Networked Physical Chessboard for Remote Play

By:

Danny Guller

Payton Schutte

Quinn Athas

Project Proposal for ECE 445, Senior Design, Spring 2026
TA: Wenjing Song

2 January 2026
Project No. 51

Abstract

This project proposes a networked physical chessboard system that enables remote players to play chess using real pieces. Each board uses magnetic pieces for detection and wireless communication for board synchronization. This document explores the problem being solved and the approach Group 51 is taking to find a solution. Furthermore, the requirements and designs to meet those requirements for each subsystem are realized. The compatibility and accuracy of the sensors and analog of digital converts is proven with basic calculations and reasonings. Finally, a look at the ethics and societal impact of this project are discussed.

Table Of Contents

1. Introduction

1.1 Problem

Chess remains one of the most globally recognized strategy games, played recreationally, competitively, and educationally. While digital chess platforms offer unmatched convenience, they fundamentally alter the nature of play. Screen-based interaction removes the tactile feedback of handling physical pieces, reduces spatial awareness of the board, and weakens the sense of presence traditionally associated with face-to-face games. For many players this results in a less enjoyable experience.

The absence of affordable solutions that combine physical play with remote connectivity presents a meaningful gap. Existing commercial electronic chessboards capable of online synchronization are often expensive, limiting accessibility to enthusiasts or specialized institutions. Consequently, players must choose between convenience and the authentic physical experience of the game.

This problem connects to broader societal considerations. Chess is widely associated with cognitive benefits, including improvements in concentration, problem-solving, and strategic thinking. However, increasing reliance on screen-based entertainment contributes to digital fatigue, eye strain, and reduced physical interaction. Systems that encourage tangible interaction while preserving remote connectivity may help mitigate these concerns. Furthermore, enabling richer remote interaction supports social well-being, particularly for individuals separated by distance, mobility limitations, or remote learning environments.

From an economic perspective, reducing barriers to entry through lower-cost technological solutions promotes wider adoption and educational accessibility. Technologically, the project reflects growing interest in hybrid physical-digital systems, telepresence interfaces, and embedded sensing technologies.

1.2 Solution

This project proposes a networked physical chessboard system that enables two remote players to participate in a fully physical game of chess. Each board will detect piece placement and movement using an array of Hall effect sensors embedded beneath the playing surface. Each piece will have a magnet embedded into its bottom. Sensor readings will be processed by a microcontroller to reconstruct board state, infer player moves, and enforce chess move legality.

Once a move is confirmed locally on the digital display, it will be transmitted over Wi-Fi to a centralized server and relayed to the opponent's board. Visual indicators, including LEDs and an integrated digital display, will guide players in replicating moves and provide system feedback such as connectivity status, turn indication, and move validation. The system is designed for minimal screen usage to maintain the tactile feel of chess.

1.3 Visual Aid

Figure 1: visual aid of what a networked physical chess setup may look like

1.4 High-Level Requirements

A. The system shall detect chess piece presence on all 64 squares with a minimum accuracy of **95%** under normal operating conditions.

B. The system shall transmit and receive confirmed moves with an end-to-end latency not exceeding **5 sec** over a standard Wi-Fi connection.

C. The system shall maintain board synchronization during gameplay and recover from temporary network interruptions of up to **30 seconds** without requiring a manual reset.

