Faculty of Information Technology

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TIC-TAC-TOE GAME

Group 10

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Table of Contents

1. Introduction

Tic-Tac-Toe, a game renowned for its simplicity and enduring appeal, has captivated players of all ages across different cultures and eras. Originally a staple of childhood fun and friendly competition, this game has remained a favorite pastime in casual settings and educational environments alike. With its basic rules and accessible gameplay, Tic-Tac-Toe has provided countless moments of enjoyment and strategic challenge.

In today's digital era, the fusion of traditional games with modern technology has given rise to innovative variations that enhance and expand the gaming experience. Embracing this trend, our project reimagines the classic Tic-Tac-Toe game through the integration of advanced technology, specifically utilizing the ESP32 microcontroller. This modern iteration of Tic-Tac-Toe incorporates sensor-based inputs and digital enhancements, offering a fresh and interactive way to engage with the game.

Our sensor-based Tic-Tac-Toe game leverages the capabilities of the ESP32 to introduce a range of interactive features, including touchless input detection, dynamic LED lighting, and real-time score tracking. By combining the simplicity of the original game with cutting-edge technology, we aim to provide a unique and immersive gaming experience that bridges the gap between tradition and innovation. This approach not only revitalizes a classic game but also showcases the potential of modern technology in enhancing traditional recreational activities.

2. Problem in Brief

Traditional Tic-Tac-Toe games, while beloved for their simplicity and nostalgic value, often fall short in terms of interactive and dynamic engagement. Classic versions of the game typically involve static boards and manual inputs, which can limit the depth of player interaction and the overall gaming experience. These physical versions do not take full advantage of contemporary advancements in technology, such as sensor-based inputs, digital interfaces, and real-time connectivity.

In modern settings, where technology plays a crucial role in enhancing user experiences, there is a noticeable gap between the potential of interactive digital elements and the traditional gameplay of Tic-Tac-Toe. Traditional versions of the game, whether they are physical boards or basic digital adaptations, often fail to provide an immersive and engaging experience that could be achieved through modern technological innovations.

Moreover, while there are many digital versions of Tic-Tac-Toe, they often lack the tactile and sensory feedback that physical games offer, and they do not fully exploit the capabilities of modern microcontrollers and sensors. This presents a significant opportunity to refresh and revitalize the classic game by integrating sensor-based technology and advanced connectivity features.

To address these limitations, there is a need for a new approach that combines the charm and simplicity of traditional Tic-Tac-Toe with the dynamic and interactive elements of contemporary technology. A sensor-based Tic-Tac-Toe game can bridge this gap by incorporating features such as touchless inputs, real-time score tracking, and interactive LED displays, offering a modern and engaging experience while preserving the essence of the classic game.

This expanded problem statement highlights the shortcomings of traditional Tic-Tac-Toe games and sets the stage for introducing your sensor-based approach as a solution.

3. Aim and Objectives

Aim:

The aim of this project is to design and implement a Sensor-based Tic-Tac-Toe game using ESP32 microcontrollers, offering a modern and interactive gaming experience. As well as the lighting setup which will give an aesthetic look where the system will placed.

Objectives:

- **Enhancing Traditional Gameplay:** The primary objective of this project is to enhance the traditional Tic-Tac-Toe gameplay experience by integrating sensor technology and IoT principles. And there is a web based storage score management system to show the score on the display.
- **Promoting Interaction and Engagement:** The project aims to promote interaction and engagement among players by leveraging modern technology to create an immersive and intuitive gaming experience.
- **Educational Outreach:** This project seeks to serve as an educational tool for understanding sensor technology, microcontrollers, and IoT applications in a fun and practical manner.
- **Encouraging Innovation:** By combining the timeless appeal of Tic-Tac-Toe with innovative sensor-based technology, the project aims to inspire creativity and innovation in game design and development.
- **Increasing Mindfulness and Flow State:** Engaging in a well-designed game with interesting items such as an illuminating setup can lead to a state of flow, where players become fully immersed and focused on the task at hand. This immersive experience can help individuals temporarily disconnect from stressors and promote mindfulness.

4. Literature Study

- Historical Evolution of Tic-Tac-Toe: A study of the historical evolution and cultural significance of Tic-Tac-Toe, examining its enduring popularity across different societies and age groups.

- Sensor Technology in Gaming: Reviewing existing literature on the application of sensor technology in gaming, including motion sensors, proximity sensors, and touch sensors, to understand their potential in enhancing gameplay experiences.

- IoT Integration in Gaming: Exploring previous research and projects that have integrated Internet of Things (IoT) principles into gaming applications, highlighting successful implementations and identifying areas for improvement.

- User Experience Design: Investigating user experience design principles and methodologies to ensure that the sensor-based Tic-Tac-Toe game delivers an intuitive and enjoyable gaming experience for players of all ages.

5. Analysis and design

5.1 Proposed Solution

The proposed Tic-Tac-Toe game box aims to deliver a unique and engaging gaming experience through the integration of Arduino, IoT, and various sensors. The game box stands apart from others on the market due to its features that enhance the overall user experience and functionality. The game box will use various sensors and devices to interact with the user and display the game state, winner, and countdown time. The proximity sensor will be used to detect the presence of the user. By Implementing signal amplification techniques and

considering the use of multiple RFID sensors for improved accuracy develop error-handling mechanisms to address potential interference.

The algorithm for the AI opponent is based on the decision tree technique, which uses a set of rules to determine the best move for each board state. The LED display will be used to show the game mode, the player's turn, the winner, and the countdown time. The lighting setup gives an aesthetic look to the surroundings in which the system is positioned during non-gaming situations. Finally, in our system there is a web based storage to collect the information about the scores.

5.2 Features of the Proposed Solution

- Interactive Gameplay : Players can interact with the game board using gestures, enhancing the immersive nature of the Tic-Tac-Toe experience.

- Real-Time Feedback : The game board provides real-time feedback to players, displaying their moves and updating the game state dynamically.

- Multiplayer Support : The solution supports multiplayer gameplay, allowing multiple players to compete against each other locally.

- Customizable Settings: Players can customize game settings such as game modes to suit their preferences.

- Educational Resources : The solution includes educational resources and tutorials to help users understand the underlying technology and principles behind sensorbased gaming.

- Multiplayer and Ranking : A web-based database facilitates multiplayer functionality by storing game state. This adds a competitive element to the game and encourages users to strive for higher scores.

• Single-Player Mode ： In single-player mode, the game features an intelligent system that evaluates various board states and makes strategic moves based on decision tree algorithms. This provides players with a challenging and engaging experience, as the system adapts its strategy to create a competitive game environment.

