MINI PROJECT REPORT

On

HARDWARE BASED PROJECT TITLE

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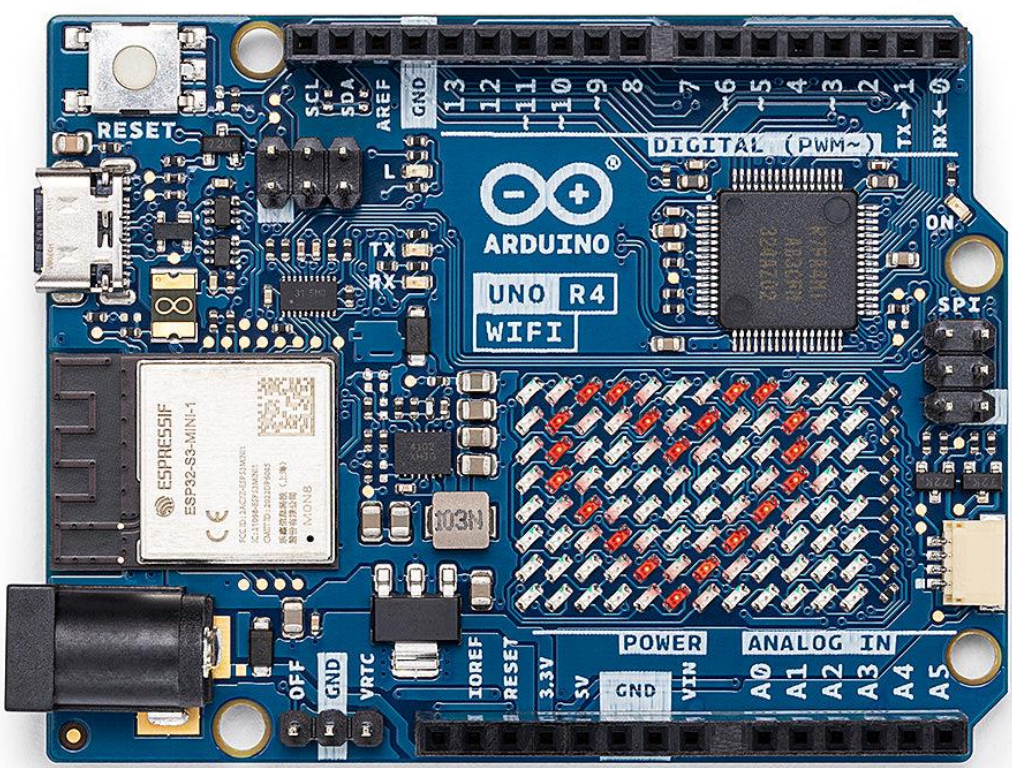
Introduction

This project implements an interactive WiFi-controlled message and emoji display system using an embedded microcontroller and a wireless communication module. Users can send messages or trigger emoji animations on a dot matrix display by connecting to a local WiFi access point, achieving practical IoT and real-time control capabilities.

The project is suitable for educational demonstrations, IoT learning, and rapid prototyping environments, showcasing the seamless integration of hardware control and wireless web-based interfaces.



