



AI Powered Speech Translation System for Classrooms

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Abstract :

Students often face academic challenges and social isolation due to a lack of proficiency in the medium of instruction in multilingual education environments [1],[5]. In the existing model, there is a Traditional language support model where they separate such students into particular dedicated language classrooms, which results in a delay of subject learning and difficulty in inclusive participation .To address this problem, we propose this project, An AI-Based Real-Time multilingual Class room assistance System which enables instant translation of instructions said by the teacher within the mainstream classrooms. This proposed system of the project integrates Artificial Intelligence (AI), Automatic Speech Recognition (ASR), and Natural Language Processing (NLP) to give instant translation of the teacher's speech into live text, and it also translates into multiple target languages in real time. Here, in this proposed system, follows a client-server architecture with role-based access for students and teachers. The Teacher speaks through a microphone-enabled interface, while students register on the web page and select their preferred language. In this, we proposed an AI engine that processes the spoken input, does the speech-to-text conversion, and applies neural machine translation to generate multilingual outputs, and gets instantly displayed on the devices of students using real time communication protocols.

Keywords :

Artificial Intelligence (AI), Inclusive Education, Multilingual Classrooms ,Natural Language Processing (NLP), Real-Time Translation, Speech Recognition (ASR).

Introduction :

The education sector has witnessed a significant increase in linguistic diversity in recent years due to the cause of globalization, migration, and the expansion of digital learning platforms. In these modern days, classrooms consist of students from different regions and countries who speak different native languages[11],[14]. This diversity introduces a major challenge: the " Language barrier between the students and the teachers ".Due to students from different regions being present, they are unable to understand the instructions of the speaker, cannot grasp concepts, participate in discussions, and cannot perform their best academically.

In the Recent research in educational psychology confirms that students can retain information more effectively when they are taught in their native language or in the language they prefer, which shows the outcome of an improvement of approximately 30-40%[1],[4],[19]. But unfortunately, most educational

institutes prefer single-language teaching, like English or their native regional language. which is not suitable for most of the learners. As a result, most of the learners suffer to keep up with the pace of the institute, which results in reduced confidence, low engagement, and low interest in active academic participation and higher dropout rates.

To overcome this language barrier problem, we had some Traditional approaches which includes hiring multilingual teachers, conducting separate language specific classes, using pre translated study materials. even though these methods provide some level of support, they are often resources intensive, time consuming, not scalable for large number of students and classrooms and can result in some difficulty for student academic performance, which is crucial for natural flow of teaching and learning [6],[7].

With the rapid growth and improvements in Artificial Intelligence (AI), specifically in Speech recognition and Natural language processing, many new opportunities have arisen for addressing these challenges and problems above [15],[18].Modern AI technology has the strength to convert spoken language into text with higher accuracy and translate it into many preferred languages instantly. These system modules can give an opportunity to design intelligent systems that can deliver real-time multilingual support in educational environments.

In this regard, this research gives a solution called Intelligent Language Support Assistance, which is an AI-NPL based system. This system is developed to facilitate real-time translations of lectures. [3]First this module captures the speech of the teacher through a microphone, and then processess the audio using advanced speech recognition, and translates it into textual form. [16]Then the subtitles are then analyzed and translated into multiple languages using NLP, based on students' preferred language. and then the outcome is displayed instantly on the student's dashboard, helping them to follow the lesson in their own language.

This system's goal is to create an Inclusive and Interactive Learning Environment where language barrier differences don't hinder the academic performance of the student. Unlike Traditional methods, this system allows many students to receive translations at the same time without any difficulties. and also ensures all the students to involve in the classroom equally.

The specialty of this research is within its integration of real-time speech recognition, and live broadcasting within a single unified platform with multilingual translation, unlike existing systems. We designed this system to be adaptable and make it suitable for educational purposes