• Aesthetic Lighting ： The system incorporates a dynamic lighting setup that enhances the visual appeal of the game box, particularly during non-gaming periods. This design element adds to the overall ambiance and attractiveness of the game environment.

5.3 Nature of the Solution

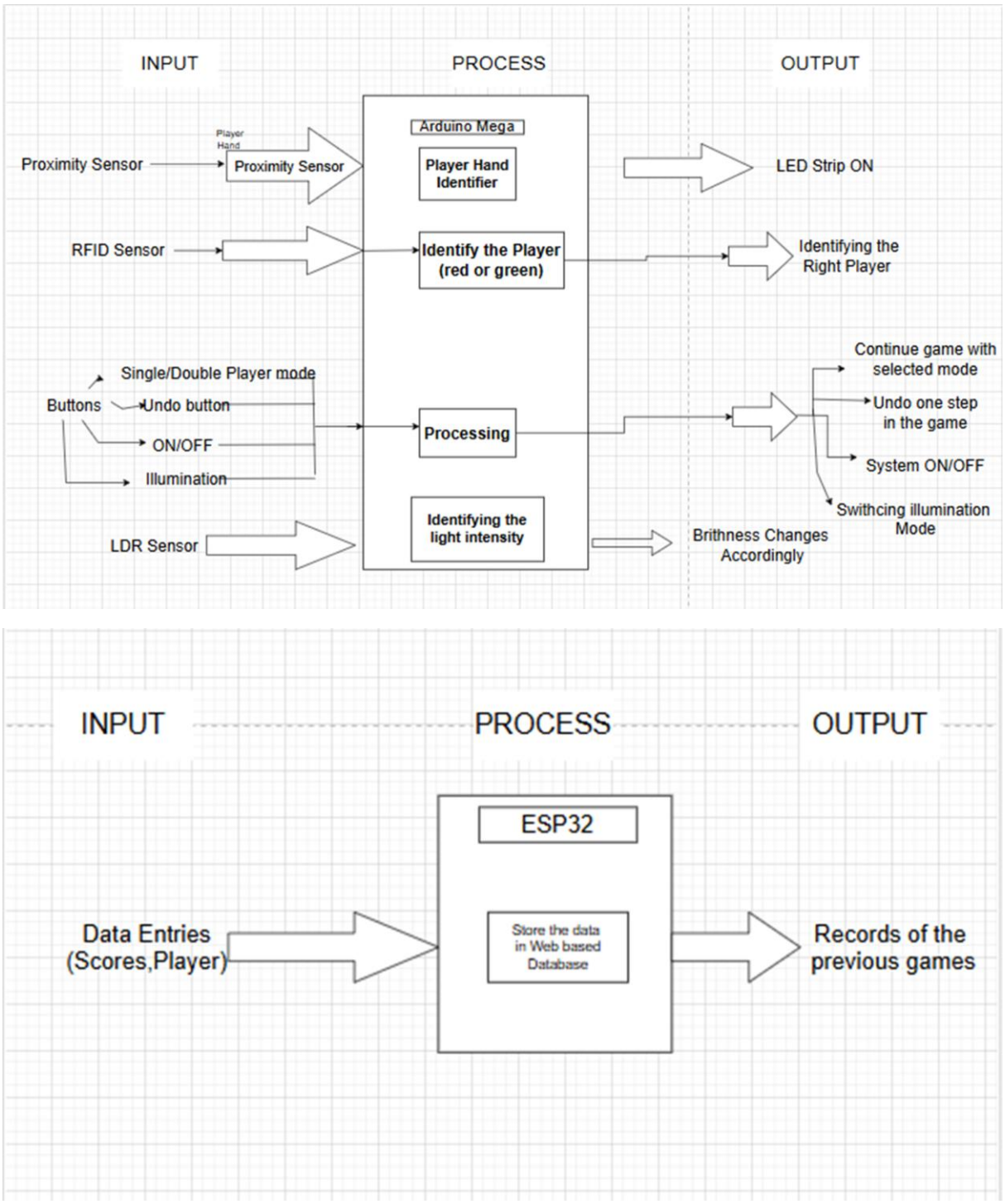


Figure 01: Block diagram of the input, process and output

5.4 Solution Design

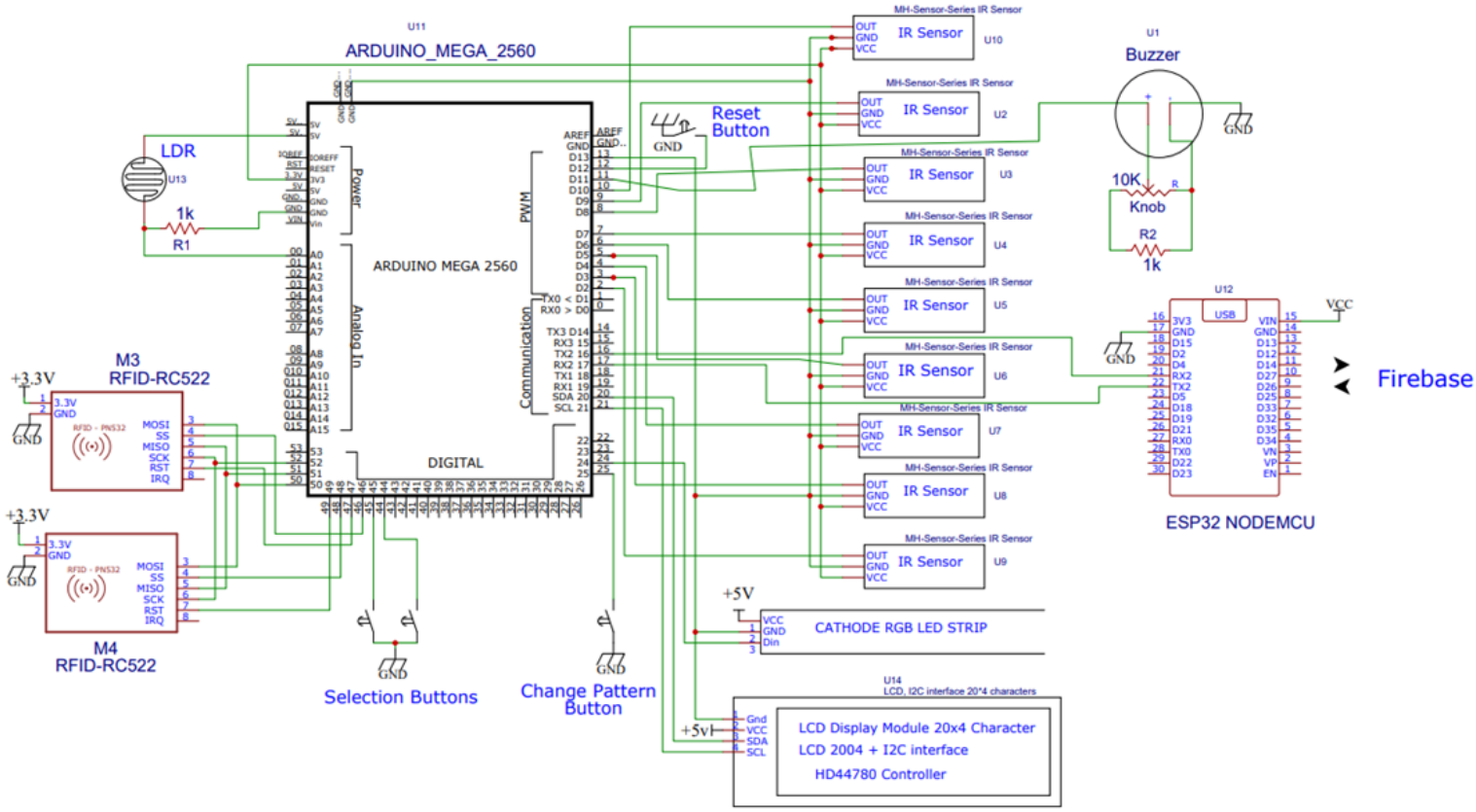


