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An AI and IOT-Based Voice Assistant for Smart Multilingual Conversational E-Commerce

Safia Naseer[1], Saniya Siddiqua[2], Fatima Nada[3], Dr. Syeda Gauhar Fatima[4] Amina Begum[5]

[123]B.E. Students, Department of Electronics and Communication Engineering, Deccan College of Engineering and Technology, Hyderabad, Telangana, India
[4]Professor and Head of the Department, Department of Electronics and Communication Engineering, Deccan College of Engineering and Technology, Hyderabad, Telangana, India
[5]Assistant Professor, Department of Electronics and Communication Engineering, Deccan College of Engineering and Technology, Hyderabad, Telangana, India

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Abstract

Conventional e-commerce platforms primarily rely on graphical user interfaces that require users to navigate through multiple screens, enter search queries, examine product listings, and manually manage shopping carts. These interaction requirements can create difficulties for elderly individuals, visually impaired users, people with limited digital literacy, regional-language speakers, and users who prefer hands-free interaction. This paper proposes an Artificial Intelligence (AI) and Internet of Things (IoT)-based multilingual voice assistant for conversational e-commerce. The proposed system is designed as a Raspberry Pi-based personal shopping assistant that enables users to search for products, compare alternatives, receive recommendations, and manage a local shopping cart through natural speech. The system captures spoken commands through a microphone and converts them into text using Automatic Speech Recognition (ASR). An AI-based natural language processing module identifies user intent and extracts relevant product requirements, including product category, budget, brand, and preferred features. Product-related requests are processed through an external Product Search Application Programming Interface (API), which retrieves relevant product information. The retrieved information is processed to provide comparisons and personalized recommendations based on the user's stated preferences. The proposed system supports English, Hindi, Telugu, and Gujarati, depending on the language coverage of the selected speech recognition and synthesis services. Text-to-Speech (TTS) technology generates spoken responses, while an LCD provides supplementary visual information, including product names, prices, recommendations, and shopping cart details. The architecture integrates Raspberry Pi 4 or Raspberry Pi 5, microphone, speaker, LCD, Wi-Fi connectivity, speech processing services, a Large Language Model (LLM), product search APIs, and Python-based cart management. The system focuses on shopping assistance rather than autonomous purchasing and does not process payments or complete merchant checkout. This paper presents the proposed architecture, literature review, implementation methodology, evaluation framework, limitations, and future enhancements. The performance of the proposed system will be established through experimental testing after implementation.



Key Words— Artificial Intelligence, Internet of Things, Conversational Commerce, Raspberry Pi, Voice Assistant, Multilingual Speech Recognition, Large Language Model, Product Recommendation, Accessibility, Speech-to-Text, Text-to-Speech.

I. INTRODUCTION

The rapid development of e-commerce has transformed the way consumers search for and purchase products. Online shopping platforms provide access to a wide range of products, price comparisons, customer reviews, and purchasing options. However, most conventional platforms depend heavily on graphical user interfaces, requiring users to interact through touchscreens, keyboards, and visually presented information. These interfaces may create difficulties for elderly individuals, visually impaired users, people with limited digital literacy, and individuals who are more comfortable communicating in regional languages. Voice-based interaction provides an alternative approach by allowing users to communicate their requirements through natural speech rather than navigating multiple application screens. Conversational recommender systems combine dialogue management, preference identification, recommendation generation, and user feedback to improve product discovery [1], [2]. Unlike conventional recommendation systems that primarily display predefined product lists, conversational systems allow users to refine their requirements through multiple interactions.

For example, a user may ask:

"Show me a Bluetooth speaker under ₹2,000 with good battery life."

The proposed assistant interprets this request, identifies the product category, extracts the budget and preferred feature, and retrieves relevant products through an external product search API.

The user can subsequently request:

- Compare the first two products.
- Which product has better battery life?
- Add the second product to my cart.
- What is the total amount in my cart?

The system processes these commands through conversational interaction without requiring the user to navigate a conventional shopping application. Recent developments in multilingual speech recognition, natural language processing, transformer-based architectures, and embedded computing have created opportunities for developing intelligent voice interfaces [3]–[7]. The proposed work integrates these technologies into a physical Raspberry Pi-based device. The system uses AI for understanding user requests, product APIs for retrieving product information, and local Python-based processing for managing shopping cart operations.

