Marwadi University
Marwadi Chandarana Group
NAAC A+

System Design and Architecture

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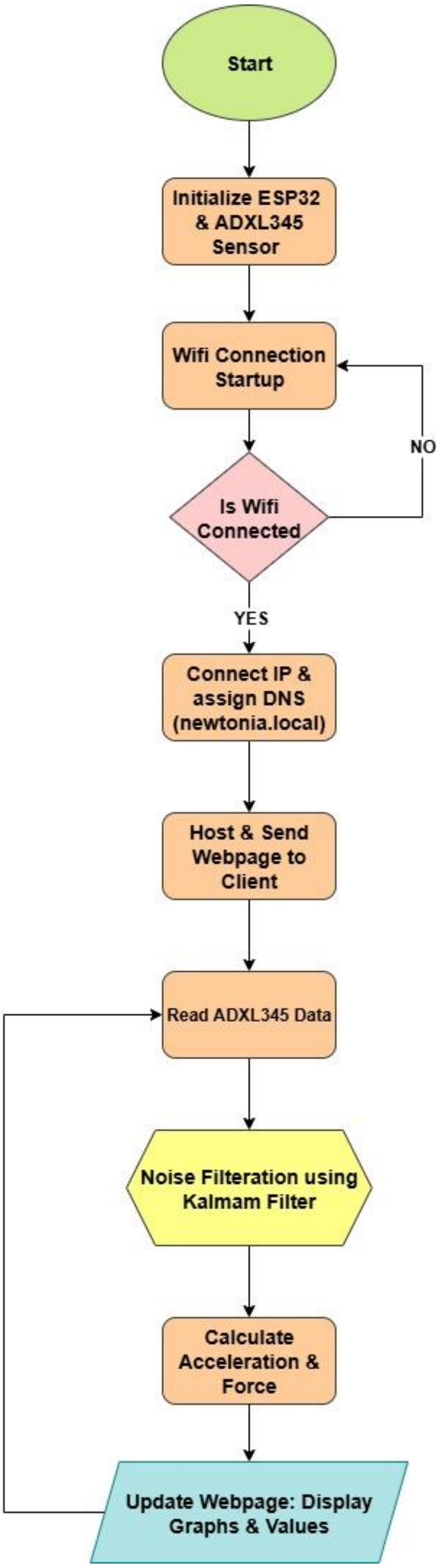
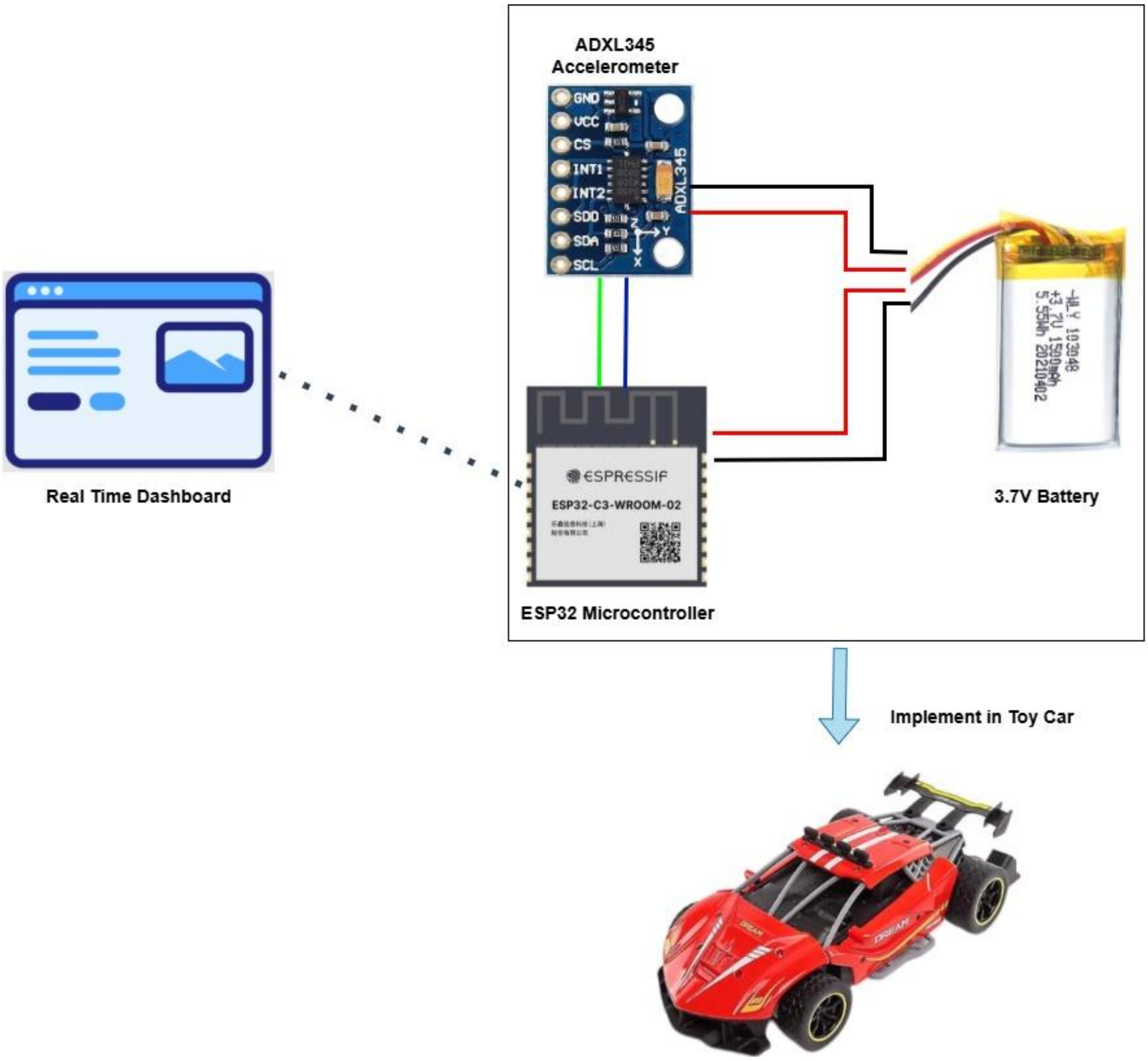
1. Flowchart


