Team A0: Tactile Chess

Mukundh Balajee, Edison Aviles, Juan Mejia

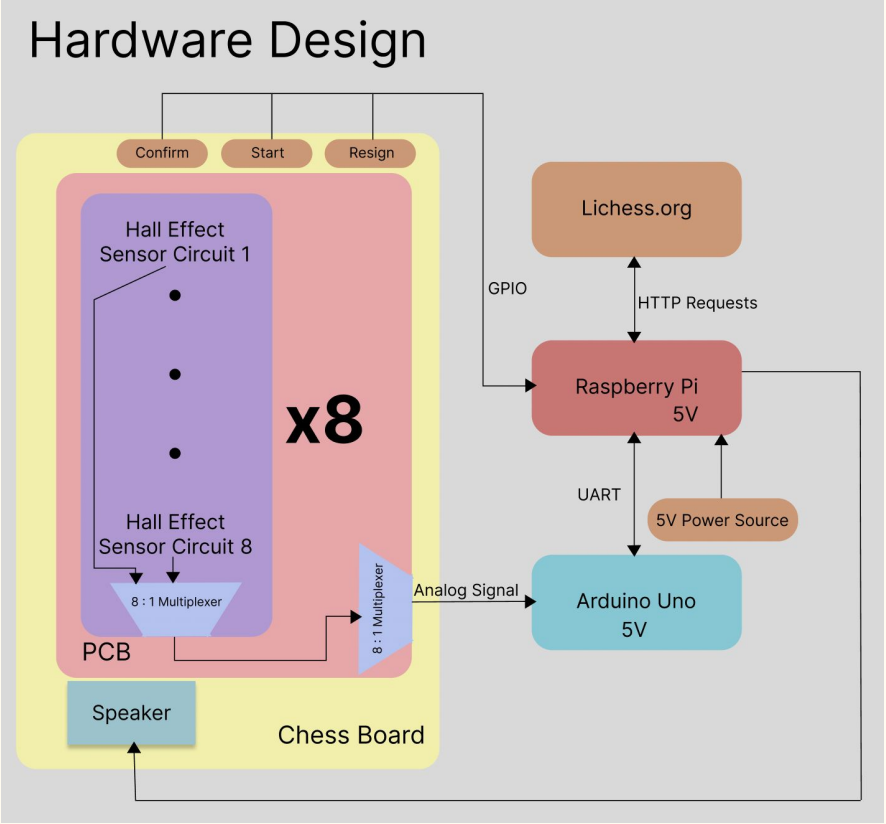
Problem Statement/Use Case

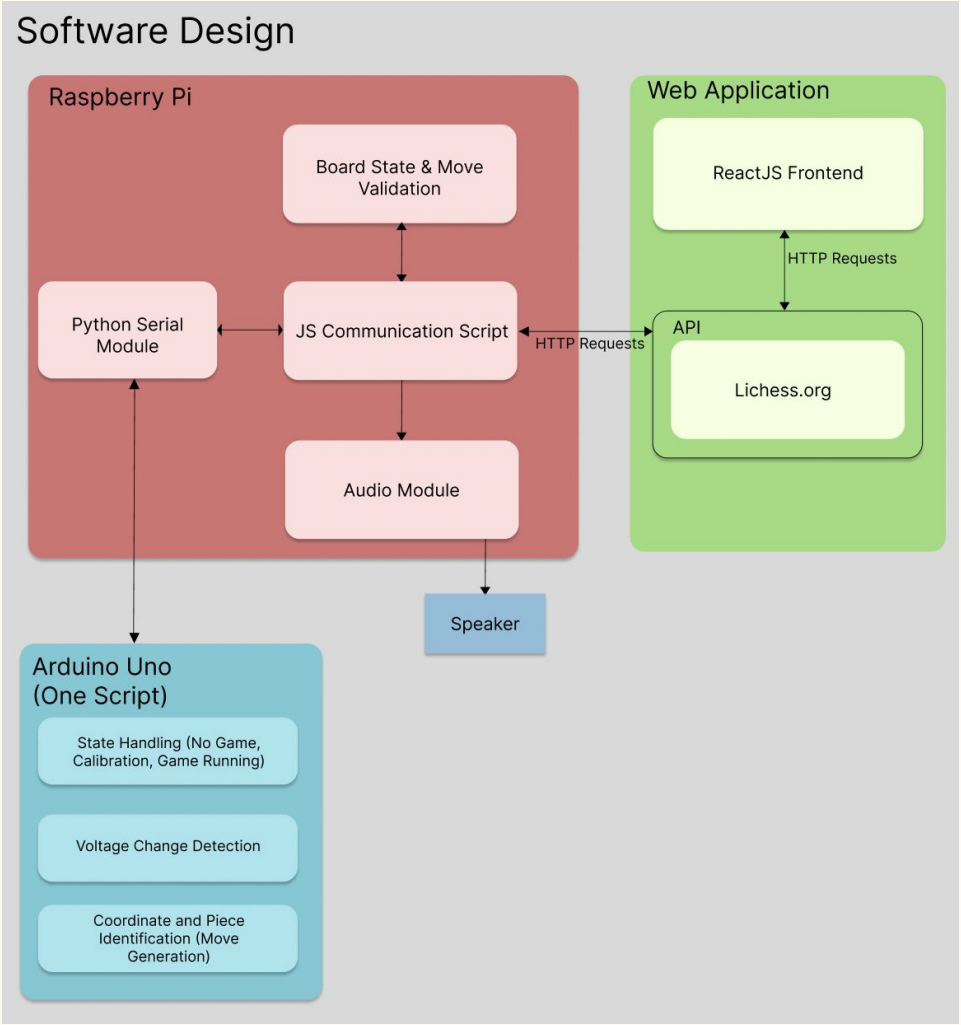
- Online chess platforms have over 1B users
- Inaccessible to blind users
  - No accessible features or products
- Difficult for beginner/novice chess players to practice chess
- Solution:
  - Develop a smart chess board to understand online gameplay
  - Provide tactile and vocal cues to our users
  - Seamless transition between online platform and physical board

