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Research Article

Sign Language Interpreter through Animation

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ABSTRACT

Introduction: Sign language is a natural mode of Communication for those with hearing or speech impairments. Despite the fact that there are many systems for deciphering and identifying sign language, little is known about text-to-sign language translation systems because there aren't many linguistic corpora available.

Objectives: This study suggests a translation framework that translates English sentences into the grammar of Indian Sign Language (ISL). To ensure compatibility with ISL grammar, which does not allow inflections, the system uses a parser module to create phrase structure grammar representations. This is followed by stopword removal and stemming. Every processed word has a corresponding video in the ISL dictionary, and terms that are not in the vocabulary are replaced with synonyms

Methods: The suggested method uses ISL-specific grammatical rules to produce translations that are both semantically and syntactically accurate, in contrast to current methods that carry out direct word-to-sign mapping. By facilitating more organic interactions between non-signers and the hearing impaired, this framework seeks to close communication gaps.

Results: When compared to baseline systems, preliminary evaluation shows improved translation accuracy and comprehension.

Conclusions: Rather than representing individual words with GIFs or images, the model successfully transforms the entire input text into a single visual representation, enhancing the model's realism and liveliness. However, there is a need for further expansion of the ISL lexicon, which presents an opportunity for future development in this area.

Keywords: Indian Sign Language (ISL), Lemmatization, Parsing, Language Processing, Indian Sign Language, Text-to-Sign Conversion

INTRODUCTION

There are currently no efficient models that translate text to Indian Sign Language, despite the fact hat sign language is used all over the world to help people with speech or hearing impairments communicate on a daily basis. Appropriate and efficient audio-visual support for spoken communication is still lacking. Computers in other countries have made great strides in recognizing sign languages, but comparatively little research has been done to identify ISL. There aren't many systems in place for Indian Sign Language, but most of the research in this field has focused on American Sign Language (ASL) or British Sign Language. The underlying architectures of the majority of systems are based on transfer-based architecture, statistical machine translation, and direct translation. Indian Sign Language is at the heart of the system. Every word will have a corresponding video. Considering word duplication and parts of speech, terms that are not included in this dictionary would be substituted with other terms that have similar meanings. Translating between two spoken languages takes a lot of time because each language has its own grammar and rules.

Additionally, translation becomes more challenging when one language is spoken and the other is sign language.

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OBJECTIVES

The English language and its grammatical constructions have been extensively studied. The structure of an English sentence is subject-verb-object. The English language has multiple inflections. In order to convey different grammatical meanings, such as tense, voice, gender, and so forth, an inflexion is a change in word form, typically the ending. The English language's vocabulary is also extraordinarily extensive and has developed over time. Nevertheless, not much research has been conducted in the ISL language. ISL sentences have a subject-object-verb structure. Gerunds, suffixes, and other word forms are among the inflections that ISL typically ignores. Additionally, there are only about 3000 terms in the ISL lexicon. Additional requirements include the use of WH-question words at the end and the lack of conjunctions and connecting words in ISL.

Relevant Studies Addressing the Issue

1. Direct Translation System

Word-to-word translation is the cornerstone of this approach. The meaning and context of sentences are not considered. Neither the syntax nor the translation into the target sign language are changed. Even the conversion order remains unaltered, and the original text is not syntactically examined. However, when translating English text to ISL, the word order may differ from that of the source text. A system that is fluent in both the source and target languages is needed to address this problem.

2. Transfer Based Learning

This method uses just semantic analysis on the original input text to create a language independent semantic structure. The name of this autonomous organization is Interlingua. This Interlingua is then used to produce the target language. Therefore, it serves as a complement to both direct and transfer-based translation.

3. Interlingua Based Learning

Not merely "natural language represented by sign" or "hand representation of the words as they are," sign languages also communicate meaning. Most of us are ignorant of a number of facts about sign language, a natural language. Following is a list of some of them:

- They have their own grammar and are not merely pantomime and gestures.
- When compared to other languages, the dictionary is smaller.
- Typing unknown words by hand.
- In the majority of sign language, adjectives come after nouns.
- Avoid using suffixes.
- Always use the present tense when signing.
- Avoid using articles.
- Don't use But I use myself.
- Have no gerunds.
- Use of non-manual expressions and eyebrows.

