SAGE

Specialised assisted Gaming Experience

A Smart Electronic Chessboard

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1. Introduction

The game of chess has been a favourite pastime of people for centuries, and it continues to intrigue and challenge people today. With the advent of technology, the game has undergone a significant transformation, and electronic chess boards are gaining popularity among enthusiasts. These boards come with several advanced features and help players learn the game and improve their skills.

Our project aims to design and develop an electronic chess board that uses RFID technology, Arduino microcontrollers, Wi-Fi/Bluetooth connectivity, multiplexers, and LED lights. This board is designed to be cost-effective, easy to use, and portable, making it an excellent choice for chess enthusiasts and learners alike. In this project, we will be using epoxy resin to make the chess pieces, which will be fitted with RFID chips to communicate with the board.

1.1 Background Information and Motivation:

Electronic chess boards have been around for some time now, and they are becoming more advanced with each passing day. These boards offer several advantages over traditional boards, such as the ability to record games, analyze moves, and connect with other players worldwide. However, most electronic chess boards in the market are expensive and not very portable, making them less accessible to people.

Our project aims to address these issues by designing an electronic chess board that is affordable, portable, and easy to use. We believe that by using external computational design paired with RFID technology, we can achieve this goal and offer chess enthusiasts a high-quality board that is both functional and cost-effective.

1.2 Objectives and Scope of the Project:

The objectives of this project are to create a cost-effective, portable, and premium-feeling electronic chess board that can eliminate the need for a human chess tutor.
The cost-effectiveness of the chessboard is important because it will make it more accessible to a wider range of people. Chess is a great game that can be enjoyed by people of all ages, but the cost of electronic chess sets can be prohibitive for some. SAGE will be much more affordable, making it possible for more people to learn and enjoy the game. The portability of the chess board is also important because it will allow

people to play chess anywhere, at any time. Electronic chess sets available in the market are bulky and difficult to transport, making it difficult to find time to play. SAGE will be much more portable, making it possible for people to play chess on the go. The premium feel of the chess board is also critical because it will make it a more enjoyable experience for players. A variety of chess sets can be made from cheap materials that feel flimsy and cheap. SAGE will be made from high-quality materials that will feel sturdy and luxurious. And at last, the ability to eliminate the need for a human chess tutor is the most important objective of this project. Chess tutors can be expensive and difficult to find. SAGE will provide players with all the information they need to learn and improve their chess skills, without the need for a tutor.

1.3 Overview of the Project Design:

Our electronic chessboard will consist of an 8x8 chessboard with RFID sensors placed under each square. These sensors will be connected to multiplexers, to connect them to RFID reader hubs which will then be connected to Arduino microcontrollers. The Arduino microcontrollers will gather the information from the sensors and send it to a mobile device or computer via Wi-Fi or Bluetooth connectivity for computation.

The chess pieces will be made from epoxy resin, and each piece will have an RFID chip embedded in it. When a piece is placed on the board, the sensor under the square will detect the RFID chip and send the information to the microcontroller. The microcontroller will then send this information to the mobile device or computer, which will analyze the move and provide feedback to the player.

LED lights will also be placed under each square, and they will light up to indicate legal moves and the type of move played, such as a blunder or a brilliant move. The board will also have a small monochromatic screen to display useful information such as what would be a good move to play, making it an excellent learning tool for new players.

1.4 Organization of the Project Report:

This project report is divided into several sections, starting with the introduction, which provides an overview of the project, its objectives, and scope. The following section provides a literature review of existing electronic chess boards and their features, advantages, and limitations.

The methodology section explains in detail the hardware and software design of the electronic chess board, including the use of RFID sensors, Arduino microcontrollers, Wi-Fi/Bluetooth connectivity,

2. Literature Review

2.1 Overview of electronic chess game boards and their features:

Electronic chess boards have been gaining popularity among chess enthusiasts due to their ability to record moves, analyze games, and play against opponents online. In this project, we present a unique electronic chess board that uses advanced technologies such as RFID sensors, multiplexers, and custom-made antennas to enhance the game experience. Our chessboard not only provides the traditional functionalities of electronic chessboards but also offers new features such as automatic piece recognition, quick response time, and improved connectivity. In this literature review, we explore the technologies used in our design and compare them with existing electronic chess boards in the market.