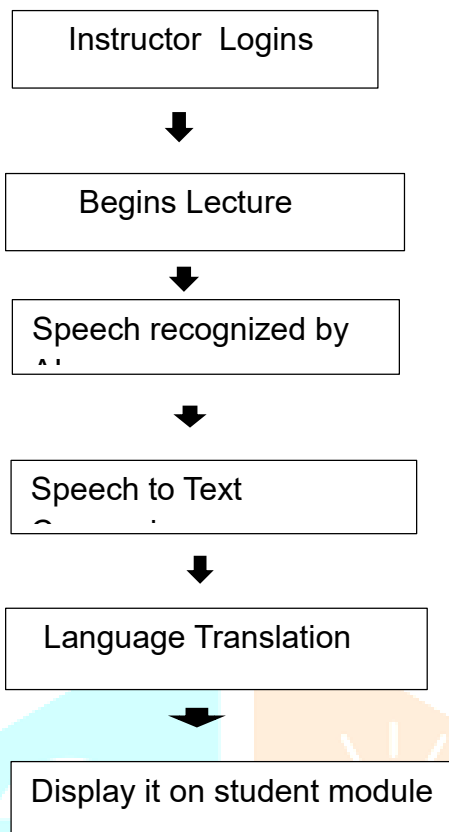
The important approach of this system is to improve the overall educational outcomes. This enables all the learners to grasp lessons effectively in their native or preferred language. it also improves comprehension, and engagement levels and also reduces load on students who need to take load on their mental state to translate the content while learning.[2] With these features, teacher can deliver their teaching without any difficulty to adjust their teaching for non-regional students to understand and maintain their natural flow of teaching without any problem.

The main motive of this research is to develop and design an AI system tool that addresses the language barrier problem in the educational environment.[8] The research focuses on implementing real-time translation using NLP and AI modules.

In conclusion, the proposed system Language Support Assistance module provides a significant step towards achieving a technology-driven education system.[20] By using the power of AI and NLP, we have the strength to transform traditional classroom methods into a smart AI multilingual learning space, making sure that no student or learner is left behind due to their language barrier.

Proposed System:

Our proposed system is based on artificial intelligence and natural language processing, which is used to stop the segregation of the students into different batches from the classroom environment. This system will allow the students to understand the lessons in their preferred language. In this system we used speech recognition, NLP, and other real-time technologies. In this system we developed an AI-based application that contains two modules. The first one refers to the teacher, and the second one refers to the student.

Overall Flowchart:**System Architecture :**

The proposed AI application is based on the client-server architecture. This means the client can request the data, and the server will manage the resources. This architecture is divided into four layers:

1. Source layer
2. Transformation layer
3. Infrastructure
4. Prediction layer

Overview:

We used this type of architecture to ensure that when the teacher provides input, the lecture is processed by the AI and converted into language preferred by the student. It handles the system in such a way that multiple students can receive the lecture at a time with milliseconds of time delay.

1. Source Layer:

The source layer refers to the teacher module, which is responsible for capturing the teacher's lecture and sending it to the system.

Elements:

1. Faculty Login
2. Faculty interface
3. Lesson start/end button
4. Audio input permission

Working:

1. The instructor gets login to the system and can see the students' login data.

2. He/she starts the lesson by clicking on the start button, and then audio recording starts.
3. This source layer works in such a way that the system accepts the data without any disruption.

2. Transformation Layer:

This is the layer where actual processing takes place. It is again divided into four modules:

- **Speech to Text Engine** :This module is used for converting instructor audio into text. AI is used to understand the words spoken by the instructor and convert them into text. [3] This helps the instructor to see what he/she is explaining.[15]

Mathematical Representation :

Let us consider

$X = \text{audio}(\text{input})$

$Y = \text{text}(\text{output})$

The system uses this formula $Y^* = \arg \max_Y P(Y|X)$ to get the best possible words .Here max function helps the system to select the sentences with higher probability.

- **Text Processing Pipeline:**

This module mainly focuses on removing the noise words. When the instructor speaks into the microphone, there may be some disturbance due to surroundings, so this layer works to remove the disturbances and helps to construct the structured and meaningful sentences.

- **NLP Understanding module:**

This module is also used to convert the speech into well-formed sentences before translating it into the student's preferred language.[2]

First, it splits the sentences into small fragments. For example, Let us consider the sentence "Good morning, students." It divides it into three parts, such as [good morning, students].

In the next step it focuses on discarding the unnecessary words from the text. It ensures that the formed sentences are syntactically correct.[13] It checks the words for vagueness and tries to avoid them for more clarity

Mathematical Representation:

Let us consider

$S = \text{Unformatted text}$

$G = \text{Formatted Text}$

Formula : $G = h(S)$

Here h refers to the operations performed by NLP which we have discussed above.