The major contributions of this work are:

1. Development of a Raspberry Pi-based multilingual voice-first shopping assistant.
2. Integration of speech recognition and AI-based intent identification.
3. Conversational product discovery using external product search APIs.
4. Product comparison and recommendation based on retrieved product attributes.
5. Local shopping cart management using Python.
6. Combined audio and LCD-based interaction for improved accessibility.

The proposed system aims to simplify product discovery and provide a more accessible shopping experience through natural multilingual communication.

II. LITERATURE REVIEW

A. Conversational Recommendation Systems

Jannach et al. presented a comprehensive survey of conversational recommender systems, explaining how dialogue-based interaction can improve preference elicitation and recommendation quality [1]. Gao et al. discussed the advancements and challenges associated



with conversational recommendation systems, including dialogue management, preference extraction, recommendation strategies, and response generation [2]. These studies establish the importance of multi-turn interaction in recommendation systems. The proposed assistant applies these concepts to conversational shopping by extracting product categories, budgets, brands, and feature preferences from spoken requests. Jannach further examined the evaluation of conversational recommender systems and highlighted the importance of measuring recommendation quality and interaction effectiveness [8].

B. Speech Recognition and Multilingual Processing

Speech recognition is an essential component of voice-based applications. Baevski et al. introduced wav2vec 2.0, a self-supervised framework for learning speech representations from large amounts of unlabeled audio data [3]. Radford et al. introduced Whisper, a multilingual speech recognition system trained using large-scale weak supervision, demonstrating the potential of robust speech transcription across different languages [4]. Diwan et al. presented MUCS 2021, a multilingual and code-switching automatic speech recognition challenge focusing on low-resource Indian languages, including Hindi, Telugu, and Gujarati [5]. Babu et al. proposed XLS-R, a cross-lingual speech representation learning framework designed to support multiple languages [6]. Vaswani et al. introduced the Transformer architecture, which uses attention mechanisms to process sequential information efficiently and has become an important foundation for modern language models [7]. These developments provide a technical foundation for implementing multilingual voice interaction. However, the recognition accuracy of individual languages depends on the selected model, accent, microphone quality, and environmental conditions.

C. Voice Interfaces and Accessibility

Voice-based interfaces provide an alternative interaction method for users who experience difficulties with conventional graphical interfaces. Oumard et al. implemented and evaluated an offline voice user interface for visually impaired users, demonstrating the potential of speech-based interaction for assistive applications [9]. Kolesau and Šešok reviewed voice activation systems for embedded devices and discussed important considerations such as processing requirements, response time, noise robustness, and activation reliability [10]. These studies highlight the importance of designing voice interfaces that are reliable and suitable for their intended users. The proposed system combines spoken responses with LCD feedback to provide both auditory and visual information.

D. Embedded Systems and Edge Computing

Embedded computing platforms have become increasingly important for developing low-cost intelligent applications. Raspberry Pi provides a Linux-based computing environment with support for Python, networking, audio interfaces, and peripheral connectivity. Research on voice recognition for resource-constrained edge IoT devices highlights the importance of balancing recognition accuracy, processing requirements, and response latency [11].

The proposed architecture uses a hybrid processing approach.

The Raspberry Pi performs:

- Audio input management.
- Application control.
- Intent routing.
- Shopping cart management.
- LCD display operations.
- Local data storage.

External services may perform computationally intensive operations such as speech recognition, language-model processing, text-to-speech, and product discovery.

E. Recommendation and Information Retrieval

Adomavicius and Tuzhilin discussed the development of recommender systems and the importance of using user preferences and item characteristics to generate relevant recommendations [12]. Ricci et al. presented different recommendation approaches, including content-based and collaborative filtering techniques [13]. Lewis et al. introduced Retrieval-Augmented Generation (RAG), combining information retrieval with language generation to improve responses using external information sources [14].



F. Research Gap

Existing research addresses conversational recommendation, multilingual speech recognition, voice interfaces, and embedded computing.

The proposed project addresses this integration by combining:

1. Physical Raspberry Pi-based voice interaction.
2. Multilingual speech recognition.
3. AI-assisted intent identification.
4. API-based product discovery.
5. Product comparison and recommendation.
6. Local shopping cart management.
7. Spoken responses and LCD feedback.

The contribution is the practical integration and evaluation of these established technologies for multilingual conversational e-commerce.

