# Pathfinder Chessboard

***"Light the Path"***

**University of Central Florida**


## Group 35 Authors:

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# 1. Project Background

Chess is widely considered the most popular board game of all time. Originating around 600CE, it has long been regarded as a symbol of strategy and intelligence. Whether introduced through family and friends, pop culture or online media almost everyone in the world has at least heard about chess. Yet despite its popularity, learning how to play can be intimidating. Beginners often feel overwhelmed when learning rules, openings, and strategies and as a result often quit. Fortunately with the growth of digital platforms and artificial intelligence the opportunities to learn and experience chess have never been as accessible, interactive, or engaging than ever before.

However, many digital platforms sacrifice the immersive experience of playing on a physical board. Many players still value the traditional feel of moving pieces by hand but want the added benefits of digital assistance and connectivity.

The Pathfinder Chessboard bridges this gap by combining the physical experience of a traditional chess game with the functionality of an online platform. Our design consists of LED indicators embedded within the chessboard to guide players through valid moves and capture opportunities, making the game more accessible to beginners while still engaging for experienced players. This interactive feedback reduces the steep learning curve for beginners, encouraging skill development through visualization for potential move sets.

In addition to local two-player games, the integration of a computer AI and remote play offers versatility that extends the chessboard's appeal. The AI opponent provides a practice environment for solo players, while online connectivity via Wi-Fi enables real time matches with friends or competitors from anywhere. These features enhance the board's usability beyond recreational play, making it suitable for chess clubs, classrooms, and home use.

The Pathfinder Chessboard presents an intricate design requiring coordination of sensors for piece detection, LEDs for move guidance, wireless communication for online play, and custom PCB design for efficient power and signal management, showcases innovation by integrating traditional gameplay with modern interactive features.

# 2. Goals/Objectives/Design Requirements

The primary goals of the PathFinder Chessboard are to create a fully functional physical chessboard equipped with accurate piece detection and LED guidance. The system should allow smooth local two-player gameplay, providing real-time feedback to highlight legal moves and capture opportunities. Another key goal at this stage is to design and implement a custom PCB that integrates the microcontroller, power regulation, sensor interfaces, and LED drivers into one cohesive system.

To meet these goals, our basic objectives are to achieve accurate detection rates for piece movement, ensure that LEDs illuminate the correct legal moves and capture squares within a timely manner, and demonstrate the stable gameplay for the duration of a full match without any subsystem failures. The chessboard must operate reliably in local two-player mode with all rules enforced, and the custom PCB should provide continuous power and coordination for all subsystems for at least 2 hours of battery-powered play.

Building upon the basic goals, the advanced goals focus on enhancing gameplay through additional features that improve user interaction and create variety. These goals include

integrating a chess engine such as Stockfish to provide a computer opponent and introducing a speed chess mode complete with a timer and sound effects for move notifications.

The advanced objectives are to run the chess engine efficiently on the embedded platform, generating valid AI moves and integrating them to appear through the LED system. For speed chess mode, the objectives are to implement a timer within per move timeframe and to generate audio cues that alert players when a move is made or when time is running low.

The stretch goals for the PathFinder Chessboard emphasize expanded connectivity and user experience enhancements. These include enabling remote multiplayer matches by synchronizing moves through a companion app, allowing a player to play against another remotely. Additional goals include incorporating customizable LED animations and a win-loss record display.

Corresponding stretch objectives include developing a companion app that can transmit moves between two PathFinder Chessboards or between a PathFinder Chessboard and a Wi-Fi enabled device, ensuring that gameplay remains synchronized across locations. The system should maintain minimal lag during move updates to provide a seamless remote play experience. Other objectives include creating dynamic LED animation patterns to highlight moves or outcomes and integrating a win–loss record feature that updates automatically at the conclusion of each game. These stretch objectives would elevate the PathFinder Chessboard beyond local play, blending traditional physical chess with modern digital connectivity.

# 3. Features and Functionalities

The PathFinder Chessboard is designed to combine the tactile experience of traditional chess with interactive benefits of modern technology. A central feature of the system is its LED-guided move indication, where embedded LEDs beneath each square highlight legal moves when a piece is lifted from the board. To improve clarity, valid moves will be displayed in one color, while capture opportunities will be distinguished by a different color. This guidance system enhances accessibility for beginners, reduces errors in gameplay, and creates a more engaging experience for all players.

The board supports three primary modes of play. First, a local two-player mode allows for traditional in-person matches. Enhanced with real-time LED guidance. Second, a computer opponent mode integrates a chess engine, such as Stockfish, enabling solo play. Third, a remote play mode uses Wi-Fi connectivity to synchronize games with players not near the chess board, ensuring accurate move tracking and consistency across devices. A mode selection switch will allow users to toggle seamlessly between these modes.

