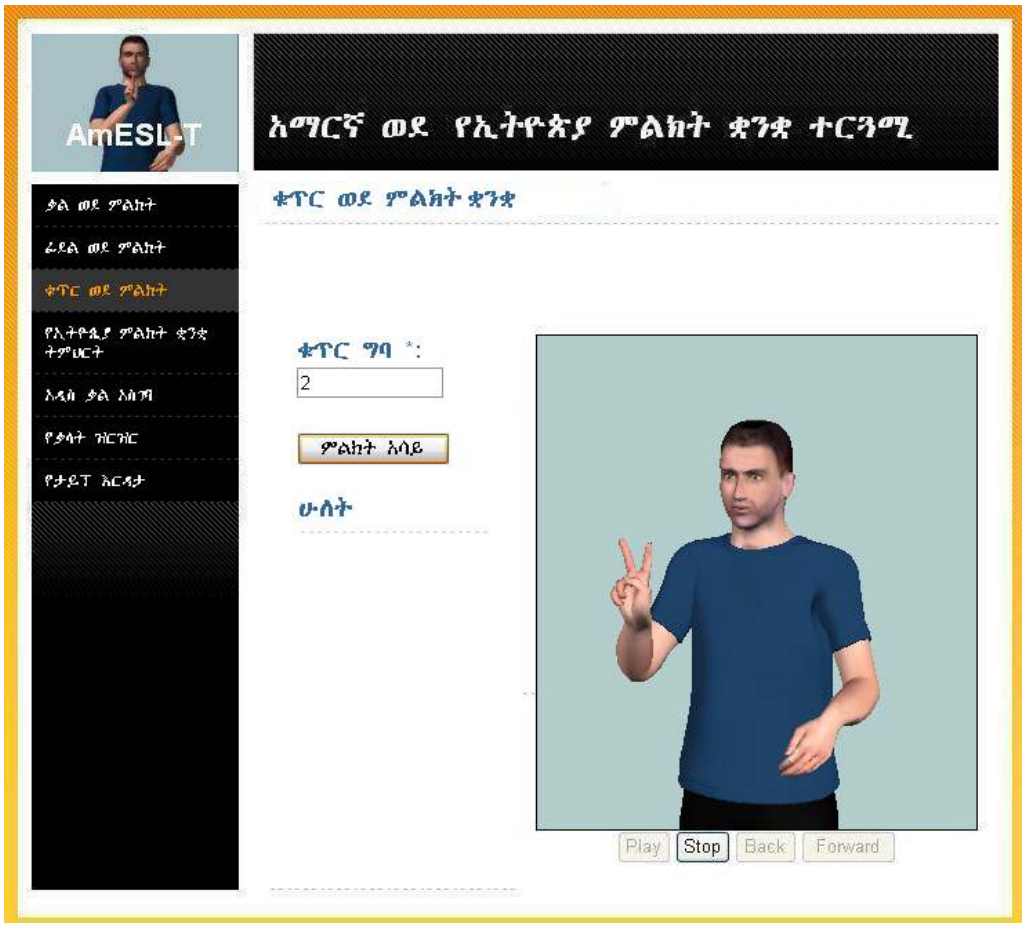


**Figure 4.12** Visual interface of number into ESL translation module

### 4.4.4 Addition of New Signs

AmESL-T also provides a facility that allows users to propose new signs and words. The user is expected to enter the word in Amharic script, its meaning in English and its part of speech. The word's English meaning is required in order to avoid ambiguity and correctly capture the meaning of the Amharic word. Some Amharic words have different meaning depending on constant lengthening. For example, the Amharic word '**ሳል**' can be interpreted as 'coughing' or 'drawing'. The user should also enter, the sign representation using a gesture description language known as HamNoSys. It is assumed that the user is familiar with the HamNoSys. HamNoSys is a phonetic transcription system for sign languages developed at the University of Hamburg (See Section 4.5.6).

New words and the corresponding sign representations are added effectively to the dictionary only after their verification. The proposed signs are first verified by an expert administering the system before their integration in the dictionary. This allows the sign dictionary to be created in an incremental way by users who propose new signs corresponding to words. Figure 4.13 shows AmESL-T's graphical interface for adding new words and their corresponding sign representation.


**Figure 4.13** Visual interface for Adding New Sign

## 4.5 Sign Animation with the eSIGN Avatar

### 4.5.1 eSIGN

The eSIGN (Essential Sign Language Information on Government Networks) European Project [45] constitutes one of the most important efforts in developing tools for automatically generation of sign language contents.

The main aim of the eSIGN project is to provide Deaf citizens in the partner countries with information of the local government on the internet, in sign. This information is usually already provided in writing and thus needs to be translated into the respective target sign languages.

In eSIGN project, the main results have been a 3D avatar (VGuido) with enough flexibility to represent gestures from the sign language, and a visual environment for creating gesture animations in an easy way. The tools developed in eSIGN were oriented to translate web content into sign language [29].

Sign language is the first language of many Deaf people, and their ability to understand written language may be poor in some cases. As such, it is very important for this group to have access to information in their first language, sign language. The result of the project is working on local Government websites in Germany, the Netherlands and United Kingdom [45].

### 4.5.2 Signing Avatar

An avatar is a virtual (i.e. 'synthetic') human which can be displayed on a computer screen [45]. The word 'Avatar' comes from the Hindu religion, where it means the manifestation of a Hindu deity in human, superhuman or animal form. The word derives from the Sanskrit "Avatara" meaning "descent". The eSIGN project uses a signing avatar, that is, an avatar which is capable of performing sign language sequences, given suitable descriptions of those sequences. These descriptions are expressed in SiGML, the notation for signing

avatars which was developed in the ViSiCAST project [46]. The official eSIGN avatar is called Virtual Guido, or VGuido for short [29] [45].

### 4.5.3 Sign Animation

The signs are represented by means of VGuido (the eSIGN 3D avatar) animations. An avatar animation consists of a temporal sequence of frames, each of which defines a static posture of the avatar at the appropriate moment. Each of these postures can be defined by specifying the configuration of the avatar's skeleton, together with some characteristics which define additional distortions to be applied to the avatar [47] (Figure 4.14).

**Figure 4.14** Example of VGuido animation [39]

In order to make an avatar sign, it is necessary to send to the avatar pre-specified animation sequences. A signed animation is generated synthetically from an input script in the Signing Gesture Markup Language (SiGML) notation (See section 4.5.6). SiGML is an XML application which supports the definition of sign sequences [30]. The signing system constructs human-like motion from scripted descriptions of signing motions. These signing motions belong to "Gestural-SiGML", a subset of the full SiGML notation, which is based on the HamNoSys notation for Sign Language transcription [34].

The concept of synthetic animation used in eSIGN is to create scripted descriptions for individual signs and store them in a dictionary [31]. Populating this database may take some time but considering a minimum amount of one hundred signs, it is possible to obtain signed phrases for a restricted domain. This process is carried out by selecting the required signs from the dictionary and assembling them in the correct order.