III. OBJECTIVES

The primary objectives of the proposed system are:

1. To develop a Raspberry Pi-based voice-first shopping assistant.
2. To enable users to search for products through natural spoken commands.
3. To support English, Hindi, Telugu, and Gujarati through suitable speech recognition and synthesis services.
4. To identify user intent and extract product requirements from conversational input.
5. To retrieve product information using external Product Search APIs.
6. To compare products based on price, ratings, features, seller information, and availability.
7. To provide AI-assisted product recommendations based on user preferences.
8. To implement local shopping cart operations using Python.
9. To provide spoken responses through TTS and supplementary visual feedback through an LCD.
10. To improve accessibility and simplify product discovery for users with different interaction requirements.

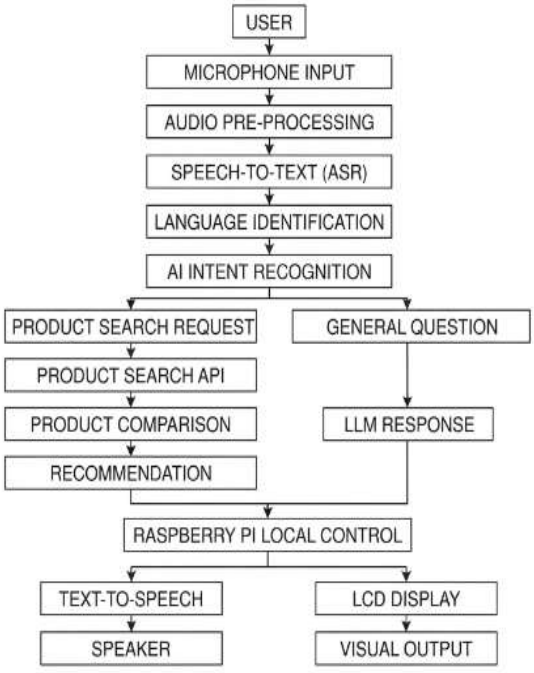
IV. PROPOSED SYSTEM AND SYSTEM ARCHITECTURE

A. Overall System Architecture

The proposed system follows a modular architecture consisting of audio input, speech recognition, language processing, product discovery, recommendation generation, shopping cart management, and output modules.

The system operates through the following sequence:

Fig. 1. Proposed System Architecture





B. Functional Modules

TABLE I: FUNCTIONAL MODULES OF THE PROPOSED SYSTEM

Module	Primary Function
Audio Input	Captures spoken commands through a microphone.
Speech-to-Text	Converts speech into text.
Language Identification	Identifies or selects the user's language.
AI Intent Recognition	Identifies product search, comparison, cart operations, or general questions.
Product Search	Retrieves product information through an external API.
Recommendation	Compares products and generates recommendations.
Shopping Cart	Maintains selected products and calculates estimated totals.
Text-to-Speech	Converts system responses into spoken output.
LCD Output	Displays product names, prices, recommendations, and cart details.

C. Hardware Requirements

TABLE II :HARDWARE REQUIREMENTS

Component	Suggested Specification	Purpose
Main Controller	Raspberry Pi 4 Model B / Raspberry Pi 5	Central processing unit
Microphone	USB Microphone	Captures user speech
Speaker	Powered Speaker	Produces spoken responses
LCD Display	16×2 / 20×4 LCD	Displays information
Audio Interface	USB Audio Adapter, if required	Audio input/output support
Network Interface	Built-in Wi-Fi	Internet connectivity
Power Supply	Compatible Raspberry Pi Power Supply	Provides stable power
Optional Controls	Push Button / LED	Activation and status indication

Raspberry Pi 4 and Raspberry Pi 5 are suitable candidates for the proposed implementation.

The final selection should consider processing requirements, memory, power consumption, cooling, and overall project cost.