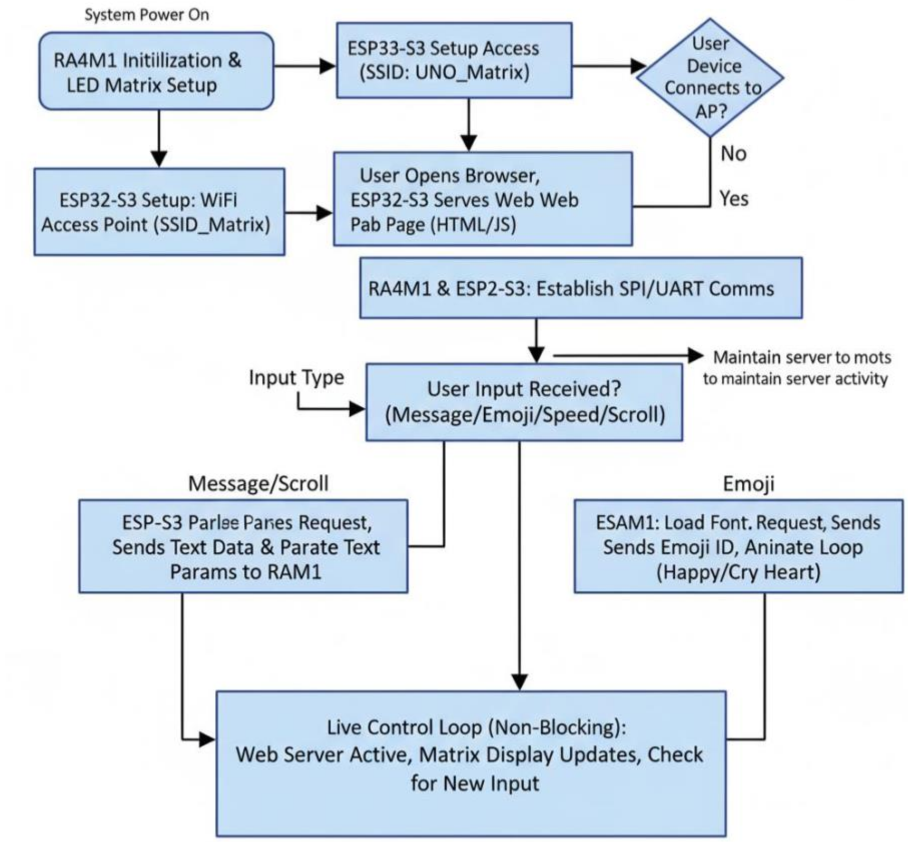
System Design and Analysis

Main Processor:
The system uses the **Renesas RA4M1** (Arm Cortex-M4, 48 MHz, 32-bit), providing high-speed processing and multitasking capabilities required for display management and system control.

Wireless Communication:
The **Espressif ESP32-S3** (dual-core, WiFi & Bluetooth LE) module operates in **Access Point (AP) mode** to host a local WiFi network. Users connect via mobile or desktop browsers to send messages or emojis directly to the system.

Display Controller:
An **LED matrix display** is driven through the **RA4M1's digital I/O lines**, enabling real-time text or emoji visualization based on user inputs.

User Interface:
A **web server** hosted on the ESP32-S3 provides an interface (SSID: `UNO_Matrix`) where users can open a browser, connect to the device, and control message text, scrolling speed, and emoji animations.