Use-Case Requirements

Case	Requirements
User Experience	● ~25s setup time ● Modified board for blind users
Piece Detection & Board Integrity	● Differentiate between piece type and colour ○ Achieve 100% accuracy ● Sensors and push-buttons to help verify board and game integrity ○ Board State at any given time ○ Move legality
Accuracy & Latency	● Maximum system latency of 1 second ● Accuracy of piece detection: 100% ● Accuracy of tactile and vocal cues: 100%

Block Diagram



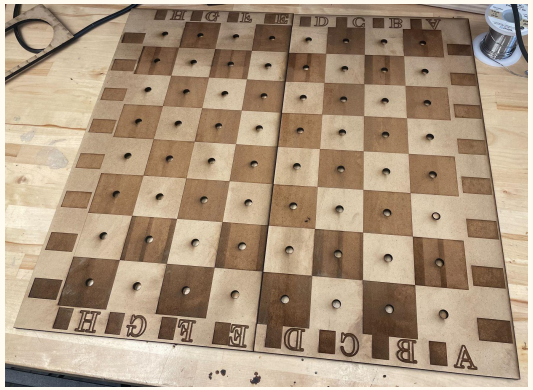


Solution - Accessibility

Barrier	Solution
Identification of Pieces	● Differentiate colours ○ Black pieces will have tips ● To identify pieces blind users touch and feel the piece
Identification of Opponent Moves	● Vocalize opponent moves (based on standard chess coordinates) ○ Using 3W 8Ω General Purpose Speakers ○ LM386 IC to amplify sound ● Vocal cues and feedback to help user move pieces
Set up convenience	● Use buttons to start and end game ● Provide vocal cues to help calibrate sensors
User Accounts	● Each board tied to a unique account ● Ability to change account on lichess.org