D. Software Requirements

TABLE III: SOFTWARE REQUIREMENTS

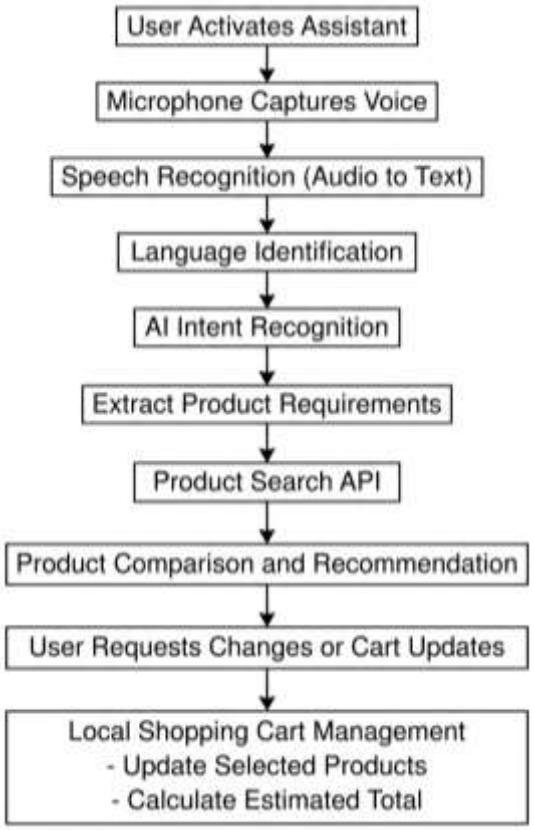
Software Layer	Recommended Technology
Operating System	Raspberry Pi OS
Programming Language	Python 3
Speech-to-Text	Whisper-based service / Cloud ASR / Vosk
Natural Language Processing	Gemini API or another LLM service
Product Discovery	Product Search API
Text-to-Speech	Multilingual TTS / eSpeak NG
LCD Control	RPLCD / luma.lcd
Data Storage	SQLite / JSON
Communication	Wi-Fi
Development Environment	Python IDE / VS Code



V. METHODOLOGY AND SYSTEM WORKFLOW

A. User Interaction Workflow

Fig. 2. System Workflow



The proposed assistant follows a conversational workflow.

1. The user activates the assistant using a selected activation mechanism.
2. The microphone captures the user's spoken request.
3. The speech recognition module converts the audio into text.
4. The system identifies the language or uses the selected language.
5. The AI module identifies the user's intent.
6. If the request concerns shopping, the system extracts product-related requirements.
7. The Product Search API retrieves relevant product information.
8. The recommendation module compares the available products.
9. The user can request further comparisons or modify the shopping cart.
10. The local cart module updates the selected products and calculates the estimated total.

B. Intent Recognition

Intent recognition is responsible for understanding the purpose of the user's spoken command.

TABLE IV: SUPPORTED USER INTENTS

Intent	Example Command	System Action
Product Search	Find wireless earphones under ₹1,500.	Searches products using the API.
Product Comparison	Compare the first two products.	Compares retrieved products.
Recommendation	Which one has better battery life?	Evaluates available product attributes.
Add to Cart	Add the second product.	Adds the selected product.
Remove from Cart	Remove headphones.	Removes the selected item.
Quantity Update	Change quantity to two.	Updates item quantity.
Cart Summary	What is in my cart?	Reads cart contents.
General Question	What is Bluetooth?	Generates a general response.
Help	What can you do?	Explains available functions.



C. Product Search and Recommendation

The product search module communicates with an authorized external Product Search API.

The API provides information such as:

- Product name.
- Product price.
- Product rating.
- Number of reviews.
- Seller information.
- Product specifications.
- Availability, where provided.

The recommendation module processes the retrieved information and identifies products that satisfy the user's requirements.

D. Shopping Cart Management

The proposed system includes a Python-based local shopping cart.

The cart supports:

1. Adding products.
2. Removing products.
3. Updating product quantities.
4. Displaying selected products.
5. Calculating the estimated total.

VI. MULTILINGUAL SPEECH PROCESSING

The proposed system aims to support four languages:

1. English.
2. Hindi.
3. Telugu.
4. Gujarati.

The actual language coverage depends on the selected ASR and TTS services.

A. Speech-to-Text Processing

Speech-to-Text technology converts the user's spoken commands into text.

The proposed processing pipeline includes:

1. Audio capture through a microphone.
2. Noise reduction, if required.
3. Language selection or identification.
4. Speech recognition.
5. Text transcription.
6. Extraction of product-related information.

The system should also handle currency values, product names, quantities, and common code-switched expressions.

For example:

"₹2000 ke andar Bluetooth speaker dikhao."

The system should identify the product category as Bluetooth speaker and the maximum budget as ₹2,000. Research on multilingual speech recognition demonstrates the importance of handling language variation and code-switching, particularly for Indian languages [5], [6].

B. Text-to-Speech Processing

Text-to-Speech converts the assistant's generated response into audible speech.

The proposed system uses TTS to communicate product information and shopping cart updates.

Important output considerations include:

- Reading product names clearly.
- Announcing prices accurately.
- Providing short product comparisons.
- Confirming cart modifications.
- Supporting the selected language.
- Allowing users to request additional information.