- **Translation module:**

Finally, in this module, the text, which is formatted by NLP in the before step, is translated into the student's preferred language . [16]The system gets the selected language of the individual from the database. [18]It gathers the required information, and finally the lecture is displayed on the student's dashboard.

Mathematical Representation:

If $H = \text{Formatted text}$

$M = \text{student's preferred language}$

$R(\text{translated})=f(H,M)$

3.Infrastructure :

This is the communication layer. After the translation of the sentences in the previous step, they are sent to the servers. The servers contain the active percentage of the students. The communication layer plays a vital role in transferring the converted text from the servers to the student's dashboard. It ensures that there is no disconnection in between. It reduces the data loss and ensures the proper and smooth connection .It uses the different types of technologies like WebSockets , CloudServers.[17]

Example:

Let us consider :

Instructor begins the lecture as “Today we are going to discuss about photosynthesis”.

Student1-Telugu

Student2-Tamil

Student3-Marati

The system allows the text conversion into these three preferred languages at a time with small time delay.

4.Prediction layer:

This layer indicates the student interface. Finally, this layer is used to demonstrate the translated text in the student's dashboard.

Elements:

Students get login to the system.

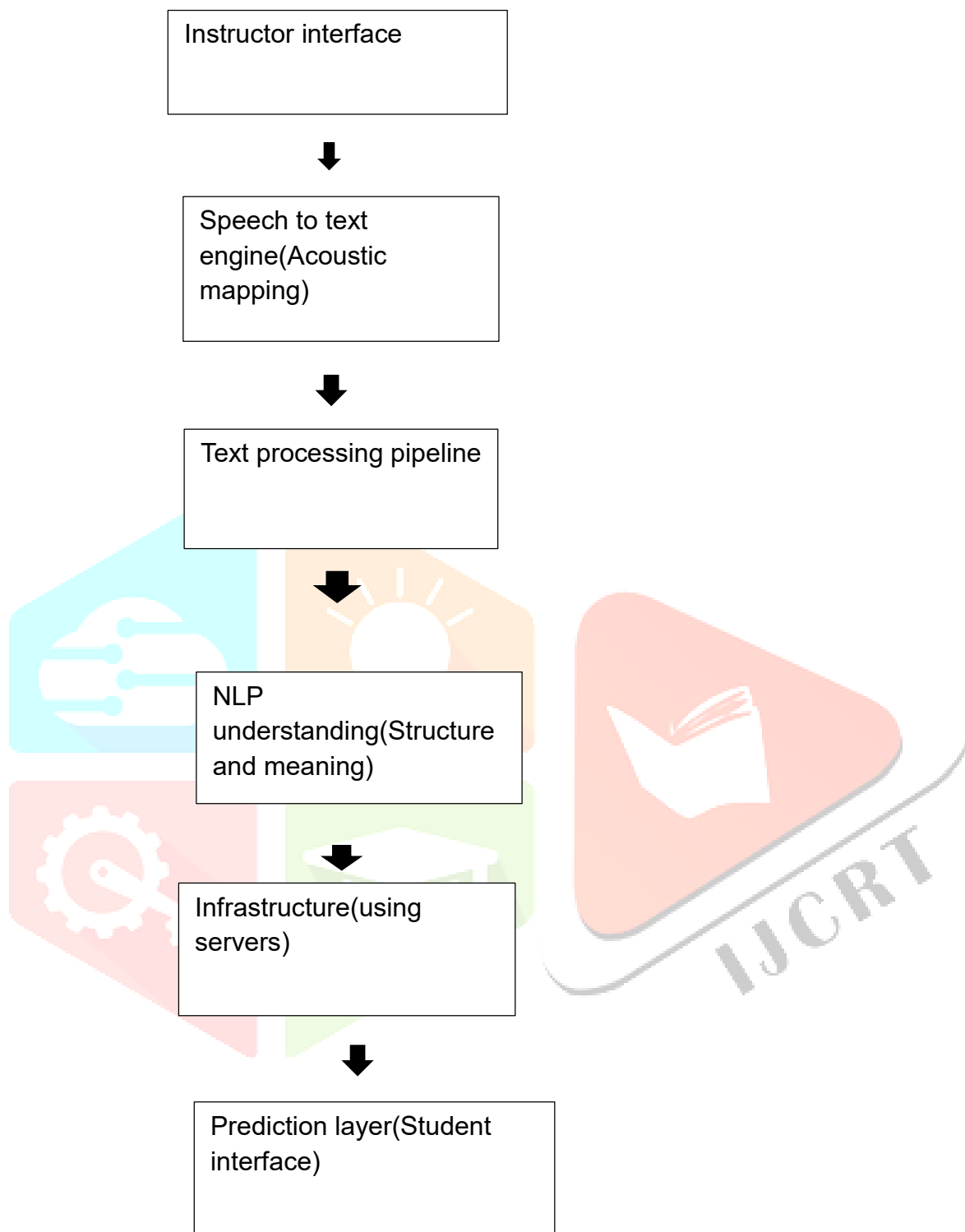
The app showcases one drop-down list so that students can change their preferred language at any time.