The major advantage of this approach is its flexibility: The lexicon-building task does not require special equipment, just a database. The morphological richness of sign languages can be modeled using a sign language editing environment (the eSIGN editor) without the need of manually describing each inflected form [30].

HamNoSys and other components of SiGML mix primitives for static gestures (such as parts of the initial posture of a sign) with dynamics (such as movement directions) by intention [47]. This allows the transcriber to focus on essential characteristics of the signs when describing a sign. This information, together with knowledge regarding common aspects of human motion as used in signing such as speed, size of movement, etc., is also used by the movement generation process to compute the avatar's movements from the scripted instructions. Figure 4.15 shows the process for specifying a sign from the HamNoSys description.

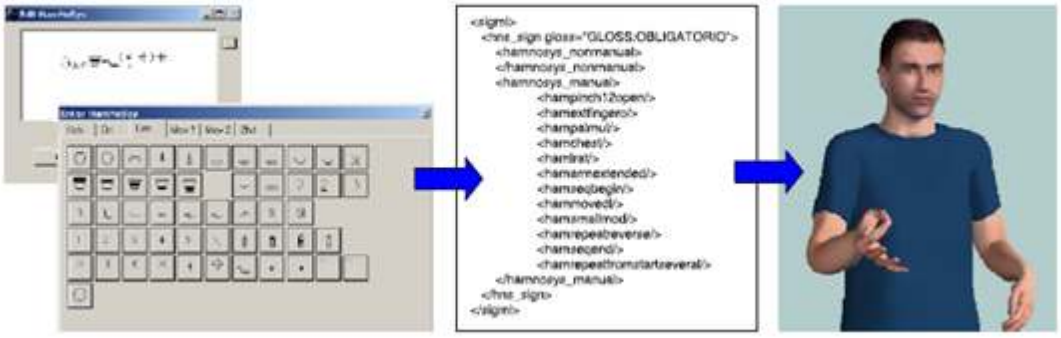

**Figure 4.15** Process to generate signs with the avatar [47]

### 4.5.4 Why is eSIGN software better than videos of signers?

Sign language can be displayed on websites using video, and this method is usually satisfactory to Deaf people, especially those who have access to fast Internet connections [29] [30]. However, there are some difficulties with this means of providing information:

• Videos must be well-produced and of high quality, which is expensive for the content provider.

• Each time content changes new videos must be made, increasing the costs further.

• There are continuity issues. Making videos consistent, i.e. using the same signer, in the same clothing and with the same background, so that signed phrases may be joined together, complicates the content maintenance process.

• Storage and download of videos can also be problematic as video files tend to be large. For home users on dial-up connections the time and cost involved in download of video sequences may be prohibitive.

Virtual human signing, as provided by the eSIGN signing avatar, can thus be a more effective alternative to videos as a means of presenting signed information on the Internet.

The avatar software needs to be installed by the user before virtual signing can be accessed. This is offered either as a free download or CD-ROM. The signed content is placed on the server of the provider. Since it consists of SiGML files (a form of XML), which are very much smaller than videos, the amount of storage space required on the server is minimal, and download time for the users is very fast [30].

Another advantage of virtual human signing over video is that it is more user-friendly [30]. A user can browse more quickly through information, control the speed of signing and change the view angle of the virtual signer, things which are not possible with videos.

### 4.5.5 eSIGN editing environment

The eSIGN editor software allows the user to compose signed text to be performed by the eSIGN Avatar. An eSIGN editor document represents a signed text. The signed text is represented by sequences of glosses parallel to the (optional) spoken language text that serves as the translation basis [49]. For creating the signed contents, each utterance is handled separately. In order to create or modify an utterance, the user opens a window to specify the sequence of signs (See figure 4.16 below).

The eSIGN editor gives the user an economic approach to creating signed sequences by selecting signs from the lexicon and then modifying them with the assistance of specialized editors (that focus on different aspects of the sign's phonetics and morphology) where necessary [49] [30]. These include pronunciation databases to ease the description of mouth pictures and mouth gestures. In some instances, mouthing instructions can be edited, or added if they were not stored alongside the sign in the database.

In the eSIGN editor it is also possible to add any necessary facial expressions, body movements and pauses, or to alter the position or location of a sign [30]. While "writing" the signed text, the user has the possibility to immediately check the contents by sending the text to the Avatar. If a sign looks different from what is expected, HamNoSys experts will check the HamNoSys string in the file. If necessary, the transcription of a sign is corrected [49].

It is possible to alter signs that are retrieved from the database. For example it may be necessary to change the HamNoSys string so that a sign performance suits the given context. Signs that are not in the dictionary are transcribed in HamNoSys and may be entered into the dictionary.

The user can also insert pauses in the signed texts which results in a much more natural signing style. The editor now also has the functionality to add URLs and link the text with illustrations that will be displayed on the webpage simultaneously with the signing.

The tool is delivered for Windows 32bit and Mac OS platforms in three user interface languages (German, English, and Dutch) [30]. Modules to support features specific to individual sign languages (such as fingerspelling and counting) can be plugged in. The figure below shows the different fields of the editor.