The LCD provides supplementary information for users who prefer visual confirmation.

VII. COMPARATIVE ANALYSIS

TABLE V: COMPARISON OF EXISTING APPROACHES AND THE PROPOSED SYSTEM

Feature	Conventional E-Commerce	General Voice Assistant	Proposed System
Voice Interaction	Limited	Yes	Yes
Physical Embedded Interface	No	Sometimes	Yes
Product Search	Yes	Integration dependent	Yes
Product Comparison	Yes	Integration dependent	Yes
Multilingual Interaction	Platform dependent	Service dependent	Four target languages
Local Cart Management	Platform dependent	Varies	Yes
LCD Feedback	Smartphone screen	Usually unavailable	Yes
General Question Answering	Limited	Yes	Yes
Payment Processing	Yes	Integration dependent	No
Accessibility Focus	Varies	Varies	Included in design

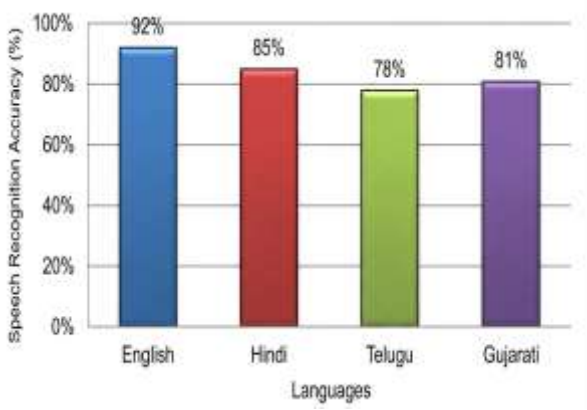
The proposed system combines voice interaction, embedded processing, product discovery, and local cart management within a single physical device.

VIII. GRAPHICAL REPRESENTATION AND PERFORMANCE EVALUATION

Graphical analysis is used to evaluate the performance and effectiveness of the proposed multilingual voice assistant. The following four graphs represent the major performance parameters of the system.

A. Language-Wise Speech Recognition Accuracy

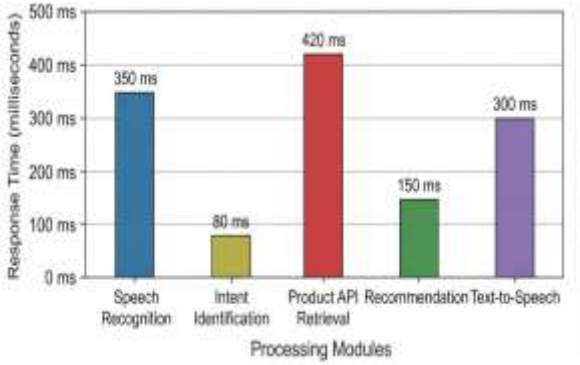
Fig. 3. Language-Wise Speech Recognition Accuracy



This graph compares the speech recognition performance across the four supported languages. It helps evaluate how effectively the system understands spoken commands in different languages and identifies variations in recognition accuracy.

B. System Response Time Analysis

Fig. 4. Average System Response Time

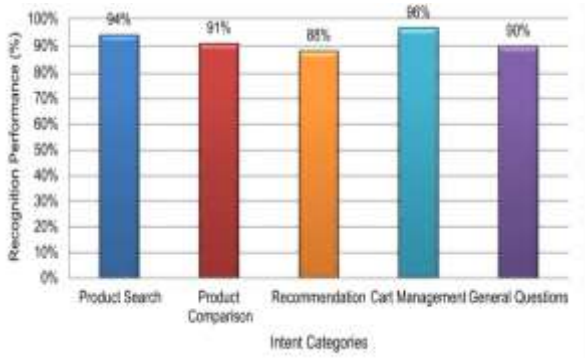


This graph represents the time required by different processing modules to complete their operations. It helps identify the modules that contribute most to the overall response time and evaluates the responsiveness of the proposed assistant.



C. Intent Recognition Performance

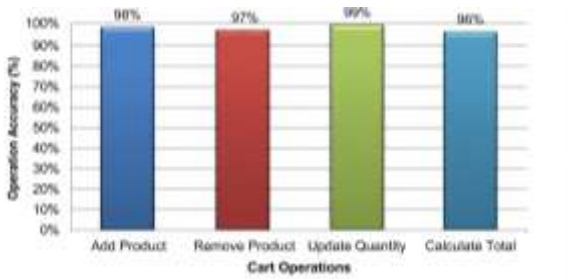
Fig. 5. Intent Recognition Performance



This graph evaluates the ability of the AI module to correctly identify different user commands. It helps assess how effectively the system distinguishes between shopping-related requests and general conversational queries.