Indian Sign Language Grammar

The manual depiction of spoken Hindi or English does not accurately reflect this language's grammar. It has a few distinctive qualities, including:

1. Hand movements for each hand are used to symbolise numbers.
2. Male or female is used to indicate familial links.
3. All of the WH questions are positioned at the end of interrogative sentences.

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4. It also includes a variety of non-verbal signals, such as eye and head gazing, body postures, mouth motions, and mouth patterns.

5. The symbols for before, then, and after stand in for the past, present, and future tenses, respectively.

METHODS

Problem Statement

By giving hearing-impaired persons a video to grasp the text's content, the translation module will make it quick and simple for them to comprehend.

Proposed Solution

The proposed system approach stands out by utilizing videos instead of graphics to transmit information, distinguishing it from other solutions. Furthermore, the elimination of stopwords minimizes the amount of text processing needed.

Comparison of English Grammar and Indian Sign Language Grammar

The grammatical structures of English and Indian Sign Language (ISL) differ significantly. While English follows subject-verb-object (SVO) ordering and relies heavily on inflections, ISL adopts a subject-object-verb (SOV) structure and does not use inflections extensively. Furthermore, ISL makes use of non-manual expressions such as facial movements and body postures, which are absent in English grammar. A detailed comparison is provided in Table I.

Table I. Comparison of English Grammar and Indian Sign Language Grammar

Feature	English Grammar	Indian Sign Language Grammar
Sentence Structure	Subject-Verb-Object (SVO)	Subject-Object-Verb (SOV)
Inflections	Extensive (tense, gender, voice, suffixes, etc.)	Minimal, mostly absent
Vocabulary Size	Very large, >170,000 words in use	Limited (~3000 words in ISL dictionary)
Question Formation	WH-words at beginning or middle of the sentence	WH-words always placed at the end
Articles & Conjunctions	Widely used (a, the, and, but, etc.)	Rarely used or omitted
Tenses	Past, present, future indicated by inflections/auxiliary verbs	Past, present, future shown through signs like “before/then/after”
Adjective Placement	Usually before nouns (“red car”)	Usually after nouns (“car red”)
Non-Manual Features	Not applicable	Crucial (facial expressions, eyebrow raise, body posture)

Data Collection

Each word's video clip is downloaded from http://www.indiansignlanguage.org/. Videos that aren't relevant will be eliminated, and each video will be manually labeled. Maintaining an unfiltered input that includes a large number of words is the goal.

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System Architecture

The proposed system consists of five main modules as shown in **Fig. 1**.

1. **English Parser Module:** Creates a representation of phrase structure and grammar from English text.

2. **Sentence Reordering Module:** Rearranges the parsed text to follow the subject-object-verb order of ISL.

3. **Stopword Removal Module:** Removes conjunctions, auxiliary verbs, and articles that are not necessary for ISL..

4. **Lemmatization & Synonym Module:** Replaces words that are absent from the ISL dictionary with synonyms and returns words to their base form

5. **Video Generation ModuleConcatenates each word with its matching ISL video to generate a continuous sign output**

This modular architecture ensures syntactic correctness, minimizes redundant processing, and enables natural ISL sentence construction.

