Team 10

MagiChess

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Advisor: Shira Epstein

Meet the team

Shira Epstein
Faculty Team Advisor

Sai Thuta Kyaw
Electrical Engineer

Samantha Klein
Electrical Engineer

Jack Deguglielmo
Computer Engineer

Weishan Li
Computer Engineer

Problem Statement

For centuries, the game of chess has been played by two players sitting across a chessboard. The advent of digital technology in the last decades has brought virtual chess to computers and mobile phones and for the first time, this has allowed players to be anywhere across the world.

Digital chess lacks:

- *A physical aspect/satisfaction of seeing and moving your own pieces*

Physical chess lacks:

- *Ability to play from anywhere and with anyone*

Our Solution

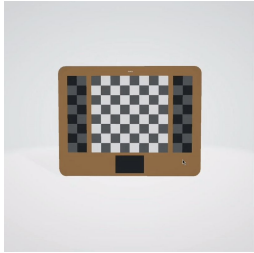
We've decided to close the gap between physical and digital chess. To do this, we plan to create a chess board that allows users to play with an AI or a remote human opponent.

Our board will:

- *Move pieces replicating an opponent*
- *Include a display for user interface*
- *Include a speaker for audio feedback*
- *Have internet connectivity for remote games*

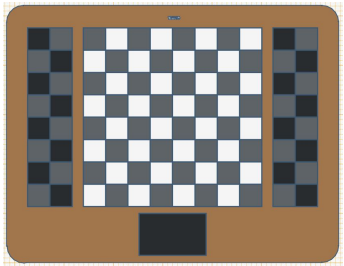
Preliminary System Specifications (Design-agnostic)

- Mechanically move a piece to destination cell
- Remove/replace a piece to/from game board
- Provide visual feedback
  - Game setup
  - Game announcements
  - Where pieces can move after picked up
- Provide audio feedback
  - Notification alerts
- Play versus remote opponent or AI opponent, or learn how to play chess.
- Playback previous games
- Includes buffer zone to store captured pieces



Preliminary System Specifications (Quantitative)

- Total system dimensions: no larger than 26in x 26in x 6in (65cm*65cm*15cm)
- Speed of XY plotter: 4-5 cm/s
  - Max time for a move: 15s, x2 for capture and transport
  - Average time for a piece to move: 7.5s
- Weight: Under 25lbs



Competing Solutions in Marketplace

Commercial Solutions and Products

- Square Off ($399 - 450)
  - Globally connected, autonomous chess board
  - Capabilities:
    - Autonomy, Chess.com integration, PvP and PvB modes, move speed
  - Differences:
    - no native display, limited auditory feedback

- DGT Chess ($400 - 900)
  - Chess “E-Boards”
  - Capabilities:
    - piece detection, portability, integration with various chess engines
  - Differences:
    - no autonomously moved pieces

Project/University Solutions

Chess automation and connectivity is topic of many university and recreational projects. Square Off and other commercial solutions have influenced the design of new chess automation capabilities.