Figure 02: High-level design of the product

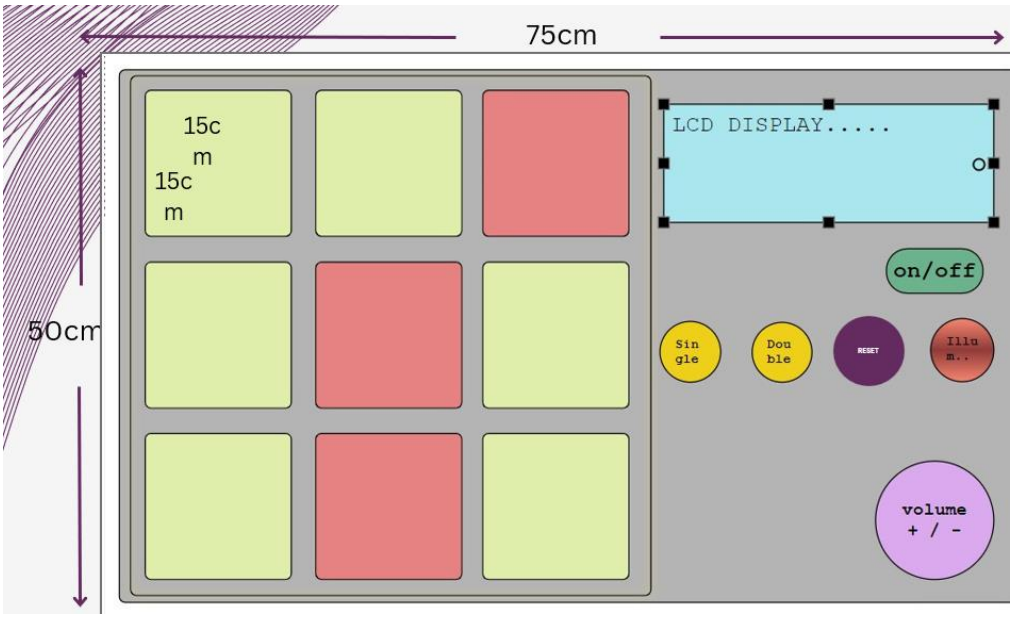


Figure 03: A graphical view of the solution (if applicable)

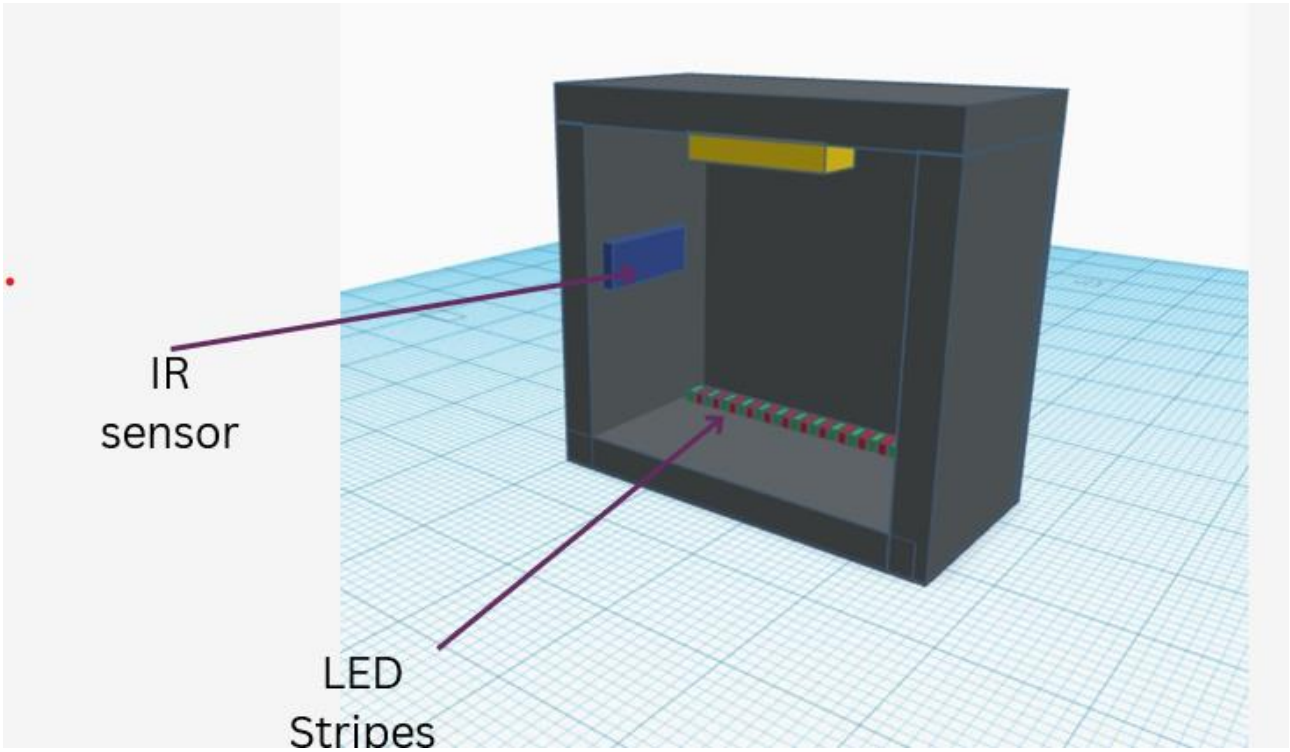


Figure 03: A 3D view of the solution(a grid)

6. Components

Arduino Mega 2560

The Arduino Mega 2560 is a versatile microcontroller board based on the ATmega2560 chip, ideal for complex projects requiring extensive I/O operations and memory.