Hardware Implementation

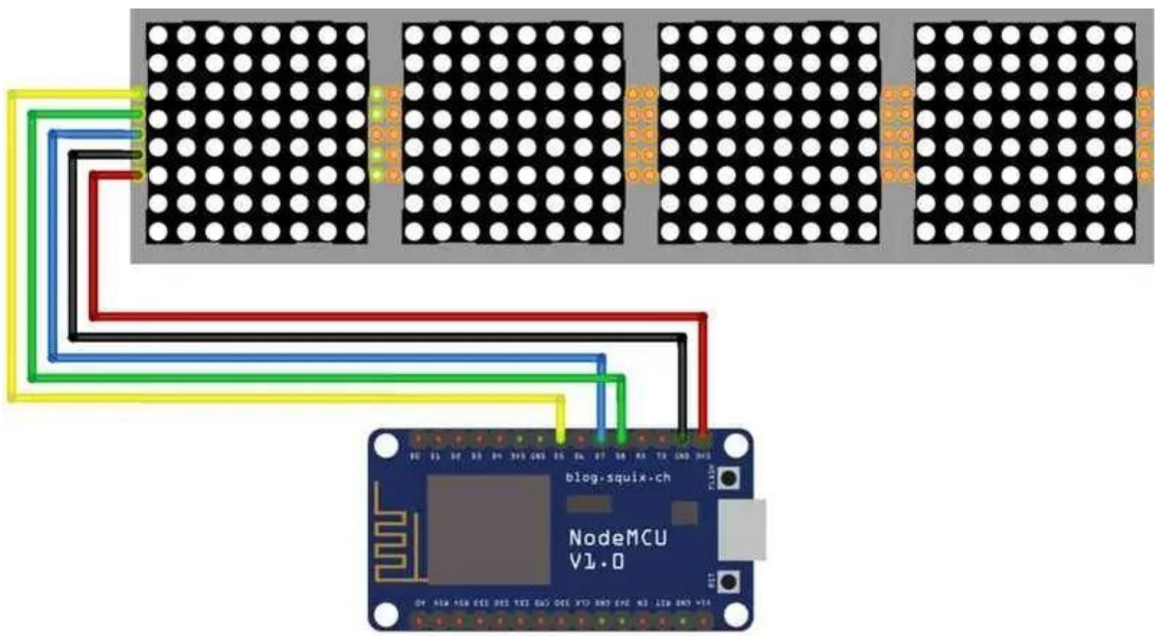
1. **Microcontroller Unit (MCU):** Renesas **RA4M1** (R7FA4M1AB3CFM#AA0), ARM Cortex-M4F, 48 MHz, 256 KB Flash, 32 KB SRAM.

2. **WiFi/Bluetooth Module: ESP32-S3-MINI-1-N8** (Espressif, 240 MHz dual-core).

3. **Power Supply:** Operates via **USB or DC jack**.

4. **Onboard Features:** LED matrix display, standard digital/analog I/O headers, and a **TXB0108DQSR logic level shifter** for communication between MCU and WiFi module.

Photographs of the working prototype show the LED matrix displaying text and emoji animations sent through the web interface.



Software Implementation

Libraries Used:

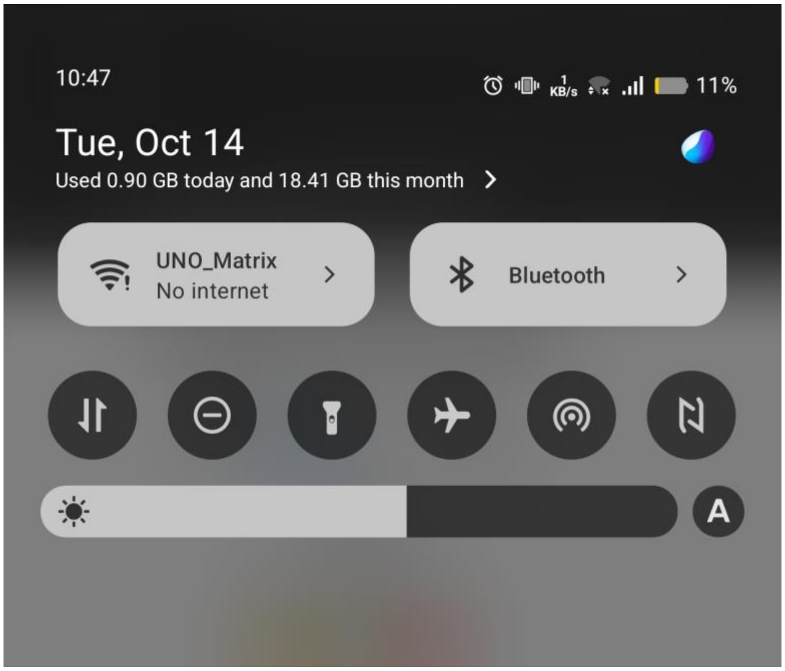
- `WiFiS3` – for AP configuration and local networking using the ESP32-S3.
- `ArduinoGraphics` and `Arduino_LED_Matrix` – for bitmap rendering and font handling on the LED matrix controlled by the RA4M1.