Additional functionalities include automatic piece detection using magnets attached to the chess pieces and hall sensors embedded in each square to reliably register the presence and movement of chess pieces. This system ensures synchronization between physical actions and digital processing. A timer for each player may also be implemented for a player's move.

Potential extended functionalities may include game logging, which would record moves for post-game review, as well as a companion application for an online multiplayer feature.

# 4. Existing Products / Related Works

## 4.1 SMART Chess Board

While researching for our design, we came across a previous Senior Design project from 2023, where the group also made a smart LED chess board titled “SMART Chess Board”. Their design made use of hall effect sensors to determine where and when a piece was lifted, and would then indicate on the chess board where valid moves were using LEDs. This group also made their own chess library to avoid having to alter an existing one, but found it difficult as time went on. This project gives us an understanding of one way to implement our systems, though we have chosen to alter ideas, such as adding in the ability to play against a computer player, and also deciding to use an existing open-source chess library that we can change as needed.

## 4.2 DIY Super Smart Chessboard

Another source we came across, this time while trying to develop our idea of being able to connect the chess board with Wi Fi, was an existing hobbyist project, named the “DIY Super Smart Chessboard”. This project makes use of a LED strip to light the board similar to our plan, though it is controlled by manually selecting the space the player wishes to move to through the use of buttons, which then light the LEDs, then after a manual confirmation, the player moves the piece. To make sure the move is legal in chess, libraries are implemented. While this program lacks a sensor to indicate when a piece is moved, we found value in reading how they implemented their ability to play against a computer player and human player using Wi-Fi.This project uses Wi-Fi capabilities granted by the raspberry pi board and various libraries it has to connect with other Super Smart Chessboards to allow online play. Though we do not plan to use the raspberry pi board, this project still provides an outline of what we are striving for, and also shows us one way to do it, which we can alter as needed.

# 5. Engineering Specifications

Table 1: System-Level Specifications

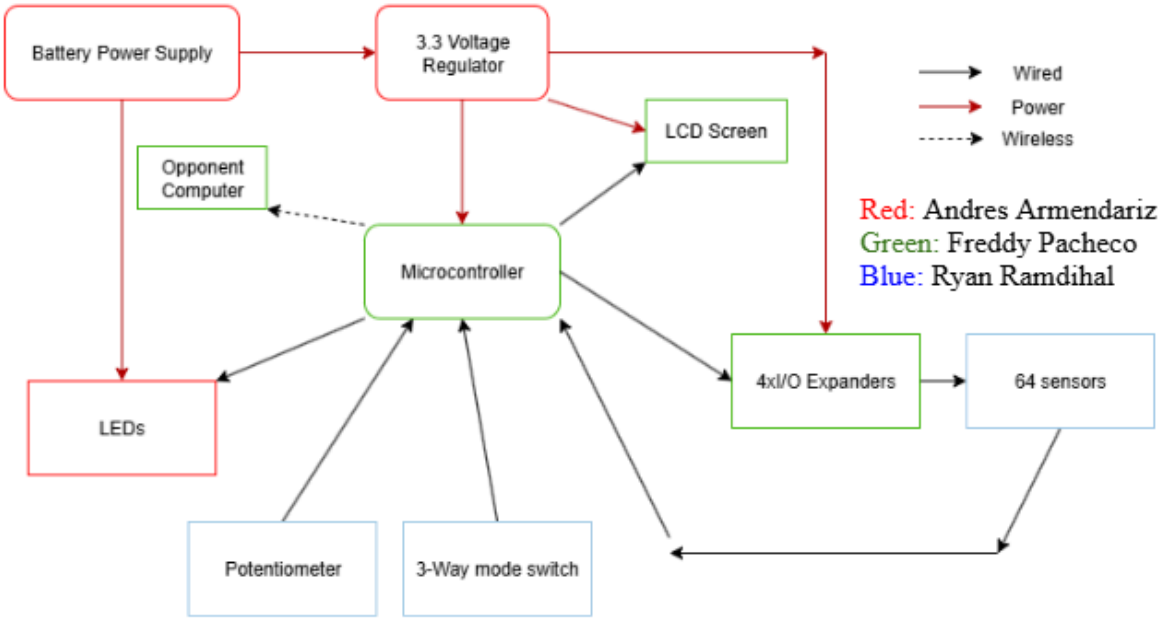
| **Parameters** | **Target Value** | **Notes** |
|---|---|---|
| Chess Board Dimensions | Main chess board:<20x20x2 in<br>Side box: <5x5x2 in<br>(Length x Width x Height) | Standard chessboard size with space for electronic components. |
| Battery Life | ≥ 2 hours | Duration of normal gameplay session on one charge |

| | | |
|---|---|---|
| Manufacturability (Cost) | < $350 | Budget target for prototype parts |
| Temperature | < 100 degrees Fahrenheit | Safe for indoor operation |
| Weight | < 15 lbs | Portability |
| Modes | 3 | The path finder chessboard should have a minimum of 3 different modes the user can select. |