It features:

- 54 Digital I/O Pins: For connecting multiple sensors and actuators.
- 16 Analog Input Pins : For reading analog signals.
- 256 KB Flash Memory : To store the program code.
- 8 KB SRAM : For running variables and temporary data.

In our sensor-based Tic-Tac-Toe game project, the Arduino Mega 2560 is utilized for managing various components, including IR sensors, RFID readers, LCD display, and a buzzer. Its ample I/O pins and memory capacity support the complex game logic and multiple game modes, ensuring seamless integration and operation of the game's features.

MFRC522 RFID Reader Module

The MFRC522 RFID reader module is an essential component for RFID-based applications. It operates at a frequency of 13.56 MHz and communicates via the SPI interface
. Key attributes include:

- High Performance : Efficiently reads and writes data to RFID tags.
- Easy Integration : Compact and straightforward to connect with microcontrollers.
- Flexible Use : Supports a variety of RFID tags and is suitable for diverse identification tasks.

In our Tic-Tac-Toe game, the MFRC522 is used to detect and authenticate players through RFID cards. This feature allows the game to differentiate between players and enable specific game modes based on the detected RFID card.

Infrared sensor module

The IR Sensor Module is a versatile component used for detecting the presence of objects or measuring distances. It operates using infrared light to sense changes in the reflected signal. Key features include:

- Object Detection : Efficiently detects the presence of objects by measuring the reflection of infrared light.
- Distance Measurement : Can be used to gauge the proximity of objects, making it useful for various applications.
- Simple Integration : Easy to connect and interface with microcontrollers.
- Voltage: Most IR sensor modules work with a supply voltage of 5V DC. Some modules may also operate with a voltage range of 3.3V to 5V.
- Current: The current consumption of IR sensor modules is usually quite low. Typically, it ranges from 10mA to 50mA depending on the specific module and its functions.

In our Tic-Tac-Toe game, IR sensors are employed to detect when a player's hand is placed over a specific block, thereby registering their move. This method is used in scenarios where players are seemed reliable and where there is no expectation of third-party interference. The IR sensors provide a straightforward and effective way to interact with the game board, ensuring accurate move detection in a controlled environment.

ESP32-WROOM-32

The ESP32-WROOM-32 is a powerful microcontroller module with integrated Wi-Fi and Bluetooth capabilities. It is ideal for projects requiring wireless communication and data handling. In our project, the ESP32-WROOM-32 is used to connect to Firebase Realtime Database for storing and managing high scores.
This key attributes include :

- Wireless Connectivity : Utilizes built-in Wi-Fi to connect to Firebase for real-time data updates.
- Powerful Processing : The dual-core processor enables efficient handling of complex tasks and simultaneous operations.
- Flexible Integration : Interfaces seamlessly with various components, allowing it to manage game logic and communicate with Firebase effectively.
- Dual-Core Processor : Provides robust performance with its dual-core architecture.

It is utilized to connect to the Firebase Realtime Database, manage wireless communication, and handle game logic. This setup allows us to dynamically update and store high scores in the cloud, ensuring that score data is always current and accessible from anywhere.

LDR Sensor

An LDR (Light Dependent Resistor) also known as a photoresistor, is a type of sensor that changes its resistance based on the amount of light falling on it. It is widely used in various applications to detect light levels and adjust systems accordingly.

- The LDR's resistance decreases as the light intensity increases, and vice versa. This change in resistance can be measured by connecting the LDR to an analog input pin on a microcontroller.
- Voltage: Typically operates within a voltage range of 3.3V to 5V.
- Current: The current drawn by the LDR is very low, generally in the microampere (µA) range when exposed to light. In darkness, the current is higher but still minimal.

In our project, the LDR is used to detect ambient light levels and can be used to trigger specific actions or adjustments based on light conditions. For example, it could be used to control the illumination mode of the game.
The LDR helps in adapting the game's display or behaviour according to the lighting environment, contributing to a dynamic and interactive user experience.

Buzzer

A buzzer is used to produce sound alerts or notifications in various applications.
In our project, the buzzer is integrated to provide audible feedback during gameplay.

- Feedback Mechanism : The buzzer emits short or long beeps to indicate game events, such as marking a block or winning/losing a round.
- Integration : It is controlled via a digital output pin on the Arduino Mega 2560, which triggers sound signals based on game state changes.
- Versatility : The buzzer helps enhance the user experience by giving immediate acoustic signals, making the game more interactive and engaging.
- Voltage: Typically operates at 5V DC.
- Current: Generally consumes between 20mA to 30mA when active

It helps in giving immediate audio feedback to the players, enhancing the overall interactivity and engagement of the game.

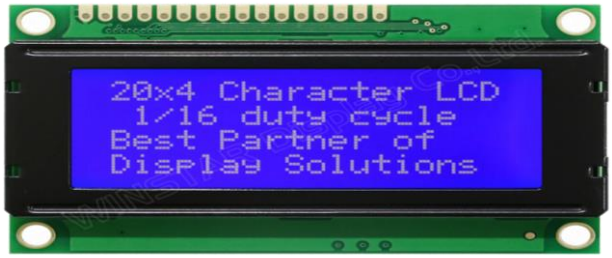
5V 5A SMPS Power Supply

5V 5A SMPS (Switched-Mode Power Supply) is a power supply unit designed to provide stable and efficient electrical power. It converts the main AC voltage into a regulated DC voltage output.

- Function: The SMPS converts the higher AC voltage from the mains into a regulated 5V DC output, suitable for powering electronic components that require a stable voltage, such as microcontrollers and sensors.
- Capacity: With a 5A current rating, this power supply can handle high current demands, making it suitable for powering multiple devices and components simultaneously.

In our project, the 5V 5A SMPS provides reliable power to the Arduino Mega, sensors, LED strips, and other components. It ensures that all parts of the system receive adequate power without voltage drops or instability.

20x4 LCD Display



The 20x4 LCD Display is a type of Liquid Crystal Display that features 20 columns and 4 rows of characters, making it suitable for displaying a variety of information in a structured format.

- Voltage: The 20x4 LCD display typically operates at 5V DC. This voltage is supplied through the VCC pin of the LCD.
- Current: The current consumption of the display is relatively low, usually ranging from 1mA to 3mA in operation. However, during backlight operation, it can draw slightly more current, up to around 40mA.
- Display Functionality: The LCD screen is used to provide real-time feedback and information to users during gameplay.

The LCD screen enhances user experience by presenting game-related information in an organized manner, ensuring that players can easily follow the game's progress and results.