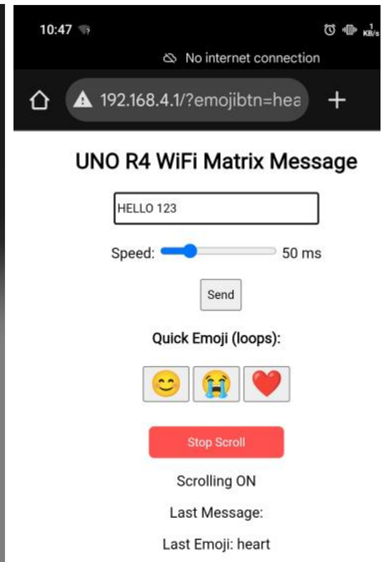
Web Server Flow:
The ESP32-S3 hosts a local web page that accepts **GET requests** containing parameters such as message, speed, emoji type, and scroll mode. These parameters are parsed and sent to the RA4M1 to update the display.

Emoji Animation:
Predefined animation frames (e.g., happy, cry, heart) are stored in the MCU memory. The selected emoji is continuously looped until interrupted by a new command, using **non-blocking programming techniques** for smooth performance.

Scrolling Message:
Text messages scroll across the LED matrix at user-defined speeds, adjustable via a slider in the web interface.

Live Control:
Instant updates allow users to toggle scrolling, view the last message or emoji, and receive real-time feedback, ensuring an interactive user experience.


10:47
11%
Tue, Oct 14
Used 0.90 GB today and 18.41 GB this month
UNO_Matrix
No internet
Bluetooth
A

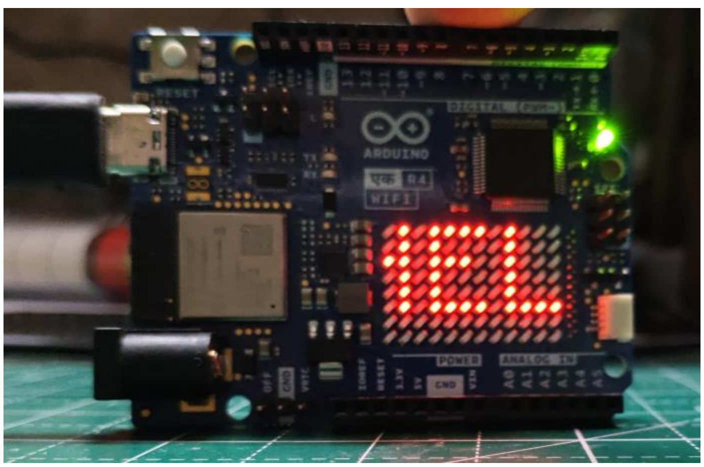

10:47
No internet connection
192.168.4.1/?emojibtn=hea
UNO R4 WiFi Matrix Message
HELLO 123
Speed:
50 ms
Send
Quick Emoji (loops):
Stop Scroll
Scrolling ON
Last Message:
Last Emoji: heart