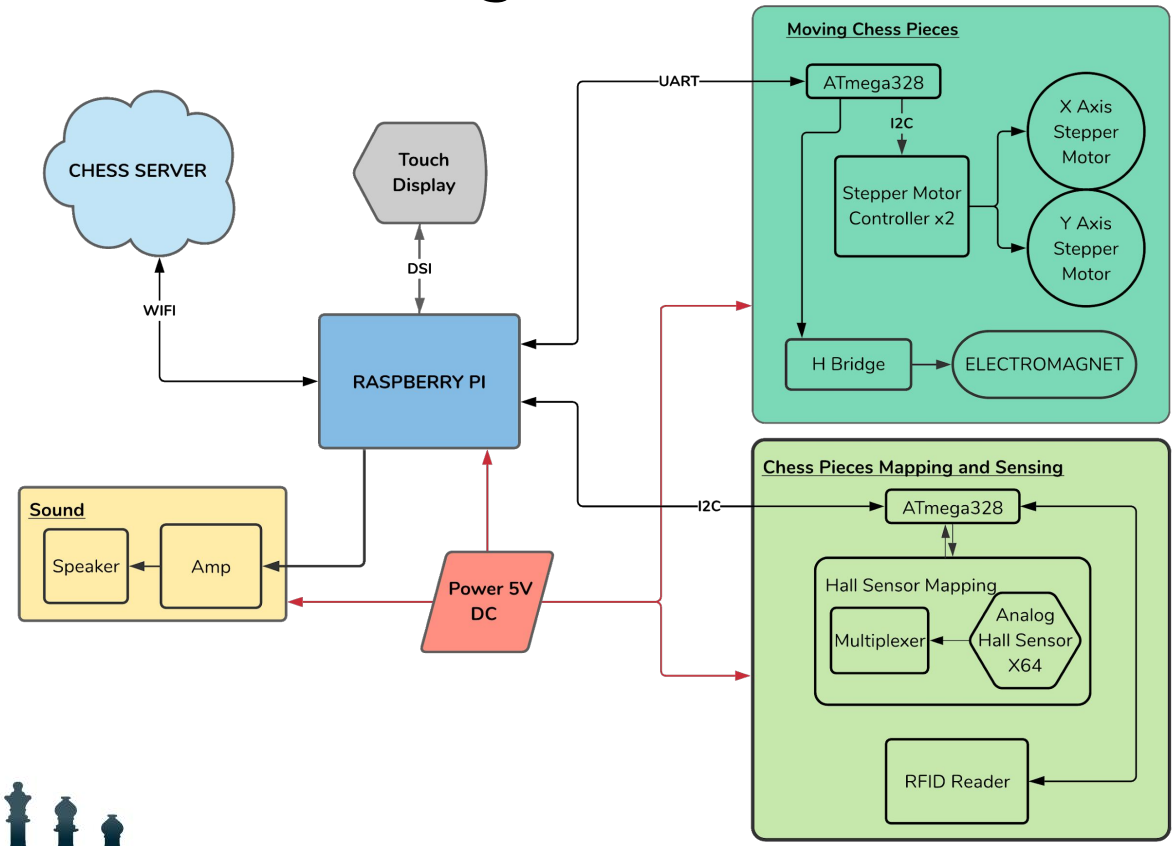
IoT Connected Chess Boards from SparkFun!

SparkFun's solution using LEDs to indicate positions of pieces

James Stanley's Project

Project built by James Stanley on Youtube. Interfaces with Lichess via API calls on linux based system

System Block Diagram

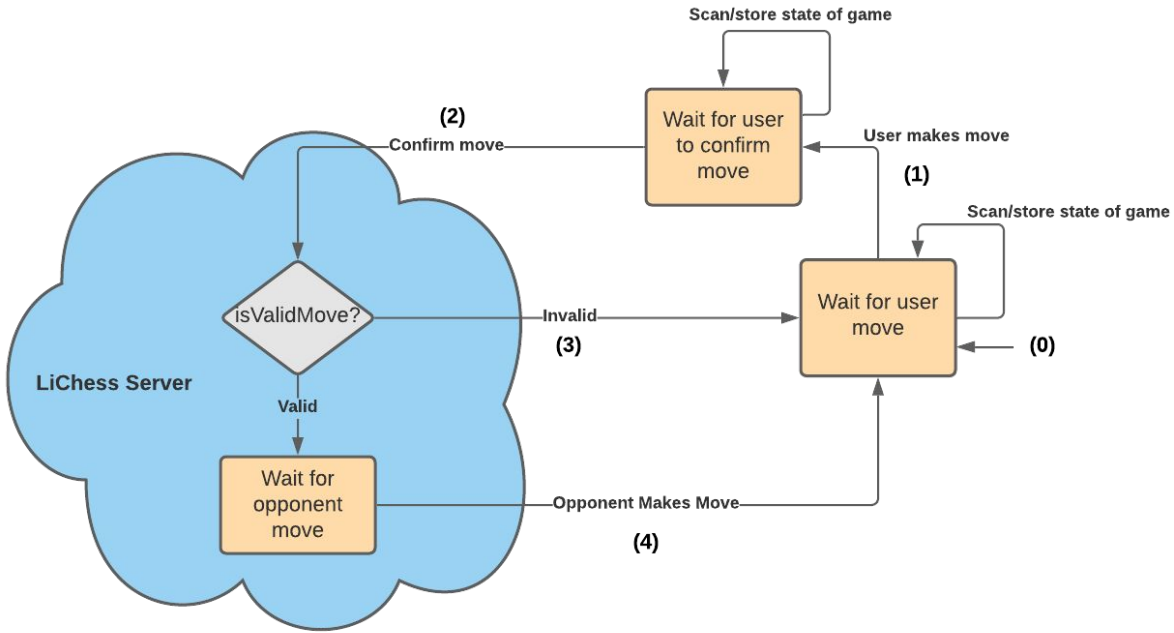


Method 1:
Use multiplexed RFID antennas across 64 cells.

