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VADAPALANI

PROJECT REPORT

TO

MINISTRY OF ELECTRONICS AND IT

Government of India

Titled

OFFLINE PRIVACY-PRESERVING HINDI VOICE ASSISTANT ON RASPBERRY PI 4

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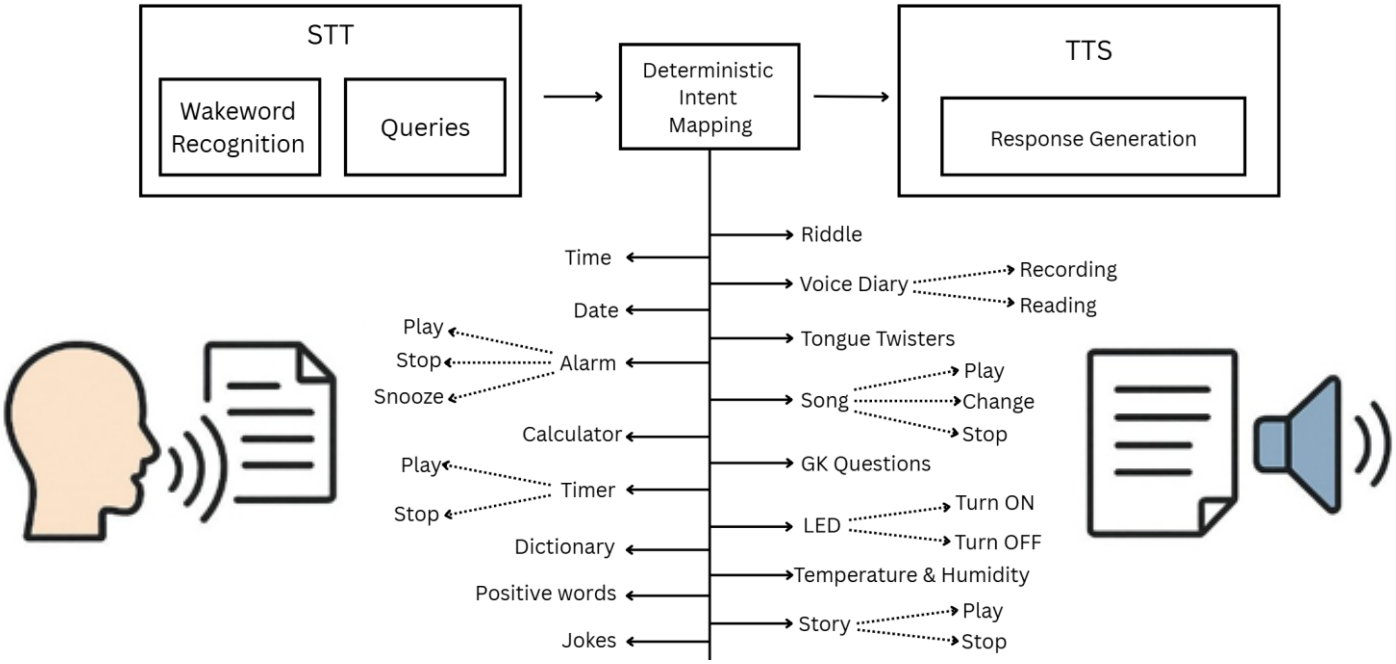
PROJECT REPORT

Objective:

To design and implement an offline, privacy-preserving Hindi Voice Assistant using Raspberry Pi 4.

Methodology:



The system is implemented on the Raspberry Pi 4 in offline mode to ensure privacy and low latency. Voice input is captured at 16 kHz and processed in freal time using the Hindi model of Vosk. A wake-word activation mechanism is used to initiate interaction, followed by keyword-based intent classification to identify user commands efficiently.

Detected intents are mapped to corresponding functions. Multi-step commands are handled in a structured manner, while multithreading allows background tasks such as alarm and timer monitoring to run simultaneously without interrupting the voice processing. GPIO-based hardware integration enables control of external devices such as LED and sensor modules.

Responses are generated using e-Speak NG, and all user data is stored locally in JSON format to maintain privacy and optimize system resources.

Hardware Utilization:

1. Raspberry Pi 4
Acts as the central processing unit of the system, handling speech recognition, command execution, and hardware control operations.

2. Raspberry Pi Display
Provides a visual interface for system status, outputs, and interaction feedback.

3. USB Microphone
Captures voice input from the user for real-time speech recognition.

4. Bluetooth Speaker
Delivers audio responses generated by the voice assistant.

5. Temperature & Humidity Sensor (DHT11)
Measures environmental temperature and humidity to enable weather-related voice responses.

6. LED
Demonstrates GPIO-based hardware control by responding to voice commands for on/off operations.

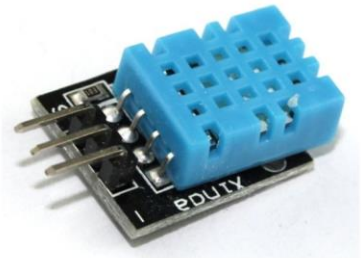
Raspberry Pi 4

Raspberry Pi Display

USB Microphone

Bluetooth Speaker

DHT11 Sensor



LED

Optimization Techniques:

- **Use of Small Hindi Model (Vosk):** A lightweight Hindi speech recognition model is used to reduce RAM consumption and minimize processing delay.

- **16 kHz Mono Audio Processing:** Audio input is captured at 16 kHz in mono format, which reduces computational load and memory usage.

- **Streaming-Based Audio Processing:** Audio is processed in small frames rather than storing complete recordings. This reduces memory usage and enables low-latency.

- **Wake-Word Based Activation:** The speech recognition and command processing modules become fully active only after detecting a predefined wake word. This prevents unnecessary processing and conserves CPU resources.

- **Active Interaction Window Optimization:** After wake-word detection, the system remains active for a short duration to allow continuous interaction without repeated activation, improving user experience while maintaining efficient resource utilization.

Future Scope and Developments:

- **Disaster-response assistant** — works without internet during emergencies (floods, earthquakes).
- **Rural digital assistant** — helps in villages where internet connectivity is limited.
- **Privacy-secure assistant for sensitive areas** — banks, defense zones, labs (no cloud data sharing).
- **Offline campus navigation system** — guides users inside colleges, hospitals, offices.
- **Voice-controlled health reminder device** — medicine alerts and daily routine support.
- **Industrial safety assistant** — voice alerts from sensors (temperature, gas, humidity).
- **Offline public information kiosk** — railway stations, museums, government offices.
- **Personal learning companion for children** — interactive offline education tool.
- **Wearable voice assistant** — small portable device for hands-free use.
- **Low-cost embedded product** using boards from the Raspberry Pi Foundation for mass deployment.

Result:

The Offline Privacy-Preserving Hindi Voice Assistant is successfully implemented on the Raspberry Pi 4 with stable real-time performance. The system accurately recognizes Hindi voice commands and executes tasks. The project demonstrates the feasibility of deploying an efficient edge-based voice assistant on embedded hardware.