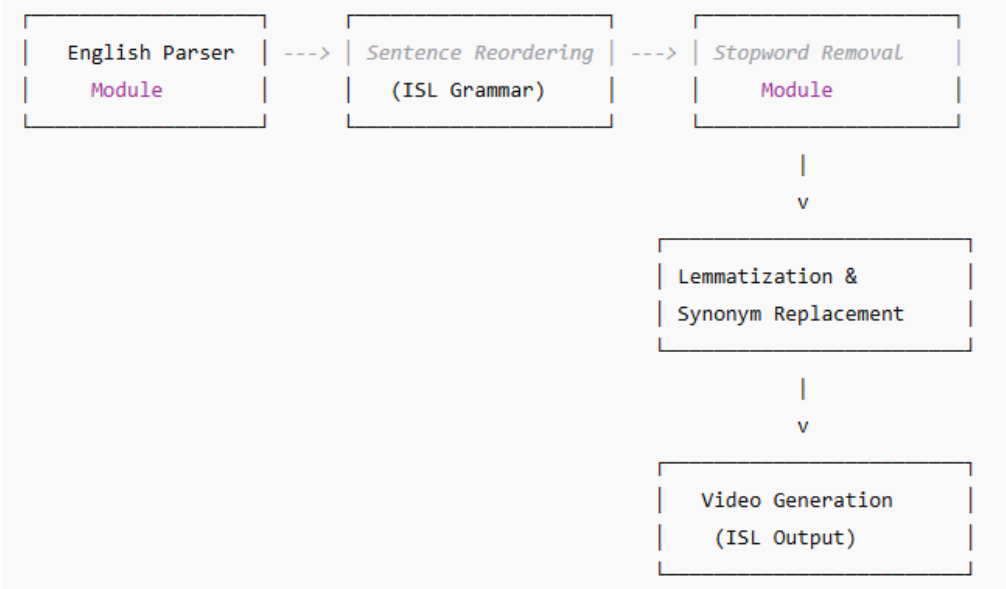

Fig. 1. System architecture of the proposed English-to-ISL translation framework.

Algorithm Design

There are five modules in the system:
1. An English parser to parse text in English

2. A module for rearranging sentences according to ISL grammar rules.

3. A stopword eliminator

4. Stepping to find each word's root words and synonyms for terms that aren't in the dictionary.

5. Module for video conversion.

The system receives a written English text as input, parses it, and uses the grammar representation to generate a phrase structure. Since English texts follow the Subject-Verb-Object structure, while ISL texts follow the same structure along with a variety of negative and interrogative sentences, reordering is then done to satisfy ISL grammar requirements. Unwanted words are then eliminated because ISL will only use words that have meaning and will not use any linking verbs, articles, or other helpful words. which sends its output to the lemmatization module, which

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breaks down each word into its most basic form. The synonyms of the words that are not found in the dictionary are used in their place.

RESULTS

Output Generation

The system seeks to provide a sign language representation of a given English text. These outputs are produced by our system in one of two ways:

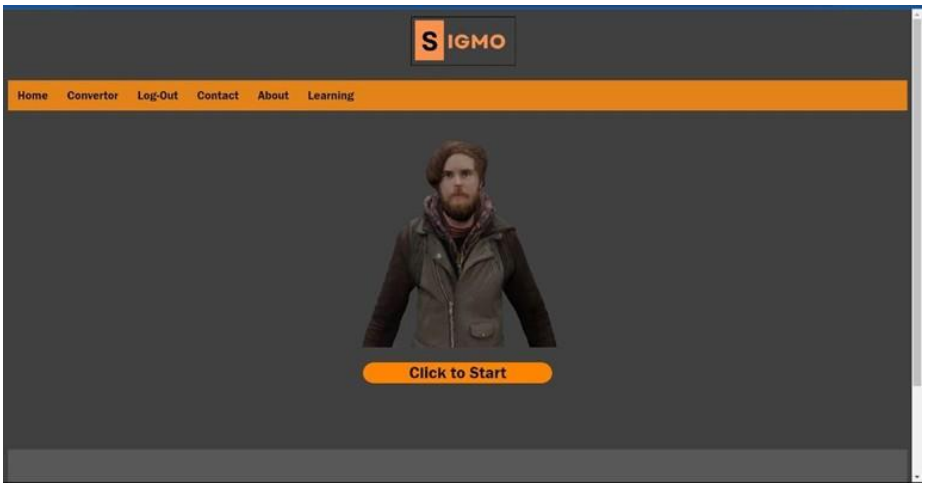
1. Video generation - A more structured, instructive, and unambiguous visual representation of Indian Sign Language is produced by concatenating all of the corresponding video files after each word in the input sentence's ISL conversion phase is passed to the video generation phase.