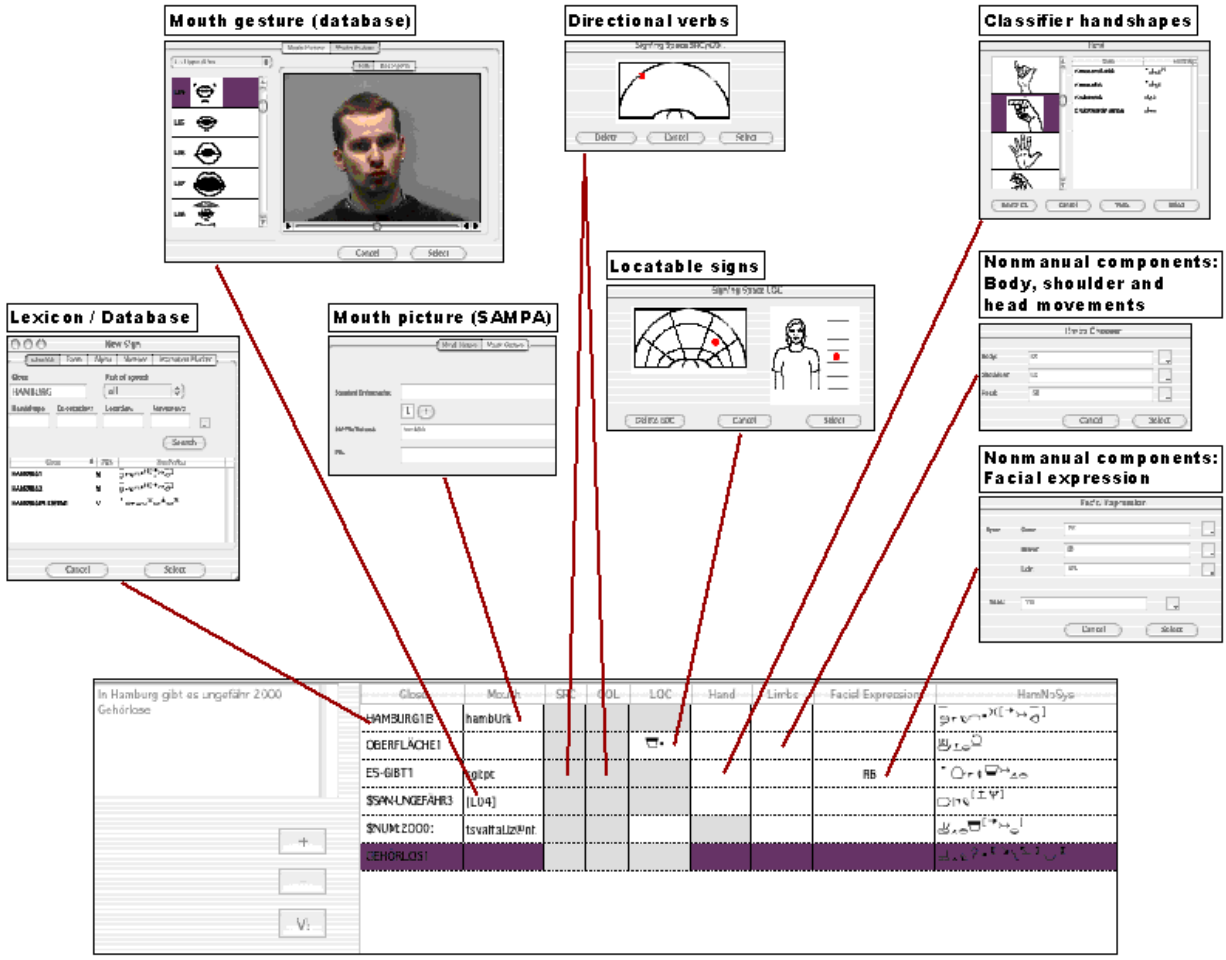


**Figure 4.16** The eSIGN editor showing the different fields of the editor [49]

### 4.5.6 HamNoSys and SiGML

*HamNoSys* – the *Hamburg Notation System* – is a well established phonetic transcription system for sign languages developed at the University of Hamburg [34]. A font was designed for use on the computer. Each sign language has its own grammatical structure – it is *not* an alternative form of some spoken language. But sign language phonetics are visual, not aural. Sign language is articulated primarily by the *hands*, but also using the head and face. Because HamNoSys describes sign language phonetics it can represent signing expressed in *any* sign language [34].

Let us take an example from German Sign Language meaning “house”:

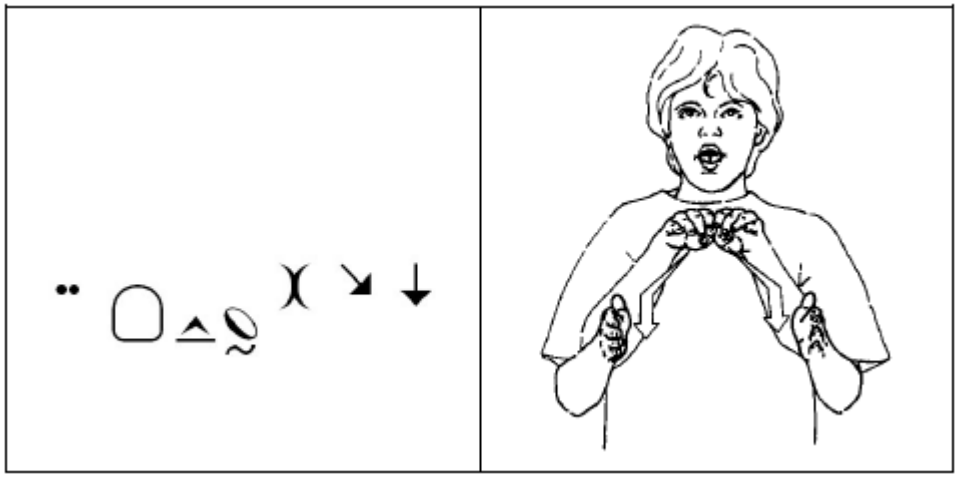

**Figure 4.17**HamNoSys notation and illustration of the DGS sign for ‘house’ (The two flat hands indicate a roof and a wall each)

The first symbol ( ) signals that the sign is two-handed symmetrical. The second symbol ( ) means a flat handshape, followed by two symbols ( ) (plus a subscript) for the orientation of the right hand at the beginning of the sign [50]. The description of the initial posture concludes with a contact symbol ( ), meaning that the two hands are in contact with each other. Two arrows finally describe the movements to be performed ( ). This sign is often accompanied by a mouthing that is derived from the German word “Haus” (house), so a description of the sequence of visemes (visible phonemes) for “Haus” is stored in the lexical entry together with the manual activity [50].

The HamNoSys transcription system originally focused on the manual part of signs. Additional transcription symbols for the non-manual part were developed in ViSiCAST, since the non-manual part of signing is as important in signing as the manual part. The transcription system for the non-manuals contains codes for several positions and movements of body parts (shoulders, back, chest), head, and face (eyebrows, eyes, nose, lips, tongue and lower jaw). These are currently implemented in eSIGN [45] [30].

With this system all of the sign components can be given specific values. It is not possible for computers to process the transcriptions as such and these, therefore, need to be translated in a language that is amenable to computer processing. To this aim, an XML encoding of HamNoSys was designed at the University of East Anglia: Signing Gesture Markup Language or SiGML, and a translator was written from HamNoSys to SiGML [45]. Together with a description of the geometry of the avatar, animation data can be sent to the avatar, who then makes the requested sign(s).

SiGML allows sign language sequences to be defined in a form suitable for performance by a *virtual human*, or *avatar*. The signing avatar can be displayed on a computer screen, or on other mobile devices.

SiGML, the avatar's "native language", is an XML encoding of all the information needed to describe signs. XML is represented as plain text – hence it is easily transported over the Internet and World-Wide Web (WWW) from the servers to the signing avatar clients [45]. This avoids having to download large video clips. The SIGML feeds the Avatar that resides on user's PC. The most important technical influence on the SiGML definition is *HamNoSys* – a notation for sign language phonetics.

The HamNoSys notation is the basis, but not the sole component of SiGML. The eSIGN editor creates SiGML that feeds the Avatar. A number of Editing Tools for SiGML are available, mostly produced by the University of Hamburg [48].

Below is the SiGML corresponding to the HamNoSys example on the left:

**Table 4.6** HamNoSys transcription and SiGML translation of the ESL sign for Amharic letter 'ሸ' [31]

| SiGML | HamNoSys |
|---|---|
|  | <sigml><br><hns_sign gloss=""><br><hamnosys_manual><br><hamflathand/><br><hamextfingeru/><br><hampalmd/><br><hamshouldertop/><br><hamlrat/><br></hamnosys_manual><br></hns_sign><br></sigml> |

Since avatar signing is driven by the combination of SiGML (on particular web pages) and the avatar descriptions (in the avatar software), it is not necessary to install a database of signs and reinstall a new one every time new animated signs become available [30].

