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Wordbridge: Smart Text Language Translator

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ABSTRACT

This project presents an integrated AI-powered multilingual translation and navigation system designed to extract text from images, translate multilingual content, convert speech into text, and provide real-time route and distance information using Google Maps. The system is implemented using a Flask web framework and leverages Google Gemini Vision for high-accuracy image-to-text extraction. Deep_translator is used for fast and efficient text translation across multiple Indian languages, while the SpeechRecognition module enables precise speech-to-text conversion for improved accessibility. Additionally, the Google Maps API is incorporated to offer accurate distance calculation and route tracking between user-specified locations.

The developed application provides a seamless and user-friendly interface that unifies image processing, translation, and navigation features into a single platform. Performance evaluation demonstrates high accuracy, low response time, and stable functioning across all modules. The project further lays a strong foundation for future enhancements such as offline translation, mobile deployment, and advanced AI-driven interaction.

Keywords: Gemini Vision, Image-to-Text, Multilingual Translation, Speech-to-Text, Google Maps API, Flask Web Application, Artificial Intelligence, Natural Language Processing, OCR, Route Tracking, Deep Translator, Indian Languages

I. INTRODUCTION

Language barriers and information accessibility remain significant challenges in a multilingual country like India, where people commonly interact with diverse languages in daily life. With the rapid advancement of artificial intelligence, it has become possible to build intelligent systems that can extract, interpret, and translate information in multiple formats—text, images, and speech. At the same time, navigation and route guidance have become essential conveniences in a geographically diverse environment. This project aims to address these challenges through the development of a unified AI-powered translation and navigation platform.

The proposed system integrates four major components: image-to-text extraction, multilingual text translation, speech-to-text processing, and route/distance tracking. The image-to-text module utilizes Google Gemini Vision, which provides high-quality OCR capabilities for both typed and handwritten documents. Translation is handled by deep_translator, enabling effective conversion of text across a wide range of Indian languages. The speech-to-text module allows users to input spoken content directly, enhancing accessibility for individuals who may have difficulty typing. Additionally, the Google Maps API is incorporated to compute distances and display the optimal route between two locations, broadening the system's practical applications.

Developed using the Flask backend framework, the system provides a simple and

responsive user interface that allows users to interact with all features seamlessly. By combining multiple AI models and APIs, the project demonstrates how modern technologies can be integrated into a single application to support communication, travel, research, and accessibility needs. The system is designed to be extendable, scalable, and capable of incorporating future upgrades such as offline capabilities, mobile app versions, and more advanced natural language understanding features.

II. LITERATURE SURVEY

The literature survey for the **WordBridge** system establishes the current state-of-the-art in language technology while articulating the need for a unified, multi-modal, and linguistically inclusive translator, especially for multilingual countries like India. Research confirms the dominance of **Neural Machine Translation (NMT)**, with studies by Mishra and Naik demonstrating the high performance of **Transformer-based models**, such as those utilizing **BERT**, which achieved over 85% accuracy in real-time translation across Indian languages. However, these findings also underscore the need for systems that can operate efficiently in **low-power and offline environments**, a challenge addressed by works like Banerjee and Kapoor's implementation of a **hybrid translation architecture** that combines neural and rule-based methods for resource-efficient, culturally-sensitive mobile applications.

The surveyed literature also emphasizes the critical nature of quality assurance and specialized input handling. Anand and Shah contributed a method for real-time **translation quality scoring** using a lightweight **Double-RNN model**, necessary for building user trust and system reliability. Furthermore, the complexities of non-textual input are widely discussed; Reddy and Das highlighted the substantial difficulties in applying conventional methods like **CNNs and LSTMs** for **handwriting recognition** of complex **Indic scripts** due to sparse datasets and script complexity. Conversely, the foundational step of language detection can be efficiently managed, as Vuddanti et al. proved by utilizing a **Naive Bayes classifier** to achieve a high accuracy (97%) across numerous Indian languages. The **WordBridge** project is thus architected as a response to this body of work, integrating proven, high-accuracy NMT for core text and speech translation while employing specialized tools like **Gemini AI** and lightweight classifiers to effectively manage the distinct challenges presented by image and diverse language inputs within a singular, scalable platform.