2.2 RFID technology and its use in gaming:

Radio Frequency Identification (RFID) is a wireless technology that automatically identifies and tracks objects. While not all electronic chess boards use RFID technology, they can provide more accurate and reliable movement tracking than other methods. The RFID tags on the chess pieces are read by an RFID reader when a piece is moved, allowing for precise movement detection.

2.3 Arduino and its use in embedded systems:

Arduino is an open-source platform used for building electronics projects, including electronic chess boards. Arduino boards are equipped with microcontrollers that can be programmed using a simple software interface, making it easy to design and develop electronic devices even for those with limited technical knowledge.

2.4 Wi-Fi/Bluetooth technology and its use in connectivity:

While some electronic chess boards use WiFi or Bluetooth to connect to external devices, most do not use external computational power. However, in some designs, WiFi/Bluetooth is used to connect the board to a mobile phone or computer device to transfer movement information and receive feedback on the quality of moves made.

2.5 Multiplexers and their Role in electronic games:

Multiplexers are electronic devices used to select one of several analog or digital input signals and forward the selected input to a single output line. While not unique to electronic chess boards, they are very common in modern electronic equipment commonly used to as they reduce the cost and complexity of the gadget. Many electronic chess boards naturally use these in their manufacturing.

2.6 Antennas and their use in wireless communication:

Antennas are devices used for wireless communication, and they are commonly used in electronic chess boards to provide communication between the RFID reader and the RFID tags on the chess pieces. In the proposed project, antennas are used to reduce the number of sensors required and to reduce the read range of sensors for effective reading of pieces. Shielding the antennas with aluminium foil ensures that the sensors only read a piece when it is placed directly above it, making the sensor more efficient.

2.7 Resin and its properties for chess pieces:

Resin is a synthetic material that has gained popularity in recent years for its versatility and durability. It is commonly used in the manufacture of chess pieces for its premium feel. Epoxy resin-made chess pieces give an elegant and high-end look and feel to the electronic chess board.

2.8 Chess API and its use in analyzing gameplay:

A Chess Application Programming Interface (API) is a software interface used to access and analyse chess games. APIs are used in electronic chess boards to collect information about legal moves and provide useful insights for users on how to improve their gameplay. Many APIs can be used such as Chess.com API, Lichess API, and Chessable API etc. In this project we will use the Chessable API, Chessable is an online platform for learning chess. They offer an API that allows developers to access course content, user information, and game data. The Chessable API is available for free but requires an API key for authentication.

2.9 Comparison of existing electronic chess game boards with the proposed project:

Existing electronic chess boards on the market offer many of the same features as the proposed project. However, the proposed project utilizes RFID technology, which ensures accurate and reliable movement tracking. It also uses a low-cost and easily programmable Arduino board for efficient and effective use of RFID sensors and controlling the LED lights and monochromatic screen. The proposed project provides a unique and engaging experience for users, especially beginners, by providing helpful feedback and insights on their gameplay.

3 Design and Implementation

Design and implementation are two critical aspects of any project, especially when it comes to building complex systems that require hardware and software integration. In this article, we will discuss the design and implementation of a system, covering system architecture, component selection, hardware design, software design, testing, and debugging methods

3.1 System Architecture and Block Diagram

The first step in designing a system is to create a system architecture that describes the overall structure and function of the system. A system architecture includes the various components of the system and the way they interact with each other. A block diagram is a graphical representation of the system architecture that shows the flow of data and control signals between different components.

In our project, the system architecture includes a microcontroller unit (MCU) that controls the entire system. The MCU is connected to a number of RFID sensors that detect RFID signals off the 7mm chips embedded in the chess pieces via the antennas they are connected to, these antennas are placed below every square to read the piece on that square. The sensors can Communicate with the MCU through SPI protocol, hence eliminating the need for an external ADC to connect the sensors and MCU.

