Adaptive Human–Robot Interaction System Using ChatGPT and Artificial Intelligence

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ABSTRACT: Human-Robot Interaction (HRI) requires robots to adjust their behaviour according to different user preferences, intentions, and communication styles. Conventional adaptation methods depend heavily on continuous human feedback, which becomes inefficient as task complexity and action space increase. To overcome this limitation, this paper presents Chat Adp, a Chat GPT-powered adaptation framework designed for real-time interaction using a Raspberry Pi-based robotic platform. The system integrates an ultrasonic sensor for environmental sensing, a voice interaction module for natural communication, and a motorized robotic unit for executing actions. In this framework, Chat GPT functions as an intelligent feedback simulator, enabling the robot to understand user commands, generate context-aware responses, and refine its behaviour with minimal human intervention. By utilizing advanced language understanding and reasoning capabilities, the proposed Chat Adp system improves learning efficiency, reduces the need for repeated user corrections, and enhances overall responsiveness and interaction quality. Experimental results show that the system performs effectively in context-aware conversational tasks, making it a promising solution for adaptive and intelligent HRI systems.

KeyWords: — Human-Robot Interaction (HRI), Chat GPT Integration, Adaptive Robotics, Raspberry Pi, Voice-Based Control

1. INTRODUCTION

The field of Human-Robot Interaction (HRI) has significantly evolved over the past two decades, moving from rigid, pre-programmed systems to intelligent and adaptive robots capable of meaningful interaction with humans. This progress is driven by advancements in artificial intelligence, natural language processing (NLP), sensor technologies, and embedded systems. A key challenge in this domain is enabling robots to understand and respond effectively to the complex and context-dependent nature of human communication. While traditional robots perform well in structured industrial environments, they struggle in dynamic, real-world scenarios where human behaviour is unpredictable and diverse. The emergence of advanced language models such as ChatGPT provides a powerful solution by enabling robots with near-human conversational abilities.

HRI finds applications across various domains including healthcare, education, assistive technologies, domestic services, and industrial collaboration. In these areas, interaction quality such as responsiveness, contextual understanding, and communication clarity is critical for user satisfaction and system effectiveness. However, conventional HRI systems rely on basic techniques like keyword matching and rule-based logic, which limit their ability to process natural language effectively. These limitations become more evident when interacting with diverse users, such as elderly individuals or non-technical users. By integrating advanced conversational AI, modern HRI systems can overcome these challenges and achieve more natural, efficient, and user-friendly interactions.

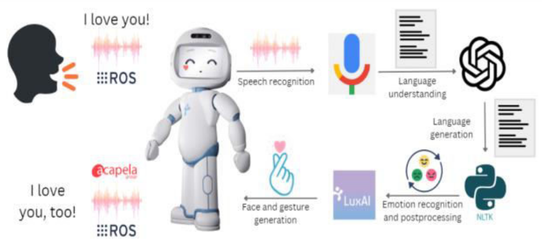

Fig1: implementation of Chat GPT Robo

The emergence of transformer-based language models like OpenAI's ChatGPT has revolutionized Human-Robot Interaction (HRI) by enabling advanced language understanding, reasoning, and context-aware communication. This project proposes a ChatGPT-powered adaptive robotic system built on a Raspberry Pi platform, integrating sensors, voice modules, and actuators to achieve real-time interaction and environmental awareness. The system processes natural language input, generates intelligent responses, and adapts robot behaviour dynamically based on user interaction and sensory data. Unlike traditional rule-based systems, this approach enhances conversational intelligence, improves user experience, and supports personalized, context-aware communication. The proposed framework is cost-effective, scalable, and suitable for applications such as healthcare, education, and service robotics, ultimately bridging the gap between humans and machines through more natural and adaptive interaction.

2. LITERATURE REVIEW

Brown et al. (2020) introduced GPT-3, a 175-billion parameter autoregressive language model that demonstrated remarkable few-shot, one-shot, and zero-shot learning capabilities without task-specific fine-tuning. The study showed that scaling model parameters and training data significantly improves performance across diverse NLP benchmarks, including translation, question answering, and text generation. This work established that large language models can generalize tasks from minimal examples provided in prompts, eliminating the need for extensive supervised retraining. The few-shot paradigm is particularly relevant to robotic conversational systems, where dynamic adaptation is necessary. Instead of pre-programming responses for every interaction scenario, GPT-3-like models can interpret user instructions contextually and generate appropriate outputs. In the proposed Chat GPT-powered robotic adaptation system, this principle allows robots to understand new commands, environmental descriptions, and user preferences without redesigning the model architecture. The scalability principle described in this paper provides the theoretical foundation for using large-scale pre-trained models in human–robot interaction (HRI). Furthermore, the paper highlights the importance of prompt engineering, which becomes crucial in robotic deployments for safe and accurate responses. By leveraging few-shot learning, the robotic system can handle diverse tasks such as guiding users, explaining procedures, or responding to emotional cues. Thus, Brown et al.'s work provides the conceptual and empirical basis for integrating advanced LLMs into adaptive robotic platforms.

3. PROPOSED SYSTEM

The proposed ChatGPT-powered adaptation system introduces an intelligent framework that enhances traditional robotic systems by integrating generative AI with a Raspberry Pi–based platform. Unlike rule-based systems, it uses the ChatGPT API to enable context-aware communication, adaptive decision-making, and real-time interaction. The system combines sensors, voice modules, display units, and motor controls to perceive user input and environmental conditions effectively.