Push Buttons

Push buttons are simple mechanical switches used to send signals or commands to a microcontroller or electronic circuit when pressed. They are essential components for user input and control in various electronic projects.

- Operation: When a push button is pressed, it completes an electrical circuit, sending a signal to the connected microcontroller. This action can trigger various functions or commands in the system.

In our project, push buttons are used for various functions. Each button is connected to specific pins on the Arduino Mega or ESP32 to handle different tasks.

Push buttons provide a straightforward and intuitive way for users to interact with the game system, allowing them to control gameplay settings and operations efficiently

RGB LED Strips

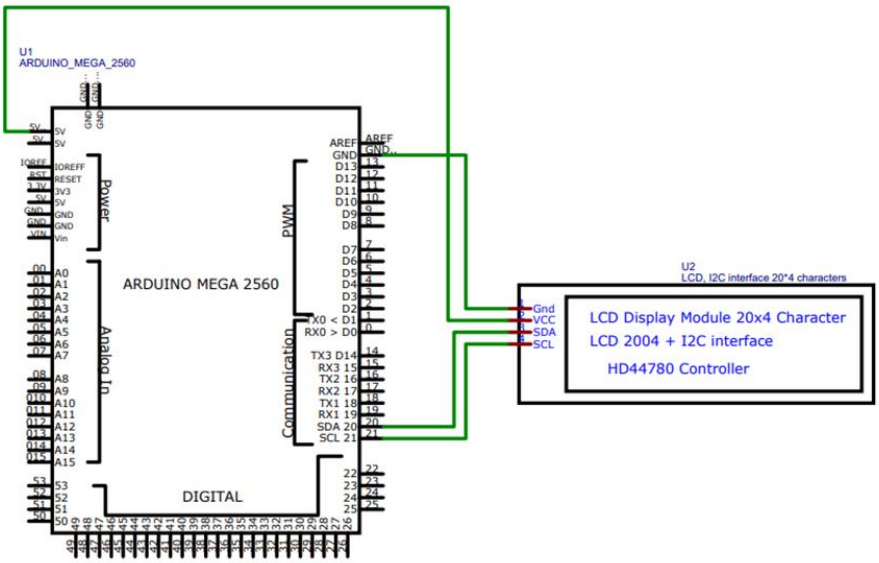
- LED Type: Typically use 5050 or 3528 SMD LEDs. 5050 LEDs are larger (5mm x 5mm) and brighter, while 3528 LEDs are smaller (3.5mm x 2.8mm) and less bright.
- Addressable LEDs : Some strips feature addressable LEDs like WS2812B where each LED can be controlled individually, offering more dynamic lighting effects.
- Color Range: Each LED has red, green, and blue chips that can mix colors to produce millions of hues.
- Voltage: Use 5V power supplies depending on the strip.
- Flexibility: The strips are flexible and can be cut between certain LEDs to fit various lengths.
- Adhesive Backing: Many strips come with an adhesive layer on the back for easy mounting.
- Waterproofing: RGB LED strips are available with a silicone coating for water resistance, rated with an IP65 or higher rating.

7. Individual Contribution

Member : 224043L Dissanayaka E.J.V.J

Responsibilities –

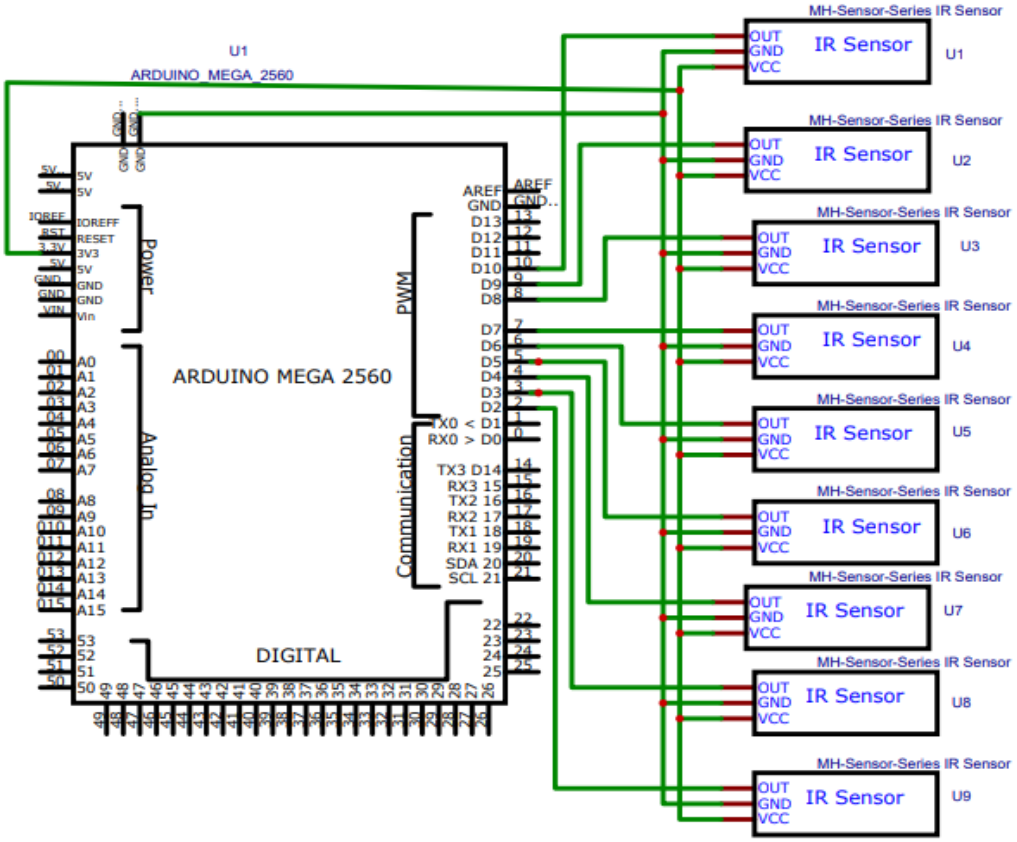
- LCD Display : 20x4 LCD display provides real-time feedback, showing current player turns,scores,mode selection,all details in game.



Display Order:

1. LED Color Selection: Display the color assigned to each player for visual differentiation.
2. Mode Selection:
    - Single/Dual: Choose between single-player or two-player modes.
    - Easy/Hard: Select the difficulty level of the game.
    - Without RFID/With RFID: Opt for the mode with or without RFID functionality.
3. Score of Each Round: Show the current score for each round played.
4. Winner Display: Announce the winner after 3 rounds of gameplay.
5. High Scores: Display the highest scores at the end of the game for record-keeping and comparison.