### 4.6 AmESL-T Database

AmESL-T uses database to store information about Amharic words, letters and numbers for translation to ESL. Microsoft Access was chosen as the storage solution of choice. Microsoft Access databases are portable, easy to access, use and deploy and were an ideal choice for AmESL-T system. It is great for working on small to medium size applications.

The AmESL-T database currently has five tables namely: WORD, HANDSHAPE, HANDMOVEMENT, NUMBER, and PROPOSED WORDS. These tables are used as word-sign, letter-sign, and number-sign dictionary.

The dictionary currently contains around 50 Amharic words, 34 letters and 30 numbers taken mostly from ESL dictionary and other sign language text books. The creation of the dictionary content can be made in an incremental way by users who propose new signs corresponding to words. A word and its corresponding sign representation are added effectively to the dictionary after its verification by an expert administering the system.

In the database, along with the Amharic word, its English meaning, Part of Speech, and the file name of the animation script (SiGML) are stored. The animation scrip is used to generate a complete ESL sign. This includes position, orientation and shape of the hands as well as motions that comprise a sign. In figure 4.18, the database tables are depicted.

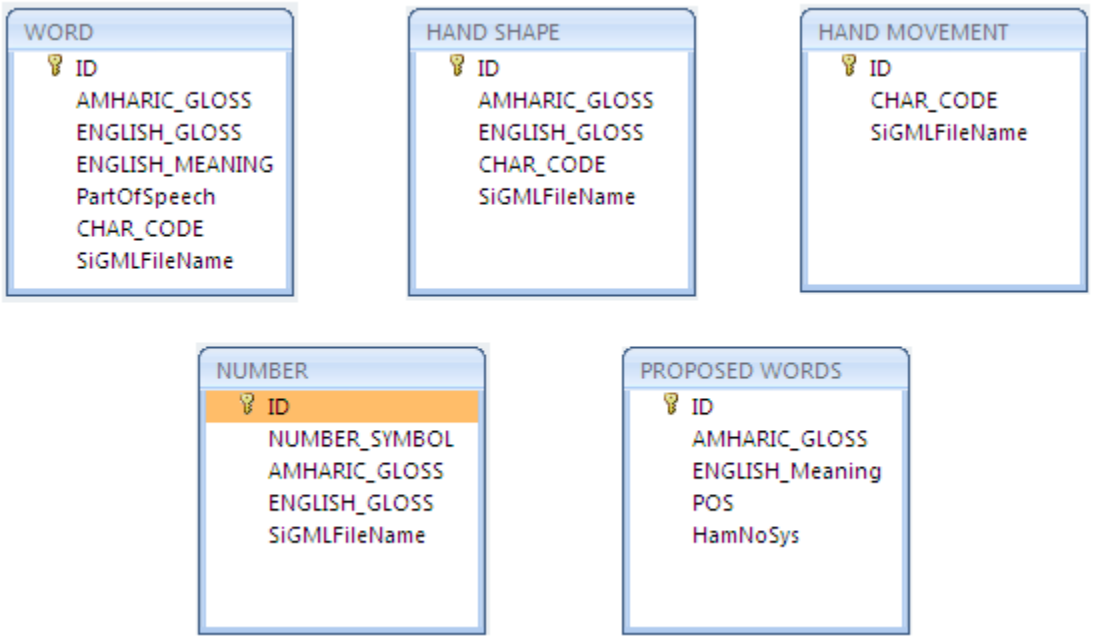


**Figure 4.18** Database Tables for AmESL-T

For the purpose of this prototype, common Amharic words were selected but this can be expanded to give translation for various domains and areas. The system is easily expandable as all what is needed is to add signs to the dictionary. Signs that are not in the dictionary are transcribed in HamNoSys and converted to SiGML file and the word and the file name

is entered into the dictionary. New signs are entered into the dictionary with Amharic gloss name.

The avatar's performance is examined and if a sign looks different from what is expected, edits can be made. HamNoSys will be checked and if necessary, the transcription of a sign is corrected.

Many more words need to be added to the underlying dictionary to accommodate a wider range of input words. An already developed ESL corpus is not currently available. Transcription of sign is a time consuming process. And this is the main reason for the small size of the dictionary.

### 4.7 Evaluation and Discussion of Results

One of the major challenges for building any sign language translation system is evaluating it. In general, there are two ways to evaluate sign language translation output. First, one can use human judgment to assess the translation quality. This method is considered the most reliable way to evaluate any translation system. However, it is expensive and time consuming [51].

Second, one can use existing automatic evaluation techniques. The standard techniques are, however, designed to evaluate natural language, which has different representation. Natural language representation is linear, while sign language is multi-linear [51]. AmESL-T is evaluated based upon the measurement of two areas of performance: Quality of signing and subjective opinions.

#### 4.7.1AmESL-T Evaluation

Two deaf and two ESL interpreters took part in the evaluation of the AmESL-T. The users from these groups were chosen in order to explore the variation in signing. Once they used the system, they were provided with a questionnaire designed to evaluate the system.

#### 4.7.1.1 Quality of Signing

The quality of the signing was measured in two ways: intelligibility of signs and acceptability of signs to users. While measurement of intelligibility of signs is objective, acceptability of sign is subjective [52].

**Intelligibility**

The participants were presented with selected signed words, letters and numbers and asked to write down what they understood. 30 words, 34 letters and 20 numbers were selected randomly for this purpose. The signs were presented on the screen without any textual description.

On the basis of written responses from each user, accuracy of identification of signs is determined. Once the users' response has been scored for accuracy of identification of signs, each user was re-presented with the sign of each word, letter and number not identified correctly along with a textual description of the intended word, letter or number.

**Figure 4.19** shows the accuracy of identification of words, letters and numbers across four users. The average accuracy of identification was 51% for words, 76% for letters and 80% for numbers.

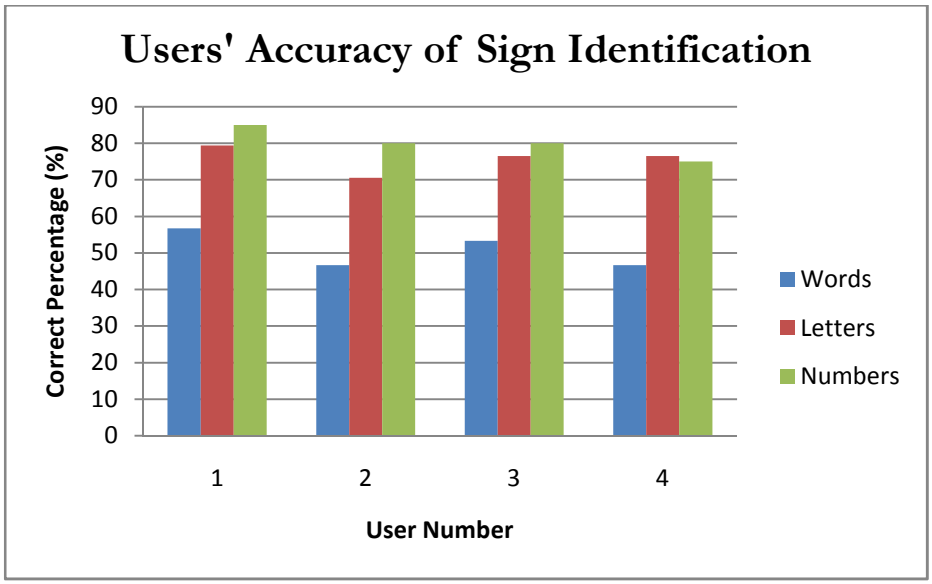


**Figure 4.19** Users' Accuracy of Sign Identification

The users were asked (Deaf users were asked with the help of an interpreter) to indicate whether the signs were considered inappropriate or just not clear. Any signs considered inappropriate were not necessarily wrong; rather they may have represented different regional variations in sign to those used by the users.