The MCU is also connected to a wireless module that allows the system to communicate with other devices over a wireless network. The wireless module uses a protocol such as Wi-Fi or Bluetooth to communicate with other devices. Finally, the system includes an LCD display that shows the piece placement on the board and other relevant information for the user such as the next best move, legal/illegal moves etc.

3.2 Component Selection and Justification

Choosing the right components for a project is critical to its success. The components must meet the project's requirements and be reliable and cost-effective. In our project, we chose the following components:

- Microcontroller Unit (MCU): We chose an STM32 MCU because it has a powerful 32-bit ARM Cortex-M processor, plenty of I/O pins, and a rich set of peripheral interfaces.

- RFID tags: we choose Syrma 7mm RFID tags because of the micro-distance read range required for this project, moreover they are compact, cost-efficient and can handle extreme temperatures which they'll have to bear in the epoxy resin manufacturing process.
- Sensors: We chose RC522 RFID Card Reader Module because of its small size, low cost and its perfect read range for this project
- Wireless Module: We chose a Wi-Fi module from ESP8266 because it is low-cost, easy to use, and widely available.
- LCD Display: We chose a 3.5 in TFT LCD because it is simple to use, easy to read, and interactive for the user.

3.3 Hardware design and schematic diagrams:

The hardware design of the electronic chess board involves various components working together to create a functional and interactive chess playing experience.

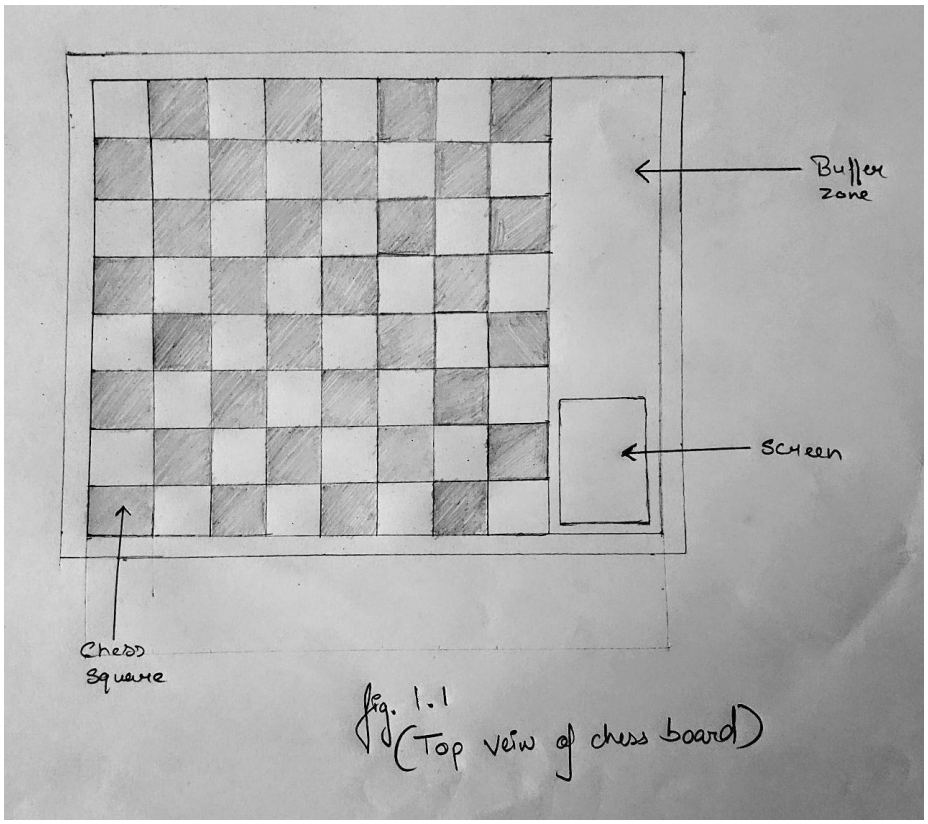

fig. 1.1 (Top view of chess board)

The core component is the chess board itself, which follows the conventional 8x8 design. Each square of the board is equipped with an RFID sensor that can detect the presence and position of chess pieces. These RFID sensors are connected to antennas placed below each square. To ensure accurate readings, the antennas are shielded with aluminum foil, limiting their range to the specific square they are placed beneath. This setup ensures that the sensors only read the RFID chips when the chess pieces are directly placed on the corresponding squares.