- Dual Without RFID : In this mode, players interact with the Tic Tac Toe grid by placing their hands over IR sensors to make moves. Hand detection triggers the corresponding grid square to light up in the player's color, confirming their move. The system ensures accurate move registration without physical contact, allowing intuitive gameplay while using distinct colors for each player to differentiate between turns.



- Score Calculation : The scoring system for the Tic Tac Toe game is based on two key factors: player round victories and the remaining time. Points are awarded to the player or AI who wins each round, while an additional bonus is applied in single-player modes based on the remaining time at the end of the game. This approach encourages both strategic gameplay and time efficiency, resulting in a cumulative score that reflects performance across multiple rounds.

Member : 224015E Asry M.I.M

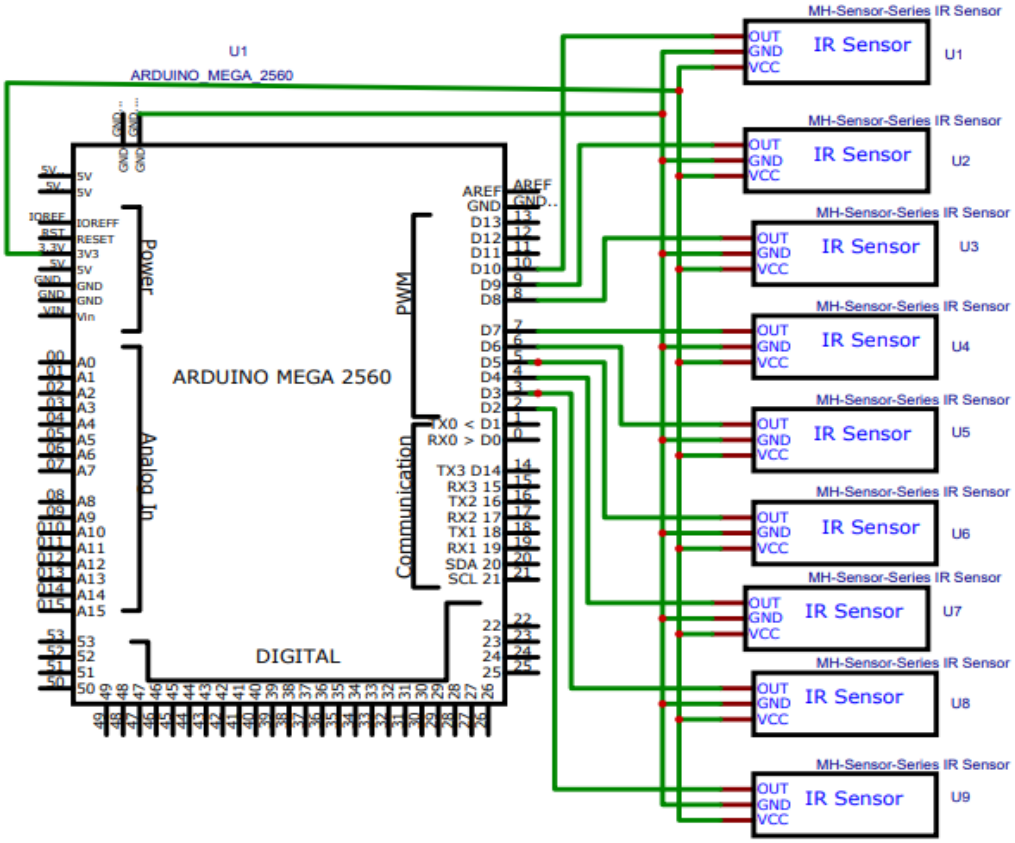
Responsibilities –

1. Single Player Mode
    - Easy mode

In this mode, the player competes against an AI opponent equipped with basic strategies. The AI is programmed with a straightforward level of intelligence, offering a suitable challenge for beginners. The game uses IR sensors to detect player moves, ensuring a seamless and interactive experience.

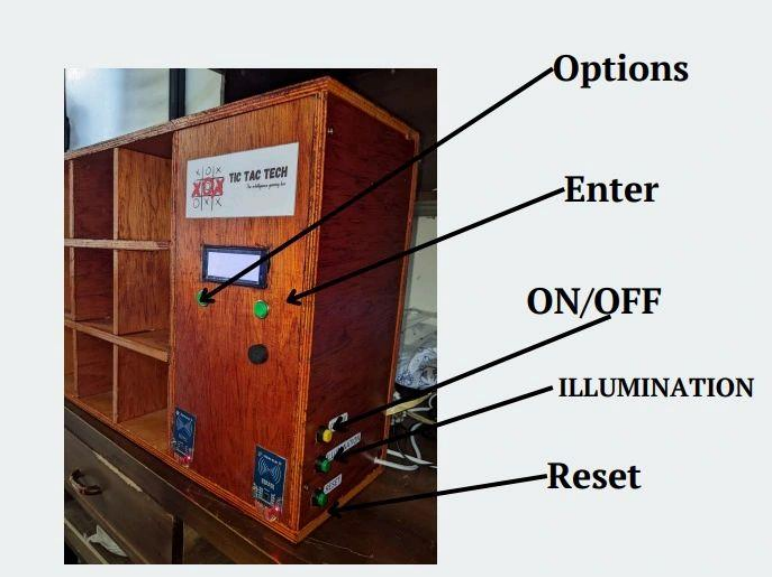
- Hard mode

  For players seeking a greater challenge, the hard mode increases the difficulty. The AI opponent utilizes more advanced strategies to block the player's moves and create opportunities for itself. This mode also relies on IR sensors to accurately detect and process player inputs, enhancing the gameplay experience.



2. Buttons

- On/Off Button :- Powers the system on and off.
- Reset Button :- Resets the game.
- Select Buttons (2) :- Navigate game modes and selections.
- Change Pattern Button :- Changes LED patterns in illumination mode.



