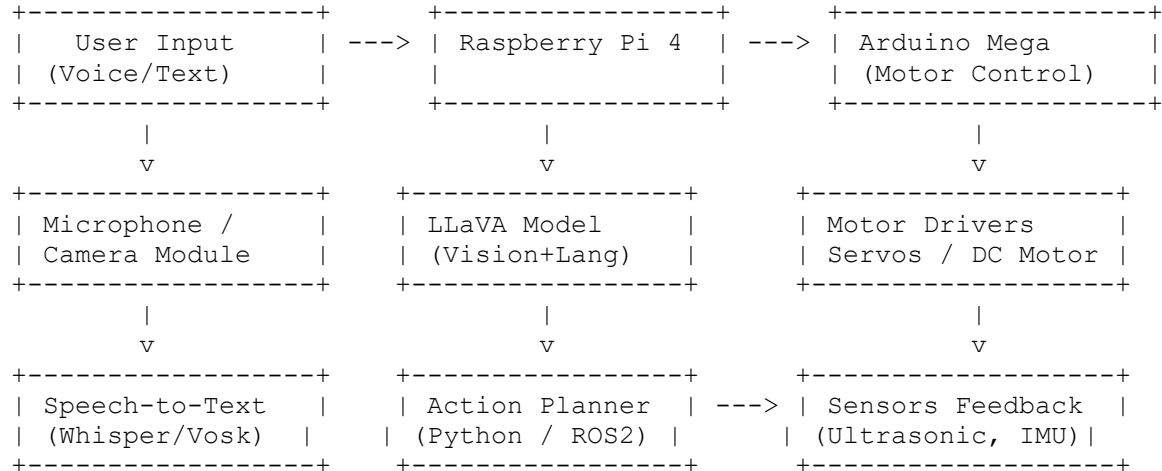


# Raspberry Pi 4 robot using LLaVA, action model, Arduino Mega, and sensors/motors.

## Architecture Overview



- **Pi 4:** high-level reasoning, LLaVA inference, action planning
- **Arduino Mega:** real-time motor & servo control
- **Sensors:** obstacle detection, position feedback

## 2 Recommended Components

Component	Purpose
Raspberry Pi 4 (8GB)	LLaVA inference + planner
Arduino Mega 2560	Real-time motor/servo control
Pi Camera Module / USB camera	Vision input
USB Microphone	Voice commands
Motor Drivers (L298N / TB6612FNG)	DC motors, servos
DC Motors + Wheels	Movement
Servo Motors	Arm / gripper
Ultrasonic Sensors	Obstacle avoidance

Component	Purpose
IMU (gyro/accelerometer)	Motion feedback

### Explanation of the One-Option Choices

Node	Chosen Library	Reason
STT	<b>Whisper</b>	Lightweight, accurate, Python ROS 2 integration
Vision	<b>OpenCV</b>	Pi-friendly, handles camera capture & preprocessing
LLaVA	<b>Tiny LLaVA</b>	All-in-one vision-language inference for Pi 4
Action Planner	<b>Python ROS 2</b>	Simple, modular, can implement rules or behavior trees
Arduino Mega	<b>rosserial_arduino</b>	Standard ROS 2 Arduino integration
Sensors	Standard sensor libraries in Arduino	Lightweight, works with rosserial

## Electronics Components List

Component	Purpose	Notes
<b>Raspberry Pi 4 (8GB)</b>	Main computer running ROS 2, LLaVA, STT, Vision	64-bit OS recommended
<b>MicroSD Card (32–128GB)</b>	OS + ROS 2 + models	Class 10 or higher
<b>Power Supply (5V 3A)</b>	Powers Pi 4	USB-C
<b>Arduino Mega 2560</b>	Handles real-time motor & sensor control	Connected via USB (rosserial)
<b>Motor Driver Board (L298N / TB6612FNG)</b>	Drive DC motors	Based on motor type & current rating
<b>DC Motors (2–4)</b>	Robot movement	Gear motors preferred for torque
<b>Servo Motors (2–4)</b>	Manipulation / gripper	5–6V servos compatible with Arduino
<b>Pi Camera / USB Camera</b>	Vision node input	Pi Camera v2 or 720p USB camera
<b>Microphone</b>	STT input	USB mic or I2S mic for Pi
<b>Ultrasonic Sensors (HC-SR04)</b>	Obstacle detection	Connect to Arduino digital pins
<b>IMU Sensor (MPU6050 / BNO055)</b>	Orientation & balance	I2C interface to Arduino
<b>Wheel Encoders</b>	Odometry feedback	Quadrature encoders connected to Arduino
<b>Battery Pack (7.4V Li-ion / LiPo)</b>	Powers motors & Arduino	Pi powered separately via 5V 3A PSU