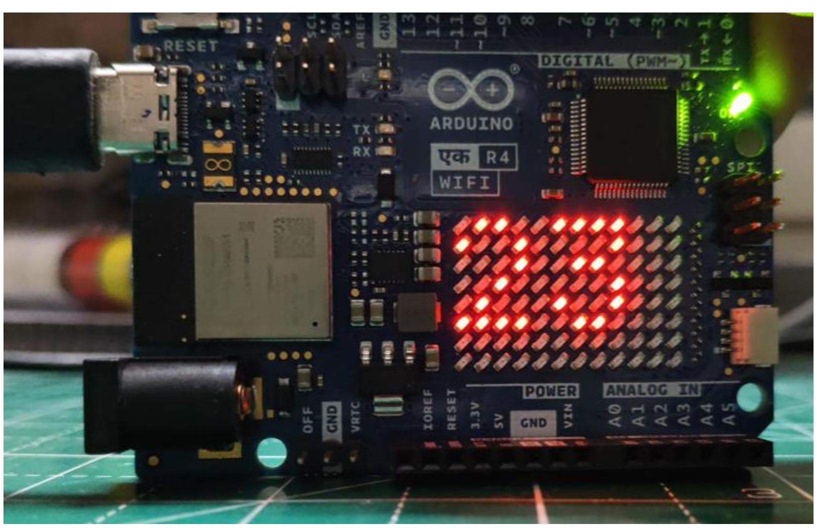
Results and Discussion

1. **User Experience:**
   Upon connecting to the UNO_Matrix network, the web interface displays the system's local IP. Users can then send new messages or select emojis, with instant updates reflected on the LED matrix.

2. **Responsiveness:**
   Non-blocking control ensures smooth animation and simultaneous web server operation, allowing multiple users to interact with minimal latency.

3. **Validation:**
   Testing confirmed that the RA4M1 and ESP32-S3 modules communicate efficiently, with the LED matrix accurately mirroring all user inputs and speed adjustments. Photographs and logs validate proper hardware interfacing and reliable wireless control.





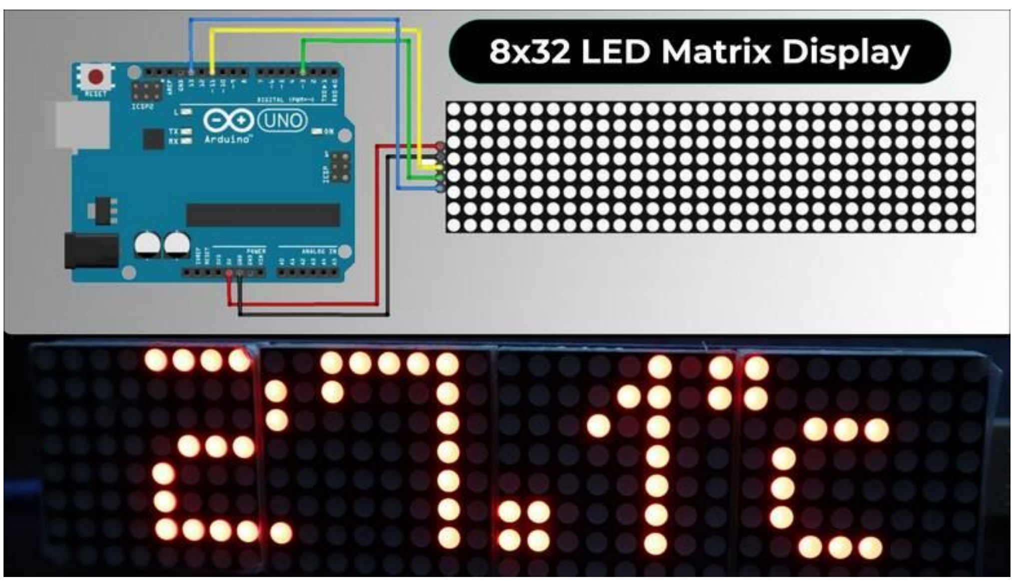
Applications and Future Scope

- **Educational Signage:**

    1. Dynamic message boards in classrooms or labs for announcements.

- **IoT Displays:**

    1. Wireless notification or feedback panels in smart environments.



- **Future Enhancements:**

    1. Integration with **cloud-based IoT platforms** for remote updates.
    2. Development of **richer animation libraries** and custom emojis.
    3. Enhanced **security/authentication** using ESP32-S3 BLE or WiFi credentials.

Conclusion

By integrating the **Renesas RA4M1 (Arm Cortex-M4)** and **Espressif ESP32-S3**, this project demonstrates an advanced **WiFi-enabled, browser-controlled LED matrix platform**. It highlights the power of combining embedded control with wireless communication to achieve **interactive, real-time IoT functionality**.
This system serves as a robust foundation for **student projects, IoT prototypes, and smart display applications**, emphasizing flexibility, user engagement, and practical embedded system design.

References

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