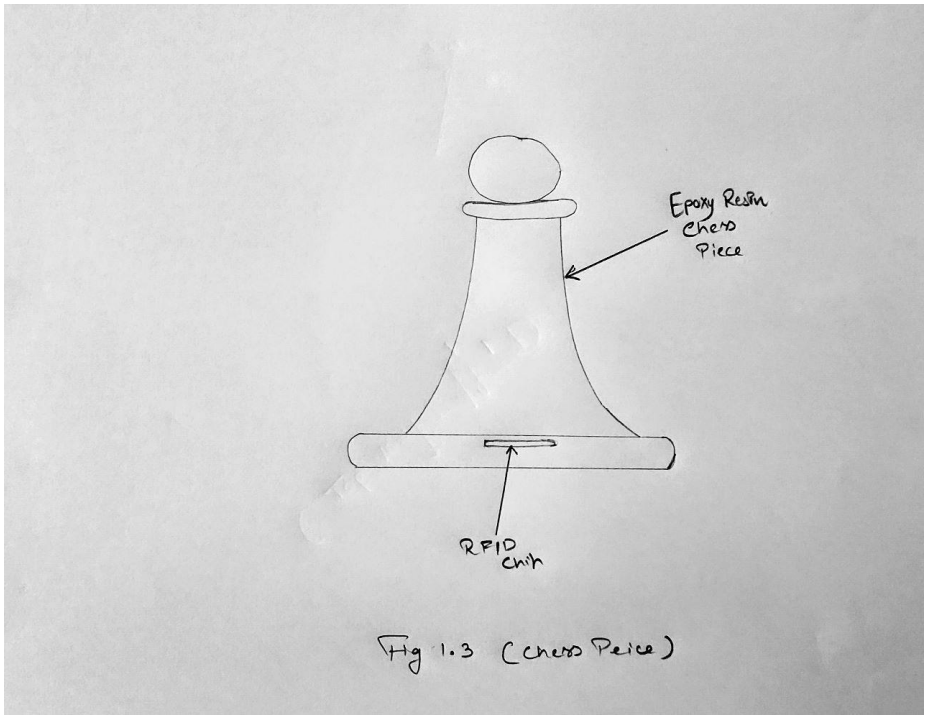

Fig 1.3 (Chess Peice)

The chess pieces used in the game are made from epoxy resin and embedded with 7mm RFID chips. These chips contain unique identification information, allowing the RFID sensors to accurately detect and identify the individual chess pieces.

