Updated HTML Wiring Guide with Raspberry Pi and Camera (hardware/wiring_guide.html) ```html

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Autonomous Vehicle Hardware Wiring Guide

Complete wiring instructions for Arduino-based self-driving car with Raspberry Pi AI

Project Overview

This guide provides detailed wiring instructions for building an autonomous self-driving car using Arduino Uno for motor control and Raspberry Pi 4 for AI processing with computer vision.

Required Components

Microcontrollers

Arduino Uno R3 ×1

Raspberry Pi 4 (4GB+) ×1

USB Cable A to B ×1

MicroSD Card (32GB+) ×1

Vision & Sensors

Raspberry Pi Camera V2 ×1

HC-SR04 Ultrasonic Sensor ×1

IR Infrared Sensors ×2

MPU-6050 Gyroscope ×1

Motors & Control

DC Gear Motors ×2

L298N Motor Driver ×1

SG90 Servo Motor ×1

Motor Wheels ×2

Power & Chassis

Li-ion Battery Pack (12V) ×1

USB-C Power Bank (5V) ×1

Robot Car Chassis ×1
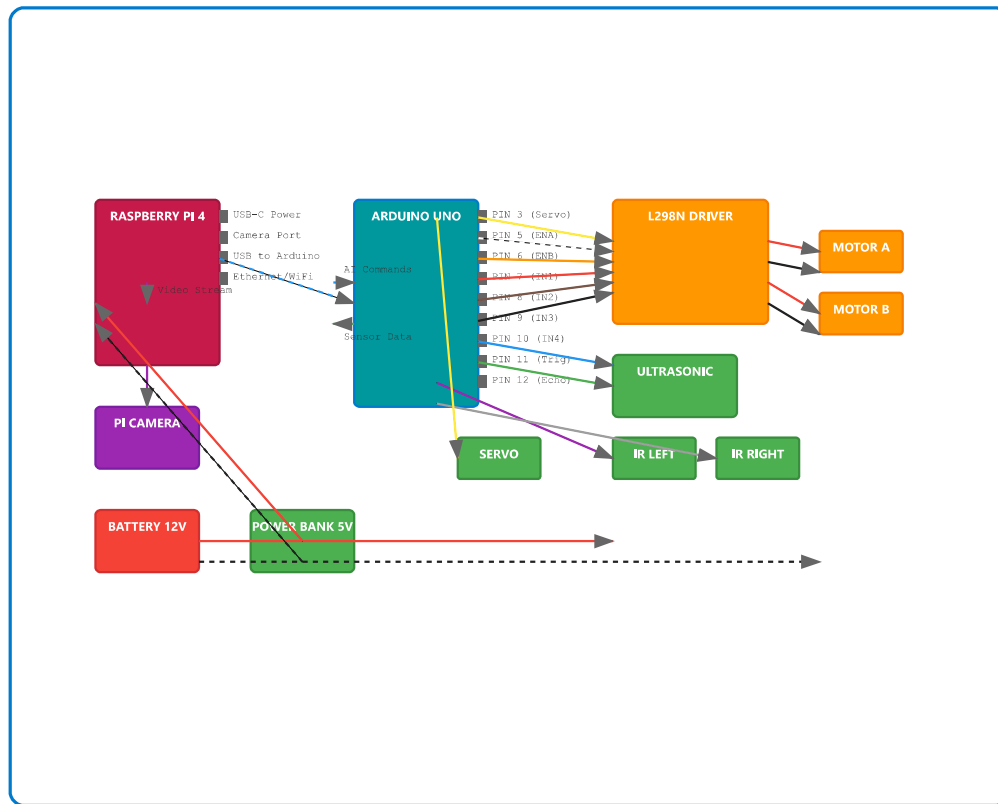
Jumper Wires (Various)

Complete System Architecture

Figure 1: Complete system architecture with Raspberry Pi and camera integration

Detailed Pin Connections

Raspberry Pi 4 Connections

Component	Raspberry Pi Port	Description	Cable Type
Camera Module	`Camera CSI Port`	15-pin ribbon cable connection	CSI Ribbon Cable