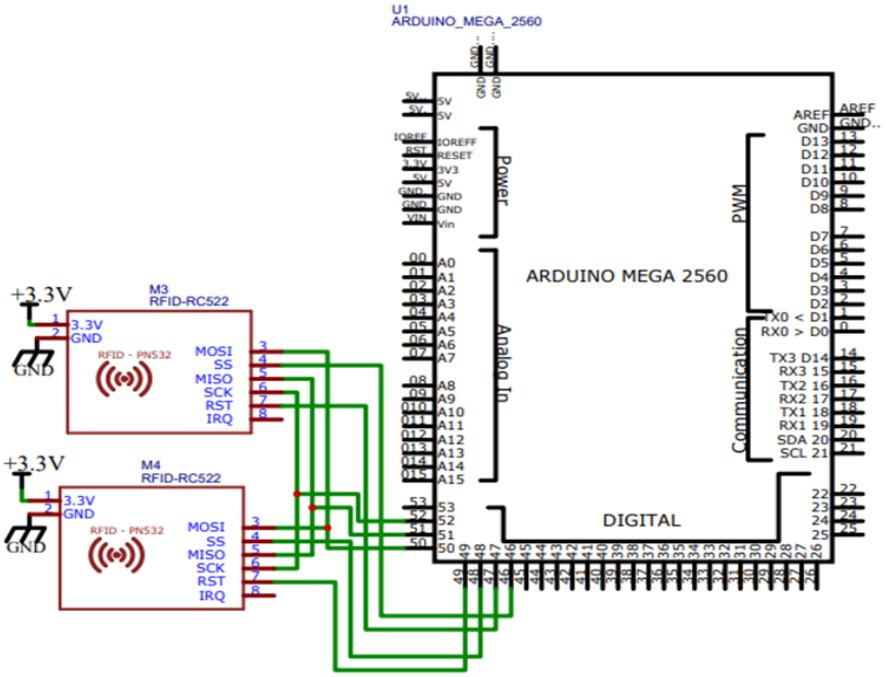
Member : 224018P Bamunusingha C.L.N

Responsibilities –

1. RFID mode

- The system is designed with RFID sensors to authenticate and identify the two designated players. This ensures that only authorized participants can engage in the game, effectively preventing unauthorized third-party access and ensuring a secure and controlled gaming environment.

- Maintain fairness and structure in the game, the system enforces a turn-based mechanism. This functionality ensures that each player can only make a move during their designated turn, thereby preventing any overlap or interference from the other player and ensuring smooth and orderly gameplay.



2. Power Management and Distribution

- A 5V 5A SMPS (Switched-Mode Power Supply) was employed to deliver stable and efficient power to the entire system. This choice ensures consistent performance and reliability, providing sufficient current to support all components and maintaining smooth operation throughout the game.

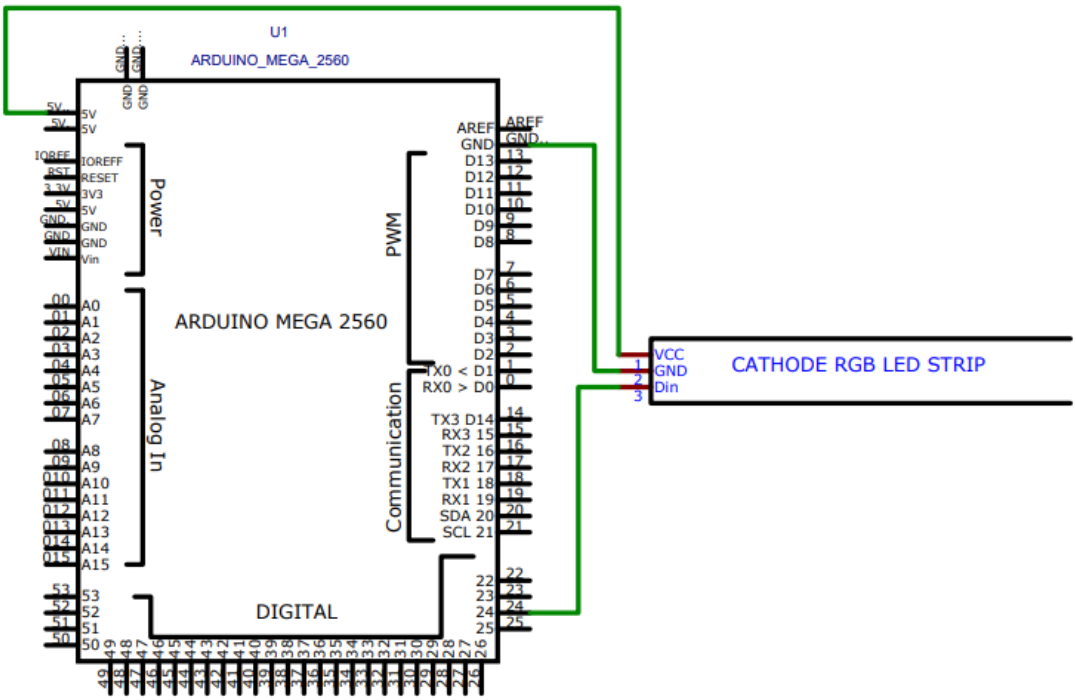
Member : 224124L Mendis B.I.P.D

Responsibilities –

1. Illumination mode

- Designed an illumination mode to enhance the aesthetic appeal of the Tic-Tac-Toe box during non-gaming periods. This mode transforms the game box into a visually captivating light display, adding to the overall ambiance and attractiveness of the setup.

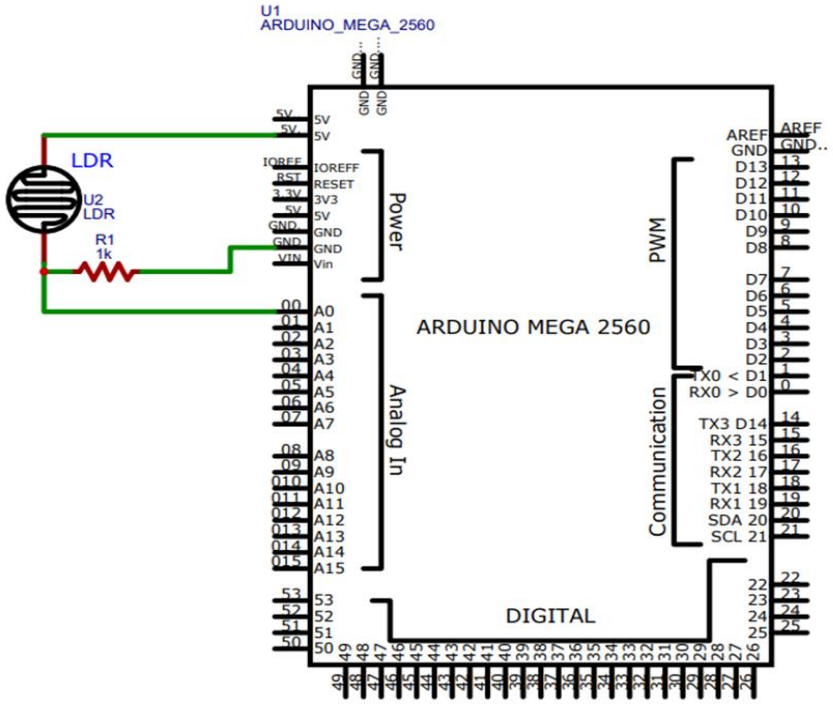
- Programmed multiple illumination patterns using a Neopixel LED strip. These patterns can be dynamically changed, allowing for a variety of visual effects. This feature not only improves the aesthetic experience but also offers customization options to suit different environments or preferences.