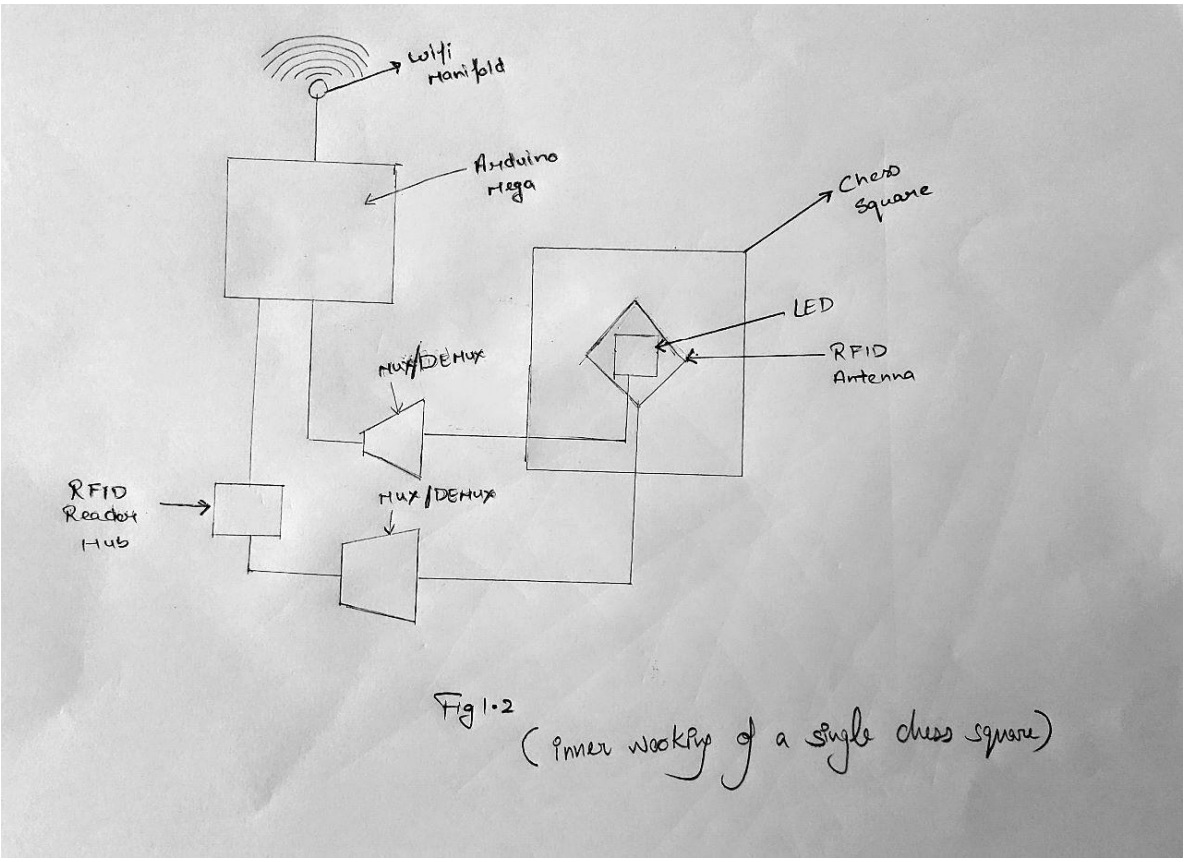

Fig 1.2 (inner working of a single chess square)

The RFID sensors are connected to an Arduino board, which serves as the central processing unit of the chessboard. The Arduino board receives the data from the RFID sensors, interpreting the movements and changes on the chess board. It processes this information and communicates it to a connected smart device, such as a mobile phone or computer, through a Wi-Fi module. This enables real-time transfer of the chess piece movements and game data to the user's device.

To provide visual feedback and guidance during gameplay, the chess board incorporates LED lights. These lights are placed beneath each square and are connected to the Arduino board using a multiplexer. The Arduino board controls the illumination of the LEDs based on the game data received from the RFID sensors. The LEDs indicate legal moves, highlight the current position, and provide other relevant visual cues to assist the user in gameplay.

Additionally, the chessboard includes a small monochromatic screen. This screen displays valuable information such as recommended moves, game status, or learning tips. The information displayed on the screen can be controlled by the Arduino board and updated based on the game state or user preferences.

3.4 Software Design and Flowcharts:

3.4.1. Mobile or Computer Application:

a. User Interface:

Approach: Design an intuitive and user-friendly interface using modern UI/UX principles.

Methods: Utilize frameworks like React Native or Flutter for cross-platform development, or choose platform-specific technologies like Swift (iOS) or Kotlin (Android).

b. Connection Management:

Approach: Implement a reliable and secure communication protocol between the chessboard and the mobile/computer device.

Methods: Utilize Wi-Fi Direct or Bluetooth Low Energy (BLE) for device pairing and data transfer.

c. Data Processing:

Approach: Process the received chess piece movement information to determine the current game state and update the chessboard display accordingly.

Methods: Utilize algorithms and data structures to track piece positions, validate moves, and calculate game conditions (e.g., checkmate).

d. Game Analysis API Integration:

Approach: Integrate with a chess engine or utilise an existing chess API to provide game analysis and move suggestions.