Subsequent analysis of the sign units which were wrongly identified indicated that on average 25% of errors were due to signs considered inappropriate and the remaining 75% were due to unclear signing.

These results suggest that regional variations or differences in personal signing style may have played a role in word, letter and number intelligibility. In future, it may also be more appropriate to use more than four people from a range of Ethiopian regions to assess sign quality.

**Acceptability**

Participants were asked to rate how acceptable the words, letters and numbers were as an example of ESL on a 3-point scale (1="Low" 2="Medium", 3="High"). Table 4.8 shows the percentage of words, letters and numbers that were rated in each category of acceptability.

**Table 4.7** The percentage of words, letters and numbers rated in each category of acceptability

| ACCEPTABILITY RATING | | % WORDS | % LETTERS | % NUMBERS |
|---|---|---|---|---|
| HIGH | 3 | 33.3 | 35.0 | 35.3 |
| MEDIUM | 2 | 46.7 | 50.0 | 50.0 |
| LOW | 1 | 20.0 | 15.0 | 14.7 |

Ratings of acceptability given across the scale indicated that 34.5% of signs (words, letters, and numbers) were rated as highly acceptable. While 48.9% of the signs were rated as medium level of acceptance, 16.6% of the signs were rated to have low level of acceptance.

If we compare the percentage of acceptability of words, letters and numbers, high level acceptance rating is greater for numbers; middle level acceptance rating is larger for letters and numbers. Moreover, it is observed that low level acceptance rating is large for words.

The above figure indicates that there is scope for improving the quality of the avatar's signing. This can be improved by correcting HamNoSys transcription of a sign to correctly convey the meaning in sign language.

**4.7.1.2 Subjective Opinions**

Questionnaires to both deaf participants and sign language interpreters were used to obtain subjective views of the translation system. The questioner was prepared in Amharic language (Refer to Sample questionnaire in Appendix II).

The small sample size (two deaf users and two sign language interpreters) makes interpretation of the questionnaires problematical.

The users were asked about ease of use of the translation system, presentation of signs and their satisfaction and general comments on the translation system. Responses indicated that AmESL- T has an easy to use interface. The users also regarded the presentations of the signs as understandable and acceptable. Generally, the responses to the questions posed to the users' showed that they responded positively to AmESL-T.

The participants provided much constructive feedback about how AmESL-T could be improved. Their main points were: Text analysis functionality needs further improvement, facial expressions need to be improved, clearer handshapes, finger configurations and lip patterns are required, especially for numbers and fingerspelling. All users said that they support the idea of the system and are interested to use the system.

# CHAPTER FIVE

# CONCLUSION AND FUTURE WORK

## 5.1 Conclusion

In this thesis, a method to design and develop software for automatic translation of Amharic text into Ethiopian Sign Language (ESL) has been reported. The translation of written text could prove invaluable to members of the Deaf community, particularly in areas of low interpreter availability.

Sign language animation through an avatar is a potentially promising method for presenting information in sign language. AmESL-T (text-to-sign translator) uses 3D avatar technology for presenting signs of ESL.

ESL is complete in both signing and fingerspelling. Signing includes the conceptual sign expressions which are dominantly applied to convey meaning in ESL. AmESL-T has successfully incorporated both the fingerspelling and conceptual expression in a single application. By doing this, it has contributed to the existing knowledge in this field.

Present architecture of the software can be followed in similar development for other sign languages as well. It can be more easily scaled up to handle large vocabularies and linguistic phenomena.

By translating Amharic text into Ethiopian Sign Language, AmESL-T provides a one way interface for communication. The ultimate sign language interface tool, however, would be one that could recognize sign language input while also having the ability to output sign language from Amharic. Such a tool would allow easy interaction between deaf signers and hearing speakers. It would also allow deaf signers natural and easy access to computers and other devices. However, a great deal of research remains to be done to make this tool a reality.

The developed system (i.e. AmESL-T) constitutes the first phase of building a system that allows communication in both directions. Up on completion, AmESL-T can be integrated with a system that generates Amharic text from sign language to permit full dialog between a hearing person and a deaf person.

### 5.2 Future Work

This research has successfully designed a tool for translating Amharic text to ESL using an avatar technology. By doing this, it has contributed to the existing sign language research. However, it can easily be observed that translator has some drawbacks that may initiate further research in the area.

In relation to technical future work, a very important line of research would be the one related to the improvement of the text analysis, quality of the signing and expansion of the sign dictionary.

The following possible recommendations are forwarded by the author.

- AmESL-T's text processing capability need to be improved in order to increase its translation capacity and make the translation as extensive as required. This would become a reality when linguistic tools for Amharic became available.
- Based on the evaluation results, some aspects of AmESL-T need further work on improving the naturalness of the signs. These include improvement of the avatar's facial expression. Moreover, clearer handshapes, finger configurations and lip patterns are required, especially for numbers and finger-spelling.
- AmESL-T currently gives translation for Amharic words, letter and numbers. The system need to be extended in order to provide translation service for Amharic phrases, sentences and documents.
- The underlying dictionary of the AmESL-T is required to be enriched and expanded to accommodate a wider range of Amharic input.

- The system should be evaluated with standard techniques and with more number of native ESL users.
- AmESL-T should be broadened to include additional functionality like ability testing module. This enables the user to assess his/her ESL skill. The author believes that this additional functionality is a necessary in the signed language learning process. The testing may consist of showing random signs and asking the user to tell what the sign represents.
- In order to permit a full dialogue (allowing communication in both directions) between a hearing person and a deaf person, it is necessary not only to translate Amharic text into sign language but also to generate Amharic text from sign language. As a result, the author recommends the development of a method to recognize gestures of ESL and translate them to Amharic text to complement the existing research gap.