2. Design

2.1 Block Diagram

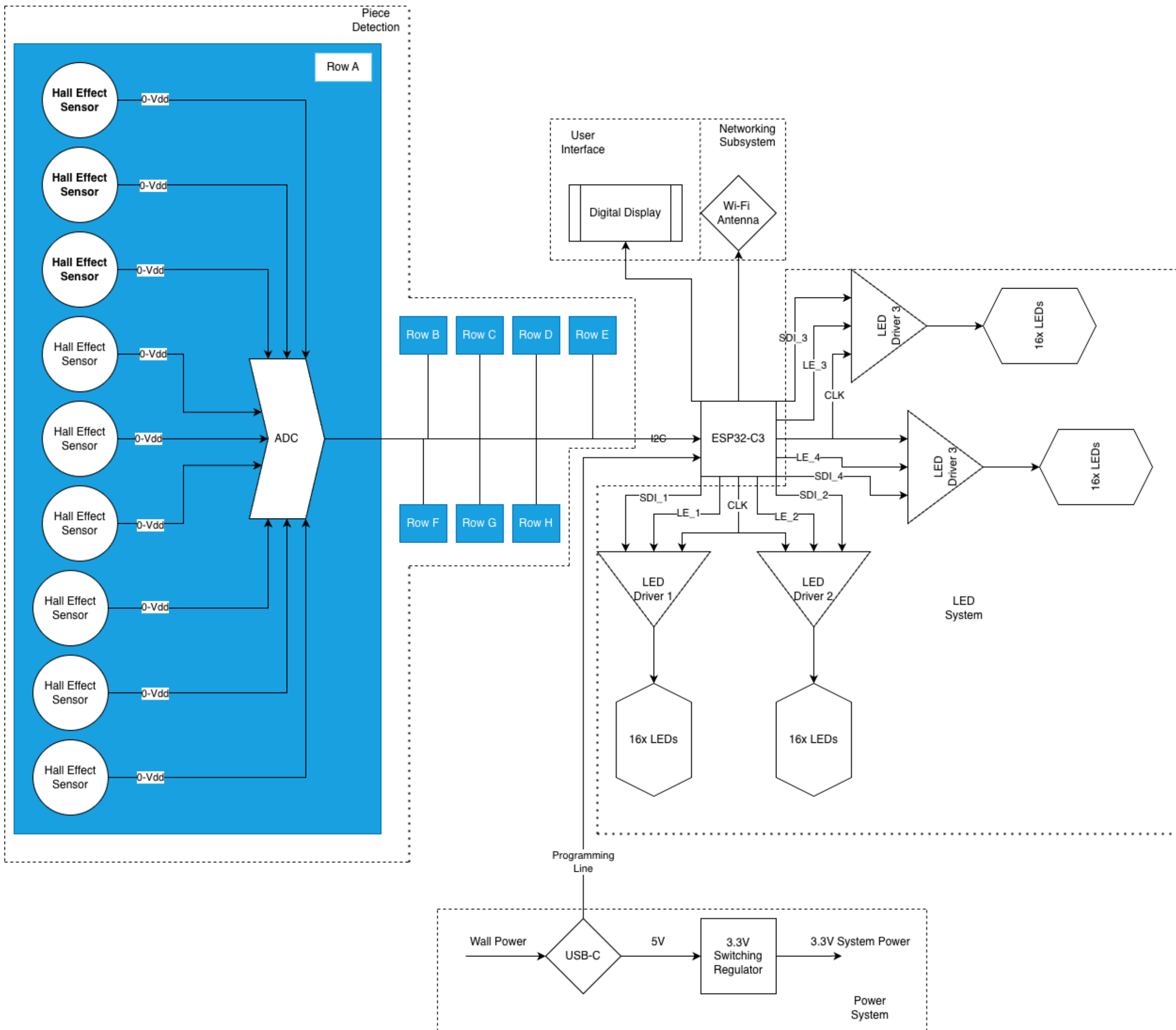

Figure 2: Block diagram of single chess board in system

2.2 Subsystem Overview and Requirements

2.2.1 Piece Detection Subsystem

The Piece Detection Subsystem is responsible for sensing chess piece presence on each of the 64 board squares. This subsystem uses an array of analog Hall effect sensors positioned beneath the board, with sensor outputs digitized through eight eight-channel ADCs. The subsystem continuously samples sensor values and provides the microcontroller with a real-time representation of square occupancy. This information forms the foundation for all higher-level system behavior. The subsystem interfaces directly with the Move Processing Subsystem by supplying calibrated sensor data used for board state reconstruction and change detection.

This subsystem directly contributes to requirement A. Piece detection must be accurate to within 1milliTesla, or 12milliVolts (the equivalent rise in voltage of the hall effect sensor). If we are unable to sense at that accuracy there is a chance that pieces will not be detected and our failure rate could drop below 95%.

2.2.2 Move Processing and Legality Subsystem

The Move Processing and Legality Subsystem is a software subsystem that interprets sensor data to reconstruct the current board state, detect changes, and infer player moves. By comparing sequential board configurations, the subsystem generates candidate move hypotheses, including captures. It then verifies move legality according to standard chess rules before permitting confirmation on the digital display. This subsystem ensures rule enforcement and prevents invalid board states from propagating through the system. It receives square occupancy data from the Piece Detection Subsystem and communicates validated moves to the Networking Subsystem. Additionally, it exchanges status information with the User Interface Subsystem to provide feedback on illegal moves or inconsistencies.

This subsystem contributes to requirements A,B, and C. Without this subsystem, no goal can be achieved because even a partial chess game can not be played. Each requirement inherently needs chess moves to be processed to be satisfied. This subsystem should be able to recognize legal vs illegal moves such as moving a pawn three spaces, and it should be able to recognize a pawn taking another pawn and update the game state accordingly.

2.2.3 Networking and Synchronization Subsystem

The Networking and Synchronization Subsystem manages communication between remote chessboards through a centralized server. Each board uses a WiFi antenna to communicate to the server. Upon move confirmation, this subsystem transmits validated move data and periodically polls the server for opponent updates. It ensures correct move ordering, handles temporary disconnections, and supports state recovery. This subsystem acts as the bridge between the local board and external systems. It receives validated moves from the Move Processing Subsystem and provides incoming move data to both the Move Processing Subsystem (for state updates) and the User Interface Subsystem (for visual guidance).

