E-LEARNING SYSTEM FOR HEARING IMPAIRED STUDENTS

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September 2021

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The dissertation was submitted in partial fulfillment of the requirements for the BSc(Hons) in Information Technology Specializing in Data Science

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	**Registration No.**	**Signature**
Accash Raveendran	IT18069600	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

…….. Date ……

Signature of the supervisor:

(Dr. Kalpani Manathunga)

…….. Date ……

Signature of the co-supervisor:

(Mrs. Samanthi Erang Siriwardene)

ACKNOWLEDGEMENT

I would like to express my gratitude to everyone who supported me to successfully complete this research. First and foremost, I would like to thank my supervisor, Dr. Kalpani Manathunga and co-supervisor, Mrs. Samanthi Erang Siriwardene who put their full time and effort towards guiding us with the research works. Also, I am very thankful for all the learnings I received from them during the process, which were a significant part in the success of the research completion. Without them, this would have never been an easy journey.

Finally, I am extremely thankful for every person who has somehow contributed and helped with the project, with their valuable information, feedback and suggestions towards our system.

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ABSTRACT

Sign language is a form of communication used by the differently-abled people, those with hearing disabilities to be specific. It enables them to lead and live their life peacefully, as normal people would do. Even though there are mediums and modern technologies that help them to mingle with the people while communicating, there are a few minor situations that make them struggle.

Therefore in terms of education, we have created an e-learning system using that would support the students of an institution along with the ones with hearing disabilities. The contribution from my side to the project is converting the text forms to sign language videos. The text formats will be gained from the subtitles of lecture videos. The process is done by retrieving the captions and applying the American Sign Language grammar rules, and thereby eliminating the stop words first. Then stemming is applied. Finally, for each of the words in the caption sentence, the database containing the sign language videos will be searched and using string matching algorithm the videos will be connected as sequence and played in order.

Our proposed research will be useful and applicable for many students that struggle to merge with the current e-learning study format.

Keywords: *Natural Language Processing, Text preprocessing, Stemming, Lemmatization.*

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LIST OF ABBREVIATION

ASL	American Sign Language
LMS	Learning Management System
NLP	Natural Language Processing
OS	Operating System
NLTK	Natural Language Toolkit

1. INTRODUCTION

1.1. Background Study

Among all the known languages present in the world, sign language is a significant one that is used by the hearing impaired people. There are many different sign languages, based on country, region or other factors. It consists of signs that are made using hands or other body parts and facial expressions. This plays a major role in the life of the deaf community that makes them able to communicate, work, learn, etc.

Our world has now immensely adjusted to the online procedures in almost every sector we know of. This majorly includes business, communication and education. In today's competitive society, there is no way a child could see self-growth without education and knowledge. Hence, it is very obvious that the knowledge-providing mediums need to be accessible to all the students.

During our research we encountered that the differently-abled students or in other words, the hearing impaired students, were finding difficulties in adapting to the online world, as it was not a part of their day-to-day life before. Hence, we decided to propose a Learning Management System (LMS) that would facilitate both differently-abled and normal students to gain benefits from it.

Hence, in order to gather information and the needs of the hearing-impaired community, as a team we conducted a survey in form of an online questionnaire. Out of the 92 responses that were gained, 28.3 % of people have admitted that it would be very helpful if the lectures happened in sign language itself. On a scale of 1 – 5, of 1 being not helpful and 5 being very much helpful, 34.8% have voted for 4, 28.3% have voted for 3, 6.5% and 2.2% for 2 and 1 respectively. From this part of the survey, it is very evident that the majority of the responders accept a medium that would provide lectures in sign language. Further
Details can be referenced in the image of the questionnaire below (Figure 1).

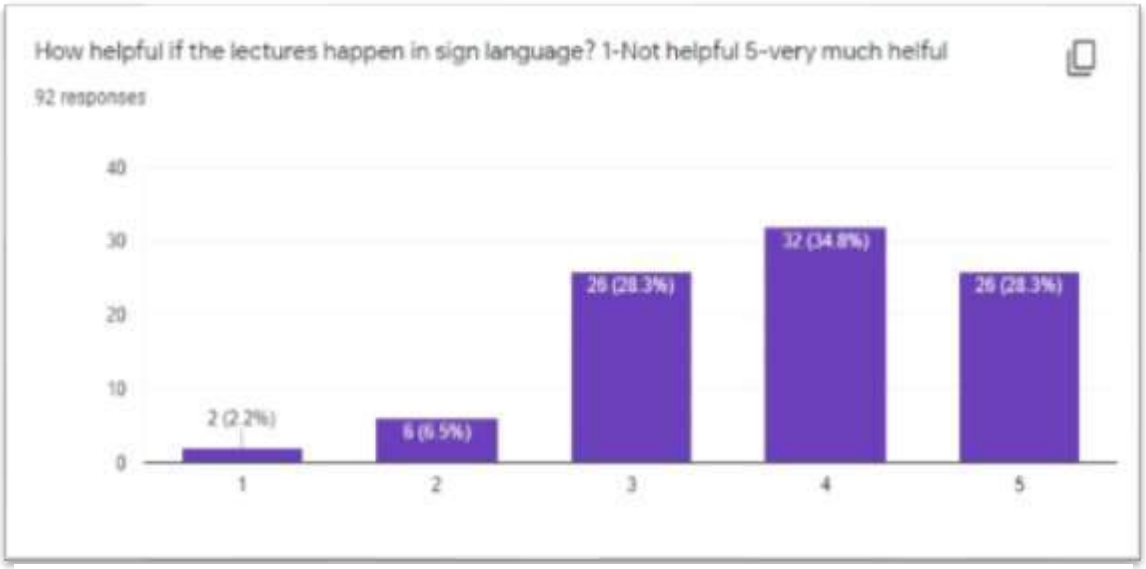


Figure 1- Survey question 1

Further, the second question, as of Figure 2, the responders were asked if it would be helpful if the interpreter could detect the face expression of the user (hearing-impaired user). The result as stated is highly positive for the research, that 81.5% people have replied positively, and 8.7% and 9.8% people have replied 'no' and maybe, respectively.

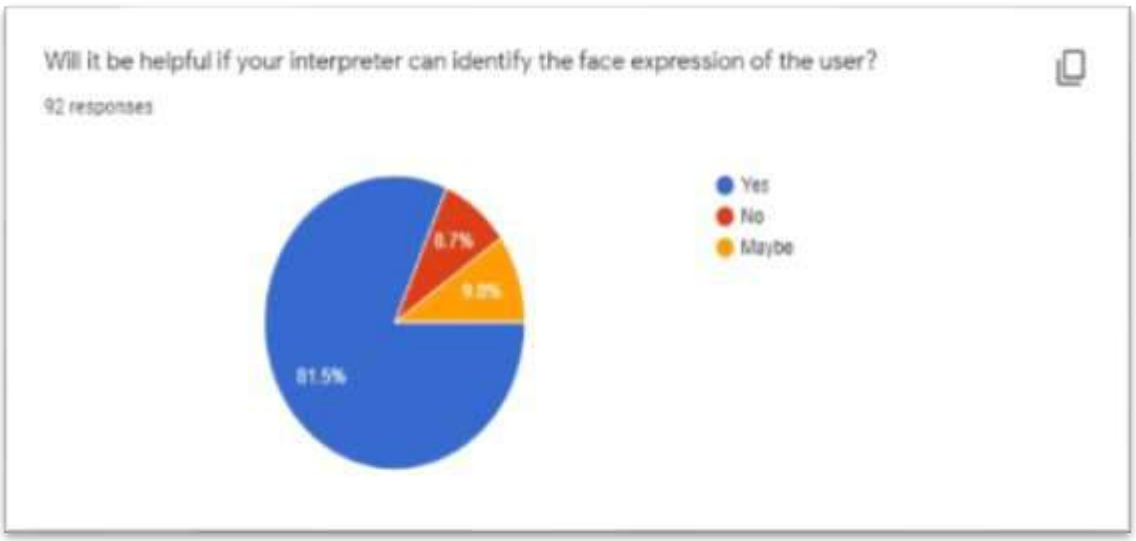


Figure 2 - Survey question 2

This module of the research focuses on converting the text into sign language videos. The term ‘text’ here refers to the captions or subtitles that were received from the lecture videos. Therefore, by using techniques such as NLP, these were converted into a format of corresponding sign language video sequence.

1.2. Literature Survey

According to the literature survey conducted on the existing research regarding sign language conversions, some of the most important works are elaborated below.

In 2005, James Ohene-Djan and Saduf Naqvi, on *“An Adaptive WWW-based System to teach British Sign Language”* [1] research paper, have presented the idea of implementing a WWW based system named KSO (Kids Sign Online), to facilitate the educational needs of deaf children under the age of ten. This has been built in order to facilitate the children on an individual basis, with progression time, and thus has been proved to give successful results too. The system basically consists of digital video content that converts from English to British Sign Language, which includes materials such as assessment exercises, children’s fairy tales and personalized online diaries too. This research paper talks about the lack of online materials for hearing-impaired students and the importance of making available of more content in the future. Also, for my part of the research, which is converting the text to sign languages, the idea of creating digital video content and making an adaptive system for each individual child was much useful.

In 2005, Oya Aran, Cem Keskin, Lale Akarun, on *“Sign Language Tutoring Tool”* [2] research paper, have presented a system that can teach the basics of sign language. This is implemented by using a simple sign language recognizer that would help the user to learn sign language, which is useful for hearing-impaired and mute people as well as people with no disabilities too. It is also said that this will gradually improve the communication rate between the hearing-impaired and non-deaf people. The system requires the user to wear colored gloves to distinguish the hand gestures from the rest of the environment. It has two interfaces, that are the learning interface and

practice interface, where a pre-recorded sign video is played for each selected sign and the practice phase will initiate the recording for that selected sign, when the user is ready to demonstrate. According to the performance of the user, a feedback will be given. For these processes, the idea behind Hidden Markov Models (HMM) has also been used in detecting the hand gestures. As the sign language involves various body movements, it is complex to build a recognizer. The factors that affect creating a proper sign video, and the use of HMM and connected components algorithm in this recognizer tool was very useful while doing our research.

In 2016, Malu S Nair, Nimitha A P, Sumam Mary Idicula, on *"Conversion of Malayalam Text to Indian Sign Language Using Synthetic Animation"* [3] research paper, have presented a machine translation system that converts Malayalam text to Indian Sign Language (ISL) and output as 3D character animation, with the HamNoSys (Hamburg Notation System for Sign Language) structure as an intermediate representation. This also allows tutoring that will enable the non-deaf to learn the sign language and thus promote the communication between people. The system uses synthetic animation approach rather than motion capture approach, as it has too many visible advantages when compared. This allows real-time generation of motion data which makes the user very interactive with the system. Also, the system can store the signs in form of HamNoSys symbols in a large database which could be further populated too. This feature is made available for the ISL experts through an interactive Sign Editor, to further extend the vocabulary of the system. This work explains the text to signs conversion in detail, including the techniques and their advantages and disadvantages. Therefore, it will help a great deal in wisely choosing the technologies according to the available data and other depending factors on the research. Additionally, the separation of the work into modules such as the sign editor module and the translator module helped to identify the best approach to work with the research works systematically.

