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Smart Autonomous Robot with Voice Interaction and Local AI Processing on Raspberry Pi 5

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Abstract - *The goal of this project is to create an AI-driven robot that can manoeuvre independently while communicating with people using a Raspberry Pi 5 as its hardware. The robot can accept a simple voice command and respond verbally. Along with being able to locally reason without needing an internet connection, it features a model called Gemma 3, enabled with Ollama, which runs entirely offline. The robot listens to voice input as a person speaks, provides input for its reasoning process, does its reasoning then determines how to move, interact with objects, and avoid obstacles, all initiated by a voice command. This project is an example of how an inexpensive system can interface and use AI to provide real-time control and communication.*

Keywords: **Autonomous Robot, Raspberry Pi 5, Voice Recognition, Offline AI, Ollama, Obstacle Avoidance.**

1. INTRODUCTION

With the advancement of technology, robots are becoming more sophisticated in their ability to interact with humans more naturally [1]. Conventional robots have been limited in their intelligence since they are often dependent on pre-programmed instructions or manual control. This project is intended to create a robot that can move automatically, understanding spoken human words, responding intelligently, and navigating itself.

The robot is based on the Raspberry Pi 5, which is powerful enough to support an offline AI model [2]. Using the Gemma 3 model with Ollama, the robot can understand natural language commands without the internet, so it is suitable for rural or unstable remote areas.

The overall goal is to create a system that:

- Listens to voice instructions
- Speaks back intelligibly
- Makes movement decisions
- Automatically detects obstacles
- Works completely offline

The robot is easy to use, quick to respond, and highly effective for educational, research and smart home contexts.

2. OBJECTIVES OF THE RESEARCH

The main goals of the AI-based robot are simple:

a. Voice Interface:
To enable the user to control the robot naturally, using speech rather than buttons or remotes [1,9].

b. Autonomous Navigation:
To enable the robot to move freely and avoid obstacles while using sensors.

c. AI Processing Offline:
To run the AI model locally the system will not process data through the internet causing delays and having privacy concerns.

d. Real-Time Performance:
To provide a responsive experience by processing commands quickly using the Raspberry Pi 5 and Python libraries.

3. SYSTEM COMPONENTS AND DESIGN

3.1Hardware Components:

1. **Raspberry Pi 5:** It is the robot's chief processor. It executes the AI model, does the voice interpretation, and regulates the movement [6,7].
2. **L298N Motor Driver:** It oversees 4 DC motors, which means it can move the motors to the front and back with the speed set.
3. **DC Motors:** Permit the robot to go forward, backwards, left, and right.
4. **Ultrasonic Sensor:** Aids the robot in determining how far away the obstacles are.
5. **Microphone:** Captures the voice of the user.
6. **Speaker:** It enables the robot to talk.
7. **Battery pack:** Supplies energy to all parts.

3.2 Software Components:

1. **Python 3:** It is the main language used for programming the motors, sensors, and AI.

2. **Speech Recognition:** It changes the voice of the user to text.
3. **pyttsx3:** The robot speaks by turning text into speech.
4. **Ollama + Gemma 3 Model:** The AI model is executed locally for command processing [4].
5. **RPi.GPIO:** It manages the GPIO pins for both the motor driver and the sensor.

3.3 Working Principle:

The robot operates simply and, in a human-like manner:

1. The microphone hears the user's voice.
2. Speech Recognition takes this audio and makes text out of it [6].
3. The text is sent to the Gemma 3 AI model to interpret the meaning.
4. The robot uses the offline AI model to generate a response.
5. Pyttsx3 has the speaker say the response.
6. Based on the command, a Raspberry Pi connects to the motor driver through the GPIO pins [6].
7. The ultrasonic sensor constantly checks to not hit an object that is too close.