This subsystem directly supports requirements B and C. Each board should be able to directly communicate with the server and receive data in under 2.5 seconds. This ensures that we meet our 5 second data transfer requirement. This subsystem should also be able to recognize when it is not connected to the server so we can maintain board state if a connection loss of 30 seconds happens.

2.2.4 User Interface Subsystem

The User Interface Subsystem provides players with system control and feedback through a digital display. It manages session configuration, connectivity indication, turn status, and move confirmation.

Digital display outputs include messages and notifications of errors or moves made. This subsystem improves usability and reduces ambiguity during gameplay. It interacts with the Move Processing Subsystem for move validation feedback and board discrepancy reporting, while also receiving network status updates from the Networking Subsystem.

This Subsystem supports requirement B. Without being able to confirm moves with the User Interface System we will not be able to understand our end-to-end latency. This subsystem should be able to display confirmation and register when the confirmation is selected. It will communicate with the Networking and Synchronization Subsystem to relay that confirmation to the server and thus the other board.

2.2.5 LED Subsystem

The LED Subsystem provides immediate visual feedback to players by illuminating board squares associated with detected or received moves. LEDs embedded beneath the board surface highlight source and destination squares, assisting players in replicating remote moves accurately. This subsystem enhances gameplay clarity without requiring continuous display monitoring. It receives control signals from the Move Processing Subsystem for local actions and from the Networking Subsystem for remote move indication.

This subsystem is important to requirement B. The LEDs will display what move the other board has communicated over the Networking and Synchronization Subsystem. To ensure this system meets our needs, the MCU should be able to individually address each square and turn on its LED. It should be 100% accurate with which LED it turns on.

2.2.6 Power Subsystem

The Power Subsystem is responsible for regulating power received from the wall to usable voltage levels for the rest of the hardware. A USB-C port is the single power connector on the board providing 5V to the Power Subsystem. A switching regulator is responsible for stepping the wall voltage to 3.3V for system use. The switching regulator provides the most efficient and lowest heat generating power regulation. This subsystem interacts with all hardware subsystems.

This subsystem supports satisfying requirement A. The Power Subsystem will need to supply 3.3v ±0.1V and 500mA. If this is not achieved, the hardware will not function and no progress can be made.

2.4 Tolerance Analysis

A critical part of this project is piece detection with hall effect sensors. It is important that we are able to read the analog output of the sensors with an analog to digital converter accurately. We have chosen the ADS7128IRTER (12-bit ADC) and the DRV5055A4QLPG (linear Hall-effect sensor) as our components.

These ICs are electrically compatible and well-suited for operation on a shared 3.3 V system. The ADS7128 uses AVDD as its reference, giving a full-scale input range of 0–3.3 V. The DRV5055A4 operates from 3.0–3.63 V and produces a ratiometric analog output centered at VCC/2 (≈1.65 V at 3.3 V supply), with a linear output range of approximately 0.2 V to 3.1 V. This ensures the Hall sensor output remains fully within the ADC's valid input range without additional signal conditioning. Because both devices are powered from the same 3.3 V rail, supply variation is inherently canceled through ratiometric measurement, improving system stability and measurement consistency.

From a performance standpoint, the 12-bit ADC provides an LSB size of 3.3 V/4096 ≈ 0.806 mV. With the DRV5055A4 sensitivity of 7.5 mV/mT, this corresponds to a magnetic field resolution of approximately 0.11 mT per LSB. Sensor output noise (~1.5 milliVolts peak-to-peak) translates to roughly 0.2 mT peak-to-peak magnetic noise, which can be reduced through digital averaging or low-pass filtering if required. While sensor sensitivity tolerance (~±5%) dominates absolute accuracy, simple offset calibration at startup and optional gain calibration can significantly improve precision. Overall, this pairing provides sufficient compatibility and specs for accurate magnetic field measurement in a 3.3 V system.

3. Ethics, safety and societal impact

This project raises ethical considerations primarily related to the potential for misuse, particularly in the context of cheating. While the system is designed to enhance the physical experience of remote chess play, it could be intentionally used alongside chess engines or external analysis tools to gain an unfair advantage in competitive settings. Consistent with the IEEE and ACM Codes of Ethics, which emphasize honesty, fairness, and the avoidance of harm, the design must avoid implying that the system prevents cheating unless such claims can be technically guaranteed. Instead, the project will be positioned as a tool for casual and recreational play, with clear communication about its capabilities and limitations. The system's reliance on game-state tracking rather than direct piece identification also introduces the possibility of deliberate piece manipulation, which will be mitigated through legality checking and board-state validation. By acknowledging these risks and ensuring transparent representation of the system's function, the project aligns with professional ethical standards while promoting responsible use of the technology.