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## APPENDICES

**Appendix I.** Sample Questionnaire for Assessing Communication Gap and Other problems

**አዲስ አበባ ዩኒቨርሲቲ**

**ኢንፎርማቲክስ ፋኩልቲ**

**በኮምፒውተር ሳይንስ ትምህርት ክፍል**

**ድህረ ምረቃ ትምህርት ክፍል**

**ሚዛ ለተሳናቸው የተዘጋጀ ማጠይቅ**

የዚህ ማጠይቅ አላማ ሚዛ የተሳናቸው ሰዎች ከሚሰሙ ሰዎች ጋር በሚያጋጥሟቸውን የመግባባት ችግር ለመዳሰስና አማራጭ መፍትሄ ለማጀት ነው፡ይህ ማጠይቅ ለዩንቨርሲቲ ጥናትና ምርምር የሚውል መሆኑን እያረጋገጥኩ ለሚሰጠኝ ትክክለኛ መረጃ በቅድሚያ አመሰግናለሁ::

**<u>መመሪያ:</u>** በባዶ ሳጥን ውስጥ የ'X' ምልክት በማስቀመጥ ወይንም ተገቢውን መልስ በመጻፍ ይመልሱ::

<u>I. Questions to assess the Communication Problems between Deaf and Hearing people</u>

1.) ከዚህ በፊት ሚዛ ከተሳናቸው ሰዎች ጋር የመግባባት አጋጣሚ ነበርዎት?

☐ አዎ ☐ አልነበረኝም

2.) አዎ ካሉ፤የመግባባት ችግር ገጥሞት ነበር?

☐ አዎ ☐ በጭኑ ☐ አልገጠመኝም

3.) ከሚከተሉት የመግባቢያ ዘዴዎች መካከል ሚዛ ከተሳናቸዉ ጋር ለመግባቢያነት የቱን ይጠቀማሉ?

☐ በኢትዮጵያ ምልክት ቋንቋ ☐ በአስተርጓሚ

☐ በከንፈር እንቅስቃሴ ☐ በፅሑፍ ☐ ሌላ (ይጥቀሱ)_____

4.) የቱን የመግባቢያ ዘዴ ማጠቀም ይፈልጋሉ?

☐ በኢትዮጵያ ምልክት ቋንቋ ☐ በአስተርጓሚ

☐ በከንፈር እንቅስቃሴ ☐ በፀሐፍ ☐ሌላ

5.) የምልክት ቋንቋ ይችላሉ?

☐ አዎ ☐ በጣኩ ☐ አልችልም

6.) የምልክት ቋንቋ መማር/ማዳበር ይፈልጋሉ?

☐ አዎ ☐ አልፈልግም

7.) የምልክት ቋንቋ ተርጓሚ በተፈለገው ጊዜና ቦታ ያገኛሉ?

☐ አዎ ☐ አላገኝም

8.) በኢትዮጵያ ወስጥ ያለው የምልክት ቋንቋ ወጥ ነው ብለው ያምናሉ?

☐ አዎ ☐ አላወቅም ☐ አላምንም

9.) ወጥ አይደለም የሚሉ ከሆነ ምክንያቱ ምንድን ነው ብለው ያስባሉ?

☐ ወጥ የሆነ የኢትዮጵያ ምልክት ቋንቋ ማስተማሪያ በስፋት ስለማይሰጥ

☐ የኢትዮጵያ ምልክት ቋንቋ በሰፊው አለማሳራጨት

☐ ሌላ ( ይጥቀሱ)_____

10.) የኢትዮጵያ ምልክት ቋንቋ ስልጠና በበቂ ሁኔታ እየተሰጠ ነው ብለው ያምናሉ?

☐ አዎ ☐ በጣኩ ☐ አላምንም

11.) የምልክት ቋንቋ ትምህርት ሞጂ መጻሕፍት (ለምሳሌ የምልክት ቋንቋ መዝገበ ቃላት) በበቂና በአነስተኛ ዋጋ ገበያ ላይ ያገኛሉ?

☐ አዎ ☐ በጣኩ ☐ አነስተኛ

12.) መሳማት የተሳናቸው ከሚሰማ የህብረተሰብ ክፍሎች በተገቢ ሁኔታ መግባባት እንዲችሉ ምን ቢደረግ ይመክራሉ?

☐ የምልክት ቋንቋ ስልጠና ማስፋፋት ☐ ተርጓሚዎችን በስፋት ማሰማራት

☐ የትምህርት ሞጂ መሳሪያዎችን ማስፋፋት ☐ ፍ መግባባት ቢለመድ ሌላ__☐

## II. Questions to assess requirement for the design of text to sign translation system

13.) የምልክት ቋንቋ መማር የሚፈልጉ ከሆነ የትኛዉን የመማሪያ መንገድ ይመርጣሉ?

☐ በክፍል ወስጥ የምልክት ቋንቋ ስልጠና መወሰድ

☐

አመቺ በሆነ ጊዜና ቦታ ጽሑፍ ወደ ምልክት ተርጓሚ ኮምፒውተር ፕሮግራም ማጠቃም

☐ የምልክት ቋንቋ መዝገበ ቃላትን ማጥናት ☐ ሌላ (ይጥቀሱ) _____

14.) ጽሑፍን ወደ ምልክት ቋንቋ የሚረጉም የኮምፒውተር ፕሮግራም ምን ጠቀሜታ ይኖረዋል ብለው ያስባሉ?

☐ በቀላሉ እና በፍጥነት የምልክት ቋንቋን ለሚር ይረዳል

☐ የምልክት ቋንቋን ወጥ በሆነ መልኩ በሰፊው ለማሰራጨት ይረዳል ሌላ (ይጥቀሱ) _____

15.) ይህ የኮምፒውተር ፕሮግራም የምን ትርጓሜ ቢኖረው ይመርጣሉ?

☐ ዐረፍተ ነገር ☐ ሓረግ ☐ ቃል ☐ ፊደል ☐ የቁጥር

16.) ይህ የኮምፒውተር ፕሮግራም በምን መልኩ ቢሆን ይመርጣሉ?

☐ በኮምፒውተር ላይ የሚጫን ሶፍትዌር መልኩ

☐ በኢንተርኔት ድህረ-ገጽ በሚኝ መልኩ ☐ ሌላ (ይጥቀሱ) _____

17.) የኮምፒውተር ፕሮግራሙ የምልክት ቋንቋወን በምን መልኩ ቢያሳይ ይመርጣሉ?

☐ በምስል ☐ በቪድዮ ☐ በአቫተር (ኮምፒውተር አኒሜሽን) ☐ ሌላ (ይጥቀሱ) _____

18.) ኮምፒውተር የማጠቃም መሰረታዊ ዕውቀት አሎት?

☐ አዎ ☐ በማጡ ☐ የለኝም

19.) የኢንተርኔት አገልግሎት ተጠቃሚ ኖት?

☐ አዎ ☐ በማጡ ☐ አይደለሁም

20.) የኮምፒውተር / የኢንተርኔት የማጠቃም አገልግሎት ያገኛሉ?