Methods: Utilize popular chess engines like Stockfish or integrate with chess-related APIs such as Lichess or Chess.com.

e. LED Control:

Approach: Control the LEDs on the chessboard to provide visual feedback for different move types.

Methods: Use GPIO (General Purpose Input/Output) pins on the Arduino board to control the LEDs and trigger specific lighting patterns.

3.4.2. Arduino Board:

a. RFID Sensor Integration:

Approach: Interface RFID sensors with the Arduino board to read chess piece movements accurately.

Methods: Utilize libraries like MFRC522 or PN532 to communicate with the RFID sensors and retrieve unique identification numbers associated with each chess piece.

b. Data Transmission:

Approach: Establish a reliable and low-latency communication link between the Arduino board and the mobile/computer device.

Methods: Implement a serial communication protocol (e.g., UART) or use wireless modules like HC-05 (Bluetooth) or ESP8266 (Wi-Fi) to transmit data.

c. Multiplexing:

Approach: Enable the Arduino board to read individual RFID sensors on each square of the chessboard efficiently.

Methods: Utilize multiplexing techniques such as time-division multiplexing (TDM) or multiplexing ICs (e.g., 74HC4051) to scan and read multiple RFID sensors.

d. Bluetooth/Wi-Fi Integration:

Approach: Connect the Arduino board to the mobile/computer device using Bluetooth or Wi-Fi for seamless data transmission.

Methods: Utilize Bluetooth modules (e.g., HC-05, HC-06) or Wi-Fi modules (e.g., ESP8266, ESP32) to establish the communication link.

3.4.3. Chess Engine or API:

a. Game Logic:

Approach: Implement the rules and logic of chess to determine legal moves, checkmate conditions, and piece interactions.

Methods: Utilize an object-oriented approach to model chess pieces and their behaviours, implement algorithms to validate moves, and handle special moves (e.g., castling, en passant).

b. Move Analysis:

Approach: Analyze user moves and provide feedback on move quality and game analysis.

Methods: Utilize chess engine algorithms, such as evaluation functions or minimax with alpha-beta pruning, to assess move quality and suggest optimal or brilliant moves.

c. Move Validation:

Approach: Validate the received chess piece movements from the RFID sensors against the game logic to ensure accuracy.

Methods: Implement methods to check the legality of moves, validate piece positions, and detect illegal or invalid moves based on the current game state.

3.4.4. LED Control:

a. LED Control Mechanism:

Approach: Develop code to control the LEDs placed under each square of the chessboard based on move types.

Methods: Utilize Arduino libraries or custom code to control the GPIO pins connected to the LEDs and trigger specific lighting patterns for different move types.

b. Data Interpretation:

Approach: Interpret the data received from the mobile/computer device to determine the move type and corresponding LED lighting pattern.

Methods: Define a mapping between move types (e.g., legal move, best move, brilliant move) and specific LED lighting patterns, and update the LEDs accordingly based on the received data.

3.4.5. Monochromatic Screen (Optional):

a. Display Output:

Approach: Display useful information on the monochromatic screen to provide game analysis or educational content.

Methods: Utilize libraries or frameworks compatible with the chosen screen technology (e.g., OLED, e-paper) to render text-based information and graphics.

3.4.6. Database Management (Optional):

a. Storage:

Approach: Set up a database to store game data, move history, and user progress for analysis and tracking.

Methods: Utilize database management systems like MySQL, PostgreSQL, or NoSQL databases like MongoDB to store and retrieve relevant data efficiently.

b. User Profiles:

Approach: Implement functionality for creating and managing user profiles, tracking performance, and providing personalized recommendations.

Methods: Utilize database tables or document collections to store user-related information and implement user authentication and authorization mechanisms.

3.5 Testing and Debugging Methods:

3.5.1. Unit Testing:

Description: Test individual components, functions, and modules in isolation to ensure their correctness.

Method: Use frameworks like JUnit or PyTest to automate unit testing. Verify RFID sensor functionality, LED control, data processing algorithms, and communication protocols.