In 2020, Tariq Jamil, on *"Design and Implementation of an Intelligent System to translate Arabic Text into Arabic Sign Language"* [4] research paper, has discussed about an intelligent system that was developed to convert the Arabic text to Arabic

Sign Language (ArSL). It has been designed to fulfil the need of integrating the Arabic deaf community with the society and to be able to communicate with them without any difficulties. The system is implemented in four crucial steps in order: the text-input, parsing, word-processing, ArSL output. Basically, the sentence that needs to be translated will be passed to the translator user interface and the system will identify each part such as, noun, verb, adjective, and consequently eliminate the words that are meaningless. Then the other meaningful words will be checked with the already updated system's database full of signs, and hence display the correct output in GIF format. The translator's user interfaces have been designed with ScreenBuilder application and Java programming language for the implementation. A toolkit named 'Farasa' was used for quick and accurate text-processing, which also contributes to identifying the parts of a sentence. Finally, an animated character provided by MindRockets, Inc has been used to display the ArSL signs output. This research work clearly outlines the implementation process, where the tools and software used for development are given too. This paper has been useful for identifying them and to grasp the idea of text-processing in easy ways.

In 2005, A.S. Drigas, D. Kouremenos, S. Kouremenos and J. Vrettaros, on *"An e-Learning System for the Deaf people"* [5] research paper, have presented a learning system that converts all the text in the learning environment into Greek Sign Language (GSL) videos. It allows deaf community people to learn in their own sign language, and therefore to minimize the unemployment issues among them as they have communicative problems and inadequate performance issues in the workplace. This is specifically made in order to resolve the problems of learning of the targeted group of people. The system consists mainly of images and videos in the GSL, which is of a higher quality to ease the learning experience. It also provides all the additional facilities that a usual LMS would give, like selecting video speed, downloading options, student activity tracker, content extraction, etc. Hence according to this study, it resembles how a learning system for the deaf community could be equally good as a usual learning system and the methodologies that make the process easier. Also, the way of allocating various user levels in the system for making it progress for a long period, helped me to identify the roles and responsibilities properly.

In 2010, Mona M. Nasr, on *"An Enhanced e-Learning Environment for Deaf/HOH Pupils"* [6] research paper, has proposed the design and implementation of a e-learning system for the deaf community, based on the Chinese Sign Language. It provides many learning activities which could help the deaf people to perform as equal as the other students in their learning environment. The system provides virtual classrooms for students, where they can learn as well as interact with others using chat rooms and discussion forums. There is also translation facility where the course material could be translated to the Chinese Sign Language and re-uploaded for others to use. They can be translated into animation or video formats. Also, it has several user roles for maintaining the system, which includes the administrator, instructor and the student. This e-Learning system has proved to be helpful for identifying the other elements of a LMS that needs to be converted into sign language too, i.e., discussion forms.

In 2007, S. Khwaldeh, N. Matar, and Z. Hunaiti, on *"Interactivity in Deaf Classroom Using Centralised E-learning System in Jordan"* [7] research paper, have presented a centralized e-learning system based on the Jordan Sign Language for the deaf community in Jordan. The system is mainly built, in order to address a few common problems faced by them in the learning environments: teacher-pupils exchange, limited feedback, unmotivated students, etc. Hence as a solution it consists of discussion groups, feedback sections, questionnaires, pre-tests and post-tests. The language is converted into Jordan Sign Language in video formats of high quality and improved consistency of video picture. There is also illustrations and animations of sign language in the system. This research study represents the significance of ensuring good user experience throughout the usage period (E.g., video quality).

In 2018, Amirita Dewani, Sania Bhatti, Mohsin Ali Memon, Wajiha Arain Arif, Quratulain Arain and Sayyid Batool Zehra, on *"Sign Language e-Learning system for hearing-impaired community of Pakistan"* [8] research paper, have presented a web-based e-learning system for the hearing-impaired in Pakistan and for normal people to communicate with them. The work had two main objectives; to teach the sign language to deaf people and to develop a text-translation system that translates English to

Pakistan Sign Language (PSL) gestures. As the Pakistan Sign Language combines of hand shapes, orientation and movement of the hands, arms or body, and facial expression, a much efficient system has been developed. A convenient user interface is provided to the user and prompted for a text input in English and the equivalent PSL will be displayed as output. The input here will be categorized into two: catalogue based and non-catalogue based. If an input word is catalogue based it will be directly mapped to the corresponding word in the database of PSL and be displayed. Or if the word is non-catalogue based, it will be analyzed character by character and the output will be displayed as a series of PSL gestures. Further, the e-learning system is also capable of allowing to create user accounts, learn sign language and provide feedbacks. This has been tested among a targeted deaf group of people and based on expert opinions, using Web Evaluation Framework and has shown positive results too. This research work emphasizes the importance of categorizing the English input words as catalogue and non-catalogue based, so that the misinterpretation of meanings could be minimized and thus provide a better user experience.

In 2002, Katja Straetz, Andreas Kaibel, Vivian Gramley, Marcus Specht, Klaudia Grote and Florian Kramer, on *"An E-learning environment for deaf adults"* [9] research paper, have presented an e-learning system for the deaf adults in Germany. This is said to help the deaf adults in learning and improving their mathematical and reading/writing skills. This has taken the factors like bilingual information (text and sign language), high level of visualization, interactive and explorative learning into consideration. The main advantages of the system are that the information is presented in both text and sign language, the user interface of the system is designed according to the requirements of the deaf researchers, various kinds of exercises, quizzes and tests are incorporated, a communication module for encouraging peer interaction and use of templates for pages, exercises and tests. The German Sign Language (GSL) videos that are converted form the text is available in different qualities, so that the user can choose according to the strength of their internet connection. The system requires the user to install a plugin 'QuickTime' in their browser to play the videos. The system designed here is a mere example of the significance of both text and the sign language to the deaf community, which will help them mingle with the others in

the society. Further the use of a communication mode within the system is beneficial to create a common atmosphere among them by allowing to socialize.

1.3. Research Gap

In relation to the literature surveys that were conducted for the module of text-to-sign language conversion, few research gaps were discovered and listed below.

1. Unable to distinguish between nouns and verbs for certain words which could result in a different meaning in a particular sentence. [4]
The Noun ‘play ’and verb ‘play ’has two different meanings, which can be misinterpreted in a sentence “A play is being staged at the auditorium today”.

2. Lack of clarity in facial expression and lip movement in the translated sign illustration/video, which could also result in a different meaning. [3]
E.g.: Saying the word ‘don’t ’angrily and the same word politely are completely two different situations, which could be misinterpreted in a context.

3. Unable to produce a complete LMS by fulfilling the needs of the hearing- impaired students. [6]

Research Reference No.	Main objective	Accuracy rate	Research Gap
[1]	A WWW-based system to teach British Sign Language	Not given (But positive result)	
[2]	Build a sign language tutoring tool		The system requires the user to wear colored gloves. Also limited signs are fed into the database.
[3]	Conversion of Malayalam text to Indian Sign Language using synthetic animation	82%	Further implementation of facial expressions and hand movements for better recognition of signs.
[4]	Design and implementation of an intelligent system to translate Arabic text into Arabic Sign Language	Positive result	Distinction between noun and verb of the same word is not implemented.
[5]	Build an e-learning system for the deaf people	Not mentioned	
[6]	An enhanced e-learning environment for Deaf/HOH pupils	Not yet tested	Incomplete system without the aimed requirements
[7]	Interactivity in deaf classroom using centralised E-learning system in Jordan	Not yet tested	

Table 1 - Research Gap

Features	System proposed by			Our solution
	M. S. Nair, N. A. P and S. M. Idicula	T. Jamil	A.S. Drigas, D. Kouremenos, S. Kouremenos and J. Vrettaros	
Sign language tutoring	X	-	-	✓
Availability of study materials like tests, quiz, etc.	-	-	X	✓
Reliable translation of words	-	X	-	✓

1.4. Research Problem

The current world of literally everything being converted to online mode, has become more and more challenging to the ones who are not already aware of it. In this case, the hearing impaired community is one too. They are facing difficulties in gaining the equal rights of online education delivery methods.

The LMSs that are present now, are not quite suitable for these students to independently study or work with. It requires the help of someone who knows the language in which the study materials are being delivered and translate it to them in form of sign language. Though it seems quite manageable, it does not suit for a long period assistance. Also, students are expected to gain knowledge and skills on their own, and thereby improve themselves on a daily basis.

Thus, our solution to these problems was to create facilities that would cater their needs and eliminate the difficulties they face. Specifically, in my component, the students were enabled to watch the sign language videos of the lecture video that was delivered by their tutors.

1.5. Research Question

The research component discussed in this document was considered a very significant step in the whole process, as it conveys the end result to the user (Hearing impaired students). It was also discovered that conversion of text to sign language was the stage where similar researches have failed to fulfill the requirements of the users. Therefore, a few research questions were identified as follows.

1. Why is a text to sign conversion essential where there are other similar systems available?

2. How crucial it is to provide a reliable conversion system?

1.6. Research Objective

1.6.1. Main Objective

The main objective of this module of the research was to enable the conversion of the captions gained from the lecture videos to videos of the corresponding American Sign Language. Hence, it was believed it would minimize the difficulties for the hearing impaired students in trying to understand the languages used by their professors. This was done using Natural Language Processing (NLP) technique.

1.6.2. Specific Objective

The specific objectives that were focused on this research component are as below.

1. Provide a user-friendly LMS to the students, especially hearing impaired ones.

2. Provide a reliable conversion system that would not collapse the meaning of the original caption.

3. Improve performance rate of the hearing impaired students in their respective study fields.

2. METHODOLOGY

2.1 System Overview Diagram

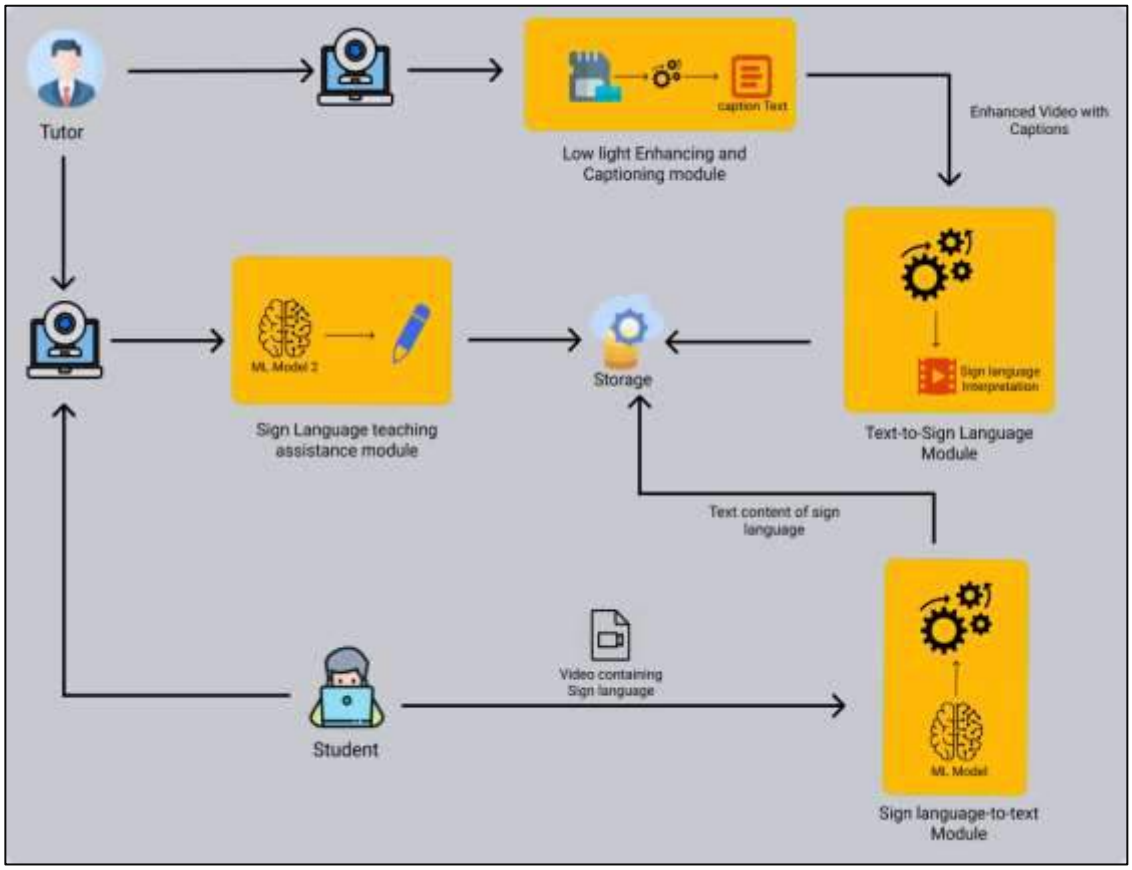


Figure 3 - System Overview Diagram

A System diagram is a visual diagram of the system that contains the components and interactions with supporting documentation. The above system diagram shows the overall system planning. The overall system is, when the tutor uploads the video it enhance the video quality and audio as well as it extracts the video caption and pass it a model to convert the English grammar into ASL grammar after that the normal grammar video will be converted into ASL video. LMS also has the capability to teach ASL to the students and also hearing impaired student can ask questions directly from the tutor by uploading ALS video once it is uploaded to the form it will be converted to English grammar question.