By processing voice commands and sensor data together, the system understands user intent and generates dynamic, personalized responses. It ensures safe and intelligent actions, such as avoiding obstacles while executing commands. With multimodal outputs like speech, display, and motion, the robot delivers a more interactive and human-like experience. This hybrid edge-cloud approach improves scalability, flexibility, and overall performance, making the system more efficient and adaptable for real-world applications.

3.1Block Diagram

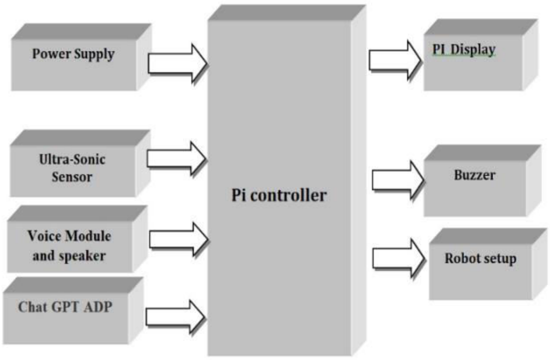

Fig 2: Block Diagram of the Proposed System

The system architecture is built around a Raspberry Pi controller, interfacing with input components such as a power supply, ultrasonic sensor, voice module, and ChatGPT API for intelligent processing, and output components like a display, buzzer, and robotic setup for interaction. The system captures voice input and environmental data, converts speech to text, and sends it to the ChatGPT API for context-aware response generation.

During operation, the Raspberry Pi processes sensor data and user commands simultaneously, enabling safe and adaptive decision-making. The generated responses are delivered through visual display, audio output, and robotic actions, creating an efficient, real-time, and interactive human-robot communication system.

4. RESULTS & DISCUSSION

The proposed Chat GPT-powered HRI system significantly improves communication, contextual understanding, and adaptive behaviour compared to traditional rule-based systems. By integrating the Chat GPT API with a Raspberry Pi controller, the robot can interpret natural language inputs, handle conversational queries, and generate context-aware responses in real time. This results in more natural, personalized, and human-like interactions. Experimental results show better accuracy, improved user engagement, and the ability to maintain context across conversations. Although the system depends on internet connectivity and may experience slight delays, it demonstrates strong potential for scalable, intelligent, and user-friendly robotic applications in various domains.

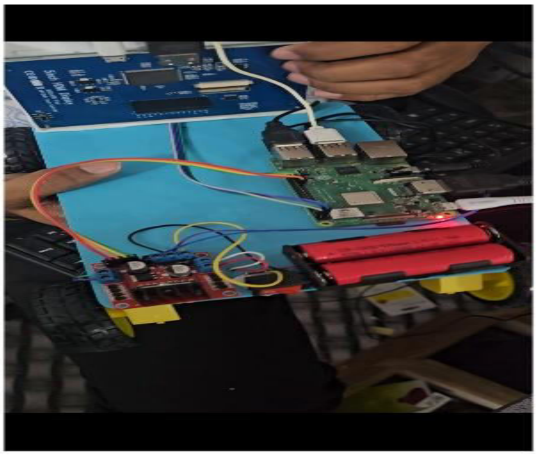

Fig 3: Hardware Implementation

A hardware implementation of a Chat GPT-based robot uses a Raspberry Pi as the main controller to handle inputs and AI communication. A microphone captures voice commands, which are processed by Chat GPT, and the responses are delivered through a speaker. A touchscreen display provides an interactive interface to show responses and allow user control.

Fig 4: Home Screen

The home screen welcomes users to a Chat GPT-based robot designed for human interaction, providing a simple and friendly interface to begin communication. It allows users to easily access voice and based person detection based ultrasonic sensor and touch controls for a smooth and engaging experience.

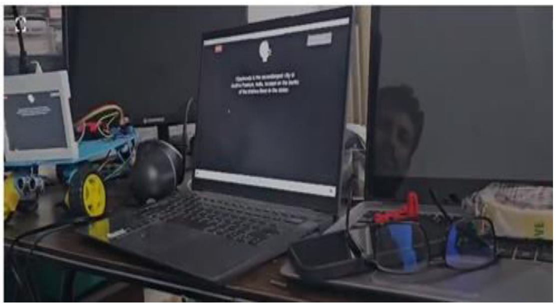

Fig 5: Listening human voice and processing

This figure shows how the system listens to human voice input using a microphone and converts it into digital signals for processing. The Raspberry Pi analyses the input and sends it to the AI model for understanding. After processing, the system generates an appropriate response for output.

Fig7: Content related voice data display on screen

This figure shows how the processed voice data is converted into meaningful text and audio output using a chatbot-based API key. The Raspberry Pi sends the captured voice to the AI via the API, receives the response, and presents it on the touchscreen while also playing the response through a speaker, allowing users to both see and hear the content for better interaction.

5. CONCLUSION

This work presents a Chat GPT-powered Human-Robot Interaction system that integrates advanced conversational AI with a Raspberry Pi-based robotic platform, enabling adaptive, context-aware, and human-like interactions. By combining sensors, voice communication, display, and robotic actuation, the system improves efficiency and user engagement compared to traditional methods, making it suitable for applications such as healthcare, education, and service robotics.

FUTURE SCOPE: In the future, the system can be enhanced with IoT integration, advanced sensors for emotion and gesture recognition, real-time processing, and multi-language support. These improvements will enable more natural interactions and allow robots to adapt to individual user needs across diverse real-world environments.

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