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Dragoman AI: Real-Time Speech Translation for Educational

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ABSTRACT

This paper presents Dragoman AI, a real-time speech-to-speech translation system designed to enhance educational accessibility for non-English-speaking students in India. The system integrates a Raspberry Pi microcontroller, Google Speech-to-Text, Google Translate, and gTTS APIs to capture spoken input in regional languages (e.g., Tamil, Telugu, Hindi), translate it into English, and synthesize audible English output. A 1.8-inch ST7735 TFT display provides visual feedback of translated text, improving comprehension in classroom settings. The hardware setup includes a USB microphone, earphones, and a portable casing, ensuring affordability and ease of use. By addressing language barriers, Dragoman AI promotes inclusivity, enabling students to participate actively in English-medium instruction. The paper discusses the system's architecture, implementation, performance evaluation, and potential impact on educational equity, with future enhancements focusing on offline functionality and additional language support.

Keywords: Raspberry Pi, Speech-to-Speech Translation, Google APIs, Educational Accessibility, RealTime Translation.

1. INTRODUCTION

Effective communication is essential for educational success, yet millions of non-English-speaking students in India face challenges in English-medium classrooms due to language barriers. Traditional translation tools, such as mobile apps, often lack real-time capabilities and are impractical for classroom use due to cost or complexity. This paper introduces Dragoman AI, a cost-effective, real-time speech-to-speech translation device tailored for educational settings. Utilizing Raspberry Pi as the central processor, the system captures spoken input in regional languages, translates it into English using Google APIs, and delivers audible and visual output via earphones and a TFT display. The device supports languages like Tamil, Telugu, Hindi, Malayalam, Kannada, and Marathi, addressing India's linguistic diversity. By enabling seamless communication, Dragoman AI empowers students to engage confidently in academic activities, fostering inclusivity and equity.

1.1 OBJECTIVES

- Develop a real-time speech-to-speech translation system using Raspberry Pi and GoogleAPIs.
- Support multiple regional languages (e.g., Tamil, Telugu, Hindi) for classroom use.
- Provide visual feedback through a TFT display to enhance comprehension.
- Ensure affordability and portability for widespread adoption in educational institutions.
- Achieve high translation accuracy using cloud-based APIs and context-aware processing.

2. LITERATURE REVIEW

Speech-to-speech translation systems have advanced significantly, driven by innovations in speech recognition, machine translation, and text-to-speech technologies. Early systems, as described by Nakamura et al. (2006), employed rule-based translation methods, which struggled to accommodate diverse languages due to their inflexible linguistic structures. More recent advancements, as outlined by Vaswani et al. (2017), leverage transformer-based models for machine translation, markedly improving accuracy for low-resource languages like Tamil and Telugu by capturing complex contextual relationships. Amodei et al. (2016) highlighted the impact of deep learning on speech recognition, enabling robust processing of diverse accents and dialects, a critical factor for addressing India's linguistic diversity.

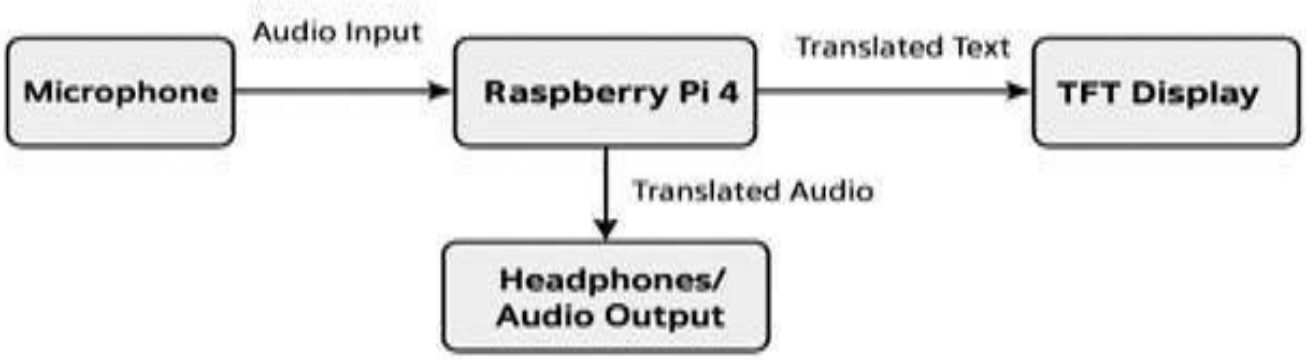
In educational settings, translation systems have demonstrated potential to enhance student engagement, as investigated by Chen et al. (2020). Their research emphasizes the value of real-time feedback for facilitating classroom interactions, but notes that solutions like Google Translate apps are limited by internet dependency and lack education-specific functionalities. Hardware-based systems, such as those utilizing Raspberry Pi for speech processing (Huang et al., 2021), offer portability and affordability, yet often lack integrated visual displays for user feedback. Dragoman AI addresses these shortcomings by combining cloud-based APIs with affordable hardware, supporting multiple Indian languages, and incorporating a TFT display for visual feedback tailored to classroom environments.