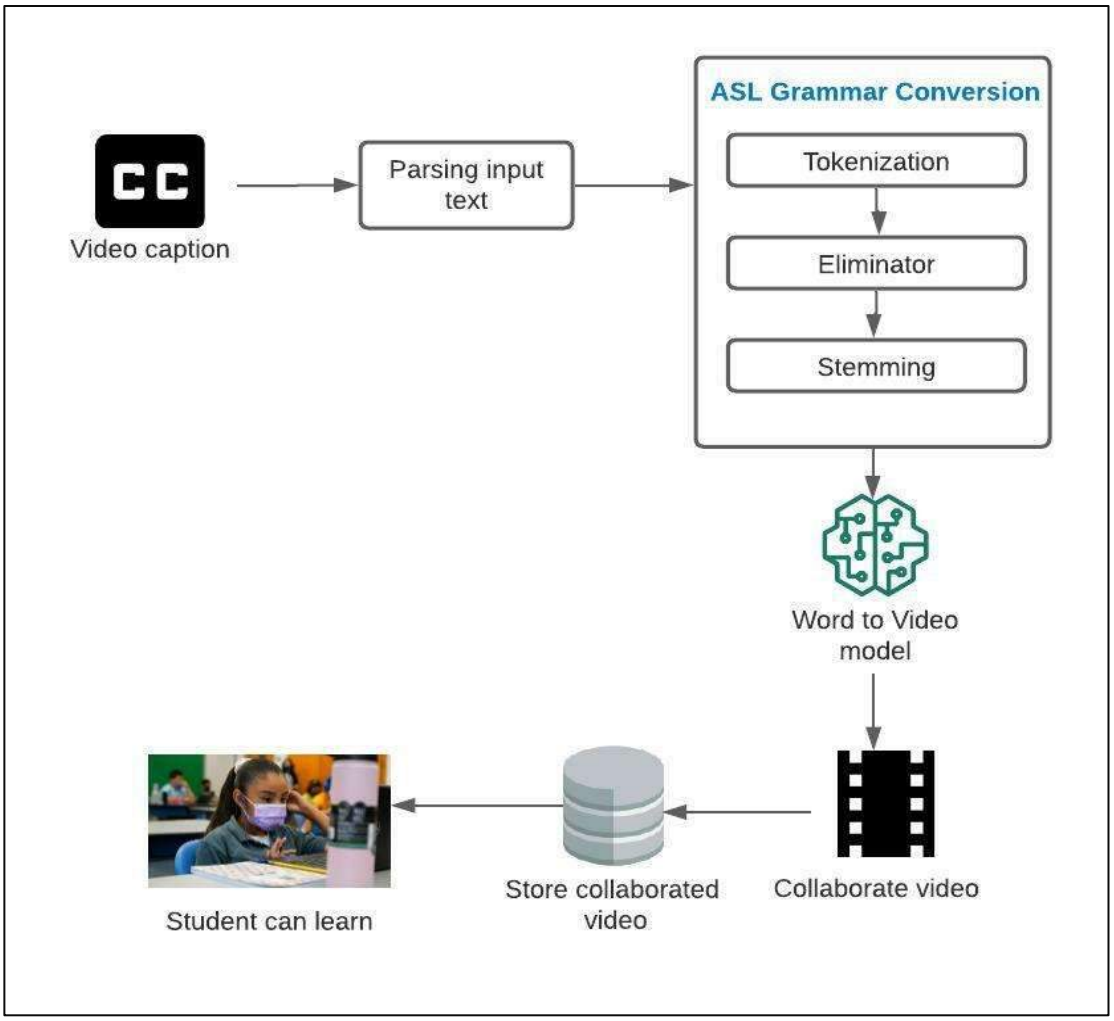


Figure 4 - Function Diagram

The above functional diagram shows the individual functionality which is converting text into ASL. The function is, it takes the video caption/ test as the input and it converts the English grammar sentence into ASL grammar sentence after that it tokenize each words and search for the ASL video for each word in the database and it combines all the videos and it will be stored in the database and it will be published in LMS which can be accessed by the hearing impaired students.

2.2 Data collection

The data for this component was collected from an online source which is Microsoft American Sign Language Data set which has 14000 words, which are the ASL videos for English words. These were stored in a database in a way it could be matched and retrieved as output.

The procedure in this module consists of five steps as mentioned below.

1. Parsing the English text.
2. Re-arrangement of the sentence based on the ASL grammar rule standard.
3. Eliminating stop words in the sentence.
4. Stemming
5. Conversion of text into video

2.3 Parsing the English text

The parsing was conducted as the initial step to prepare the retrieved text to put into the grammar based arrangement. The parser produces outputs in three parts: part-of-speech tagged text, context free grammar representation of phrase structure and type dependency representation.

2.4 Re-arrangement of the sentence

Here we rearrange the sentence based on ASL grammar standard and the grammar standard conversion is a very crucial step in the process, since the language used by the tutors and the American Sign Language have difference in terms of grammar rules. Therefore, it is essential to convert the parsed English text into a format that relates with the sign language grammar rules.

2.5 Eliminating stop words in the sentence

In the process of conversion of text into signs, it is clearly seen that some words in a sentence do not contain any meaning or is not applicable for conversion itself. Such words are referred to as stop words and the elimination of those words is done in this step. Stop words include various types, among which a few of them can be determiners (the, a, an, another), coordinating junctions (for, an, nor, but, yet), prepositions (under, from, on, of, towards), plurals (‘book’ instead of ‘books’), interjections, etc.

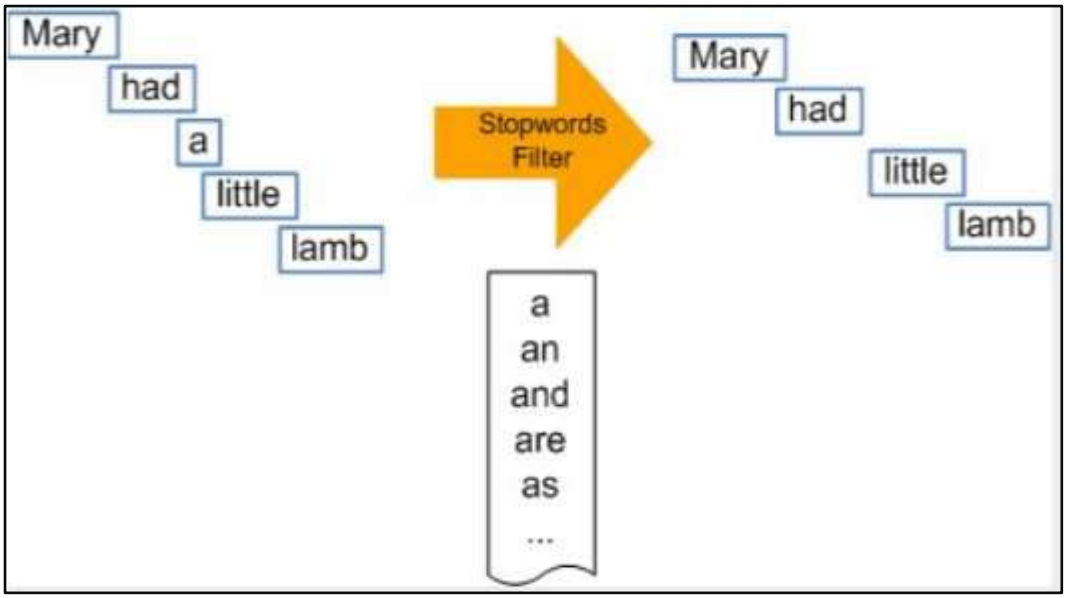


Figure 5 - Stop words filter

2.6 Stemming

The words containing prefixes or suffixes, tense related suffixes, etc. are reduced into its root form. For example, words like ‘adjustment’, ‘adjustable’ and ‘adjusting’ are reduced into its root ‘adjust’. Further, if the root word is not found in the sign database, it is matched with its synonym and then the relevant sign will be found.

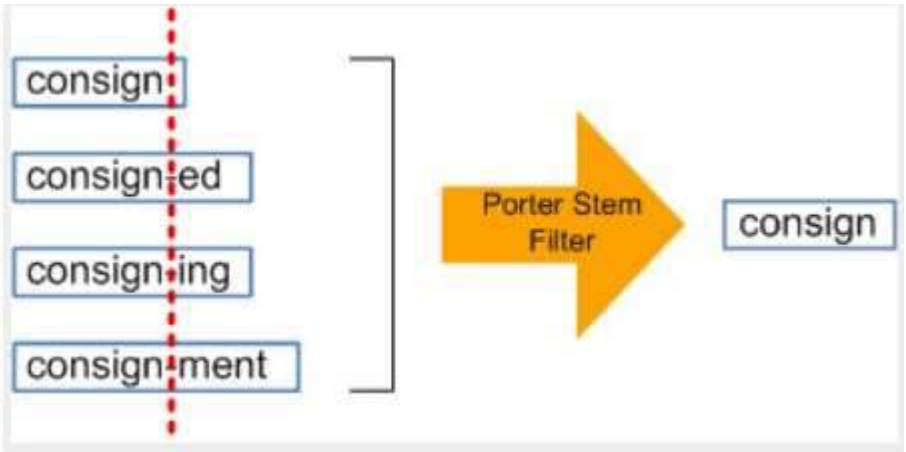


Figure 6 - Porter Stem Filter

2.7 Conversion of text into video

The string of words that was converted into the ASL format of text, will be available for matching with the sign database available in the system. This will be done accordingly with the name of the sign videos that they are labeled with. Hence, after finding the right matches, the video sequence will be displayed to the user.