2. LDR Sensor

- Integrated the Light Dependent Resistor (LDR) sensor into the system to detect ambient light levels. This enables the system to adapt its functionality based on the surrounding lighting conditions, enhancing its responsiveness and usability in various environments.

- Programmed the LDR sensor to automatically adjust the brightness of the LEDs based on the surrounding light conditions. This feature ensures optimal visibility of the game board and enhances the overall user experience by maintaining appropriate LED brightness regardless of ambient light variations.



Member : 224064C Gunawardhana G.W.G.M

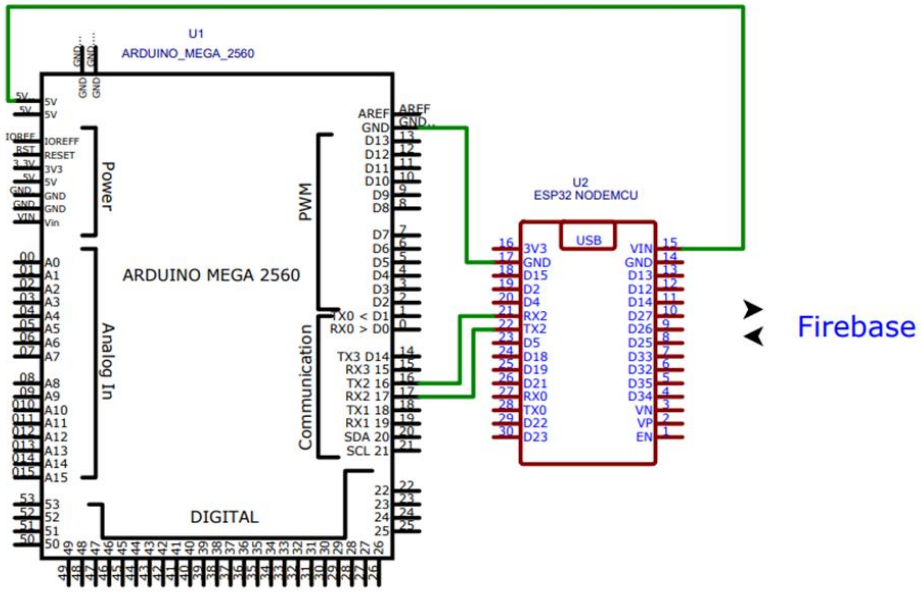
Responsibilities –

1. ESP32 + Firebase Connectivity :

- Established communication between the ESP32 WROOM 32 and Arduino Mega 2560 to facilitate data transfer. This connection was crucial for sending scores from the game system to the ESP32 for further processing and storage.
- Configured serial communication between the two devices using UART, ensuring reliable data transmission.

  It implemented Firebase Realtime Database connectivity using the ESP32. This involved setting up the Wi-Fi connection, authenticating with Firebase, and configuring the database reference.

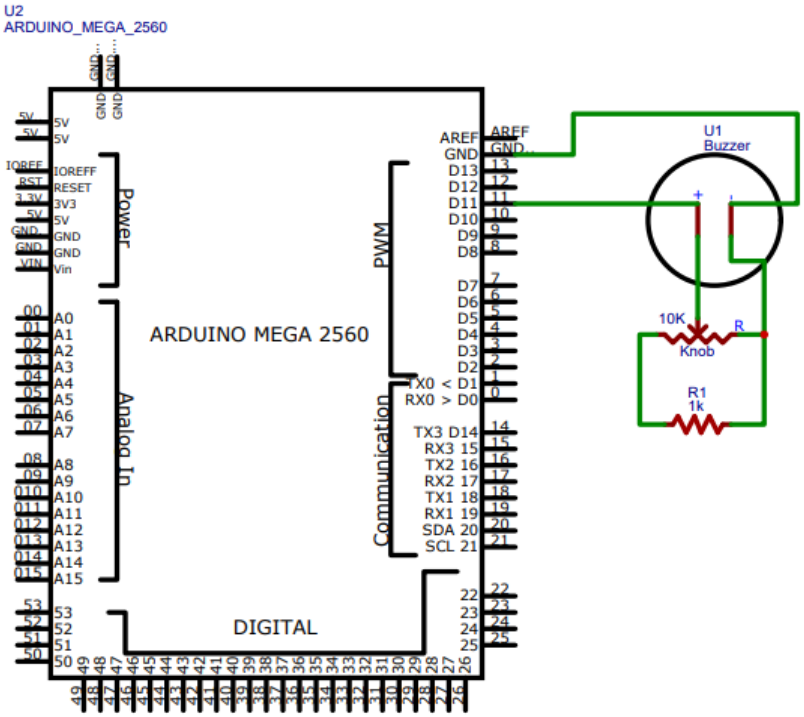
- Developed functionality to store the highest scores for each game mode (Easy, Hard, RFID, Non-RFID) in Firebase. The system checks and updates only when a new high score is achieved, optimizing database usage.



2. Buzzer Handling

- Integrated an active buzzer into the system, connected to the Arduino Mega 2560. The buzzer is used to provide audio feedback for various game events, such as start, end, and errors.

- Sound control : Managed the buzzer's activation and deactivation based on game states, ensuring it contributes to the user experience without being intrusive.The buzzer's sound is adjusted using a variable resistor, allowing the pitch and volume of the sound to be customized according to user preference and game requirements.



8. Budget

Table 01: Components with budget allocation

Component	Unit Price (LKR)	Unit	Total Price
Inductive Proximity sensors	150.00	09	1350.00
RFID readers (9) and Cards (2)	250.00	)2	500.00
Ldr sensor	130.00		130.00
5V adapter	1110.00		1110.00
ESP32	1350.00		1350.00
RGB led strip	1860.00		1860.00
Buzzer +volume control	90.00		90.00
Wooden box	5130.00		5130.00
Arduino Mega	5600.00		5600.00
I2C Module(lcd screen)	1230.00		1230.00
Solid wire (2m)	70.00	2	140.00
Buttons	500.00		500.00
Wire and nuts	24000		2400.00
others	4000.00		4000.00
Total			25930.00

8. Workload Matrix

Table 02: Workload Matrix

Registration Number	Assigned Responsibilities
224043L	Multiplayer Mode ,display,score calculations
224015E	Single Player Mode,buttons
224124L	Illumination mode and LDR sensor
224064C	Web base data base(ESP) + Buzzer,arduino mega and esp 32 connection
224018P	RFID readers,power supply,colour change

9. References

https://www.youtube.com/watch?v=UJNcmlLFBl4 -YouTube Video.

Internet of Things (IoT). What is IoT? | by Sciforce | Sciforce | Medium - IOT projects