Component	Raspberry Pi Port	Description	Cable Type
Arduino Uno	`USB 2.0/3.0 Port`	Serial communication for motor control	USB A to B Cable
Power Supply	`USB-C Power`	5V 3A power input	USB-C Cable
Network	`Ethernet / WiFi`	Internet connectivity for AI models	Ethernet Cable

Arduino to Motor Driver (L298N)

Component	Arduino Pin	Description	Wire Color
Motor A Enable	`PIN 5` (PWM)	Left motor speed control	○ Yellow
Motor B Enable	`PIN 6` (PWM)	Right motor speed control	○ White
Motor A Input 1	`PIN 7`	Left motor direction forward	○ Orange
Motor A Input 2	`PIN 8`	Left motor direction reverse	○ Red
Motor B Input 1	`PIN 9`	Right motor direction forward	○ Brown
Motor B Input 2	`PIN 10`	Right motor direction reverse	○ Black

Sensor Connections to Arduino

Sensor	Arduino Pin	Description	Wire Color
Ultrasonic Trig	`PIN 11`	Trigger pulse output	○ Blue
Ultrasonic Echo	`PIN 12`	Echo pulse input	○ Green
IR Sensor Left	`A0`	Left line detection analog	○ Purple
IR Sensor Right	`A1`	Right line detection analog	○ Gray

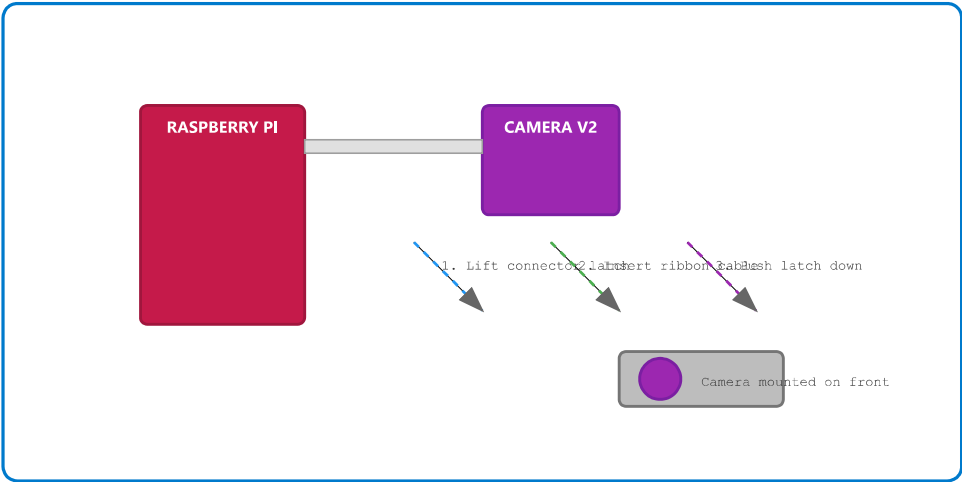| Sensor	Arduino Pin	Description	Wire Color
Servo Motor Signal	`PIN 3` (PWM)	Steering control signal	○ Yellow

Camera Installation Guide

Figure 2: Raspberry Pi camera installation and mounting

Camera Setup Steps:

1. **Enable Camera Interface:**

```
sudo raspi-config # → Interface Options → Camera → Enable
```
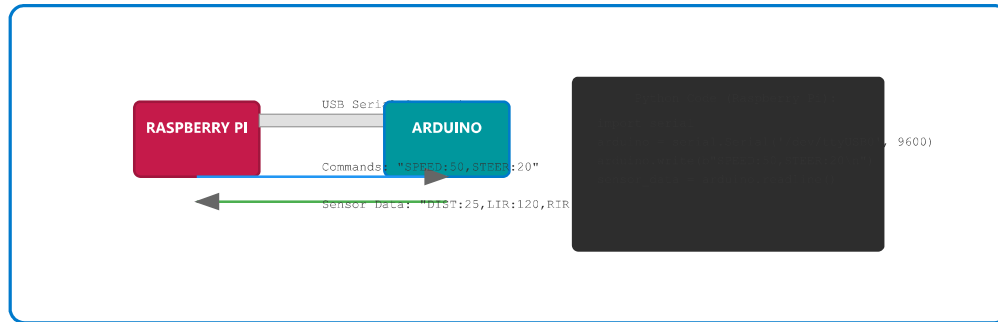
2. **Install Camera Software:**

```
sudo apt update sudo apt install python3-picamera2 python3-opencv
```