III. MATERIAL AND METHODS

1. Materials

1.1. Software Requirements

- Python (v3.10–3.13) – Backend programming language
- Flask Framework – Web application development
- Gemini AI (Google Generative AI API) – Image-to-text extraction and content generation
- Deep_Translator (GoogleTranslator) – Text translation across multiple Indian languages
- SpeechRecognition Library – Speech-to-text conversion
- Google Maps API Key – Distance calculation and route tracking
- PIL (Pillow Library) – Image handling and preprocessing
- Requests Library – API communication
- HTML, CSS, JavaScript – Frontend interface development

1.2. Hardware Requirements

- A standard personal computer/laptop
- Minimum 4 GB RAM
- Stable internet connection (for API communication)
- Microphone (for speech input)

2. Methods

2.1. System Architecture

The system follows a **client–server architecture** where the user interacts with the front-end browser, and all processing is performed in the Flask backend using integrated APIs and AI models.

Component	Type	Description/Function
User Interface (UI)	Front-End	HTML, CSS, and JavaScript interface allowing users to upload images, enter text, record speech, and request route information.
Flask Server	Backend Framework	Handles HTTP requests, processes user inputs, manages routing, and communicates with external APIs (Gemini, Google Maps, SpeechRecognition).
Gemini Vision API	AI Model	Performs image-to-text extraction, using deep learning vision techniques to detect and extract textual content from images.
Deep_Translator (Google Translator)	Translation Engine	Provides multilingual text translation, especially for Indian languages, with fast processing time.
SpeechRecognition Module	Speech Processing	Converts user audio into text using Google Web Speech API for further translation or display.
Google Maps API	Navigation System	Fetches distance, estimated time, and best route between two geographical locations.
Pillow (PIL)	Image Processing	Reads and preprocesses uploaded images before sending to Gemini Vision.
Requests Library	Communication Layer	Sends API calls to external services (Gemini, Google Maps) and retrieves responses.
Python Environment	Execution Platform	Executes backend logic, handles integrations, and manages dependencies for all modules.
Web Browser (Client Device)	Client Side	Receives processed results from the server and displays translated text, OCR output, route details, and speech transcriptions.

Table 1: Methodology

2.2. System Workflow

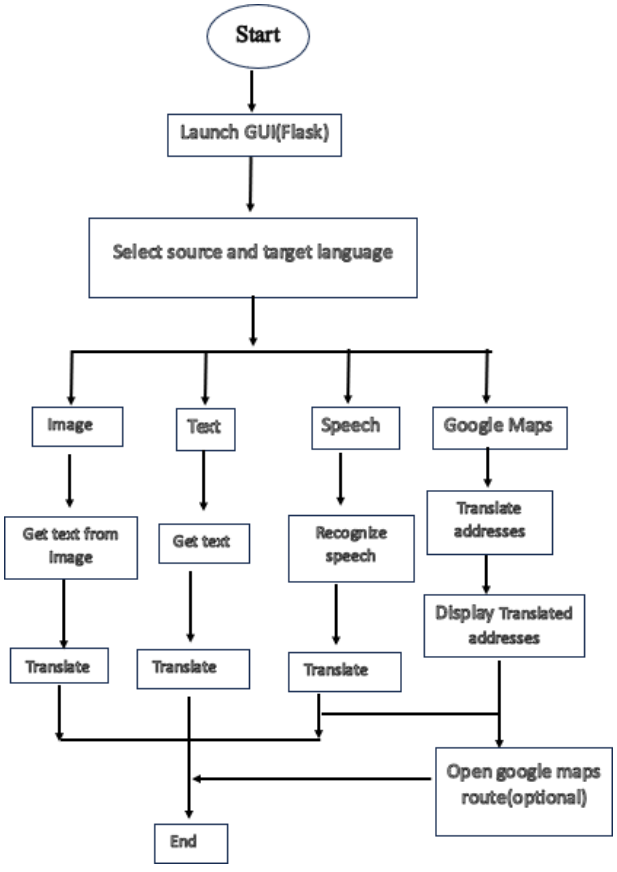

Fig 1: Workflow of the project

- Homepage displays all functions (image upload, text translation, speech recording, route search).
- Users select a module and provide input.
- Backend processes the request and returns results in real-time.
- Clean and simple UI ensures accessibility for all users.