This allows the robot to:

- Move in any direction
- Listen and talk like a smart assistant
- Avoid hitting an object
- Complete its tasks completely offline

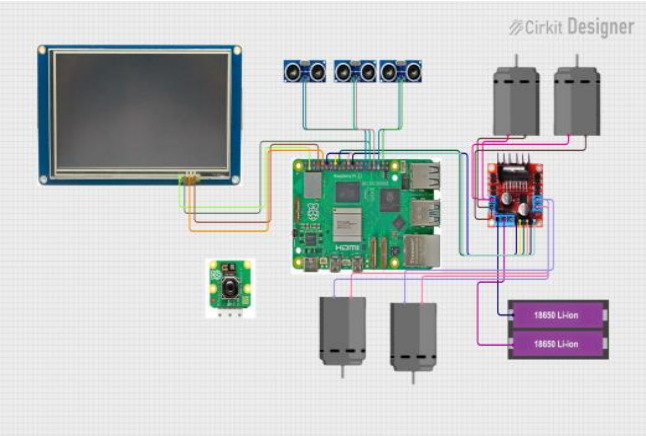

Fig -1: Circuit Diagram of Ai Autonomous robot

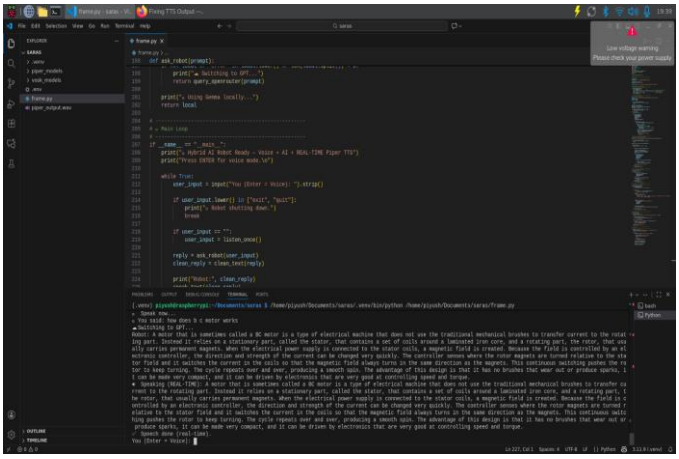

Fig -2: Simulation Result

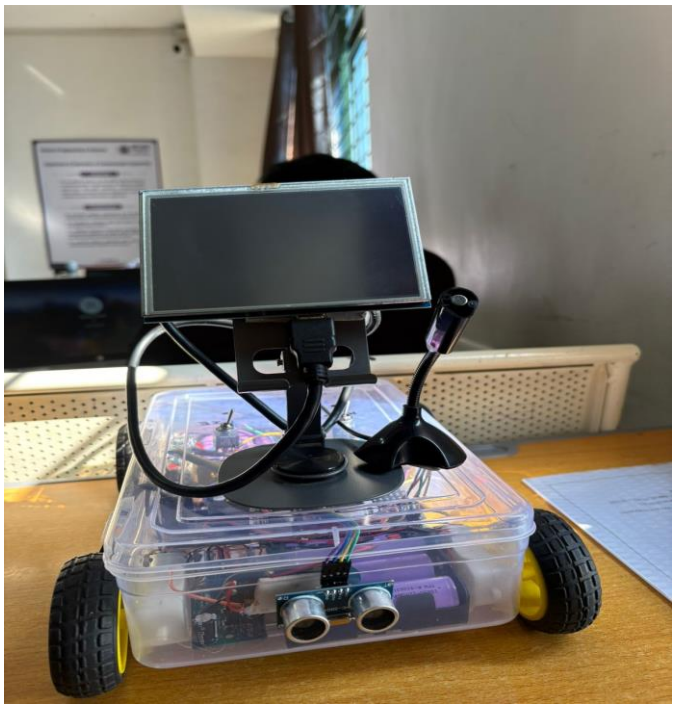

Fig -3: Hardware

4. CONCLUSIONS

The AI-powered autonomous robot merges voice command, offline intelligence, and autonomous navigation into a small size factor package. The robot, which uses the Raspberry Pi 5 and Gemma 3 model, can understand your commands, verbally respond to you with speech (text-to-speech), and navigate autonomously in different new intelligent ways without needing to be connected to the internet.

It is precise, easy to use and extendable [4] to other functionalities. This robot can be utilized by students, hobbyists and researchers interested in AI, electronics, and robotics.

FutureScope:
- Add computer vision for object detection
- Develop a mobile app for remote control
- Modify the robot for GPS for outdoor navigation
- Add additional advanced AI models for decision making.

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