3.5.2. Integration Testing:

Description: Test the integration of software components and hardware modules.

Method: Verify the interaction between the mobile/computer application, Arduino board, RFID sensors, and LED control. Check data transmission and reception accuracy and reliability.

3.5.3. User Interface Testing:

Description: Test the user interface of the mobile or computer application.

Method: Ensure a smooth and intuitive user experience. Verify correct chess piece selection, movement, and display updates. Test game analysis, move suggestions, and educational content.

3.5.4. Communication Testing:

Description: Test the reliability and stability of communication between the application and the chessboard.

Method: Verify data transmission and reception accuracy. Check responsiveness and latency of the communication link.

3.5.5. Move Validation Testing:

Description: Test move validation algorithms against different scenarios and game states.

Method: Verify the identification of legal moves and rejection of invalid moves. Test special moves like castling, en passant, and pawn promotion.

3.5.6. Game Analysis Testing:

Description: Test integration with the chess engine or API for game analysis and move suggestions.

Method: Verify the accuracy of move evaluations and feedback. Test different game scenarios for proper analysis and suggestions.

3.5.7. LED Control Testing:

Description: Test the LED control functionality and lighting patterns.

Method: Verify accurate representation of move types using LEDs. Check synchronization between the application and LEDs on the chessboard.

3.5.8. Error Handling and Exception Testing:

Description: Test error handling mechanisms to ensure graceful handling of unexpected situations.

Method: Validate error messages and responses in different error scenarios. Check for proper exception handling and logging.

3.5.9. Performance Testing:

Description: Test system performance and responsiveness under various loads and conditions.

Method: Measure and optimize response time for move validation, game analysis, and LED updates. Verify system stability and resource usage.

3.5.10. Debugging Methods:

Description: Employ techniques for identifying and resolving issues.

Method: Use logging statements, debug outputs, breakpoints, and variable inspection. Conduct systematic debugging and analyze log files, error messages, and exceptions.

4. Conclusion and Future Work

4.1 Summary of the project and its achievements:

The project aimed to develop an electronic chessboard that could read and track movements on the board using RFID sensors. The chessboard was connected to a smart device via Wi-Fi, allowing the user to receive real-time movement information and guidance on legal moves. LED lights placed under each square provided visual feedback, indicating move types such as legal moves, best moves, and brilliant moves.

The project achieved the following key accomplishments:

1. Cost-effective Design: The project utilized cost-effective materials and techniques, making the electronic chessboard more affordable compared to other similar products on the market. The use of epoxy resin for chess pieces and RFID sensors for movement tracking contributed to cost reduction.

2. Low Power Consumption and Portability: The design incorporated external competition and shielding techniques, resulting in low power consumption. This made the chessboard more energy-efficient and portable, ensuring convenience for users.

3. Educational Support: The chessboard provided educational support to users, eliminating the need for a chess tutor. The system offered information about legal moves, move types, and game analysis. The inclusion of a small monochromatic screen further enhanced the learning experience by displaying helpful information and suggesting good moves.

4. User-friendly Interface: The integration with a mobile or computer application offered a user-friendly interface. Users could easily interact with the chessboard through the application, select pieces, make moves, and receive real-time feedback on the LED lights. The interface facilitated an intuitive and engaging gameplay experience.

5. Testing and Debugging: The project incorporated comprehensive testing and debugging methods to ensure the functionality and reliability of the system. Unit testing, integration testing, user interface testing, and move validation testing were performed to

verify the accuracy of the chessboard's features. Additionally, debugging methods were employed to identify and resolve any issues encountered during development.

The project's achievements demonstrate its effectiveness in providing an affordable, educational, and user-friendly chessboard. The combination of RFID technology, LED lights, and a smart device interface creates a unique and engaging chess-playing experience. The project's testing and debugging efforts ensure the system's reliability and help deliver a high-quality product to chess enthusiasts.

