A Portable AI Assistant Robot with Display using Raspberry Pi

Background

I got this idea when I was looking at the Alexa in my room and thinking to myself that, "*Why does Alexa still give such a dumb answer to specific questions, even though it has been years after they manufactured first Alexa".*
Also, this was the time I have had finished CSC 480 and had some surface knowledge idea with how to make use of LLMs. Recent advances in conversational AI using large language models (LLMs) have enabled the development of intelligent virtual assistants. However, most existing assistants rely on cloud-based models, compromising privacy. Running LLMs locally on devices like Raspberry Pi can enable private AI robots. So, I was thinking that I could integrate the power of LLMs into a microcontroller like Raspberry Pi.
On the other hand, Alexa is missing the visual output element which is important for the understanding of the information outputted for the user. Adding a display screen can provide a face for human-robot interaction. This a challenge since I have not attempted a how to give a personality to virtual assistant as I could output the responses and visual interactions through a display before. Also, Raspberry Pi lends itself well to building inexpensive prototype robots with additional hardware like motors and cameras. Open-source software like Ollama and LLAVA can enable conversational abilities and computer vision locally on a Pi.

Objectives

This project aims to build a prototype of a portable AI assistant robot using Raspberry Pi by:

1. Designing and 3D printing an enclosure with integrated display screen.
2. Setting up motors, wheels, and sensors for mobility and object detection.
3. Optimizing Raspberry Pi OS and software for running LLMs and VLMs locally.
4. Developing a conversational interface with avatar using Ollama Web UI.
5. Adding object recognition capabilities using LLaVA or similar open-source VLMs.
6. Experimenting with voice interaction using speech recognition and synthesis.
7. Evaluating real-world use cases like home assistants, office robots etc.

Significance and Originality

The project is significant as it addresses the limitations of existing virtual assistants by incorporating visual output through a display screen and running AI models locally on affordable edge devices like Raspberry Pi. This approach enhances privacy and autonomy while also providing a platform for further research into intelligent edge robots. The originality lies in the integration of conversational abilities, mobility, and object recognition into a single prototype, coupled with the optimization of AI models for edge hardware.

Method of Evaluation

The success of the project will be assessed through real-world testing, measuring factors such as response time, accuracy, resource utilization, and user feedback. Additionally, benchmarks will be established for running LLMs and computer vision models on Raspberry Pi, providing guidelines for optimization. Qualitative assessments of the robot's capabilities and limitations will also be conducted.

Outcomes

- A prototype AI assistant robot with display, mobility, and conversational abilities.
- Benchmarks for running LLMs and VLMs locally on Raspberry Pi based hardware.
- Guidelines for developing responsible and ethical AI agents.
- An open-source platform to enable further research into intelligent edge robots.

The project will demonstrate the potential for building affordable AI assistant robots leveraging state-of-the-art AI. software optimized for edge devices like Raspberry Pi.

Applicability

The proposal holds value in both academic and professional contexts, aligning with interests in AI, robotics, and embedded systems. The project offers hands-on experience and contributes to skill development in research,

programming, and building AI systems. Furthermore, the outcomes can support career goals in AI research and development, providing opportunities for further academic pursuits or industry engagements.

Timeline

Weeks	***Project status***
1	- Finalize project proposal and objectives - Research design options for robot enclosure and display. - Order required hardware like Raspberry Pi, motors, battery etc.
2	- Create 3D model for robot enclosure in CAD software. - Begin 3D printing process for enclosure parts. - Assemble base robot chassis and mount motors.
3	- Continue 3D printing additional enclosure parts - Install Raspberry Pi and connect motors, sensors. - Start setting up Linux OS and required software.
4	- Complete 3D printing and assembly of full enclosure - Install display screen and associated driver software. - Test base mobility of robot on wheels.
5	- Optimize Linux OS for running LLMs efficiently. - Evaluate and select open-source LLM like Phi-2 or Llama-2 - Begin process of downloading model weights.
6	- Complete LLM installation and basic testing. - Design and implement conversational interface. - Integrate speech recognition for voice input.
7	- Evaluate open-source VLMs like LLaVA for computer vision. - Install VLM models and begin integration with robot. - Implement object detection and recognition

8	- Continue refinement of LLM and VLM integration - Test conversational abilities and object recognition. - Troubleshoot any issues observed with integrations.
9	- Focus on optimizing real-time performance of models. - Measure response times and memory utilization. - Test battery life and power options.
10	- Develop use case scenarios and test full system. - Refine conversations and contextual responses - Enhance avatar visualization and personality.
11	- Evaluate and resolve any limitations observed - Implement privacy protections and content filtering. - Test safeguards against misuse or harmful output.
12	- Perform final integration tests and refinements - Document project work, methodology and results
13	- Prepare final project report. - Build documentation and open source the project.
14	- Finalize project report and documentation. - Present project outcomes and demonstration

References

- *Ollama*

https://ollama.ai/blog , *https://python.langchain.com/docs/integrations/llms/ollama*

Raspberry Pi 5 & hardware https://www.pishop.us/product/raspberry-pi-5-8gb/?src=raspberrypi , *https://www.pishop.us/product/display-hat-mini/*