2.8 Use case diagram

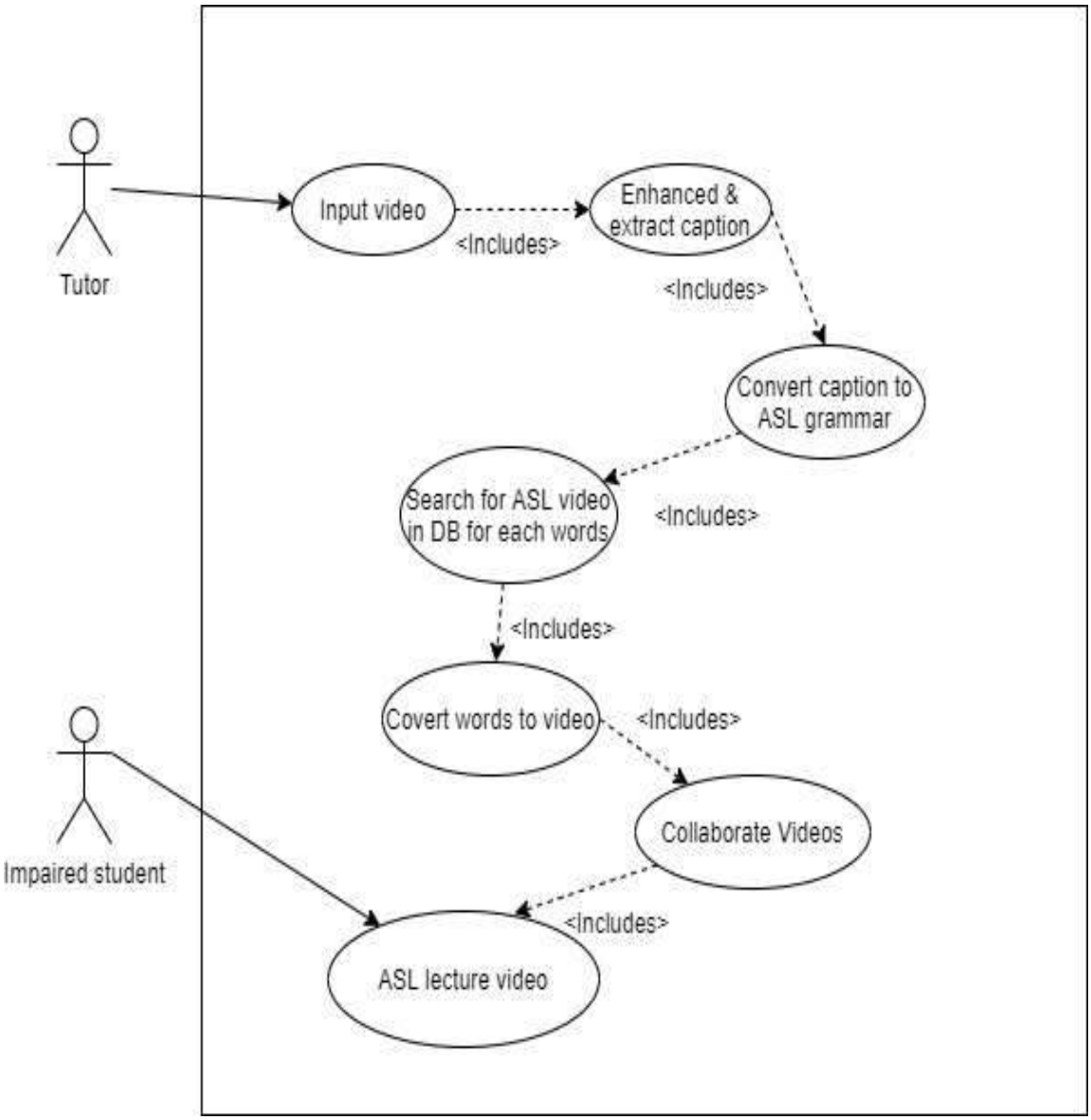


Figure 7 - Use Case Diagram

2.9 Flow chart

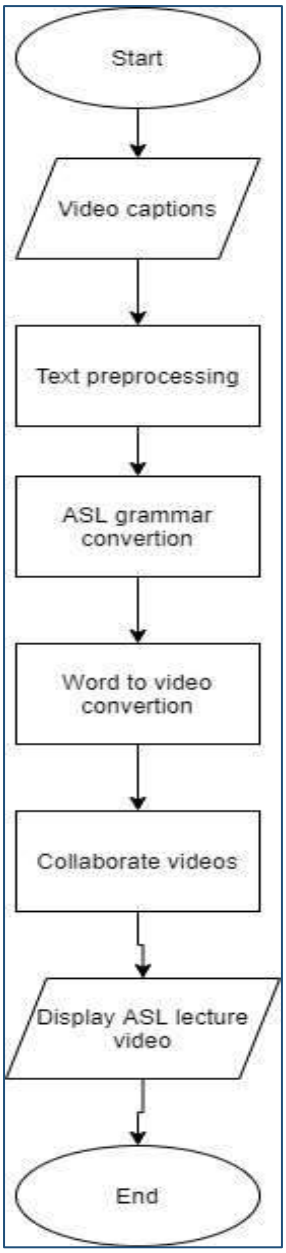


Figure 8 - Flow Chart

2.10 Development Process

The Iteration development model is considered as the most suitable method for our research when comparing to the other process models because our research processes heavily depend on the output of the previous process.

The entire requirement for the research is divided into multiple stages in the iteration model. In each iteration, the development procedure carried through the sequence of steps requirements gathering, design, implementation, and testing phase. The reason for selecting this model is,

- The requirement of the system is well-defined. Though, some of the functionality may evolve or change with time. When changes occur, it is essential to consider them before finishing the implementations.
- During the development time of the project, new technologies can be used based on the process requirements. So, it is important to iterate the steps when there is a change like these.

By considering these factors, the iteration model is considered as a most suitable model.

2.11 Feasibility Study

The main technologies that were used in the development are natural language processing, parsing, stop word removal and stemming. Whereas, the tools that were used for these technologies NLTK for stop word removal and stemming process. As a summary, we used the following technologies to successfully implement the system. The following tools and technologies are used to develop this system.

- Python
- NLTK
- GIT
- MS Planner

2.12 Requirement Gathering

This phase is one of the important steps that need to be done before implementing any system. It is a must to analyze and read a lot of previous research works related to this project, to know what kind of implementations to be done, what are the technologies used in the previous researches, and what are the research gaps in those existing works.

1. Literature Review

Under the supervision of our former supervisor we discussed the research project idea and she guided us in collection information from online conference paper and article which gave us a knowledge on what we are going to work on and the current trending technologies which supports the project.

2. Survey Results

We prepared a set of questionnaire to hearing impaired community to find out the difficulties they face in learning and if they are willing to switch to E-learning platform with the guidance of our supervisor. We visited a special school Senkadagala Deaf & Blind School, Kandy and the survey was given to students in the school and few teacher as well with the help of few voluntaries we were able to complete the survey.

2.13 Resources Used

2.13.1 Soft Boundaries

Software required throughout the project will be divided into following categories,

1. Designing software
2. Implementation Software
3. Documentation Software

Designing Software

- Diagram Designing – Draw.io
- Wireframes Designing- Balsamiq application tool

Implementation Software

- Database Implementation – Firebase
- Interface Implementation – PyCharm Community Edition(flask)
- Software Designing – Visual Studio 2019,
- Version Control – GitLab
- Task Planning – Microsoft Planner

Documentation Software

- Project proposal/ Research Paper/ Final Report - Microsoft Office 2019
- Presentation Document Design – Microsoft Power Point 2019

2.13.2 Hardware Boundaries

The specifications mentioned below are of the hardware that was used while developing the system.

Data Storage facility – Maximum of 8GB.(depends on dataset)
RAM- Minimum 8GB, 16GB is recommended.
Processor speed – 1.0GHz minimum.
Server machine with higher processing power

2.14 Commercialization aspect of the product

The main reason to implement a learning management system for the deaf community students was to make them feel confident in the education field and to achieve success. It absolutely is very helpful for them as they never got to experience an LMS same as the other students (non-hearing impaired). Therefore, they won't be having the feeling of missing out in a community.

The proposed system is very reliable, highly accurate and rapid enough to follow the tutorials, simple and user-friendly application. These aspects will influence very much in making the application a highly demanded one for the whole deaf community people. Thus it will also increase the user count. Along with that, we can ensure that the students who benefit from this, will come out and shine in the society as they will have no more hurdles in gaining knowledge or skills.

Gradually, there will be expectations for other fields other than education, like IT industries, banking industry, finance industry, advertising industry, etc. to make use of this application, just to convey important information to the hearing impaired users.

The following feature can be considered as the main commercialization aspects

- It can be hosted on a cloud platform and provided as a *Software as a Service* (SaaS) product, where the customer will pay a one-time fee or a subscription to use it.
- It can be developed as a website and advertisements can be incorporated into the system.
- It can be developed as a Freemium model, where services are provided free of charge and certain premium services can be provided for a fee such downloading feature, certification and etc.

2.15 Implementation

Utilizing the methodology explained the system was build based on the system architecture shown below.

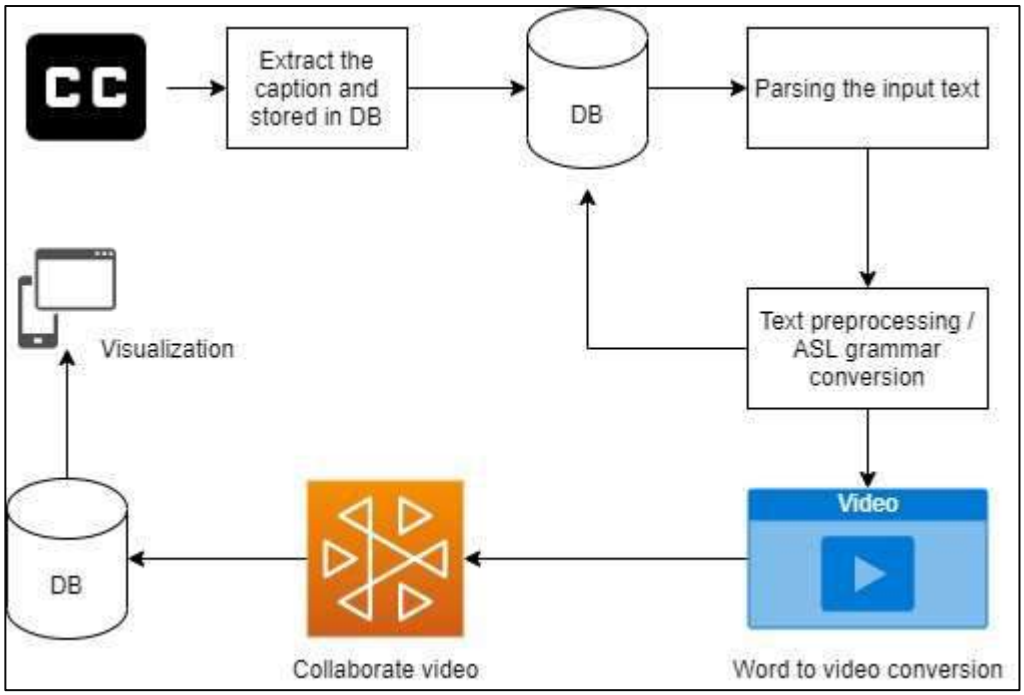


Figure 9 - System Architecture

2.15.1 Parsing of the video caption

Rule-based grammar system for translating one language into another

Must be familiar with both the source and target language. Parsing is the answer to getting this grammatical structure. Stanford Parser is capable of producing three different releases, Part of speech Free grammatical representation of the context of the tag text, phrase structure and type pro representation. The parser uses the Penn tree tags to parse the English sentence.

