LUMI: Lifestyle Utility and Monitoring Interface

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ABSTRACT

This project seeks to develop a sophisticated desktop companion robot that combines artificial intelligence, robotics, and IoT to enhance home automation and personal assistance. Powered by the Raspberry Pi 5, the robot will manage tasks like scheduling, smart home control, and entertainment while providing an engaging, emotionally expressive interface. The goal is to create a versatile, functional prototype, highlighting the potential of companion robots to enrich daily life with assistance, entertainment, and security. This prototype could pave the way for a future consumer device integrating advanced technology into everyday life.

Keywords: Desktop Robot, Raspberry Pi 5, Internet of Things

I. INTRODUCTION

The rapid advancement in robotics and IoT has revolutionized how technology integrates into daily life, enabling smarter homes and more interactive personal devices. Desktop companion robots represent a unique fusion of automation and emotional interaction, offering users practical functionality and engaging companionship. With increasing demand for such innovations, these robots are poised to transform home automation and personal assistance.

This project aims to develop a versatile desktop companion robot powered by the Raspberry Pi 5. Designed to manage scheduling, smart home control, and entertainment tasks, the robot also focuses on creating emotionally expressive interactions through voice recognition, speech synthesis, and an LCD screen for dynamic facial expressions.

The prototype combines hardware and software features, including a camera for motion detection, servo motors for expressive gestures, and modules like IR blasters and Bluetooth for seamless device control. By integrating robotics, IoT, and various other functionalities the project demonstrates how such a device can enhance daily life with personal assistance, entertainment, and security, paving the way for future consumer-ready products.

The current desktop companion robots often suffer from limited adaptability, constrained processing power, and lack of seamless integration with smart home ecosystems. Many existing models rely on proprietary software, restricting customization and third-party integrations. Additionally, their emotional expressiveness is often rudimentary, with limited facial expressions and inconsistent voice interactions. The proposed system, powered by the Raspberry Pi 5, addresses these limitations by leveraging improved computational efficiency and modular expandability.

II. METHODOLOGY

The modern world increasingly relies on intelligent systems to assist with daily tasks, enhance connectivity, and provide companionship. The project centers around Raspberry Pi 5, a powerful yet cost-effective microcontroller facilitating seamless interaction between hardware and software components.

A. Hardware Implementation

Central Processing Unit

The Raspberry Pi 5, equipped with the BCM2712 processor, serves as the main controller of the system, managing all input and output operations while executing processing tasks efficiently. It is selected due to its robust performance, extensive connectivity options, and cost-effectiveness, making it a suitable choice for an embedded robotic assistant.

Input Devices

A microphone is used to capture user voice commands, which are processed in real time for speech recognition tasks. A touch sensor, connected via GPIO, enhances interaction by allowing the user to engage with the robot. Additionally, a camera module, connected via USB, facilitates functionalities such as detection, thereby providing more security.

Output Devices

A speaker, connected through a USB port, is responsible for providing audio feedback, including synthesized speech responses and notifications. A high-resolution LCD display, connected via HDMI, visually represents the robot's emotional expressions, displays notifications, and provides a user interface for interaction.

Actuators & Peripherals

The system employs multiple servomotors, controlled through GPIO pins, to enable physical movement, such as minor mechanical responses. An IR blaster, also connected via GPIO, extends the system's functionality by enabling it to control infrared-enabled home appliances remotely. A vibration motor, driven by GPIO signals, is included to provide haptic feedback, reinforcing the robot's emotional states and responses.

