Testing and Validation

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Table Contents

1. Testing Strategy

Testing and validation were carried out to ensure that the Newtonia Project prototype meets its functional, performance, and usability objectives. The main focus was on verifying:

- Accurate sensor data collection.
- Proper Filtration of Noise Data
- Reliable WiFi connectivity and WebSocket communication.
- Correct real-time graph updates on the web dashboard.
- Smooth integration of hardware and software components.
- Alignment with the project objectives defined earlier.

2. Unit Testing

2.1 Wi-Fi Connectivity

The ESP32 was tested by connecting to a local Wi-Fi router. Several SSIDs and incorrect passwords were entered to check error handling. The device was successfully connected within 5–7 seconds under correct SSID & password.

2.2 Noise Data Filtration

ADXL345 accelerometer was placed in static positions. Expected values: ~0 m/s² on X/Y, ~9.81 m/s² on Z. Readings were within ±0.60 m/s² error margin with data fluctuation. After applying the moving average and EMA filter, noise was reduced by ±0.10 m/s².

2.3 ESP32 DNS

The EPS32 is registered with the hostname “newtonia.local”. This means that instead of typing the device’s IP address, users can simply enter “http://newtonia.local” in their browser to access the system. During testing, the DNS worked seamlessly, and no errors such as Error 404 – Page Not Found occurred.

2.4 Dynamic Website

Newtonia Project are connected to a device (laptop + smartphone) which accessed the dashboard simultaneously. Both clients received synchronized updates within 50 ms without any disconnection during a 30 min stress test or any lagging. Real-time reliability confirmed.

2.5 Hardware + Software Integration

Tested end-to-end flow. System successfully plotted real-time acceleration in graph after every 100ms update. Force calculation ($F = m \times a$) matched manual calculation. Integration fully aligned with project objectives.

3. Validation

- Graph updates after 100ms.
- ESP32 + WebSocket + Chart.js dashboard integrated successfully.
- 30 min stress test without disconnected.
- 4-5 device can connect without lag.
- Proper Noise Data Filtration
- Newtonia device connected instantly with Wi-Fi Router within 4-5 seconds.
- Newtonia device can run around 2-4 hours on single charge battery
- Force Calculation accuracy

4. Limitation

- Limited to local Wi-Fi; no cloud access yet.
- Can not applied in incline or decline surface.
- Still not filtered the noise data with 100 percent accuracy.
- Only X-axis tested; Y/Z axis can be added for 3D visualization.
- Performance may degrade if more than 5 clients connect simultaneously.