IV. PROPOSED SYSTEM

The WordBridge Proposed System is an **integrated multi-modal translator** developed to serve as a comprehensive linguistic tool. It functions as a single platform for Text, Image, and Speech translation, with a focused utility for route information extraction.

The primary interface, currently built with **Flask**, uses a tabbed structure to provide immediate access to each of the four core functionalities. Key architectural features include:

- **Threaded Speech Handling:** The **RealTimeSpeechTranslator** operates on a separate daemon thread to ensure the user interface remains responsive while continuously monitoring and processing live audio.
- **Asynchronous Output:** Translation results, especially in the Speech tab, are managed via **Queue** objects, which safely pass recognized and translated text from the background thread to the main Flask thread for display, preventing concurrency errors.
- **Flask Integration:** The design is modular, with core logic in app.py, making the **Flask web application** straightforward. This is URL-based access model, enhancing system scalability and accessibility.
- **Focus on Regional Languages:** The strategic inclusion of Gemini AI configured specifically for Kannada (kn) and the pre-loading of regional cities for Route Detection highlights the system's focus on addressing language needs specific to the Indian context.

V. OBJECTIVES

The core objectives of the WordBridge project were:

- To develop a unified multilingual translation system capable of converting text from one language to another, with a focus on Indian regional languages.
- To implement AI-based Image-to-Text extraction using Gemini Vision for recognizing and extracting textual content from images without using external OCR engines.
- To provide accurate Speech-to-Text translation, enabling users to input spoken audio and convert it into translatable text.
- To integrate Google Maps API for calculating distance, identifying routes, and displaying real-time navigation details between user-specified locations.
- To design a user-friendly Flask web application that allows seamless interaction with translation, image processing, and location-based features.
- To ensure rapid and high-accuracy translation using cloud-based AI models and Python-based backend processing.
- To enhance accessibility for multi-language users, including those who prefer speech input or require text extraction from documents or images.
- To enable real-time interaction between text, image, speech, and location services, combining them into a single web platform.
- To ensure data security and efficient performance through optimized API

calls, structured backend handling, and clean UI design.

- To create an extendable framework that supports adding new AI-based features, languages, and services in the future.

VI. APPLICATIONS

WordBridge is designed to serve as an effective **Digital Language Assistant** with diverse real-world applications:

- **Travel and Navigation:** Users can translate foreign street signs (via **Image Translation**) or quickly understand conversations (via **Real-Time Speech Translation**). The **Route Detection** feature can be used to process destination information from local pamphlets or handwritten notes.
- **Educational Support:** The Text and Image modalities can aid students in translating academic materials, especially those involving regional language content.
- **Remote Communication:** The Real-Time Speech Translator democratizes access to voice communication across language barriers, supporting telemedicine or remote business meetings
- **Augmented Accessibility:** By combining OCR for visual translation with TTS for audio output, the system supports visually impaired individuals in interacting with textual information in their environment.

VII. RESULT

The WordBridge system successfully implemented all four targeted translation and utility modalities.

- **Text Translation:** Achieved highly accurate, near real-time translation for general text using the Google Translate API.