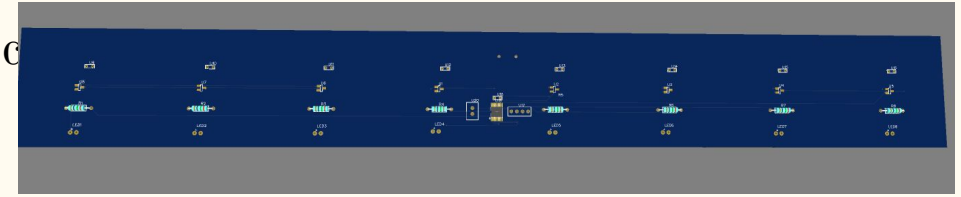
Final Solution - Board and Piece Design

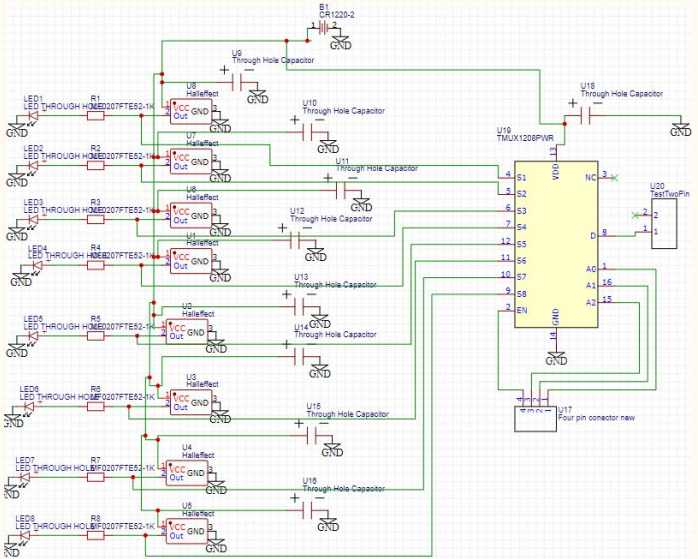
- Chess Board laser cut from wood
  - Etched and raised tiles
  - Braille annotations for coordinates and buttons
- 3D printed pieces
  - Magnets in a custom printed base
  - Black pieces will have a tip to help differentiate
- Lock-and-Key mechanism between piece and board
  - Pieces will have pegs on the bottom
  - Board will have holes on each tile



Final Solution - Piece Detection and Board Integrity

- PCB with Hall Effect sensors to detec pieces
  - One sensor per square
  - Switch polarity for different colours
  - Different magnetic strength for each unique piece
- Validate board state at any instant
  - Generate a FEN notation of current board state
  - Check legality of FEN using Stockfish API
- Validate any move made by user
  - Generate move at the Arduino
  - Send move to a move legality checker
    - If move is valid, send to lichess.org
    - Provide vocal feedback to user





Final Solution - Software

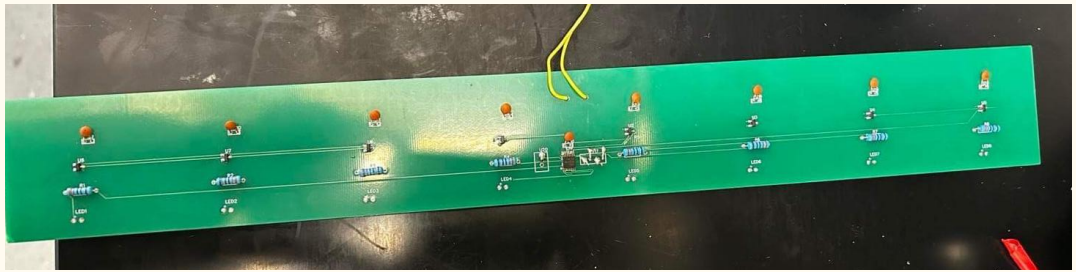
- JavaScript Communication
  - Delegate information being piped from Arduino and Lichess to other modules
- Python Serial Module
  - Read and send information between RPi and the Arduino
  - Flags ensure accurate move generation and communication flow
- Audio Module
  - Used to vocalize messages from the JS Communication script
- Move & Game State Validation
  - Verifies a user's move based on the current state of the live game

Testing & Validation - Implemented

- Move & Board Legality
  - Testing script generating games with random moves
  - All errors caught successfully
  - Latency: <25ms
- Board Components
  - Chess board and pieces have been tested for usability and accessibility
  - Buttons tested for functionality and fast communication
  - Speaker tested for sound, and ability to vocalise accurately
    - Tested with our final vocalization script to ensure accuracy
- Latency Tests
  - Arduino UNO and RPi Communication: <80ms
  - Vocalization: <500ms
- Power Tests
  - Speaker and buttons tested with 5V input from RPi

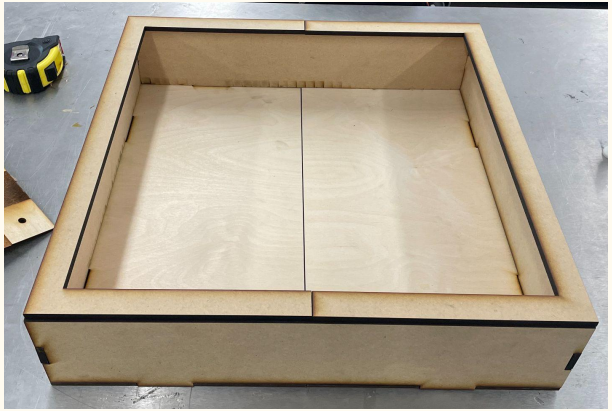
Testing & Validation - Future Plans

- Piece Detection:
  - PCB with magnets in pieces and chess board
  - Multiple pieces on board
  - Latency: <100ms
- Power Tests:
  - 5V across all PCBs
- Latency Test:
  - Piece detection: <100ms
  - System Latency: <1500ms
- Usability Tests:
  - Simulate 3 different types of games for blind users and beginners
  - Record feedback regarding
    - Latency
    - User Experience
    - Accessibility