The below code shows how it is implemented in python.

```
inputString = " "

java_path = "C:\\Program Files\\Java\\jdk-16.0.1\\bin\\java.exe"
os.environ['JAVA_HOME'] = java_path

for each in range(1, len(sys.argv)):
    inputString += sys.argv[each]
    inputString += " "

# inputString = raw_input("Enter the String to convert to ISL: ")
inputString = input("Enter sentence to check :\n")
#"I am going to School to do my Presentation tomorrow."


# D:\accash\stanford-postagger-full-2015-12-09\models
parser = StanfordParser(
    model_path='D:/stanford-parser-full-2015-12-09/edu/stanford/nlp/models/lexparser/englishPCFG.ser.gz')

o = parser.parse(inputString.split())

englishtree  (variable) englishtree: list se(inputString.split())]
parsetree = englishtree[0]

dict = {}
```

```
# "**********subtrees**********"

parenttree = ParentedTree.convert(parsetree)
for sub in parenttree.subtrees():
    dict[sub.treeposition()] = 0

# "-------------------------------------------"

isltree = Tree('ROOT', [])
i = 0
for sub in parenttree.subtrees():
    if(sub.label() == "NP" and dict[sub.treeposition()] == 0 and dict[sub.parent().treeposition()] == 0):
        dict[sub.treeposition()] = 1
        isltree.insert(i, sub)
        i = i+1

    if(sub.label() == "VP" or sub.label() == "PRP"):
        for sub2 in sub.subtrees():
            if((sub2.label() == "NP" or sub2.label() == 'PRP') and dict[sub2.treeposition()] == 0 and
               dict[sub2.parent().treeposition()] == 0):
                dict[sub2.treeposition()] = 1
                isltree.insert(i, sub2)
                i = i+1

for sub in parenttree.subtrees():
    for sub2 in sub.subtrees():
        print(sub2)
        print(len(sub2.leaves()))
        print(dict[sub2.treeposition()])
```

```
            if(len(sub2.leaves()) == 1 and dict[sub2.treeposition()] == 0 and
               dict[sub2.parent().treeposition()] == 0):
                dict[sub2.treeposition()] = 1
                isltree.insert(i, sub2)
                i = i+1

parsed_sent = isltree.leaves()

words = parsed_sent
```

2.15.2 Grammar for converting English to ASL

The grammar standard conversion is a very crucial step in the process, since the language used by the tutors and the American Sign Language have difference in terms of grammar rules. Therefore, it is essential to convert the parsed English text into a format that relates with the sign language grammar rules.

Therefore ASL grammar needs all the verb patterns should be shifted once the corresponding noun occurred. Some of the rule conversion are represented in the below table.

Table 2.1 - Conversion Rule

Verb Pattern	Rule	Input Sentence	Parsed Sentence	Output Sentence
verb+object	VP TO NP	Go to school	(VP (VB Go)(TO to) (NP (NN school)))	School to go
Subject + verb	NP V	Birds fly	(NP (NNS birds)) (VP (VBP fly))	Birds fly
subject + verb + subject complement	NP V NP	His brother became a soldier	(NP (PRP$ his) (NN brother)) (VP (VBD became) (NP (DT a) (NN soldier)))	His brother a soldier became
subject + verb + direct object + preposition +prepositional object	NP V NP PP	She made coffee for all of us	(NP (PRP She)) (VP (VBD made) (NP (NN coffee)) (PP (IN for) (NP (NP (DT all)) (PP (IN of) (NP (PRP us))))))	she coffee for all of us made

2.15.3 Stop Words Removal

In the process of preprocessing, it is clearly seen that some words in a caption is not applicable for conversion itself. Such words are referred to as stop words and the elimination of those words is done in this step. Stop words include various types, among which a few of them can be determiners (the, a, an, another), coordinating junctions (for, an, nor, but, yet), prepositions (under, from, on, of, towards), plurals (‘book’ instead of ‘books’), interjections, etc. this word will be removed in this phase which will be easier to connect the words with the ASL dataset by eliminating the stop words.

The below code represent how stop word will be removed from the input caption.

```
words = parsed_sent

stop_words = set(stopwords.words("english"))
print(stop_words)
```

Figure 10 - Stop words code

2.15.4 Lemmatization and synonym replacement

The words containing prefixes or suffixes, tense related suffixes, etc. are reduced into its root form. For example, words like ‘adjustment’, ‘adjustable’ and ‘adjusting’ are reduced into its root ‘adjust’. Further, if the root word is not found in the sign database, it is matched with its synonym and then the relevant sign will be found.

The below code shows how the lemmatization part is done

```
lemmatizer = WordNetLemmatizer()
ps = PorterStemmer()
lemmatized_words = []

for w in parsed_sent:
    w = ps.stem(w)

    lemmatized_words.append(lemmatizer.lemmatize(w))
aslsentence = ""
print(lemmatized_words)
for w in lemmatized_words:
    if w not in stop_words:
        aslsentence += w
        aslsentence += " "
print(aslsentence)
```

Figure 11 - Lemmatization code

2.15.5 Video Conversion

After completing the above steps, we get the ASL converted text to find matches from each word database based on basic string matching algorithm between processed input text and labels of videos. Finally a one set of videos can be displayed on the screen one after the other which is the final stage of the process converting text into ASL videos.

This stage can be divided in to two parts:

1. **Tokenizing the words**
   In this stage the ASL converted caption will be tokenized into words using NLTK.

2. **Connecting the video with tokenized words**
   Once the tokenization part is completed the system will find matches from each word database based on basic string matching algorithm between processed input text and labels of videos.

The below code shows how it is done:

```
try:
    os.remove("my_concatenation.mp4")
except:
    pass
print(sys.path)
name = "school present tomorrow go"

for each in range(1, len(sys.argv)):
    name += sys.argv[each]
    name += " "

input_text = name

text = nltk.word_tokenize(input_text)

result = nltk.pos_tag(text)

for each in result:
    print(each)

dict = {}
dict["NN"] = "noun"
arg_array = []

for text in result:
    arg_array.append(VideoFileClip(text[0]+".mp4"))
    print(text[0]+".mp4")
print(arg_array[0])

final_clip = concatenate_videoclips(arg_array)
final_clip.write_videofile("my_concatenation.mp4")
```

Figure 12 - Video Conversion Code

The above code shows the ASL caption tokenization part and string matching algorithm to join word with video and the video concatenation part.

2.15.6 User interface

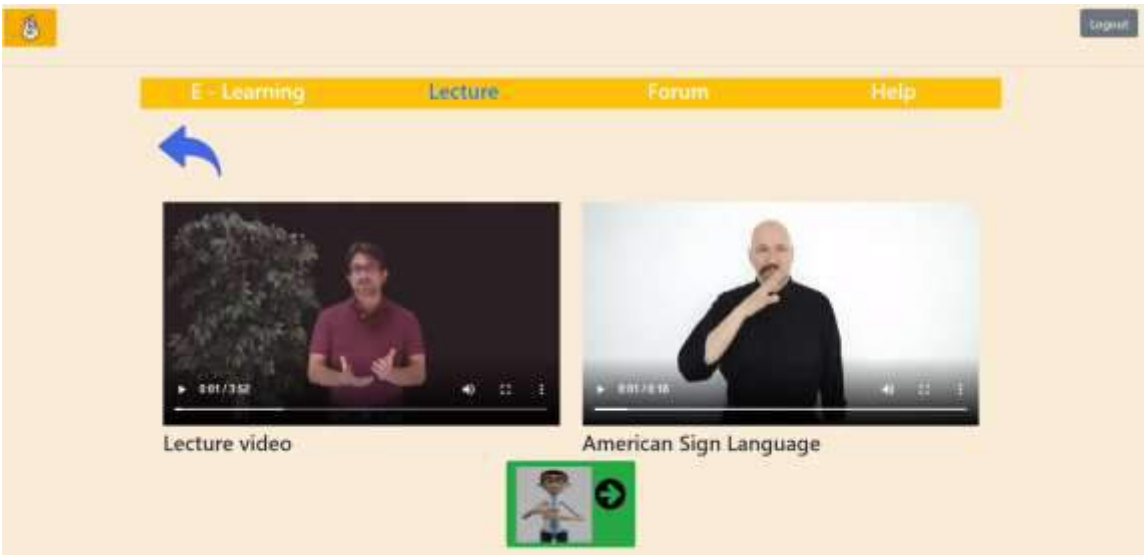


Figure 13 - UI

The above user interface shows the final system where the hearing impaired students can see the ASL converted lecture in the right side where the tutor uploaded English grammar video will be in the left side of the system. Since our research comes under human computer interaction we were mainly forcing on UI and UX this interface will be modified more to provide more comfortable to the end users who is hearing impaired students.

2.16 Testing

Regardless of the many significant steps mentioned above, the testing phase too is very important. It helps the developers to mold the system by identifying the mistakes and the feedback. Hence, this step was done in four stages that improved the test accuracy of the system, which are unit testing, module testing, integration testing and system testing.

2.16.1 Unit Testing

This testing phase is the initial and base to the rest of the testing phases. Here, every single components were tested individually and were reported to proceed to the next

level, if that was error free. In accordance to that, individual test cases were made to test them.

In the text to conversion module, the aspects like data input to the system, correct displaying of the sign video were tested out.

2.16.2 Module Testing

Here, all the modules were tested separately, meaning each classes and components available in the system.

2.16.3 Integration Testing

This testing phase was done after integrating the individual components of the system, and made sure there were no error or bugs to be fixed while it is being used. Also, it is notable that it was ensured that the integration process did not change the functionality of the existing components.

2.16.4 System Testing

This is the final stage of the testing process where the system is tested as a whole. It was done to confirm that the system fulfilled the requirements that were gathered before the development. This was pretended to be tested as an actual user, in this case a hearing impaired student. Therefore, the test cases were based on actual captions that were received from the lecture videos and it was converted into sign language video output.

Below are some test cases that are done for each testing method.