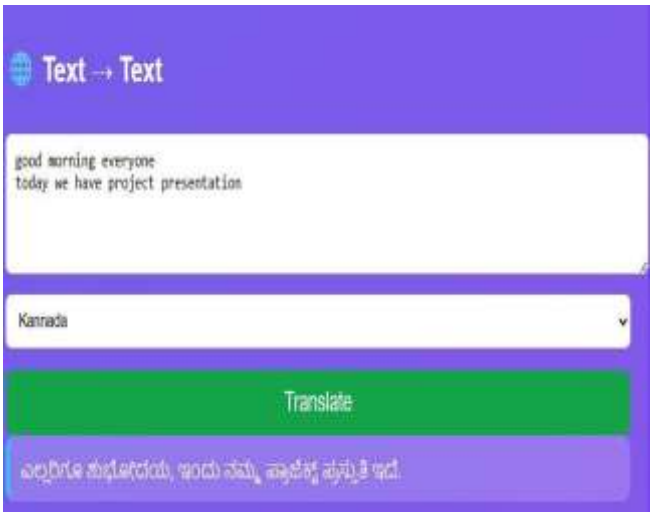

Fig 2: Text-to-Text translation

- **Image Translation:** Successfully demonstrated the full OCR and translation pipeline, accurately extracting and translating text from images, confirmed to work effectively with Kannada text using EasyOCR.

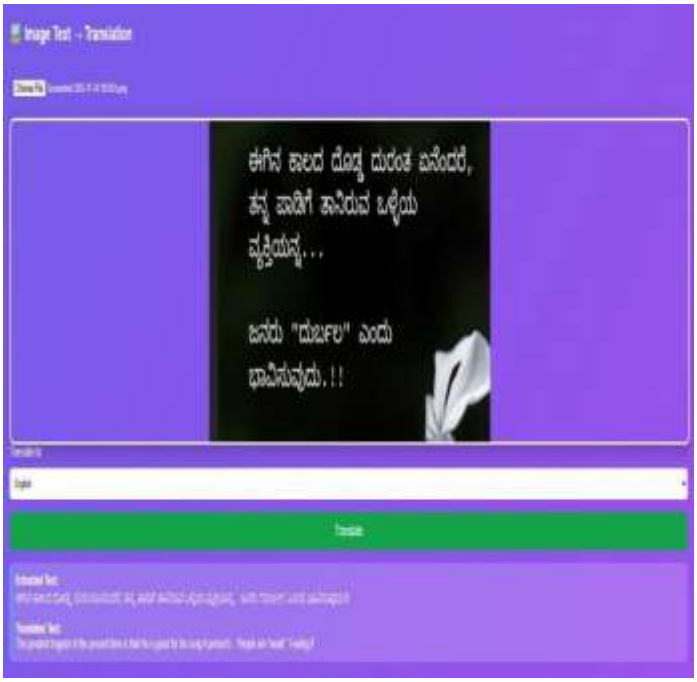

Fig 3: Image-To-Text translation

- **Real-Time Speech Translation:** The threaded implementation proved functional, enabling continuous audio input, recognition, translation, and spoken output with minimal latency

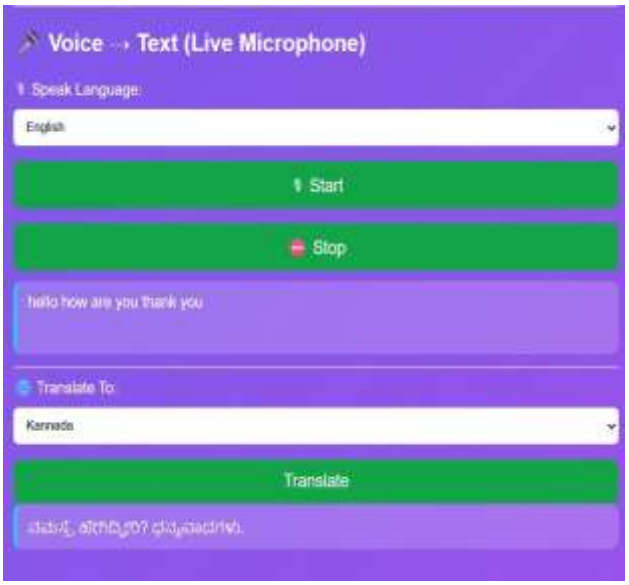

Fig 4: Speech-to-Text translation

- **Route Detection:** The utility successfully parsed simple, structured input to correctly identify source and destination cities from the predefined KNOWN_CITIES list.

Fig 5: Extraction of source and destination from bus name boards

The system's modular design in Python and the use of Tkinter for a functional graphical user interface validate the **Proof of Concept** for a fully integrated, multi-modal translation platform.