Table 2: Component-Level Specifications

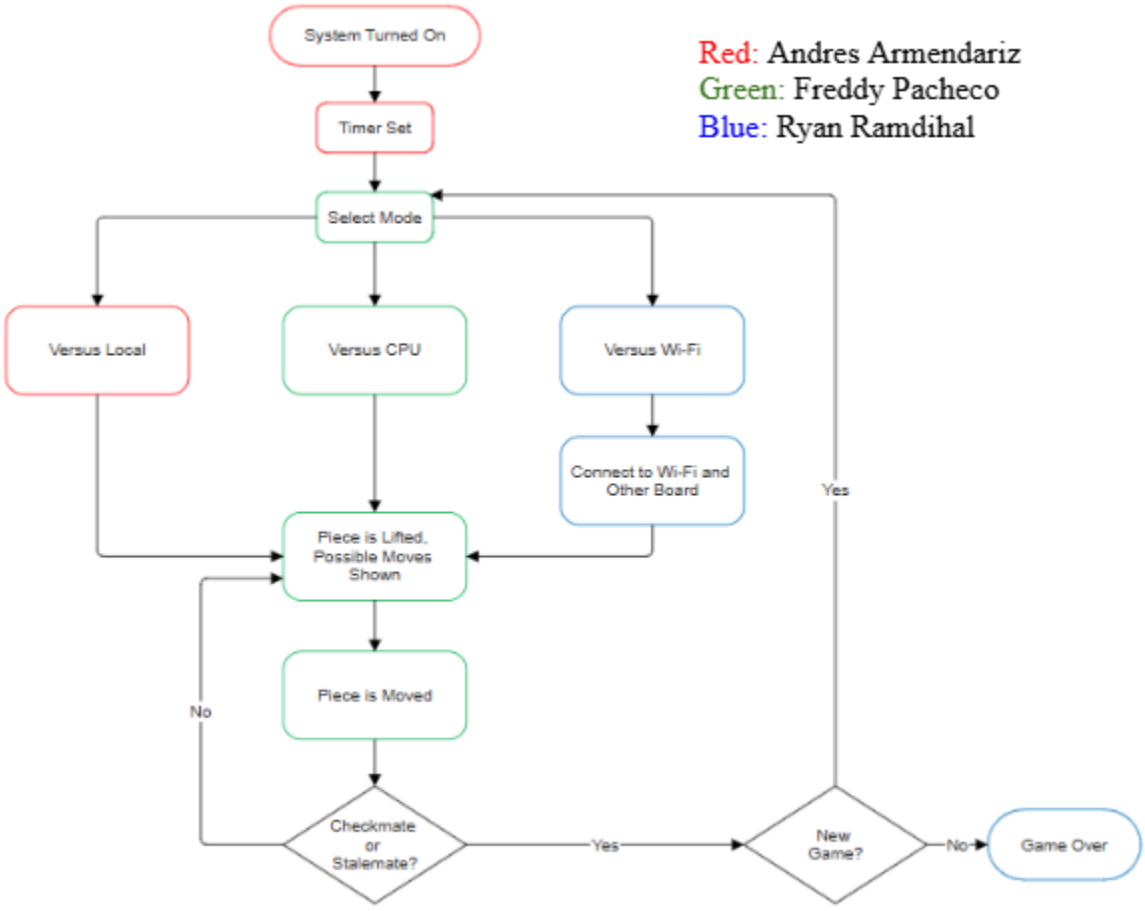
| **Component** | **Parameter** | **Subsystem and Description** | **Target Value** |
|---|---|---|---|
| LED | Power | Electrical - The LED watt usage should ideally be less than the maximum wattage. | <22 Watts |
| ESP32 | Wifi | Wifi signal strength should be strong enough for reliable online play within 5-15 meters. | >-75 dBM |
| Sensors | Magnetic Flux | Electrical-The magnetic sensors should be able to pick up when a piece is there or not. | ~0 V for values >3.32mT<br>~5V for values < 1.17 mT |