Table 3 - Test case 1

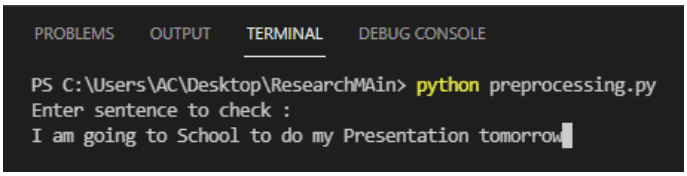
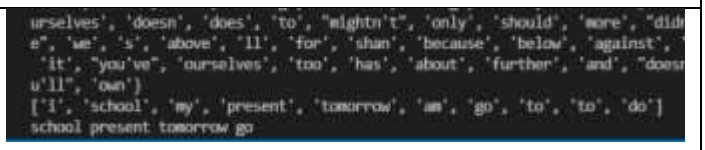
Test Case No	Test case 01
Description	Testing the ASL grammar conversion.
Test Procedure	1. Insert the sentence to convert. 2. Run the script.
Input	
Expected Output	ASL converted grammar - school present tomorrow go
Actual results	
Pass/Fail	Pass

Table 4 - Test Case 2

Test Case No	Test case 02
Description	Testing the ASL grammar conversion.
Test Procedure	1. Insert the sentence to convert. 2. Run the script.
Input	Video caption / Text “I am going to shop to buy some books”
Expected Output	ASL converted grammar - book go shop buy
Actual results	ASL converted grammar - book go shop buy
Pass/Fail	Pass

Table 5 - Test Case 3

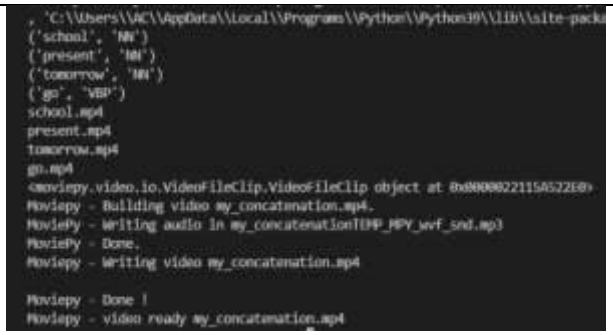
Test Case No	Test case 03
Description	Testing the video conversion
Test Procedure	1. Run the script with input caption
Input	ASL grammar converted caption
Expected Output	ASL video for each word should be concatenated and displayed as one video.
Actual results	
Pass/Fail	Pass

Table 6 - Test Case 4

Test Case No	Test case 04
Description	Testing the stop word removal phase.
Test Procedure	1. Insert the sentence to convert. 2. Run the script.
Input	Video caption / Text “I am going to shop to buy some books”
Expected Output	Removed stop words - ['I', 'some', 'am', 'to']
Actual results	Removed stop words - ['I', 'some', 'am', 'to']
Pass/Fail	Pass

3. RESULTS & DISCUSSION

3.1 Results

This topic discuss the result/output derived by developing this system. Education is very important for all human being even for hearing impaired students also should get a proper education without any difficulties like a normal students. When it comes to online learning it is very difficult for hearing impaired students to get proper education from a lecture who doesn't know sign language. To solve this problem, this kind of system will be very useful for both tutors and also hearing impaired students. That is the main reason for developing this application for recruiters. As mentioned above, this system contains some sub-components and these components depend on each other to produce the final results in ASL. The output from one component will be the input for the other component. So, the accuracy of each component is very important to get an accurate final result.

The main idea of this system is to solve the main language barrier between the lecturer who doesn't know ASL and the hearing impaired student who speak ASL. This chapter will discuss the results / output for text to sign language function with the code segment and the output.

3.1.1 Output of ASL grammar conversion

When running the preprocessing script it will request for the video caption / text to convert it from English grammar to ASL grammar. Since the language used by the tutors and the American Sign Language have difference in terms of grammar rules. Therefore, it is essential to convert the parsed English text into a format that relates with the sign language grammar rules. This phase includes following steps,

1. Sentences reordering module based on ASL grammar rules.
2. Stop words removal
3. Stemming and lemmatization

The below picture will show the output after running the script which has been build using NLTK techniques to convert English grammar to ASL grammar

The input caption to convert it into ASL grammar is: “I am going to school to do my presentation tomorrow” which is shown below.

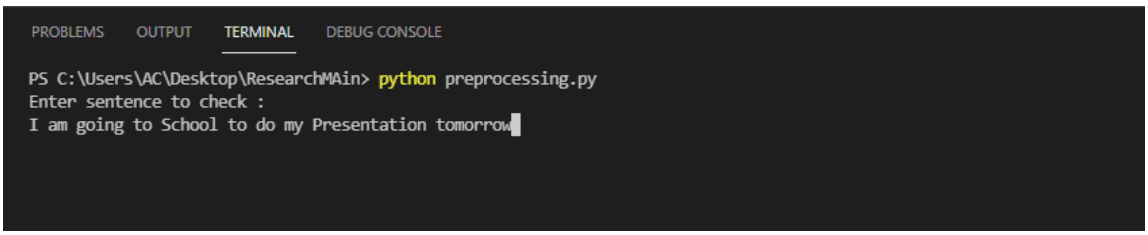


Figure 14 - Input Caption

The figure shows the output after converting the caption in to ASL grammar which is “School present tomorrow go”

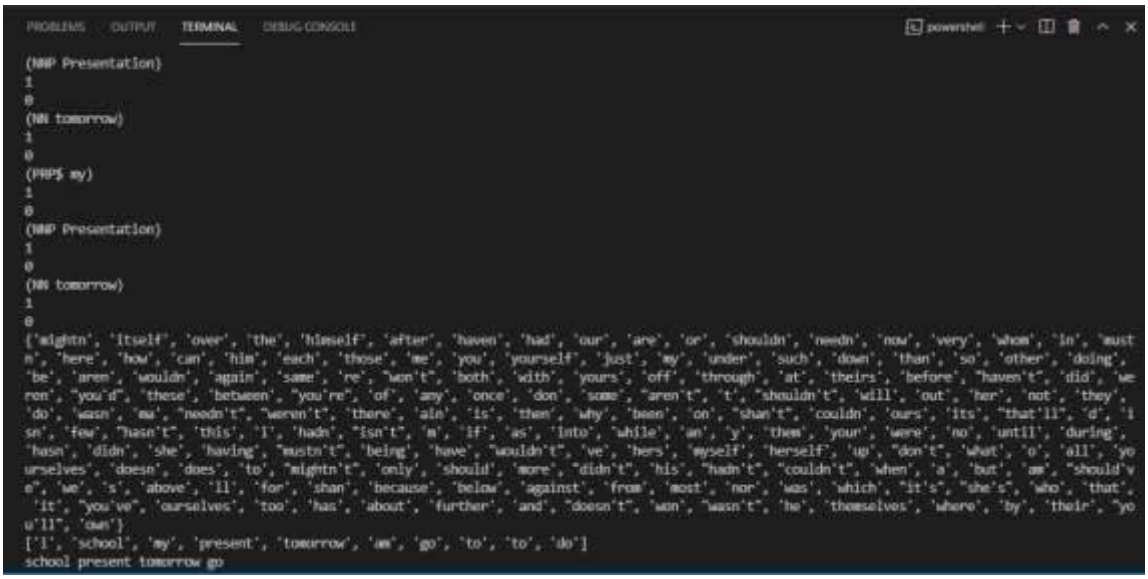


Figure 15- ASL grammar output

3.1.2 Output of video conversion module

The final stage of converting text into ASL video is video conversion module. This module use the ASL converted caption to find matches for each word from the database based on string matching algorithm between ASL converted input caption and labels of videos. Finally a one set of videos can be displayed on the screen one after the other which is the final stage of the process converting text into ASL videos.

This stage can be divided into two phase which is:

1. Tokenizing the ASL grammar converted caption / text
2. Video conversion

The output after running the video conversion script is shown below:

Figure 16- Tokenization

The above figure shows the tokenized part of the caption after running the script and it search for the videos for each word from the database to concatenate.

Figure 17- Video Conversion

The above figure shows the final results after running the video conversion module. Once tokenization part is completed the system search for the videos for each words in the database to do the string matching algorithm to concatenate videos for each word and present it as a final output of the system.

The below image shows the concatenated video images after converting the caption into ASL.

3.1.3 Output of final results

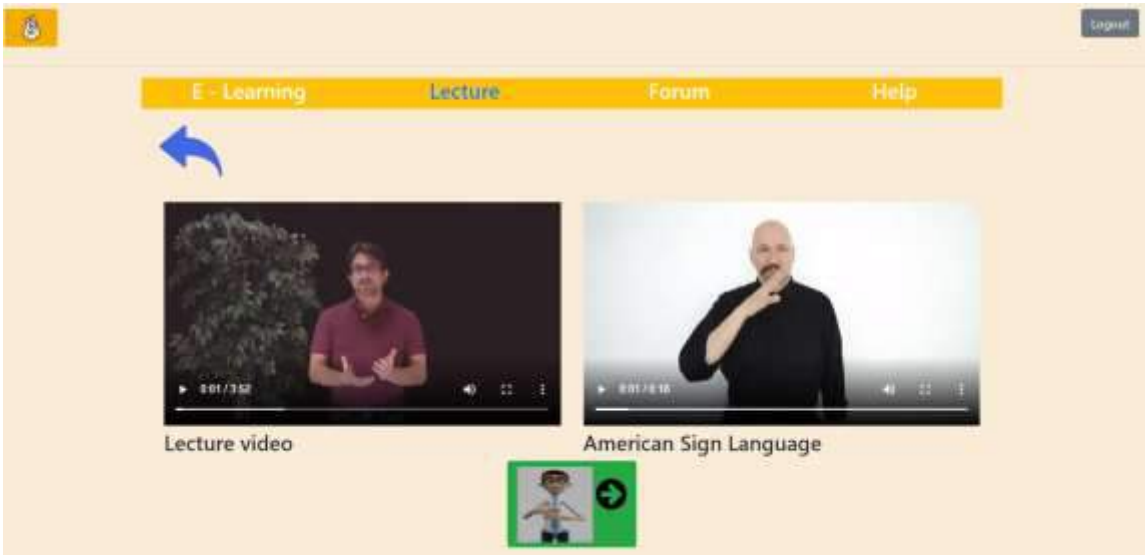


Figure 18- Final UI output

Once the above tasks completed the final concatenated video will be visualized in the LMS which is shown in the figure. Since our research comes under human computer interaction we were mainly forcing on UI and UX this interface will be modified more to provide more comfortable to the end users who is hearing impaired students.

3.2 Research Findings

The ultimate goal of this research study was to provide a system that will enable the hearing impaired students to learn from the online platforms on their own, without any difficulties or others' assistance. It was achieved to almost a hundred percentage, which is evident from the test results.

Hence, our developed system is found to consist of the following features.

1. Reliable and trustworthy

As the translations of the captions are tested by many test cases, it was found they were very accurate, that the meaning of the sentences were not collapsed. Therefore, it will be useful for students to learn without any doubts in the conversion system.

2. User-friendly interface

Since the development was done to minimize the difficulties faced during the online learning, it was made sure all the things in the application should be simple enough and must have a user-friendly interface.

3. High speed

The conversions take place very rapidly, since the data has been already put into the system's database. The process is to find the matching words with the same labels of the videos.

Although our system has the good features mentioned above, there is a con to it. The output that is generated from the system definitely relies on the vocabulary scale which is fed to the system database. Therefore, some words might be missed, but very rarely.

3.3 Discussion

This chapter discusses the results obtained from the development of the application. We have achieved an accuracy of 90% accuracy for the system. Most of the accuracy level is depends on the conversion between English grammar to ASL grammar since our system accurately converts the caption into ASL with the proof of test cases our system archived 90% of accuracy by developing the system.

When comparing the text to sign language functionality with other existing systems it is proofed that there is no existing LMS system for hearing impaired students is available by doing this research. Since there is no existing LMS for hearing impaired students out system with 90% accuracy is considered as best success rate by developing this system.

3.4 Future Works

Even though we find the research completed, there is also expectations for updates in the system by adding more signs to the database with time, and enhancing the synonym finding feature in the system. We expect this would be more helpful and trustworthy to the users of the system. For output generation the data can be created with the same person and also this can be converted to animation output as well which will solve the issue for finding the dataset for some words.

As our system is fully developed based on American Sign Language it is possible to develop the system to support other sign language as well. This can help more target users to get maximum use out of this system. This kind of features can be developed in future to provide more advantage to the hearing impaired students.

4. CONCLUSION

In summary, this research work is about developing a learning management system for hearing impaired students. Since the technology is growing very fast in every sector the education sector also rapidly moving into online based education system. When it comes to normal people it is very convenient for them to learn and interact with the tutors through the learning management system specially during the pandemic situation but when it comes to hearing impaired students they are facing many difficulties while the education sector is migrating into online platform because of this problem we came up with a solution to solve the communication barrier between the tutor and hearing impaired students and the education barrier. Therefore, in this function the tutor who doesn't know ASL can upload his lecture video to the system once it is uploaded the system will extract the caption from the video and pass it as input for this function which is test-to-sign language conversion.