We can see all the details of students, like their selected language, and it also showcases whether the lesson is active or not.

Working:

The students first sign in to the system. If they already have their accounts, they should log in with their ID and password. They can see if the lecture begins. And there is a dropdown list so they can change the language at any time.

Diagrammatical representation of system architecture:



Advantages :

Role of MIKA-D in the existing system:

When any student joins the school first, they need to attend the test in MIKA-D, which is used to predict the German levels of the students. According to that, the system divides the students into 3 batches. The first batch is not allowed into normal classes and is allowed to continuously attend the German classes. The second batch are allowed to attend normal classes, but the system teaches them German for limited hours. Again, the students are allowed to attempt the test and get eligible for normal classes. The disadvantage is the system predicts the students with only marks, which are not accurate.

To avoid the disadvantage of MIKA-D, our system avoids the segregation of students and instead converts the German language into their preferred language[5],[19]. By this all the student's can learn at a time without any time waste.

Disadvantages :

1. The text generation may not be accurate due to some background noise disturbances.
2. It requires a proper internet connection.
3. The system may fail to translate the complex statements.
4. Students may get addicted to the technology.

Experimental Setup :

The suggested AI-NLP-based Intelligent Language Support Assistant was implemented using both software and hardware facilities to check the performance of the system in a multilingual classroom. The software facilities used for the implementation of the system include the Python programming language, Speech Recognition library, NLP [15],[18].

The hardware facilities used for the implementation of the suggested AI-NLP-based Intelligent Language Support Assistant system include a laptop/desktop computer, microphone, speaker, and internet connection. The microphone receives the voice of the teacher and sends it to the speech recognition system for translation. The translated language is then sent to the students using the devices that are connected to the system.

The proposed AI-NLP based Intelligent Language Support Assistant was evaluated to assess the efficacy of the proposed system in providing effective multilingual translation support in a classroom environment. The system was evaluated under different conditions, including speech quality, noise, and multiple language options. The evaluation was based on certain performance criteria, including speech recognition, translation accuracy, and system response time. The evaluation results show that the proposed system can operate efficiently in a real-time environment, providing effective support to multilingual students.

Results :

The system provides the results using the following elements:

1. Command Success Rate
2. Translation Fidelity
3. Response Latency
4. System Scalability
5. User Contentment

1. Command Success Rate:

This module gives the precision rate based on the different types of inputs.

Table 1.1 Command success rate

SNO	SITUATION	PRECISION RATE
1.	Clear content	95%
2.	Moderate noise	89%
3.	High noise	80%
4.	Fast speech	82%

Final Conclusion of Table 1.1 :

From the above table, we can conclude that the system accuracy varies based on the situation. If the speech is clear, then accuracy is higher. [12]The system always tries to maintain 80% accuracy.

2. Translation Fidelity :

This module gives precision rate based on the sentences of different languages.

Table 1.2 Translation accuracy

SNO	SENTENCES	PRECISION RATE
1.	Simple terminology	92%
2.	Moderate	84%
3.	Complex	79%
4.	More technical terms	82%
5.	Informal speech	75%

Final Conclusion of Table 1.2 :

Finally, we can conclude that the system accuracy varies based on the sentences. If the sentences are simple, then accuracy is higher, and as the sentences become complex, the accuracy may decrease. But the system maintains the accuracy, which is acceptable.