Component	Purpose	Notes
Voltage Regulator (5V/3A)	Powers Pi from battery	If using a mobile setup
Jumper Wires, Breadboard, Connectors	Connections	For prototyping circuits
Chassis / Robot Platform	Mounting for motors, Pi, Arduino, sensors	Custom or off-the-shelf

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## Connections Overview

- **Raspberry Pi 4**
  - Runs ROS 2 nodes: STT, Vision, Tiny LLaVA, Planner
  - USB connection → Arduino Mega (rosserial)
  - USB mic or I2S mic for audio input
  - Pi Camera or USB camera for vision
- **Arduino Mega**
  - Receives `/robot_commands` → controls motors & servos
  - Reads sensors → publishes `/sensor_feedback`
  - Motor driver board connects between Arduino and DC motors
  - Servos connected directly to Arduino PWM pins
- **Sensors**
  - Ultrasonic → digital pins
  - IMU → I2C pins
  - Encoders → digital pins

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## Optional Components

- **OLED / LCD display** → show status, sensor readings
- **Wi-Fi dongle / Ethernet** → remote control or debugging
- **Buzzer / LEDs** → feedback for actions

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This list ensures your **Pi 4 robot fully supports:**

- Voice commands (STT)
- Vision-language understanding (Tiny LLaVA)

- Action planning + motion execution
- Obstacle sensing and feedback for closed-loop control

Here's a **detailed wiring checklist** for your Pi 4 + Arduino Mega robot. This lists **exact pins, connections, and cable recommendations** so you can wire everything safely and correctly.

## 1 Raspberry Pi 4 Connections

Component	Pi Pin / Port	Notes
Pi Camera	CSI port	Use ribbon cable; enable camera in <code>raspi-config</code>
USB Microphone	USB port	Any USB mic supported by ALSA
Arduino Mega	USB-A → USB-B	For rosserial communication <code>/dev/ttyACM0</code>
5V Power	USB-C 5V 3A PSU	Separate from motor battery; Pi only
Common Ground	Any GND pin	Connect to Arduino & sensors for shared ground

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## 2 Arduino Mega 2560 Connections

Peripheral	Arduino Pin(s)	Notes
Servo 1	PWM Pin 9	Connect 5–6V power; common ground
Servo 2	PWM Pin 10	Same as above
Motor Driver EN A	PWM Pin 5	Control left motor speed
Motor Driver EN B	PWM Pin 6	Control right motor speed
Motor Driver IN1/IN2	Digital Pins 22/23	Direction control left motor
Motor Driver IN3/IN4	Digital Pins 24/25	Direction control right motor
Ultrasonic Sensor 1	Trig: D2, Echo: D3	5V Vcc, GND to Arduino
Ultrasonic Sensor 2	Trig: D4, Echo: D5	Optional extra sensor
IMU (I2C)	SDA: 20, SCL: 21	3.3V or 5V per module specs
Wheel Encoder Left	D18 (A), D19 (B)	Quadrature decoding, use interrupts
Wheel Encoder Right	D20 (A), D21 (B)	Same as above
Common Ground	GND	Connect to Pi ground & battery negative

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## 3 Motor Driver (L298N / TB6612FNG)

Pin	Connection
ENA	Arduino PWM Pin 5
ENB	Arduino PWM Pin 6
IN1/IN2	Arduino D22 / D23
IN3/IN4	Arduino D24 / D25

Pin	Connection
VCC	Motor Battery +7.4V–12V
GND	Motor Battery -, also common ground with Arduino/Pi
5V OUT (if available)	Optional to power Arduino logic (if no other supply)

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#### 4 DC Motors

Motor	Connection
Left Motor	Motor Driver OUT1/OUT2
Right Motor	Motor Driver OUT3/OUT4

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#### 5 Servos

Servo	Arduino Pin	Power	Notes
Gripper / Arm 1	D9	5V	Common GND with Arduino
Gripper / Arm 2	D10	5V	Optional

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#### 6 Sensors

Sensor	Pins	Notes
HC-SR04 Ultrasonic	Trig → D2/D4, Echo → D3/D5	5V Vcc, common GND
IMU (MPU6050/BNO055)	SDA → 20, SCL → 21	3.3V or 5V supply, common GND
Wheel Encoders	Left → D18/D19, Right → D20/D21	Quadrature decoding, interrupts

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## 7 Power Summary

Device	Voltage	Source
Raspberry Pi 4	5V 3A	USB-C PSU
Arduino Mega	5V	USB from Pi or regulated supply
Motors	7.4V–12V	Separate Li-ion / LiPo battery
Servos	5V	Arduino or separate regulated supply
Sensors	5V	Arduino or Pi (depending on module)

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## 8 Cable Recommendations

- **Power wires (motors, battery):** 16–20 AWG
- **Logic wires (Arduino, sensors):** 22–24 AWG jumper wires
- **I2C / PWM / Digital signals:** Shielded if long wires (>50 cm)
- **USB / CSI / USB mic:** Standard cables provided