The text-to-sign conversion module in the research has been successfully developed and tested that it accommodates the hearing disabled students to fulfill their requirements and eliminate struggles in shifting to the e-learning platform. The system flawlessly converts the given sentence to American Sign Language video format to ensure there is no grammar mistakes in the sentence. Therefore, it is hoped that they benefit from this and more users will find this enlightening for their studies.

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APPENDICES

ASL Grammar conversion script

preprocessing.py

```
import os
import sys
import argparse
from nltk.parse.stanford import StanfordParser
from nltk.tag.stanford import StanfordPOSTagger, StanfordNERTagger
from nltk.tokenize.stanford import StanfordTokenizer
from nltk.tree import *
from nltk import word_tokenize
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
from nltk.stem import PorterStemmer
import nltk

inputString = " "

java_path = "C:\\Program Files\\Java\\jdk-16.0.1\\bin\\java.exe"
os.environ['JAVA_HOME'] = java_path

for each in range(1, len(sys.argv)):
    inputString += sys.argv[each]
    inputString += " "

# inputString = raw_input("Enter the String to convert to ISL: ")
inputString = input("Enter sentence to check :\n")
#"I am going to School to do my Presentation tomorrow."


# D:\accash\stanford-postagger-full-2015-12-09\models
parser = StanfordParser(
```

preprocessing.py

```
parser = StanfordParser(
    model_path='D:/stanford-parser-full-2015-12-09/edu/stanford/nlp/models/lexparser/englishPCFG.ser.gz')

o = parser.parse(inputString.split())

englishtree = [tree for tree in parser.parse(inputString.split())]
parsetree = englishtree[0]

dict = {}

# "**********subtrees*********"

parenttree = ParentedTree.convert(parsetree)
for sub in parenttree.subtrees():
    dict[sub.treeposition()] = 0

# "----------------------------------------"

isltree = Tree('ROOT', [])
i = 0
for sub in parenttree.subtrees():
    if(sub.label() == "NP" and dict[sub.treeposition()] == 0 and dict[sub.parent().treeposition()] == 0):
        dict[sub.treeposition()] = 1
        isltree.insert(i, sub)
        i = i+1

    if(sub.label() == "VP" or sub.label() == "PRP"):
        for sub2 in sub.subtrees():
            if((sub2.label() == "NP" or sub2.label() == 'PRP') and dict[sub2.treeposition()] == 0 and
```

preprocessing.py

```
                if((sub2.label() == "NP" or sub2.label() == 'PRP') and dict[sub2.treeposition()] == 0 and
                   dict[sub2.parent().treeposition()] == 0):
                    dict[sub2.treeposition()] = 1
                    isltree.insert(i, sub2)
                    i = i+1

    for sub in parenttree.subtrees():
        for sub2 in sub.subtrees():
            print(sub2)
            print(len(sub2.leaves()))
            print(dict[sub2.treeposition()])
            if(len(sub2.leaves()) == 1 and dict[sub2.treeposition()] == 0 and
               dict[sub2.parent().treeposition()] == 0):
                dict[sub2.treeposition()] = 1
                isltree.insert(i, sub2)
                i = i+1

    parsed_sent = isltree.leaves()

    words = parsed_sent

    stop_words = set(stopwords.words("english"))
    print(stop_words)

    lemmatizer = WordNetLemmatizer()
    ps = PorterStemmer()
    lemmatized_words = []

    for w in parsed_sent:
```

preprocessing.py

```
                if((sub2.label() == "NP" or sub2.label() == 'PRP') and dict[sub2.treeposition()] == 0 and
                   dict[sub2.parent().treeposition()] == 0):
                    dict[sub2.treeposition()] = 1
                    isltree.insert(i, sub2)
                    i = i+1

    for sub in parenttree.subtrees():
        for sub2 in sub.subtrees():
            print(sub2)
            print(len(sub2.leaves()))
            print(dict[sub2.treeposition()])
            if(len(sub2.leaves()) == 1 and dict[sub2.treeposition()] == 0 and
               dict[sub2.parent().treeposition()] == 0):
                dict[sub2.treeposition()] = 1
                isltree.insert(i, sub2)
                i = i+1

    parsed_sent = isltree.leaves()

    words = parsed_sent

    stop_words = set(stopwords.words("english"))
    print(stop_words)

    lemmatizer = WordNetLemmatizer()
    ps = PorterStemmer()
    lemmatized_words = []

    for w in parsed_sent:
```

```
for w in parsed_sent:
    w = ps.stem(w)

    lemmatized_words.append(lemmatizer.lemmatize(w))
islsentence = ""
print(lemmatized_words)
for w in lemmatized_words:
    if w not in stop_words:
        islsentence += w
        islsentence += " "
print(islsentence)

```

Video Generation code

second.py × preprocessing.py

second.py > ...

```
import sys
import os
import nltk
from moviepy.editor import VideoFileClip, concatenate_videoclips
from nltk.parse.stanford import StanfordDependencyParser
import numpy as np
import cv2
import imageio
#imageio.plugins.ffmpeg.download()


try:
    os.remove("my_concatenation.mp4")
except:
    pass
print(sys.path)
name = "school present tomorrow go"

for each in range(1, len(sys.argv)):
    name += sys.argv[each]
    name += " "

input_text = name

text = nltk.word_tokenize(input_text)

result = nltk.pos_tag(text)

for each in result:
```

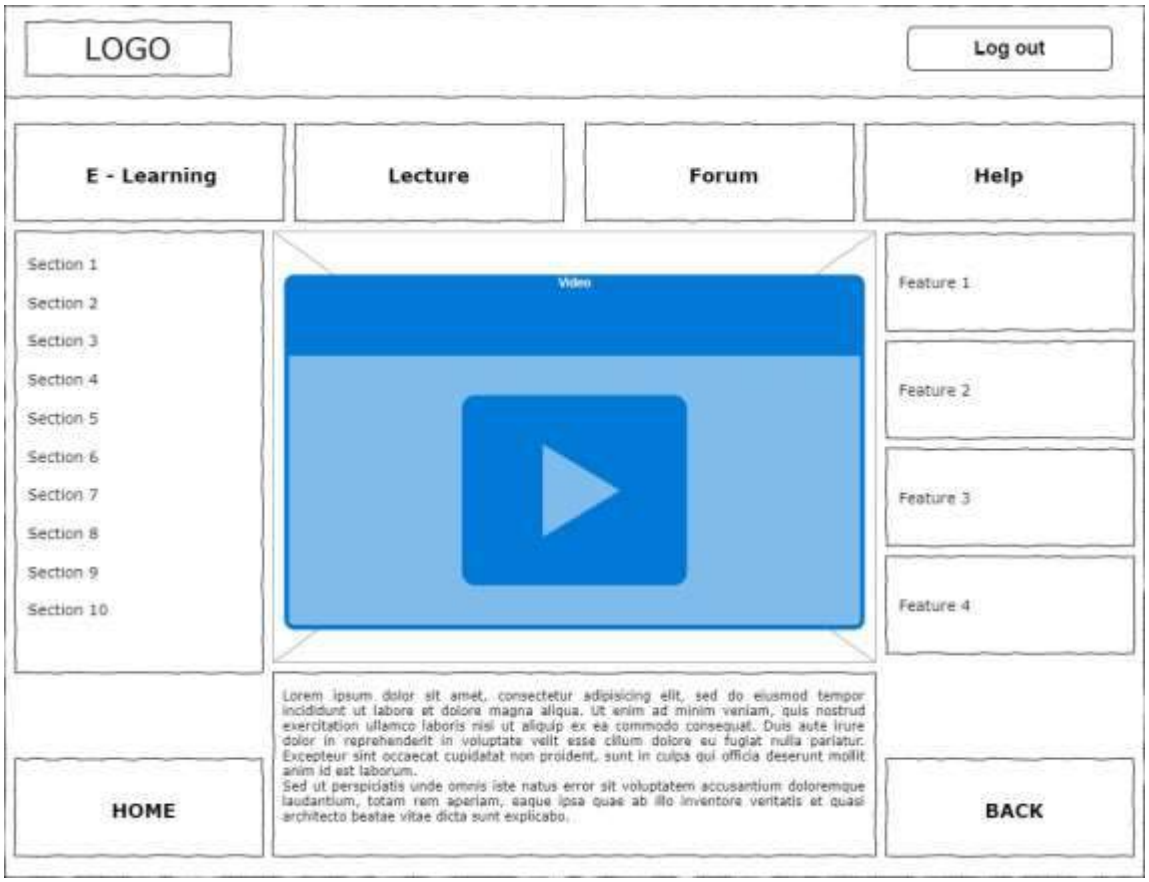
```
for each in result:
    print(each)

dict = {}
dict["NN"] = "noun"
arg_array = []

for text in result:
    arg_array.append(VideoFileClip(text[0]+".mp4"))
    print(text[0]+".mp4")
print(arg_array[0])

final_clip = concatenate_videoclips(arg_array)
final_clip.write_videofile("my_concatenation.mp4")
```