3.Response Latency:

The following table gives the response time of each step.

Table 1.3 Response Time

SNO	PROCESS STATE	RESPONSE TIME
1.	Audio Transcription	0.7 seconds
2.	NLP processing	0.4 sec
3.	Translation	0.6 sec
4.	Transmission	o.2 sec

Conclusion Of Table1.3 :

Finally, we can conclude that the proposed system has a time delay less than 2 seconds, which is efficient and acceptable.

4.System Scalability:

The following table gives the performance status based on the number of students.

Table 1.4 System scalability

NUMBER OF STUDENTS LOGIN	PERFORMACE STATUS	TIME DELAY
10-25	Excellent	Less delay
25-45	Good	Less delay
45-70	Stable	Moderate
70-100	Acceptable	Slight delay

Final Conclusion of Table 1.4 :

Finally, we can conclude that the system is suitable for a classroom environment.

Graphical Representation

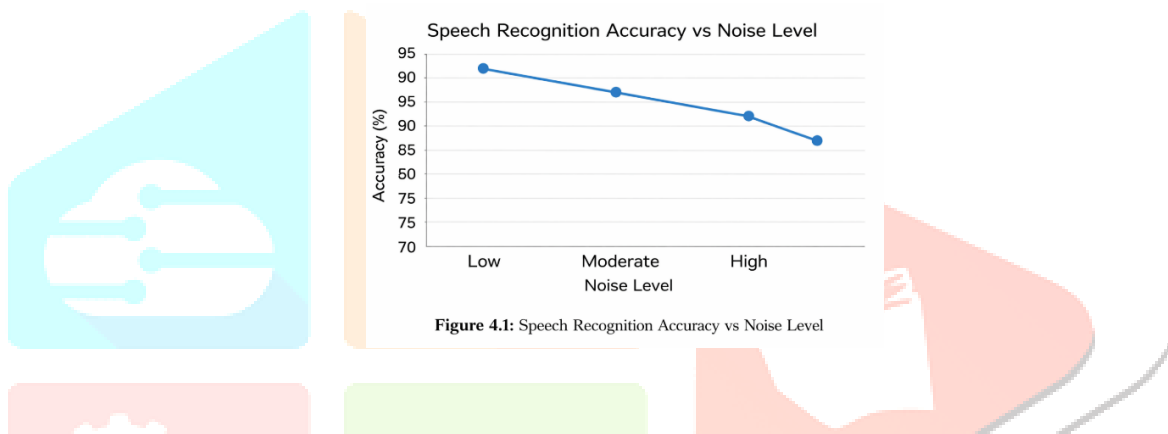


Figure 4.1: Speech Recognition Accuracy vs Noise Level

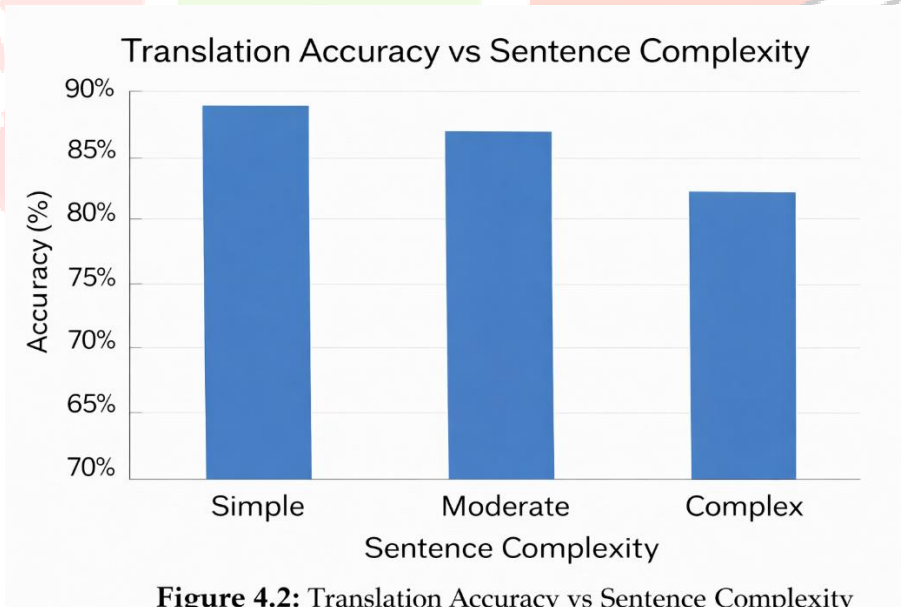
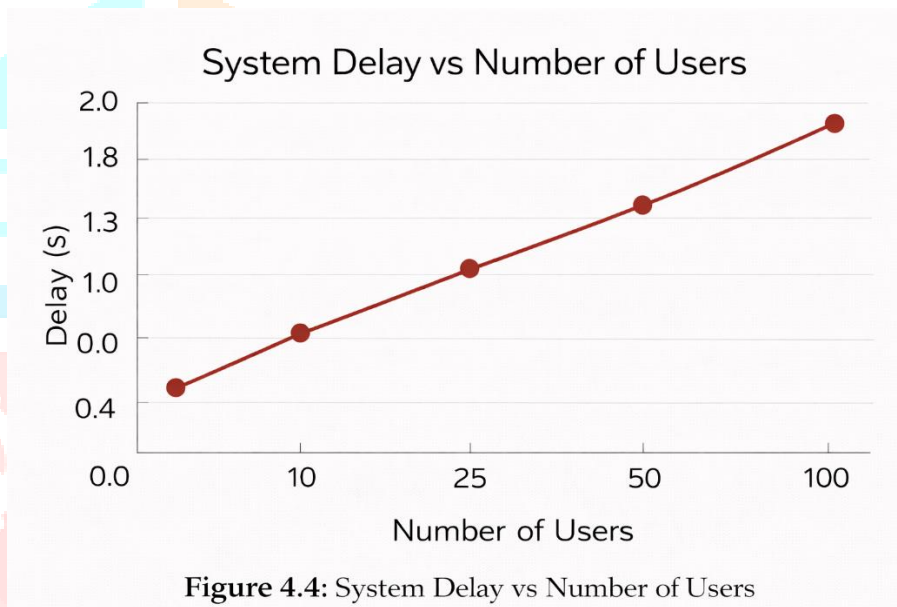
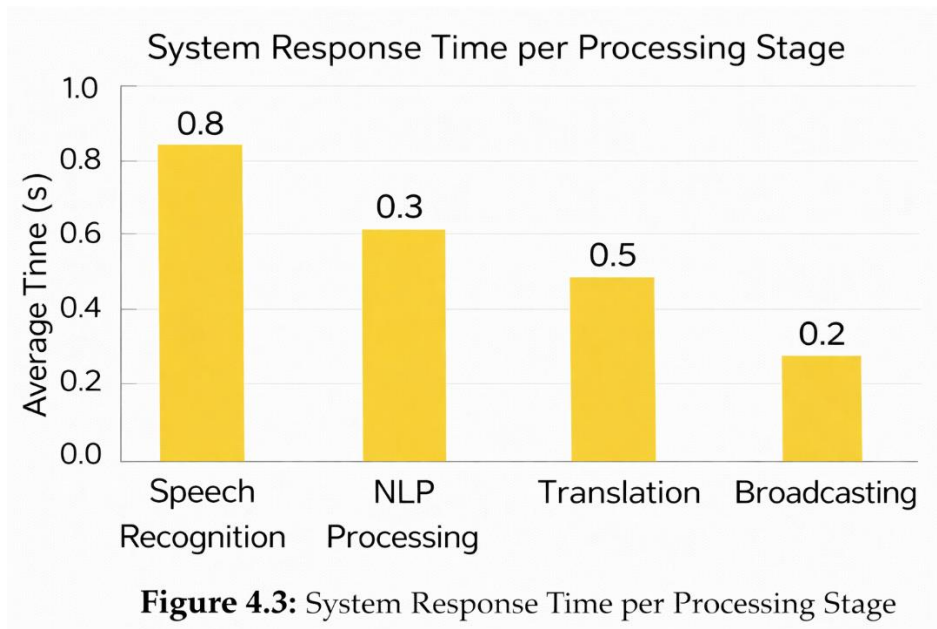


Figure 4.2: Translation Accuracy vs Sentence Complexity



Screenshots :

Example 1:

Teacher module :

Real-Time Classroom Translation System

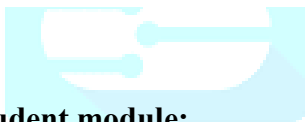
Teacher Module

Start Speaking

Speak Now...