☐ አዎ ☐ አልፎ አልፎ ☐ አላገኝም

## III. Additional Comments

**Appendix II**. Sample Questionnaire for AmESL-T Evaluation

**አዲስ አበባ ዩኒቨርሲቲ**

# ኢንፎርማቲክስ ፋኩልቲ

# በኮምፒውተር ሳይንስ ትምህርት ክፍል

# ደህረ ምረቃ ትምህርት ክፍል

ይህ ማጠይቅ ለዩንቨርሲቲ ጥናትና ምርምር የሚውል ሲሆን ዐላማውም አማርኛ ቃል/ፊደል ተቀብሎ ወደ ኢትዮጵያ ምልክት ቋንቋ የሚተረጉም የኮምፒውተር ፕሮግራምን ለመገምገም ነው፡፡ ይህ ፕሮግራም ምልክቶችን በኮምፒውተር አኒሜሽን (animation) ቴክኖሎጂ በማቀም የሚያሳይ ነው፡፡ ይህን ማጠይቅ የሚሞሉት የኮምፒውተር ፕሮግራሙን ከተጠቀሙ በኋላ ነው፡

ለትብብሮ በቅድሚያ አመሰግናለሁ።

**N.B** በዚህ ማጠይቅ ውስጥ አቫተር የሚለው ቃል የሚወክለው በኮምፒውተር ፕሮግራሙ ላይ ምልክት የሚያሳየውን ነው፡፡

***<u>መመሪያ</u>***

በባዶ ሳጥን ውስጥ የ'**X**' ምልክት በማስቀመጥ ወይንም ተገቢውን መልስ በመጻፍ ይመልሱ::

1.) ለትርጓሜ የተጠቀማቸትን ቃላት፡ ፊደል እና ቁጥር ያስፍሩ

| ቃላት | ፊደል | ቁጥር |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

2.) ከተጠቀማቸው ቃላት፡ ፊደል እና ቁጥር የኮምፒውተር ፕሮግራሙምን ያህሉን በትክክል ተርጉሟል?

| | ሙሉ በሙሉ | ግማሽና ከዚያ በላይ | ከግማሽ በታች |
|---|---|---|---|
| ቃላት | | | |
| ፊደል | | | |
| ቁጥር | | | |

3.) የአቫተሩ የእጅ ምልክት: እንቅስቃሴ እና የፊት ገፅታ ምልክቶቹን በትክክል ይገልፃል?

አዎ በጣሙ አይገልጽም

4.) አቫተሩ በትክክል የሚገልፅውን ቃላት፡ ፊደልና ቁጥር ካለ ይግለፁ

| | ቃላት | ፊደል | ቁጥር |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

5.) የኮምፒውተር ፕሮግራሙን አቀራረብ/ገፅታ እንዴት አገኙት?

☐ ጥሩ ☐ መጠነኛ ☐ ጥሩ አይደለም

6.) የኮምፒውተር ፕሮግራሙ ለመዩርገም የሚወስደውን ጊዜ እንዴት ይገልፁታል?

☐ አጭር ጊዜ ☐ መጠነኛ ☐ ረዥም ጊዜ

7.) የኮምፒውተር ፕሮግራሙን ለመጠቀም ያስቸግራል?

☐ አዎ ☐ በመጠኑ ☐ አያስቸግርም

8.) አዎ ካሉ ምኑ ምኑ እንዳስቸገሮት ይግለጹ?

9.) የኮምፒውተር ፕሮግራሙን በድጋሚ መጠቀም ይፈልጋሉ?

☐ አዎ ☐ በመጠኑ ☐ አልፈልግም

10.) የኮምፒውተር ፕሮግራሙን ሃሳብ ይደግፉታል?

☐ አዎ ☐ መጠኑ ☐ አልደግፈውም

11.) የኮምፒውተር ፕሮግራሙን ጠቀሜታ እንዴት ይገጹታል?

☐ ይጠቅሟል ☐ መጠኑ ☐ አይጠቅምም

12.) በተረዱት መሰረት የፕሮግራሙን ሃላማ ያስቀምጡ

13.) ከኮምፒውተር ፕሮግራሙ ጋር በተያያዘ ተጨማሪ አስተያየት ካሎት ይግለጹ

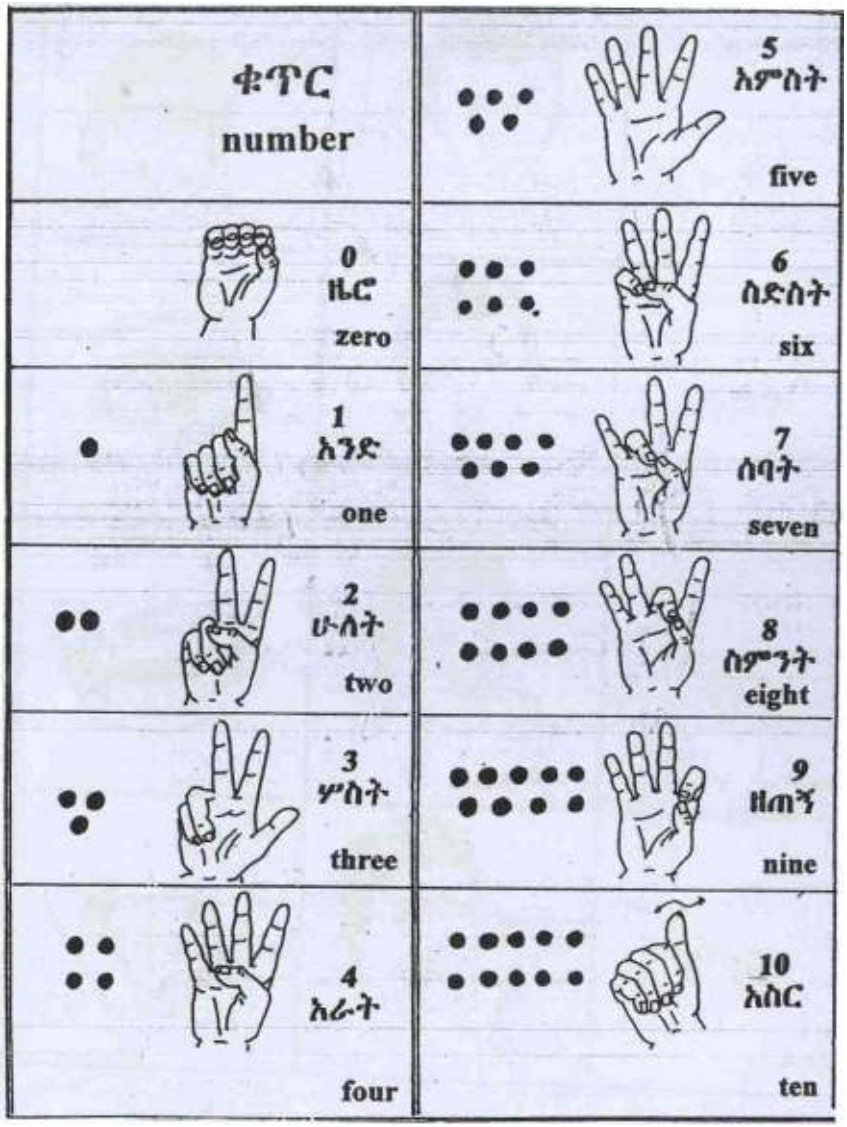
**Appendix III**. Guide to Typing in Amharic Script