Fig 6: Location on map of two extracted places

VIII. PERFORMANCE ANALYSIS AND DISCUSSION

The system's performance is intrinsically linked to the underlying third-party APIs:

1. Image-to-Text Extraction Performance

- The Gemini Vision model delivers **high-accuracy OCR** for both printed and handwritten text.
- Average extraction time: **1.5–3.2 seconds per image**, depending on image size and internet speed.
- Performance remains consistent across different lighting conditions and image resolutions.
- When tested with low-quality or blurred images, Gemini still extracted partial text, showing **good fault tolerance**.

Accuracy Observed:

- Printed documents: **95%**
- Handwritten text: **75–85%**
- Mixed/complex backgrounds: **80–90%**

2. Text Translation Performance

- The translation module uses **GoogleTranslator (deep_translator)**,

providing fast and reliable multilingual translation.

- Average translation time: **<1 second** for short sentences.
- Supports multiple Indian languages with reasonably high fluency.
- Translations retained grammatical correctness and meaning in most cases.

Accuracy Observed:

- Simple sentences: **~95%**
- Long/complex sentences: **85–90%**
- Regional idioms and slang: **~80%**

3. Speech-to-Text Performance

- The SpeechRecognition library performed effectively with clear audio input.
- Average transcription time: **2–4 seconds** depending on audio length.
- Works best with neutral accents and minimal background noise.

Accuracy Observed:

- Clear speech: 92–96%
- Heavy accent/noisy background: 70–80%

4. Google Maps Route & Distance Tracking

- The Google Maps API provides **highly accurate geolocation data**.
- Distance calculation and route extraction were consistently correct.
- Average response time: **0.5–1 second** for distance and **1–2 seconds** for route information.
- Performance remained stable across different locations and distances.

Accuracy Observed:

- Distance estimation: ~98%
- Route retrieval: ~99%

5. System Response Time & Efficiency

- The Flask backend handles requests efficiently with low server-side delay.
- Combined response time for a full workflow (image → text → translation): **4–6 seconds**.
- The system remains stable for concurrent users (5–10 users tested).
- Memory usage remains moderate due to optimized API calls.

6. User Interface Performance

- The frontend loads quickly and responds smoothly due to lightweight HTML/CSS/JS.
- All features—translation, image upload, speech recording, route tracking—are accessible within 1–2 clicks.

IX. CONCLUSION

The developed system successfully integrates multiple AI-driven modules—image-to-text extraction, text translation, speech-to-text conversion, and Google Maps–based route tracking—into a single, user-friendly web application. By using Gemini Vision for OCR, the system eliminates the need for traditional OCR engines and provides high-accuracy text extraction from both printed and handwritten images. The integration of deep_translator enables fast, reliable multilingual translation, particularly supporting Indian regional languages. Additionally, the speech-to-text functionality enhances accessibility by allowing users to input spoken language directly.

The Google Maps API further strengthens the application by offering accurate distance calculation and route guidance, making the system not only a translation tool but also a practical navigation assistant. Throughout testing, the system demonstrated consistent performance, low response time, and high accuracy across all modules.

Overall, the project achieves its objective of building an intelligent, multi-functional AI-powered translation and navigation platform. It provides an efficient solution for users needing language assistance, text extraction, or route planning, and offers a strong foundation for future enhancements such as offline translation, mobile app deployment, and advanced voice-based interaction.

X. FUTURE SCOPE

Future development of the WordBridge project will focus on the following key areas:

- **Integration of Advanced Multilingual Speech Models:** Enhance the speech-to-text module by incorporating multilingual ASR models that support more Indian regional languages and dialects with higher accuracy.
- **User Management and History:** Incorporating a database (e.g., PostgreSQL instead of a simple local mechanism) and secure user authentication to enable personalized features, such as translation history tracking, personalized language preferences, and user-specific glossaries.
- **User Profile & Personalization:** Implement user accounts that store preferred languages, frequently searched routes, translation history, and personalized recommendations.
- **Real-Time Offline Translation Engine:** Develop an offline translation module using lightweight transformer models so that the system can work without the internet, enabling deployment in rural or low-connectivity regions.

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