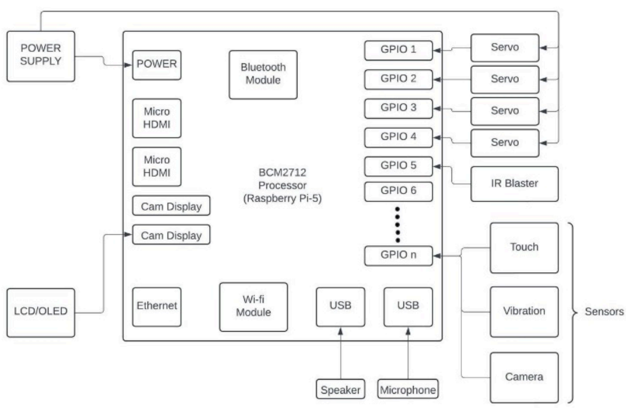

Figure 1: Raspberry Pi 5 Block Diagram

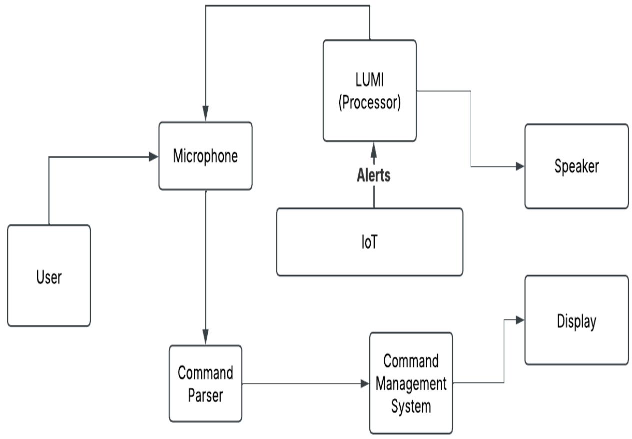

Figure 2: LUMI Block Diagram

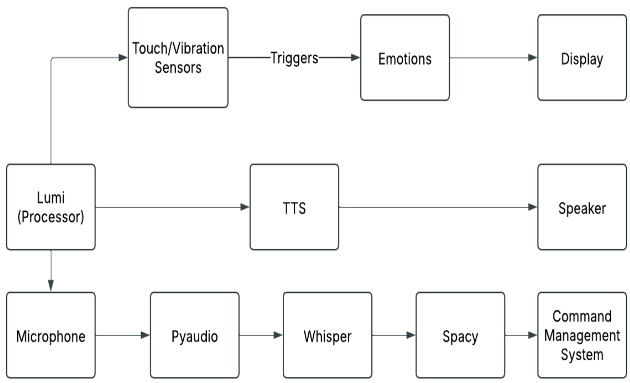

Figure 3: LUMI Processor

B. Software Implementation

Voice Interaction

The speech-to-text functionality is implemented using Whisper, which processes real-time voice commands effectively. The PyAudio library is utilized to capture and handle audio input from the microphone, ensuring seamless voice recognition performance. Once the speech input is transcribed, natural language processing techniques, leveraging SpaCy, are employed to analyze the text and determine user intent. This allows the system to interpret commands accurately and execute appropriate functions based on user instructions. Text-to-speech conversion is handled using pyttsx3, which generates audio responses that are played through the speaker, enabling effective two-way interaction between the user and the robot.

Emotional Expression via Display

The emotional representation of the robot is managed to facilitate the rendering of expressive animations on the LCD screen. The transitions between different emotional states, such as happiness, sadness, and neutrality, are smoothed out for image processing by using interpolation. The emotions displayed by the robot are triggered based on contextual interactions, such as receiving user greetings, completing tasks, or entering idle states. Additionally, the robot's expressions can be influenced by sensory inputs, such as user touch detected by the touch sensor or facial recognition analysis performed by the camera module.

IoT Integration for Smart Home Control

The robot interacts with IoT devices through various communication protocols, including MQTT, HTTP APIs, and Bluetooth, allowing it to control home automation systems efficiently. A practical use case of this integration is when the user issues a command, such as "Turn off the living room lights," the robot processes the instruction, formulates an MQTT request, and sends it to the respective smart lighting system to act.

Task Management Features

The robot provides comprehensive task management functionalities, including reminders, alarms, and note-taking. The reminder system stores and retrieves scheduled tasks, ensuring efficient data storage and retrieval. Notifications for reminders are delivered through both visual cues on the display and audio alerts from the speaker. The alarm functionality is implemented using Python's built-in time and schedule libraries, ensuring accurate timekeeping and persistence across system reboots. Additionally, timer, date, and time are also implemented. The weather details are also retrieved using the OpenMeteo API.

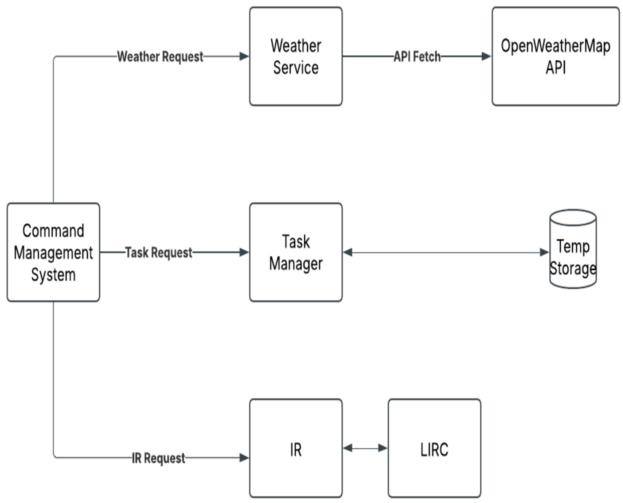

Figure 4: Command Management System

III. RESULTS

The implementation of the companion robot demonstrates a comprehensive integration of multiple advanced functionalities, creating a highly interactive and intelligent personal assistant. Built around the Raspberry Pi 5, the system efficiently manages hardware and software components, ensuring seamless execution of voice commands, emotional expression, IoT-based smart home control, and task management. The robot's ability to dynamically update its emotional state based on user interactions enhances engagement, making it more lifelike and intuitive.