# 6. Hardware Block Diagram



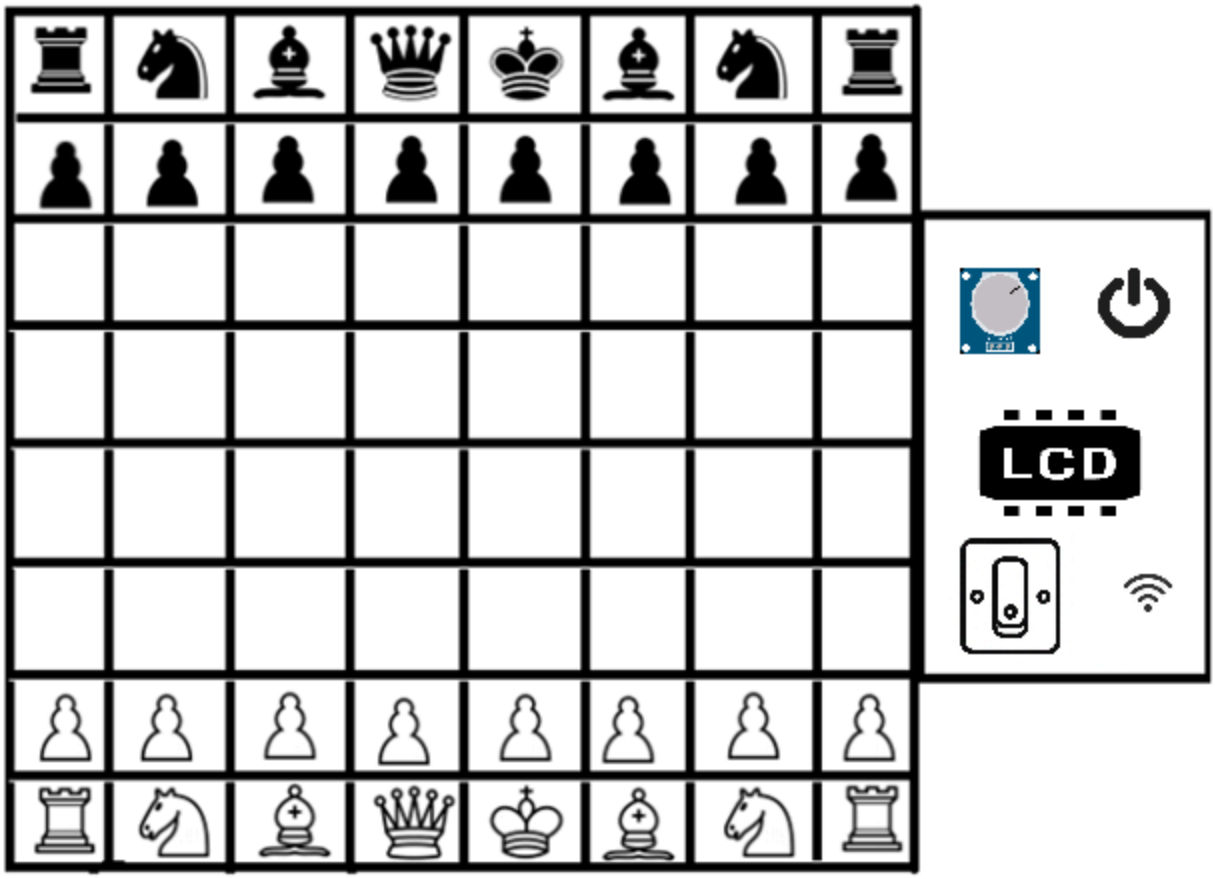

| **Block** | **Status** |
|---|---|
| Battery Power Supply | Investigating |
| 3.3 Voltage Regulator | Investigating |
| LCD Screen | To be acquired |
| Microcontroller | To be acquired |
| LEDs | To be acquired |
| I/O Expanders | Investigating |
| Opponent Computer | Acquired |
| 3 mode switch | Investigating |
| 64 Sensors | Investigating |
| Potentiometer | To be acquired |

# 7.Software Diagram/ Flow Chart




# 8.Prototype Illustration/ Blue Print

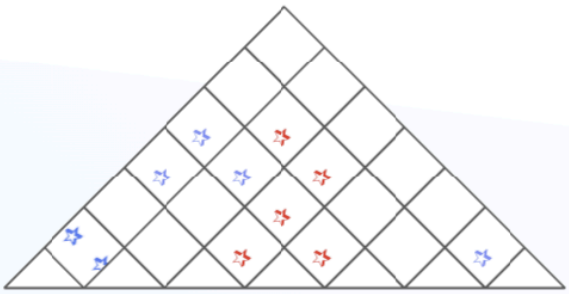
The image below is a prototype illustration of the PathFinder Chessboard.The illustration does not show the height of the box which would be around 1.5 inches. The dimensions of the chess board measure around 18x18x2 for the main chessboard and 4.5x4.5x2 for the box to the right of it. Underneath each of the 64 tiles of the Chessboard will be a magnetic sensor and a LED mounted on the PCB. The LEDs would be daisy chained with the microcontroller, with the regulators and other components embedded in the PCB as well. To the right of the chess board will be the on/off switch, 3-way mode switch, LCD screen, potentiometer used as a timer, and wi-fi antenna.