Start
Initialize ESP32 & ADXL345 Sensor
Wifi Connection Startup
Is Wifi Connected
NO
YES
Connect IP & assign DNS (newtonia.local)
Host & Send Webpage to Client
Read ADXL345 Data
Noise Filteration using Kalmam Filter
Calculate Acceleration & Force
Update Webpage: Display Graphs & Values

2. Circuit Diagram



3. Technology Stack

To implement the Newtonia Project, a balanced mix of hardware and software is selected. The chosen stack ensures **real-time data collection, wireless transfer, visualization, and user-friendly interaction**.

Hardware

- **Microcontroller ESP32C3WROOM02**
  - Chosen for low cost, wide community support, and built-in sensor compatibility.
  - ESP32 additionally offers **Wi-Fi and Bluetooth** support for wireless communication.
- **Accelerometer ADXL345**
  - Used to measure motion, force, and acceleration in real time.
  - Chosen because it is lightweight, reliable, and widely used in physics-related IoT experiments.
- **3.7V 1500mAh Battery**
  - Powers the system, enabling portability and continuous operation without dependency on wired connections.
  - Chosen for being compact, rechargeable, and having sufficient capacity for classroom experiments.

Software

- **Programming Languages: C/C++ (Arduino IDE)**
  - C/C++ is used for microcontroller programming because it is **lightweight and fast**.
- **Frameworks and Libraries**
  - WebSocket & Node.js: For real-time communication between the microcontroller and the web server, ensuring smooth and fast data transfer.
  - HTML,CSS & JavaScript: Used to build a web-based dashboard for interactive visualization of acceleration, velocity, and force data.
    - HTML provides structure,
    - CSS ensures styling and a clean layout
    - JavaScript manages dynamic updates and interactivity, allowing real-time display of acceleration, velocity, and force.

4. Scalability

The Newtonia Project is designed to remain simple and efficient while still being scalable for classroom or laboratory use.

Support for Multiple Devices

- A single Node.js server with WebSocket can handle multiple ESP32 devices at once.
- Each device can send data streams independently, allowing several students to run experiments at the same time.

Optimized Data Transfer

- Sensor data (acceleration, velocity, force) is processed and reduced on the ESP32 before being sent.
- This minimizes network traffic, reduces packet loss, and ensures smooth graph updates in the web dashboard.

Real-Time Graph Updates

- The dashboard is designed with JSON-based chart libraries to efficiently update only the latest data points instead of re-rendering the entire graph.
- This reduces CPU load on student computers and ensures a responsive user experience.

Performance Tuning

- The sampling rate of the accelerometer (ADXL345) can be adjusted to balance data accuracy and system load.
- The system avoids overload and ensures smooth operation.

Scalable Classroom Use

- Teachers can project the web dashboard on a big screen to display experiments for the entire class.
- Alternatively, each student group can connect their ESP32 device to the same server, making it scalable for large classrooms without extra infrastructure.

Cost and Reliability

- The system uses open-source tools (Arduino IDE, Node.js, WebSocket, HTML/CSS), which keeps costs low.
- No dependency on cloud subscriptions.