4.2 Conclusions drawn from the project:

The project successfully developed an electronic chessboard with RFID sensors for movement tracking, LED lights for visual feedback, and integration with a smart device for real-time guidance and educational support. The project's achievements highlight its cost-effectiveness, low power consumption, portability, user-friendly interface, and comprehensive testing and debugging methods.

By utilizing cost-effective materials and techniques, the project addressed the affordability concerns associated with electronic chessboards currently available in the market. The use of epoxy resin for chess pieces and RFID sensors contributed to cost reduction without compromising functionality.

The incorporation of external competition design and shielding techniques ensured low power consumption, making the chessboard energy-efficient and suitable for portable use. This feature enhances convenience for users who can enjoy extended gameplay without frequent battery replacements.

The educational support provided by the chessboard offers a valuable resource for beginners learning the game of chess. The system's ability to provide information on legal moves, move types, and game analysis promotes skill development and strategic thinking. The inclusion of a small monochromatic screen further enriches the learning experience by displaying useful information and suggesting optimal moves.

Through thorough testing and debugging methods, the project ensured the reliability and functionality of the system. Unit testing, integration testing, user interface testing, move validation testing, and comprehensive debugging techniques were employed to

identify and resolve any issues. This rigorous approach helped deliver a high-quality product to chess enthusiasts, ensuring an enjoyable and error-free experience.

In conclusion, the developed electronic chessboard with RFID sensors, LED lights, and educational support demonstrates its effectiveness in providing an affordable, user-friendly, and educational chess-playing experience. The project's achievements in terms of cost-effectiveness, low power consumption, educational support, user interface, and testing efforts contribute to its success and viability in the market. The project serves as a testament to the possibilities of combining technology with traditional games to enhance user engagement and learning.

4.3 Future Scope and Further Improvements:

4.3.1. Enhanced Game Analysis: The project can be further improved by integrating advanced chess engines or machine learning algorithms for more accurate and sophisticated game analysis. This would provide users with deeper insights into their gameplay, offer personalized suggestions, and facilitate skill improvement.

4.3.2. Multiplayer Functionality: Adding multiplayer functionality would enable users to play against opponents remotely, either through online matchmaking or with friends connected to the same network. This would enhance the competitive aspect of the game and increase its appeal to a wider audience.

4.3.3. Mobile Application Enhancements: The mobile application can be expanded to include additional features such as tutorials, puzzles, and interactive lessons. This would provide a comprehensive learning platform for chess enthusiasts at various skill levels.

4.3.4. Cloud Integration: Integrating the system with cloud services would allow users to store and access their game history, progress, and analysis across multiple devices. Cloud integration would enhance user convenience, data backup, and synchronization.

4.3.5. Voice Commands and AI Assistance: Implementing voice recognition capabilities would enable users to control the chessboard and make moves using voice commands. Additionally, integrating AI assistants like chatbots or voice assistants could provide real-time guidance, answer queries, and offer interactive learning experiences.

4.3.6. Expanded Platform Support: Expanding the project's compatibility to include other platforms and devices, such as tablets or smart TVs, would broaden its

accessibility and reach. This would allow users to enjoy the chess-playing experience on their preferred devices.

4.3.7. Improved Hardware Design: The hardware design can be refined to enhance durability, aesthetics, and user comfort. For instance, incorporating high-quality materials for the chessboard, optimizing the LED lighting system, and improving the overall ergonomics of the design.

4.3.8. Community and Online Features: Creating an online community platform or integrating with existing chess communities would enable users to connect, share their gameplay, participate in tournaments, and engage in friendly competition. This would foster a sense of community and enhance the overall user experience.

4.3.9. Localization and Language Support: Adding support for multiple languages and localization would make the project more accessible to users worldwide. This would enable players from different regions to fully understand the instructions, game analysis, and educational content.

4.3.10. Continuous Software Updates and Bug Fixes: Regular software updates should be provided to address any bugs, improve performance, and introduce new features based on user feedback and evolving technology.

By incorporating these future enhancements and improvements, the project can further solidify its position as an innovative, educational, and engaging chess-playing system, attracting a wider audience and providing an enriching experience for chess enthusiasts.