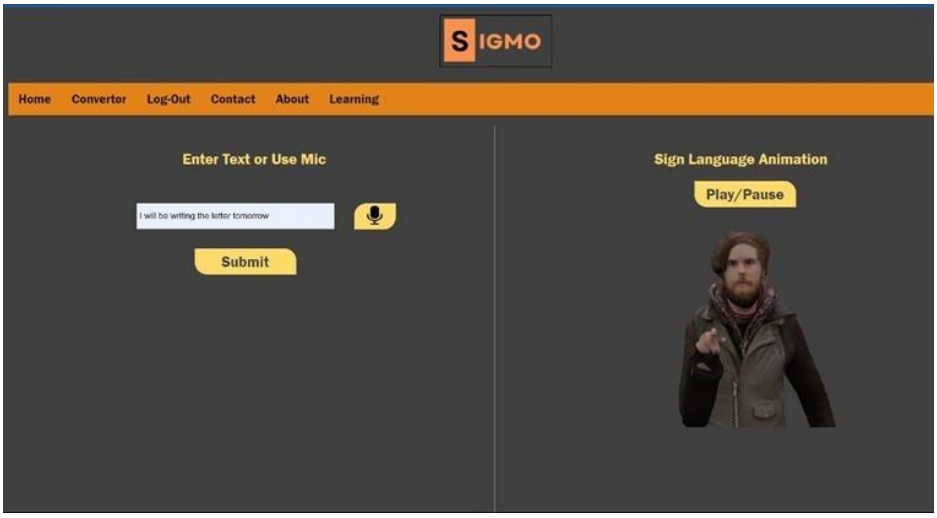
2. Synthetic Animation generation This approach compares the corresponding SigML file with the ISL-converted text. The Hamnosys to SigML conversion process creates this SigML file and a markup language that can be used with the JASIgning tool to create similar artificial animations.

English input text: What is your name?.

ISL parsed text: What is your name.

Video Generated Output:





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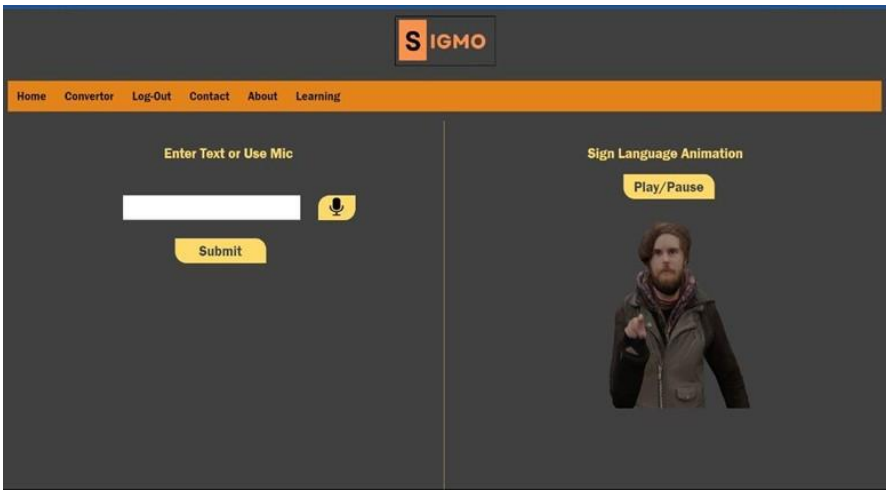

The application is deployed on a Kubernetes cluster. Initially, the application is dockerized by writing a dockerfile and creating a docker image. Subsequently, a Kubernetes cluster is created, enabling the creation of a Kubernetes deployment for the application using the docker image.

This deployment strategy is chosen based on several reasons such as:

Scalability: Whenever there will be load/traffic in our website/application, the application will easily scale itself in just a few seconds and the load will be balanced. For this purpose, the concept of Horizontal Pod Autoscaler in Kubernetes is employed, which automatically creates a new pod containing the application.

Resource Optimization: With the help of Kubernetes autoscaling, the application will scale itself according to the workload and the underlying resources will be optimally utilized.

Resilience: Kubernetes promotes resilience by implementing self-healing mechanisms for applications. It has features like pod replication and automatic restarts. So whenever there will be some error or any kind of problem in the application/pod, Kubernetes will recreate the pod and the application will be up and running.

Hosting the application

The application is hosted on the Azure cloud, utilizing an Azure VM where the Kubernetes cluster is created for deploying the application. By hosting the application on the cloud, the chances of downtime are virtually eliminated. Additionally, leveraging Azure VM provides the advantage of integrating the application with various Azure services such as Azure Load Balancer, Azure Traffic Manager, and Azure Virtual Network.

DISCUSSION

The aim of this project is to develop a system that benefits individuals with communication difficulties, particularly those who are handicapped, by providing them with a tool to express themselves clearly and concisely. Rather than representing individual words with GIFs or images, the model successfully transforms the entire input text into a single visual representation, enhancing the model's realism and liveliness. However, there is a need for further expansion of the ISL lexicon, which presents an opportunity for future development in this area.

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