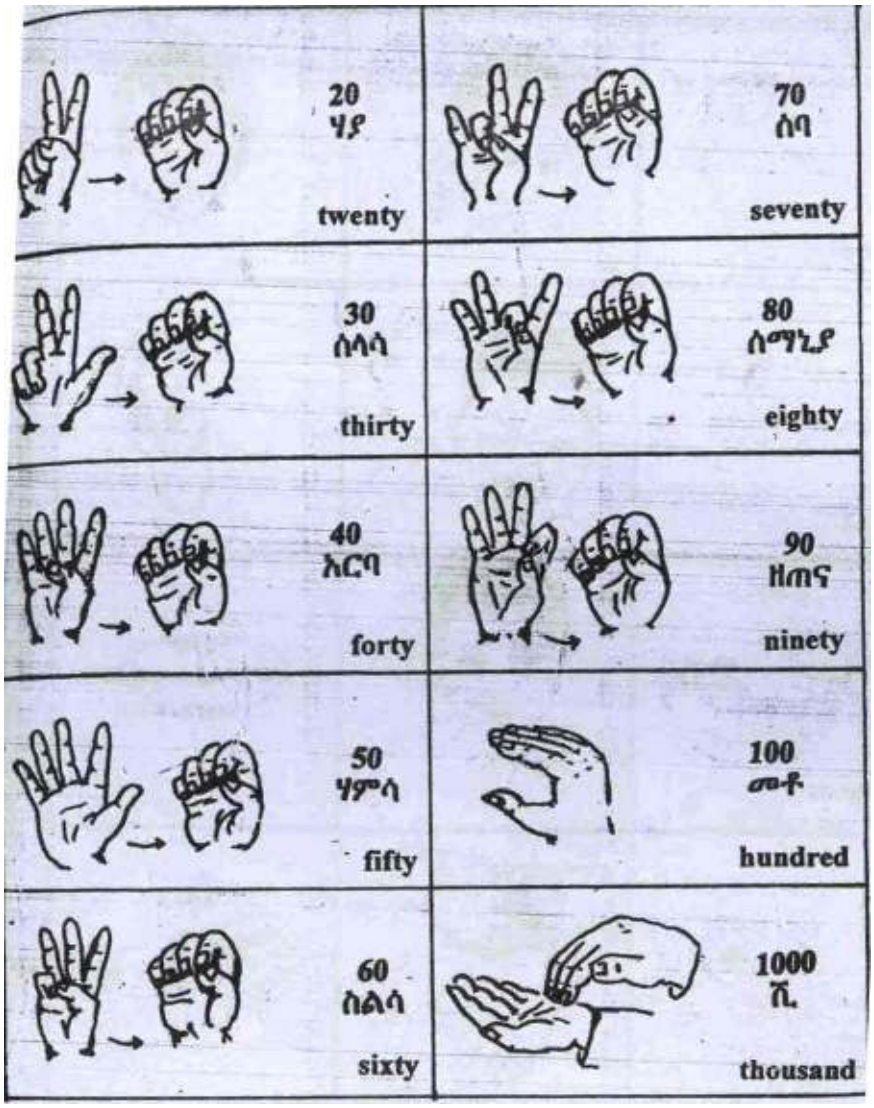
## 'የአሜርኛ አጻጻፍ መምሪያ'

| Vowel Order | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | |
|---|---|---|---|---|---|---|---|---|
| | e | u | i | a | E | | o | W |
| | | | | | | | | |
| H | ሀ | ሁ | ሂ | ሃ | ሄ | ህ | ሆ | |
| Hh | ሐ | ሑ | ሒ | ሓ | ሔ | ሕ | ሖ | |
| Hhh | ኀ | ኁ | ኂ | ኃ | ኄ | ኅ | ኆ | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S | ሰ | ሱ | ሲ | ሳ | ሴ | ስ | ሶ | ሷ |
| Ss | ሠ | ሡ | ሢ | ሣ | ሤ | ሥ | ሦ | ሧ |
| | | | | | | | | |
| S | ሸ | ሹ | ሺ | ሻ | ሼ | ሽ | ሾ | ሿ |
| | | | | | | | | |
| Q | ቀ | ቁ | ቂ | ቃ | ቄ | ቅ | ቆ | |
| | | | | | | | | |
| C | ቸ | ቹ | ቺ | ች | ቼ | ች | ቾ | ቿ |
| C | ቨ | ቩ | ቪ | ቫ | ቬ | ቭ | ቮ | ቯ |
| | | | | | | | | |
| N | ነ | ኑ | ኒ | ና | ኔ | ን | ኖ | ኗ |
| N | ኘ | ኙ | ኚ | ኛ | ኜ | ኝ | ኞ | ኟ |
| | | | | | | | | |
| a,u,i,A,E,e | አ | ኡ | ኢ | ኣ | ኤ | እ | ኦ | |
| aa, uu… | ዐ | ዑ | ዒ | ዓ | ዔ | ዕ | ዖ | |
| | | | | | | | | |
| K | ከ | ኩ | ኪ | ካ | ኬ | ክ | ኮ | |
| K | ኸ | ኹ | ኺ | ኻ | ኼ | ኽ | ኾ | |
| | | | | | | | | |
| T | ተ | ቱ | ቲ | ታ | ቴ | ት | ቶ | ቷ |
| T | ጠ | ጡ | ጢ | ጣ | ጤ | ጥ | ጦ | ጧ |
| | | | | | | | | |
| P | ፐ | ፑ | ፒ | ፓ | ፔ | ፕ | ፖ | |
| P | ጰ | ጱ | ጲ | ጳ | ጴ | ጵ | ጶ | |
| | | | | | | | | |
| X | ፀ | ፁ | ፂ | ፃ | ፄ | ፅ | ፆ | |
| X | ጸ | ጹ | ጺ | ጻ | ጼ | ጽ | ጾ | ጿ |
| | | | | | | | | |
| qW | ቈ | ቍ | ቊ | | ቋ | | | ቌ |
| hW | ኈ | ኍ | ኊ | | ኋ | | | ኌ |
| kW | ኰ | ኵ | ኲ | | ኳ | | | ኴ |
| gW | ጐ | ጕ | ጒ | | ጓ | | | ጔ |
| | | | | | | | | |
| ፣ = , ፡ = : : ፤ = ; | | | | | | | | |

**Appendix IV.** Sign Representation for Numbers


ቁጥር
number
0
ዜሮ
zero
1
አንድ
one
2
ሁለት
two
3
ሦስት
three
4
አራት
four
5
አምስት
five
6
ስድስት
six
7
ሰባት
seven
8
ስምንት
eight
9
ዘጠኝ
nine
10
አስር
ten


20
ሃያ
twenty
70
ሰባ
seventy
30
ሰላሳ
thirty
80
ሰማንያ
eighty
40
አርባ
forty
90
ዘጠና
ninety
50
ሃምሳ
fifty
100
መቶ
hundred
60
ስልሳ
sixty
1000
ሺ.
thousand

**Appendix V.** Software Specification

| | |
|---|---|
| **Application** | Web Application |
| **Database** | MS Access |
| **Technology** | HTML ,JavaScript, CSS |
| **Platform** | Windows XP |
| **Web Server** | Apache Server [ to be implemented in the future] |
| **Client-side Requirements** | Web browser(Internet Explorer 6.0)<br>Avatar plug-in for Internet Explorer<br>Java Runtime Environment (JRE) 1.4 or higher. |