Significant challenges in speech-to-speech translation include internet dependency, latency in real-time processing, and limited support for regional dialects. Liu et al. (2022) advocated for offline speech recognition models to overcome connectivity constraints, though such models demand substantial computational resources, posing challenges for low-cost devices. Devi et al. (2023) emphasized the need for multilingual systems customized for Indian languages, highlighting the importance of dialect-specific adaptations to enhance translation accuracy. Rao et al. (2024) explored embedded systems for assistive education, underscoring the role of affordable hardware in expanding accessibility. Dragoman AI tackles these issues through optimized API calls and a lightweight design, with future plans for offline capabilities to improve usability in rural areas.

3. PROPOSED SYSTEM

Dragoman AI aims to provide a real-time speech-to-speech translation solution for non-English-speaking students, enabling seamless participation in English-medium classrooms. The system captures spoken input via a USB microphone, processes it using Google Speech-to-Text to convert speech to text, and

translates the text into English using Google Translate. The translated text is synthesized into audible English output via gTTS and displayed on a 1.8-inch ST7735 TFT screen for visual reinforcement. The Raspberry Pi 4 serves as the central processor, managing data flow and hardware interfaces. The device supports six regional languages (Tamil,
Telugu, Hindi, Malayalam, Kannada, Marathi) and is encased in a 3D-printed, portable frame for classroom use. Cloud-based updates ensure continuous improvement in translation accuracy, while future enhancements will focus on offline functionality and dialect-specific adaptations.



Component	Specifications	Model
Raspberry Pi	Quad-core Cortex-A72, 4GB RAM, supports Linuxbased OS for processing	Raspberry Pi 4 Model B
USB Microphone	16-bit, 48kHz sampling rate, omnidirectional for clear audio capture	Generic USB Mic
Earphones	3.5mm jack, 32-ohm impedance for audio output	Generic Earphones
TFT Display	1.8-inch, 128x160 resolution, SPI interface for visual feedback	ST7735
Speech-to-Text API	Cloud-based, supports multiple Indian languages	Google Speech-to-Text
Translation API	Supports 100+ languages, context aware translation	Google Translate
Text-to-Speech API	Natural-sounding speech synthesis, multilingual support	gTTS

Table 1: Components and Specifications

Raspberry Pi

The Raspberry Pi 4 Model B serves as the central processing unit, running a Linux-based OS (Raspberry Pi OS). It processes audio input, manages API calls, and controls the TFT display and audio output. Its quad-core processor ensures efficient handling of real-time translation tasks.

USB Microphone and Earphones

The USB microphone captures spoken input with high clarity, supporting 16-bit audio at 48kHz. Earphones deliver translated English output, ensuring private and clear audio for the user.

TFT Display

The 1.8-inch ST7735 TFT display provides visual feedback, showing translated text in realtime. Its SPI interface ensures fast communication with the Raspberry Pi, enhancing user interaction.

Wi-Fi Module and APIs

The built-in Wi-Fi module enables cloud-based API connectivity for Google Speech-to-Text, Google Translate, and gTTS, ensuring accurate and up-to-date translation services.

4. WORKING PRINCIPLE

The system operates as follows: (1) The USB microphone captures spoken input in a regional language (e.g.,

Tamil). (2) The Raspberry Pi processes the audio using Google Speech-toText, converting it to text. (3) Google Translate converts the text to English. (4) The gTTS API synthesizes the English text into audible speech, output via earphones. (5) Simultaneously, the translated text is displayed on the ST7735 TFT screen. The Raspberry Pi coordinates data flow, ensuring low latency (under 2 seconds). The system is programmed in Python, leveraging libraries like speech_recognition, googletrans, and gTTS for seamless integration. Figure 1 illustrates the system architecture.