Speech Recognized

Teacher Said: morning students today we are going to discuss chapter 1



Student module:

Real-Time Classroom Translation System

Student Translation Section

Select Student Language

Tamil

Translate Speech

Translated Text

இன்று காலை மாணவர்கள் அத்தியாயம் 1 பற்றி விவாதிக்கப் போகிறோம்

Example 2:**Teacher module:**

Real-Time Classroom Translation System

Teacher Module

Start Speaking

Speak Now...

Speech Recognized

Teacher Said: good morning

Student module:

Converted teacher lecture into Telugu

Real-Time Classroom Translation System

Student Translation Section

Select Student Language

Telugu

Translate Speech

Translated Text

శుభోదయం

Applications :

The proposed AI–NLP-based Intelligent Language Support Assistant has vast applications in the real world in the academic field, especially in schools and online learning platforms, where students of different linguistic backgrounds are facing language barriers. The proposed system can be effectively employed in schools, colleges, and online learning platforms for the translation of the lectures in real time.

The proposed system has vast applications in government schools and international schools, especially in classrooms with students of different linguistic backgrounds. In rural schools, students are not proficient in the medium of learning. In these schools, the proposed system can be effectively employed to enhance the academic performance of the students.

In addition to the above, the proposed AI–NLP-based Intelligent Language Support Assistant can also be employed in online learning platforms and webinars. Teachers can conduct classes in one language, and the students can receive the translation of the language in multiple languages. This makes the proposed system highly scalable and applicable in the global environment.

Moreover, the proposed AI–NLP-based Intelligent Language Support Assistant can also be employed in training programs and corporate learning environments, especially in workshops with participants of different linguistic backgrounds.

Discussion :

The results obtained from the proposed system clearly indicate that real-time translation can greatly minimize language barriers in classrooms.[1] The accuracy of the speech recognition module was high in normal classroom conditions. [11]The NLP translation module was also successful in translating the text into multiple languages within acceptable accuracy levels. The system also showed low latency in its response, making it efficient for classroom usage.

The combination of speech recognition, NLP translation, and real-time communication was also efficient in the smooth functioning of the system. Students were also able to understand the translated text in real time, making them more engaged in the lectures. The proposed system can be more efficient in providing learning support to students compared to other traditional methods like language assessment and support classes.

During the testing of the system, some limitations were also observed. Background noise and unclear pronunciation affected the accuracy of the speech recognition module. Complex sentences also affected the translation module to some extent. Despite some limitations, the system was efficient and showed great potential for real-time usage.

Ablation Study :

An ablation study was carried out to evaluate the significance of each module in the proposed system. All modules were individually tested by removing each module to evaluate how it affects the overall system. The results of the ablation study reveal that each module is significant in ensuring the overall efficiency of the proposed system. For instance, when the speech recognition module was removed, it was not possible to convert speech to text. Similarly, when the translation module was removed, it was not possible to support multilingual capabilities. The communication layer was also significant in ensuring that content was communicated in real time.

The ablation study proved that all modules must be integrated to achieve an efficient system. The combination of all modules ensures an effective multilingual learning system.

Conclusion:

The research proposed an AI-NLP-based "Intelligent Language Support Assistant" that can cater to language problems in multilingual classrooms. The system utilizes speech recognition, NLP, and translation technologies to offer real-time multilingual support to students. The experimental results show that the proposed system has high speech recognition accuracy, translation efficiency, and low latency. This makes the system highly efficient for real-time applications.

Contribution of the work :

The major contributions of the research are as follows:

1. Development of a real-time multilingual classroom support system using AI technology
2. Incorporation of speech recognition, NLP, and translation tools
3. Development of a scalable system for multiple student users
4. Creating a more inclusive classroom environment
5. Overcoming the language barrier in education [1], [2].

Future work:

The future enhancements of the suggested system will be as follows:

1. Support for more regional languages
2. Incorporation of mobile applications
3. Offline support for low internet connectivity
4. Enhanced speech recognition accuracy in a noisy environment
5. Incorporation of learning management system

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