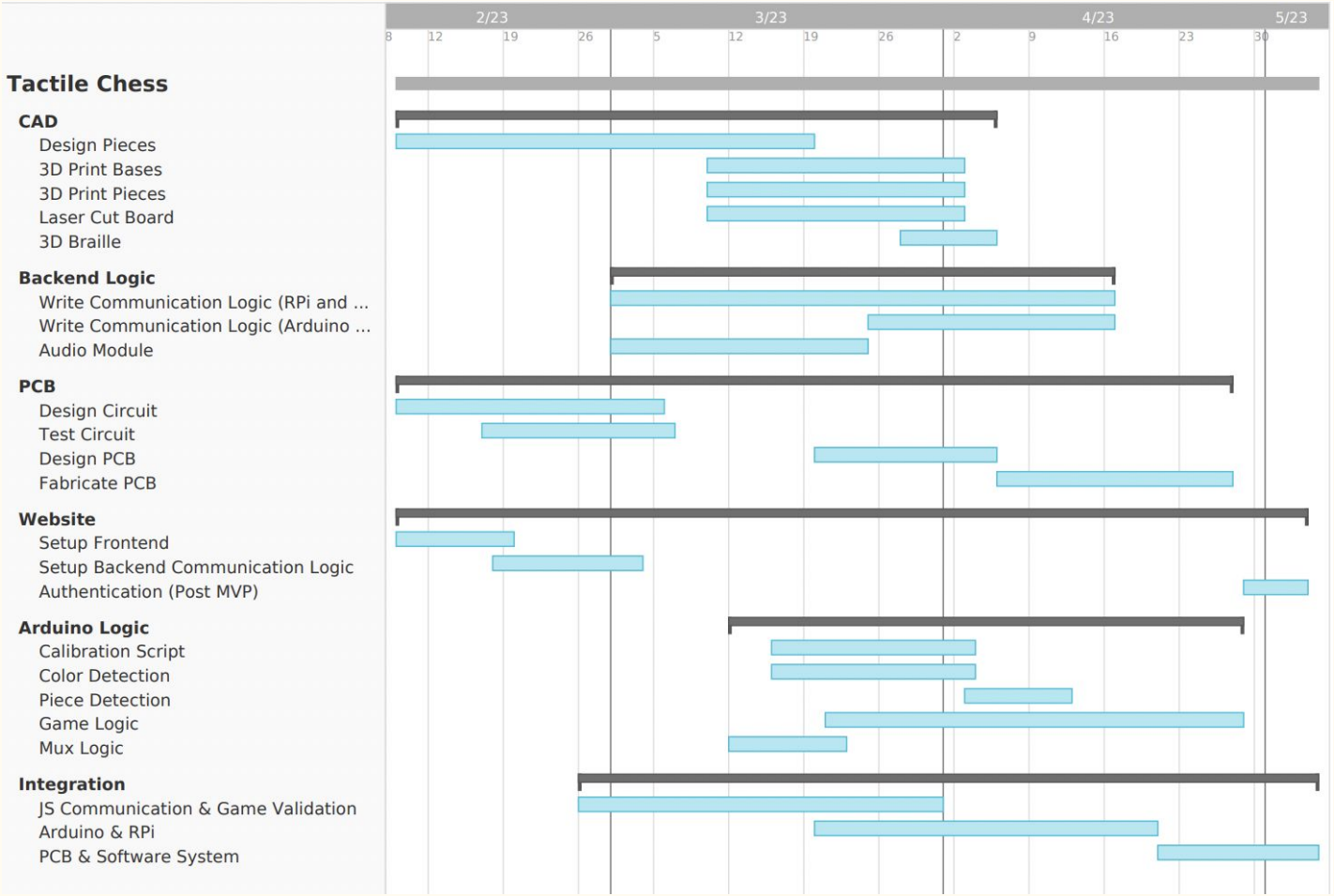


Design Trade Offs

- Power
  - Wall outlet to power RPi
  - RPi powers Arduino and other systems (PCB, speaker, etc.)
  - Cheaper than buying batteries
  - No limit on battery life
- Board Design
  - Laser cut board from wood
    - Cheaper than 3D printing
  - Laser cut supports for PCB, speaker and buttons



Schedule


2/23
3/23
4/23
5/23
8
12
19
26
5
12
19
26
2
9
16
23
30
Tactile Chess
CAD
Design Pieces
3D Print Bases
3D Print Pieces
Laser Cut Board
3D Braille
Backend Logic
Write Communication Logic (RPi and ...
Write Communication Logic (Arduino ...
Audio Module
PCB
Design Circuit
Test Circuit
Design PCB
Fabricate PCB
Website
Setup Frontend
Setup Backend Communication Logic
Authentication (Post MVP)
Arduino Logic
Calibration Script
Color Detection
Piece Detection
Game Logic
Mux Logic
Integration
JS Communication & Game Validation
Arduino & RPi
PCB & Software System