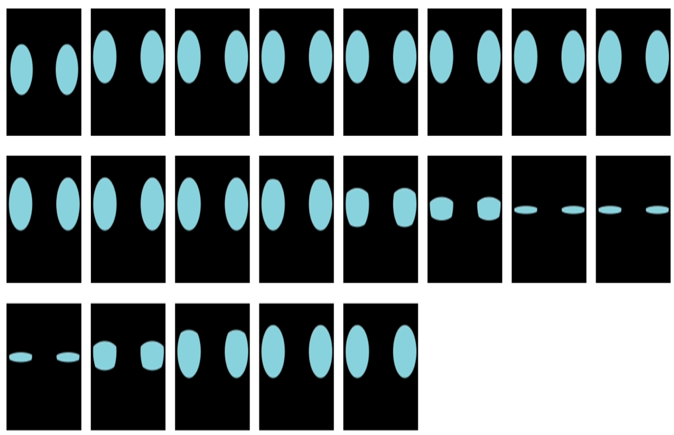

Figure 5: Original emotion frames

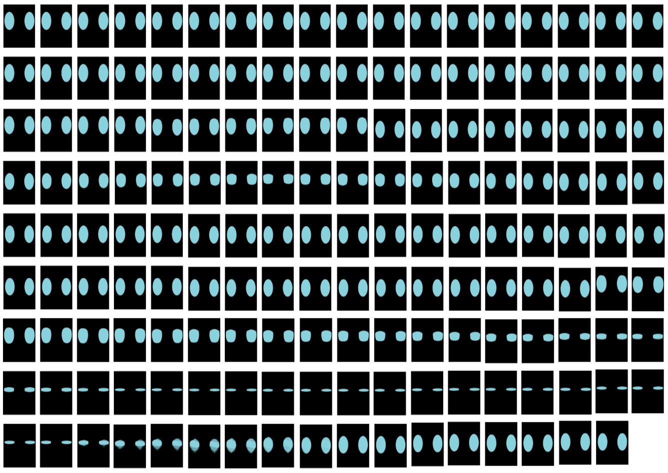

Figure 6: Interpolated Frames

The voice recognition system leverages the Whisper model for accurate speech-to-text conversion, allowing the robot to understand and process user commands in real time. The text-to-speech engine (pyttsx3) enables natural-sounding responses, facilitating effective two-way communication. Additionally, the integration of SpaCy for natural language processing (NLP) allows the system to comprehend complex commands, improving the overall interactive experience.

For enhanced sensory interaction, the robot is equipped with a USB microphone, a touch sensor, and a camera module. These input devices enable the system to respond to user engagement. The LCD display visually conveys emotional expressions, adapting in real time based on user interactions, greetings, and completed tasks.Interpolation is used to generate intermediate frames between key emotional states, ensuring smooth and natural transitions in your bot's facial expressions. This gradual shifting enhances realism and user engagement, making interactions feel more lifelike. The process involves designing key frames, applying frame interpolation using DAIN (Depth-Aware Video Frame Interpolation) to create in-between frames, and smoothing transitions for a fluid motion effect. As a result, the bot can seamlessly express emotions, improving the overall interactive experience and making user interactions more engaging and realistic.

The robot also serves as an effective smart home assistant through IoT integration, leveraging Wi-Fi and Bluetooth for seamless connectivity with smart devices. It communicates using MQTT and HTTP APIs to control home automation systems, such as adjusting lighting, operating appliances, and managing security features. The integration of a motion detection system using the Mi Home Security Camera 360 further strengthens its utility, allowing it to receive and process real-time security alerts.

For remote control of infrared-enabled devices, the system utilizes the HW-201 IR Blaster, which captures and replays IR signals. A menu-driven interface provides an intuitive method for users to configure and control appliances such as televisions, air conditioners, and other IR-based electronics. The Raspberry Pi efficiently processes IR signals, ensuring reliable communication with multiple devices.

The task management capabilities of the robot include reminders, alarms, note-taking, and real-time weather updates, providing a well-rounded functionality suite. The OpenMeteo API enables the robot to fetch and display weather details, enhancing its utility for daily planning. The alarm and scheduling system is built using Python's time and schedule libraries, ensuring reliable timekeeping and execution of scheduled tasks.

Overall, the successful implementation of the companion robot highlights its ability to function as an intuitive, interactive, and intelligent assistant. Its modular architecture and scalability make it adaptable to evolving user needs, paving the way for further enhancements in personal assistance, smart home automation, and security applications.

IV. CONCLUSION

The development of this companion robot showcases the successful fusion of artificial intelligence, human-computer interaction, and IoT-based automation within a cost-effective and scalable framework. By leveraging voice recognition, natural language processing, and expressive emotional displays, the system fosters an engaging and intuitive user experience. Its integration with smart home devices, motion detection, and infrared control extends its functionality beyond personal assistance, enhancing convenience and security. The robot's modular design ensures adaptability to future technological advancements, allowing for improved interaction capabilities, expanded automation features, and enhanced personalization. As smart environments continue to evolve, this project establishes a strong foundation for more sophisticated human-robot interactions, bridging the gap between assistive technology and everyday life.

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