Wireframe


LOGO
Log out
E - Learning
Lecture
Forum
Help
Section 1
Section 2
Section 3
Section 4
Section 5
Section 6
Section 7
Section 8
Section 9
Section 10
Video
Feature 1
Feature 2
Feature 3
Feature 4
Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.
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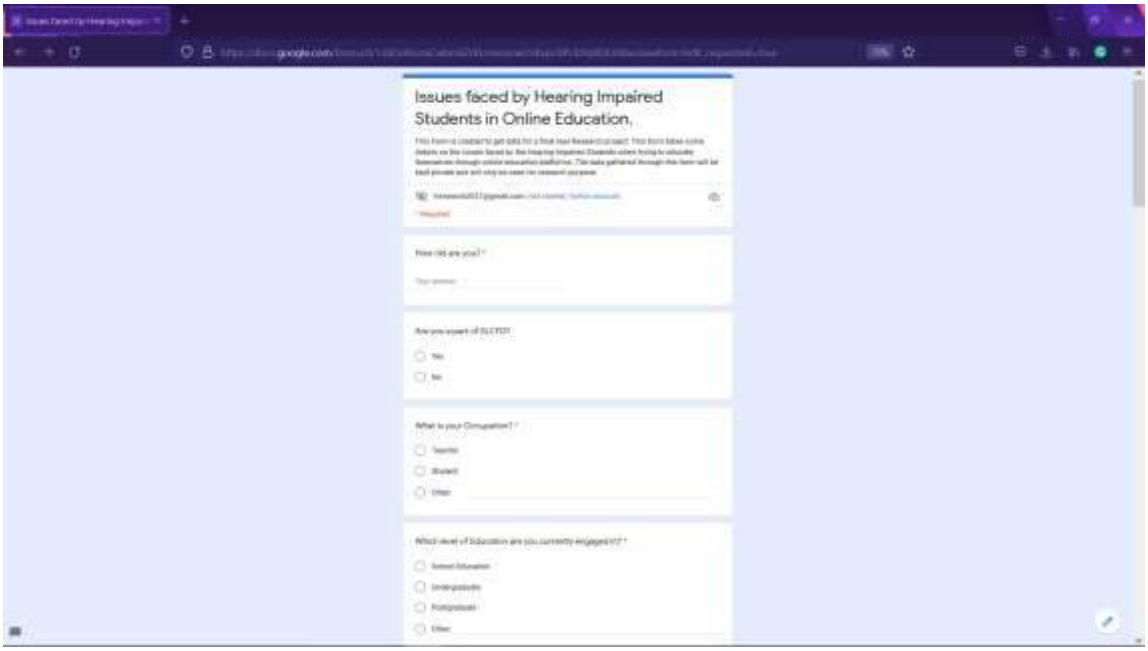
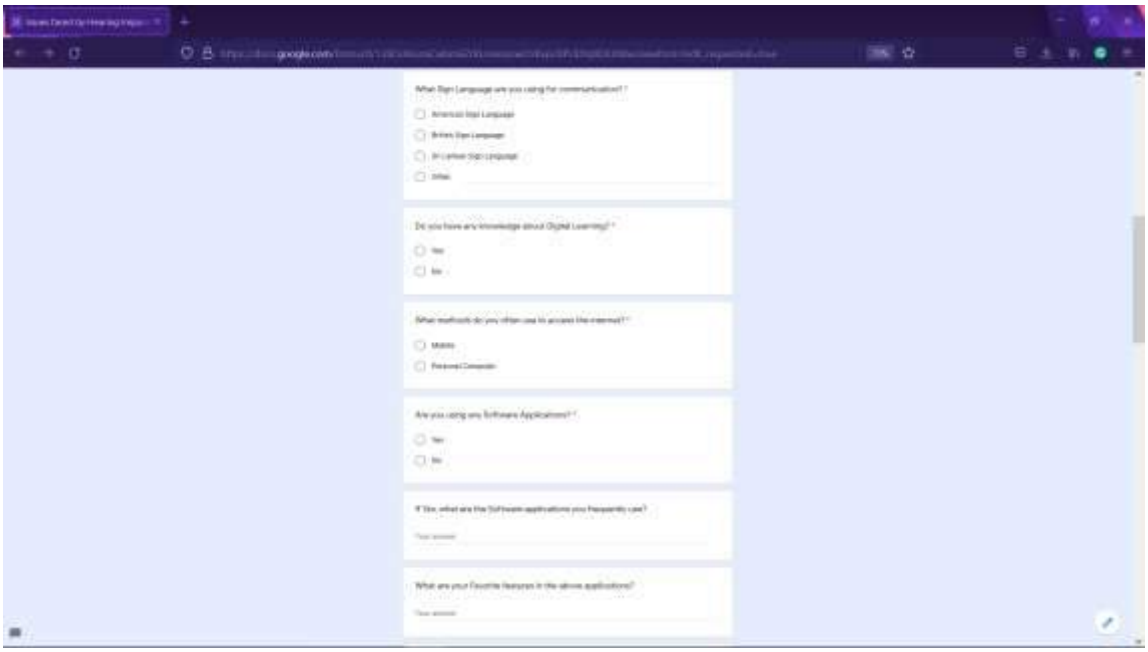
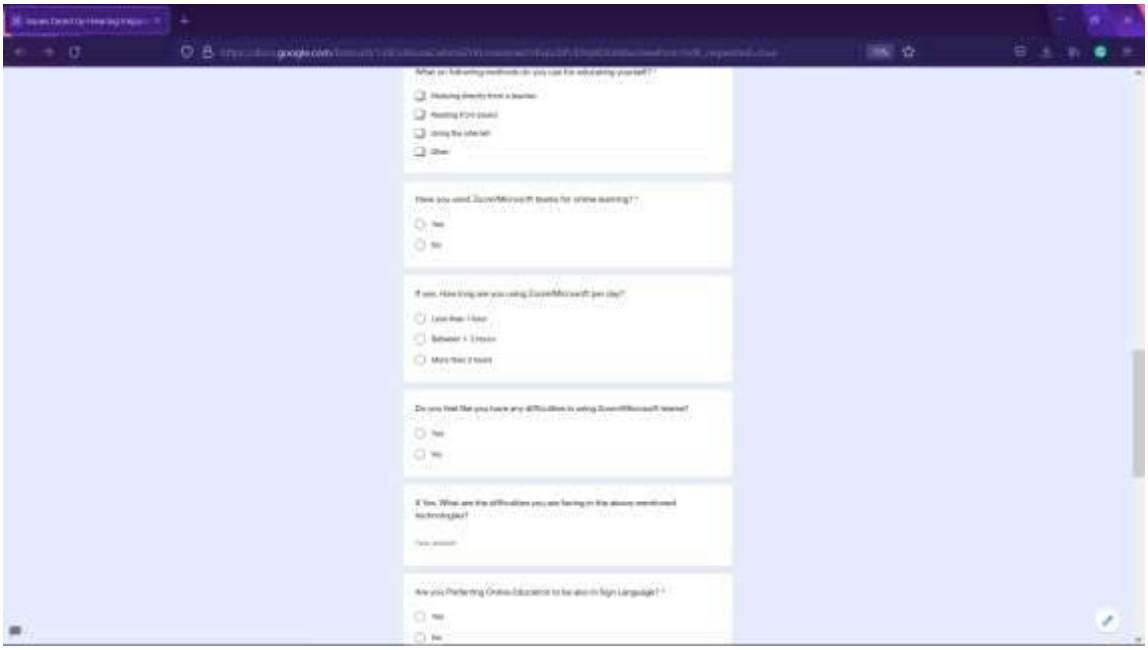
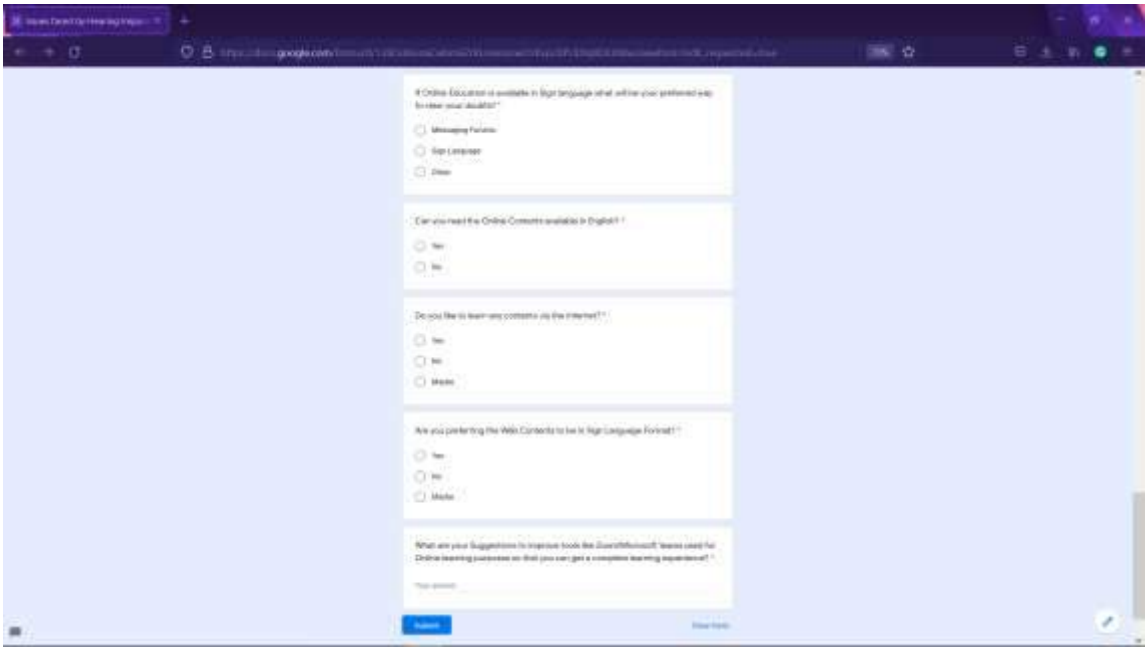
HOME
BACK

Survey

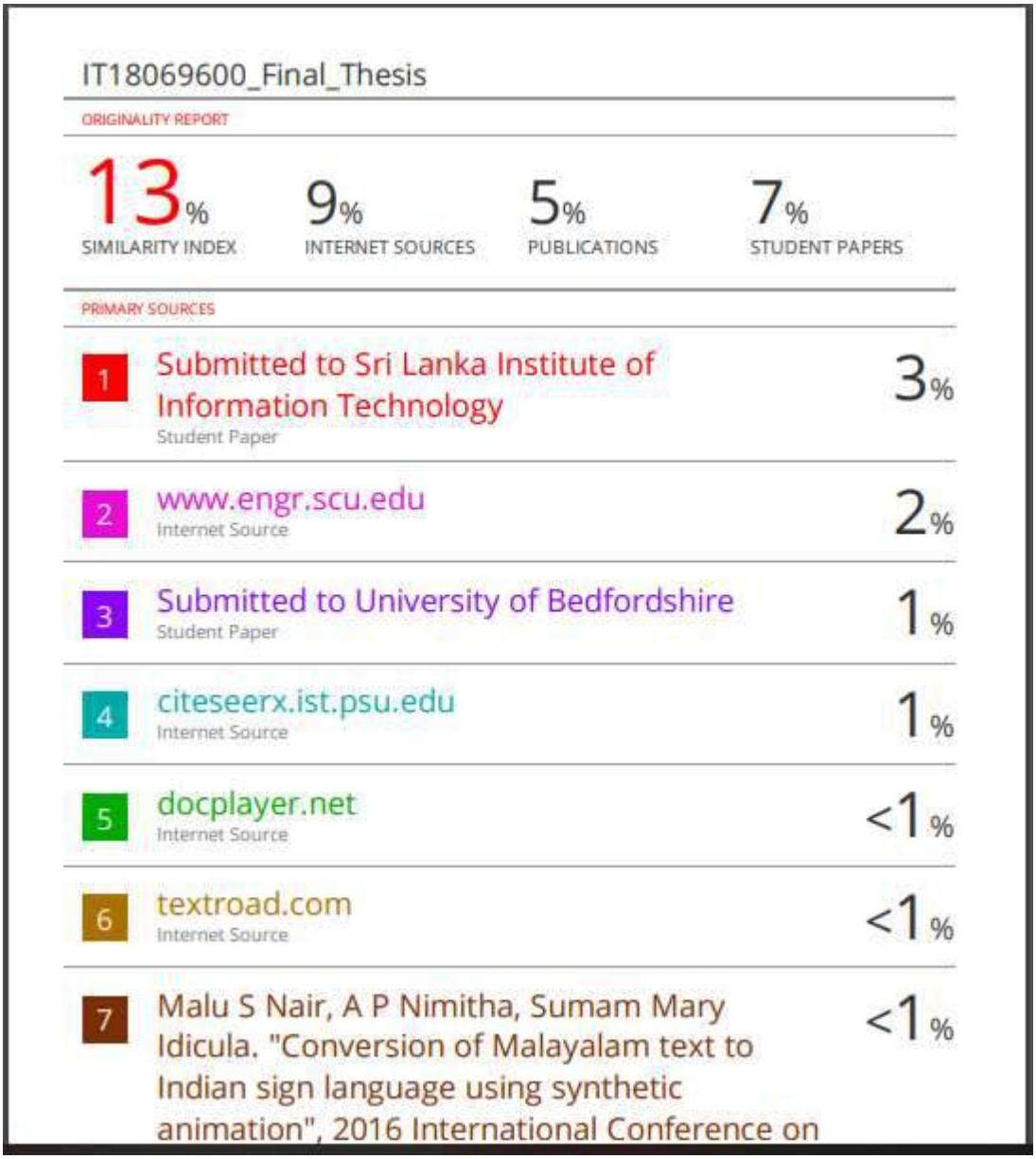

Issues faced by Hearing Impaired Students in Online Education.







Plagiarism Report



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