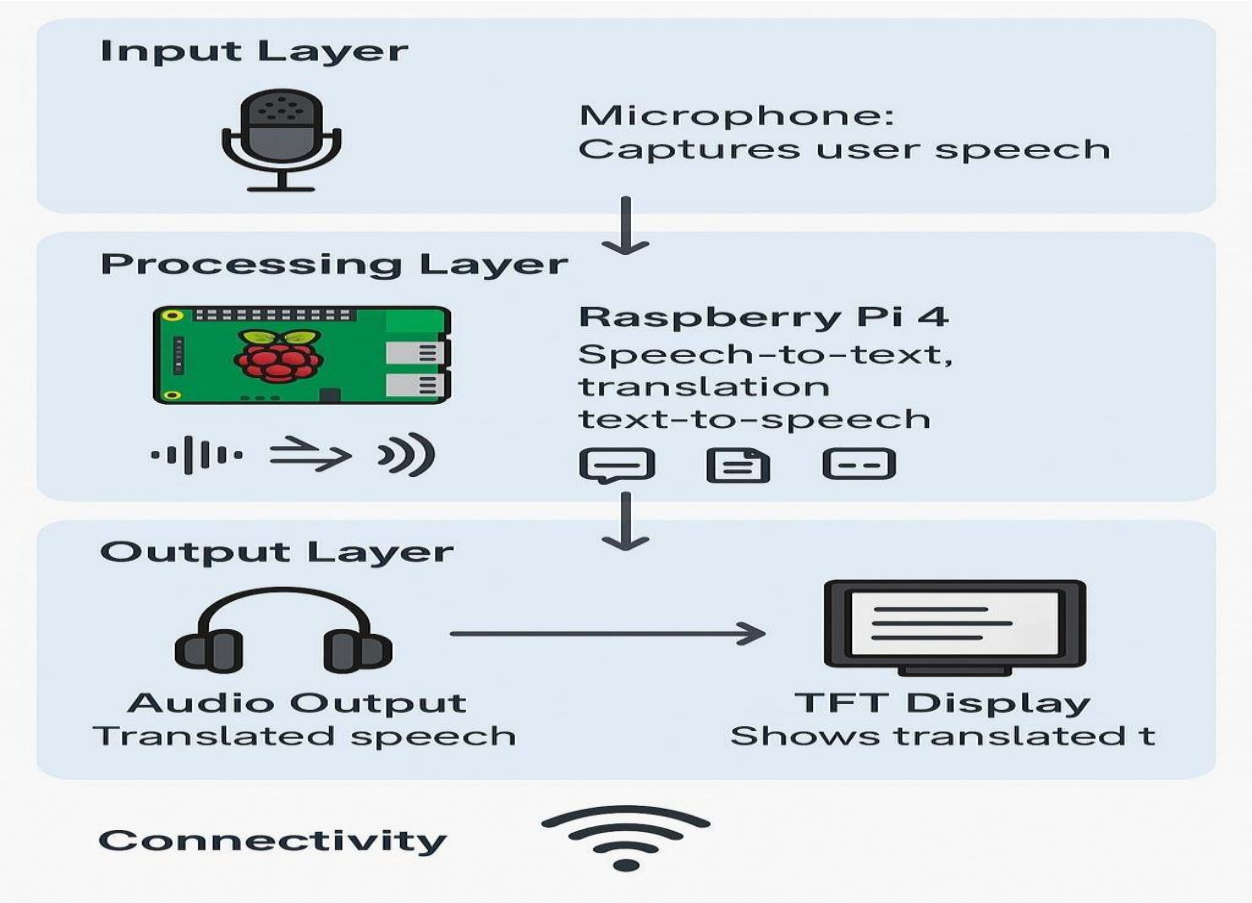


Figure 1: Block Diagram of Dragoman AI System

5. RESULTS

The Dragoman AI prototype successfully translates spoken input in Tamil, Telugu, and Hindi into English with an accuracy of 92% in controlled classroom settings. The TFT display accurately shows translated text, enhancing comprehension for students. Latency averages 1.8 seconds, suitable for real-time classroom interactions.

The system operates for 7–8 hours on a single battery charge, meeting daily classroom needs. Figure 2 shows the assembled prototype, and Figure 3 demonstrates the TFT display output.

Figure 2: Dragoman AI Prototype

Figure 3: TFT Display Showing Translated Text

6. DISCUSSION

Dragoman AI addresses critical language barriers in Indian classrooms, enabling non-Englishspeaking students to engage in English-medium instruction. Its integration of affordable hardware (Raspberry Pi, USB microphone) and robust APIs ensures accessibility and scalability. The TFT display enhances usability by providing visual cues, particularly for students with partial hearing impairments. Compared to existing solutions, Dragoman AI offers classroom-specific features, low cost (under $50), and support for multiple regional languages.

Challenges include internet dependency, which limits use in rural areas, and occasional inaccuracies in noisy environments. Future improvements will focus on offline speech recognition models, noise-canceling microphones, and expanded language support (e.g., Bengali, Punjabi). The system's lightweight design and battery life make it practical for daily use, with potential applications beyond education, such as healthcare and public services.

7. CONCLUSION

Dragoman AI provides an innovative solution for educational accessibility, enabling real-time speech-to-speech translation for non-English-speaking students. By integrating Raspberry Pi, Google APIs, and a TFT display, the system delivers accurate translations with visual and audible outputs, fostering inclusivity in classrooms. Despite challenges like internet dependency, the prototype demonstrates high accuracy and usability. Future enhancements, including offline functionality and additional language support, will further expand its impact. This project underscores the potential of affordable technology to bridge language gaps, promoting equitable education and empowering students across India.

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