9. House of Quality

**Key**

| | | |
|---|---|---|
| Positive Correlation | ☆ | ↑ |
| Strong Positive Correlation | ☆☆ | ↑ ↑ |
| Negative Correlation | ☆ | ↓ |
| Strong Negative Correlation | ☆<br>☆ | ↓ ↓ |



| Consumer Requirements | LED Response time | Sensor accuracy | Component Costs | Chess engine integration | Power Consumption | Material Quality | Weight |
|---|---|---|---|---|---|---|---|
| | | | | | | | Engineer Requirements |
| Accessibility | ↑ ↑ | ↑ ↑ | | ↑ | | ↑ | ↓ |
| Power Efficiency | | | | | ↑ ↑ | | |
| Speed | ↑ ↑ | ↑ ↑ | | ↑ | ↑ | | |
| Affordable Cost | | | ↓ ↓ | | | | |
| Portability | | | | | | | ↓ ↓ |
| Durability | | | | | ↑ | ↑ ↑ | ↓ |
| **Target for Requirements** | ≤ 250ms | ≥ 90% | ≤ $100 | - | ≤ 5 W | scratch resistant | ≤ 10 lbs |

# 10. Budget and Financing

## BOM:

| Component: | Part name: | Quantity: | Unit Price: | Total Price: |
|---|---|---|---|---|
| Microcontroller | ESP32-S3 | 1 | $1.85 | $1.85 |
| Development Board | Arduino uno | 1 | $20 | $20 |
| I/O Expander | MCP23017 | 4 | $1.62 | $6.48 |
| 3.3 voltage regulator | TC1262-3.3VDB | 1 | $0.69 | $0.69 |
| LCD screen | HD44780 | 1 | $10.95 | $10.95 |
| LEDs | WS2812B addressable LEDs | 64 | $0.267 | $17.09 |
| 64 Hall effect Sensors | DRV5032 | 64 | $0.276 | $17.66 |
| Frosted acrylic top | 1 | 1 | $17.99 | $35.98 |
| 32 chess pieces | Chess Pieces | 32 | $8.73 | $8.73 |
| Magnets | Neodymium magnets | 32 | $0.07 | $6 |
| 3d Print fillament | 3d print filament | 1 | $50 | $50 |
| Custom PCB | PCB | 1 | $150 | $150 |
| TOTAL COST: | | | | $325.43 |

Estimated Costs:
- Components: $54.72
- Tools: $20
- Fabrication: $235.98
- Other:$14.73

Funding Sources:
- Self-funded: $325.43

- Sponsors: $0
- Other:$0

# 11. Project Milestones

| **Senior Design 1 Task** | **Expected Completion** | **Progress** |
|---|---|---|
| Divide & Conquer Document | 9/5/2025 | Completed |
| First Meeting with Mentor | 9/10/2025 | Scheduled |
| Research Chess Libraries (Solo and CPU) | 9/20/2025 | Researching |
| Start Gathering Materials | 10/01/2025 | In Progress |
| Midterm Report | 10/31/2025 | In Progress |
| Finish Breadboard Prototype | 11/03/2025 | Not Started |
| Finish PCB Prototype | 11/15/2025 | Not started |
| Final Report | 11/25/2025 | In Progress |
| Mini Demo Video | 11/25/2025 | Not Started |
| Committee Meeting | December 2025 | Not started |

| **Senior Design 2 Task** | **Expected Completion** | **Progress** |
|---|---|---|
| Order PCB | December 2025 | Not Started |
| Construct PCB | December 2025 | Not Started |
| PCB and Software Testing | January 2026 | Not Started |
| General Testing and Bug Fixing | January 2026 | Constant |
| Meeting with Mentor | February 2026 | Not Started |
| Project Completion | April 2026 | Not Started |
| Final Demo Video | May 2026 | Not Started |
| FInal Check Before Presentation | May 2026 | Not Started |

| | | |
|---|---|---|
| Final Presentation | May 2026 | Not Started |

# References: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