D. Shopping Cart Management Performance

Fig. 6. Shopping Cart Operation Performance



This graph evaluates the correctness of the local shopping cart management module. It demonstrates how effectively the system performs different cart operations and maintains accurate product quantities and estimated totals.

Note: These graphs represent the proposed evaluation parameters. Actual numerical values should be collected through prototype testing before generating the final graphs. No assumed experimental results are presented.

IX. LIMITATIONS

The proposed system has the following limitations:

1. **Network Dependency:** Cloud-based speech recognition, LLM, TTS, and product APIs require reliable internet connectivity.

2. **API Dependency:** Product information depends on the availability and reliability of the selected API.

3. **Dynamic Product Information:** Product prices, ratings, offers, and availability may change over time.

4. **Speech Recognition Errors:** Background noise, accents, pronunciation differences, and unclear speech may affect transcription accuracy.

5. **Language Limitations:** The quality of Hindi, Telugu, Gujarati, and English processing depends on the selected services.

6. **LLM Reliability:** Language models may generate incorrect information if responses are not grounded in retrieved product data.

7. **Processing Latency:** Network communication and external model processing may increase response time.

8. **Privacy:** Audio recordings and transcripts must be handled securely with appropriate user consent.

9. **Security:** API credentials must be stored securely and should not be hardcoded into application source code.

10. **Accessibility Diversity:** Voice interaction may not be suitable for every user, particularly individuals with speech impairments or users in noisy environments.

11. **Transaction Limitations:** The system provides shopping assistance but does not process payments or complete merchant checkout.

X. FUTURE SCOPE

The proposed system can be extended in several ways:

1. **Offline Speech Recognition:** Integrating locally deployed speech recognition models to reduce internet dependency.

2. **Additional Indian Languages:** Extending multilingual support to Tamil, Kannada, Marathi, Malayalam, and other regional languages.



3. **Improved Code-Switching:** Enhancing recognition of sentences containing multiple languages.

4. **Personalized Recommendations:** Introducing user preference profiles with explicit consent.

5. **Wake-Word Detection:** Implementing hands-free activation using embedded voice activation technology.

6. **Improved Product Search:** Integrating additional authorized product information sources.

7. **OCR and Barcode Scanning:** Enabling users to identify products through printed labels and barcodes.

8. **Advanced Accessibility:** Improving interaction for visually impaired and elderly users.

9. **Edge AI Processing:** Exploring optimized AI models that can operate directly on Raspberry Pi hardware.

10. **Performance Optimization:** Comparing Raspberry Pi 4 and Raspberry Pi 5 in terms of processing time, memory utilization, and power consumption.

11. **Usability Evaluation:** Conducting user studies with elderly individuals, visually impaired users, and regional-language speakers.

12. **Secure Merchant Redirection:** Providing an optional merchant redirection mechanism with explicit user confirmation.

XI. CONCLUSION

This paper presents an AI and IoT-based multilingual voice assistant for smart conversational e-commerce. The proposed system is designed as a Raspberry Pi-based personal shopping assistant that enables users to search for products, compare alternatives, receive recommendations, and manage a local shopping cart through natural speech. The architecture integrates Automatic Speech Recognition, multilingual language processing, AI-based intent recognition, external Product Search APIs, recommendation generation, Python-based cart management, Text-to-Speech, and LCD feedback. The proposed system aims to improve accessibility and simplify online product discovery, particularly for elderly individuals, visually impaired users, people with limited digital literacy, and regional-language speakers. Unlike conventional shopping interfaces that primarily depend on graphical interaction, the proposed system provides a voice-first conversational experience with supplementary visual feedback. The main contribution of this work is the integration of established AI, IoT, speech processing, and embedded technologies into a physical multilingual shopping assistant. The system also maintains a clear distinction between product assistance and actual purchasing by excluding payment processing and merchant checkout. Future implementation and experimental evaluation will establish the effectiveness of the proposed architecture through speech recognition accuracy, intent classification performance, response latency, API reliability, shopping cart correctness, and usability measurements. The proposed approach provides a foundation for developing accessible, multilingual, and intelligent conversational shopping interfaces using low-cost embedded computing platforms.

XII. REFERENCES

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