3. **Test Camera:**

```
libcamera-hello --list-cameras # Test capture: libcamera-jpeg -o
test.jpg
```

Communication Protocol

Complete Connection Summary

```
RASPBERRY PI 4 CONNECTIONS:
============================
📷 CAMERA → CSI Camera Port (15-pin ribbon cable)
🔌 ARDUINO → USB Port (USB A to B cable)
⚡ POWER → USB-C Port (5V 3A power supply)
🌐 NETWORK → Ethernet Port or WiFi

ARDUINO UNO PINOUT:
```

```
==================
DIGITAL PINS:

PIN 3   (PWM)   → SERVO Signal (Yellow)
PIN 5   (PWM)   → L298N ENA - Left Motor Speed (Yellow)
PIN 6   (PWM)   → L298N ENB - Right Motor Speed (White)
PIN 7           → L298N IN1 - Left Motor Forward (Orange)
PIN 8           → L298N IN2 - Left Motor Reverse (Red)
PIN 9           → L298N IN3 - Right Motor Forward (Brown)
PIN 10          → L298N IN4 - Right Motor Reverse (Black)
PIN 11          → HC-SR04 Trig (Blue)
PIN 12          → HC-SR04 Echo (Green)

ANALOG PINS:

A0 → IR Left Sensor (Purple)
A1 → IR Right Sensor (Gray)

POWER DISTRIBUTION:
==================
BATTERY 12V → L298N VCC (Red thick wire)
BATTERY GND → L298N GND & Arduino GND (Black)
POWER BANK 5V → Raspberry Pi USB-C
ARDUINO 5V → All Sensors VCC
```

Software Setup

Raspberry Pi Setup

```
# Install required packages sudo apt update sudo apt install
python3-pip python3-opencv python3-picamera2 # Install Python
libraries pip3 install pyserial numpy torch torchvision # Enable
camera and serial interface sudo raspi-config # → Interface
Options → Camera → Enable # → Interface Options → Serial Port →
Enable
```

Arduino Code Structure

```
// Arduino communicates with Raspberry Pi via Serial void setup()
{ Serial.begin(9600); // Match baud rate with Python code } void
loop() { // Read sensors readSensors(); // Send sensor data to
Raspberry Pi Serial.print("DIST:");
Serial.print(ultrasonicDistance); Serial.print(",LIR:");
Serial.print(irLeftValue); Serial.print(",RIR:");
Serial.println(irRightValue); // Check for commands from
Raspberry Pi if (Serial.available()) { String command =
Serial.readStringUntil('\n'); processCommand(command); // Execute
motor commands } }
```

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Last Updated: December 2024 | Version: 3.0

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``` ## Key Additions in This Version: 1. **Raspberry Pi Integration:** - USB serial communication with Arduino - CSI camera port connection - Power management with USB-C - Network connectivity 2. **Camera System:** - Raspberry Pi Camera V2 connection - CSI ribbon cable installation - Camera software setup steps - Mounting position on vehicle 3. **Communication Protocol:** - Serial data exchange between Raspberry Pi and Arduino - Command format for motor control - Sensor data transmission - Python code examples 4. **Power Management:** - Separate power for Raspberry Pi (5V power bank) - Motor power from 12V battery - Proper grounding between systems 5. **Complete System Architecture:** - Shows data flow between components - Visual representation of AI decision pipeline - Integration of computer vision with motor control