Method 2:
Use six different strength magnets with different poles to identify pieces.

Method 3:
Use magnets to sense occupied cells and single RFID reader to identify.

Software Diagram - Game State



(0) A game has started, piece locations have been scanned and verified

(1) Physical user makes move

(2) After confirmation and preliminary validation, the user's move is sent to the server

(3) Invalid move message sent back to board. System prompts user to make a different move

(4) Opponent's move message sent to board. System gantry moves opponent's piece to destination cell using path planning algorithm.

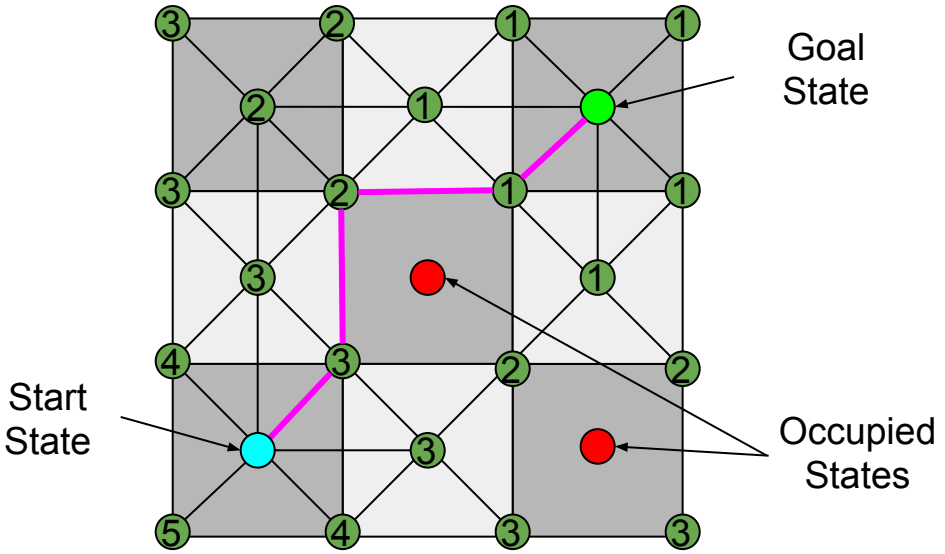
Path Planning the Chess Pieces

Why A* Search?

1. Completeness
2. Optimality
3. Best-First Search
4. Allows for diagonal movements

Heuristic Function:

- number of moves from solution



$$f(n) = g(n) + h(n)$$

Significant Custom Hardware Design

- Provides power to all subsystems
- Microcontroller for communication with Pi and Motor Controllers for moving chess pieces
- Microcontroller for communication with ADC and RFID reader for chess pieces mapping and sensing
- H bridge to control electromagnet
- Includes pin headers for easy debugging and programming

Proposed MDR Deliverables

- LiChess integration with Raspberry Pi (initiate games, execute moves, etc.)
- GUI prototype for Raspberry Pi touch display
- Raspberry Pi outputting digital communication protocols
- Assembly and movement of XY plotter (gantry)
- Results from RFID multiplexing / Hall Effect sensor testing
    - Decision on which sensing technique to use

Cost Estimates

Scenario #1: RFID	
Component	Est. Cost
Gantry	$121
Raspberry Pi	$35
Touch Screen Display	$44
Motor Drivers	$30
Chess Pieces	$20
Electromagnet	$15
RFID Test	$35
Hall Sensor Test	$15
RFID Solution	$130
Total	$445

Scenario #2/3: Hall Sensor or Hybrid	
Component	Est. Cost
Gantry	$121
Raspberry Pi	$35
Touch Screen Display	$44
Motor Drivers	$30
Chess Pieces	$20
Electromagnet	$15
RFID Test	$35
Hall Sensor Test	$15
Hall Sensor Solution	$140
Total	$455

Technical Responsibilities

Jack

- LiChess Server + Pi Integration
- Software interface between GUI/API
- XY Plotter (Gantry) Assembly and test
- Altium Lead

Weishan

- Touch GUI Prototype for Pi
- Software interface between GUI/API
- XY Plotter (Gantry) Assembly and test

Sam

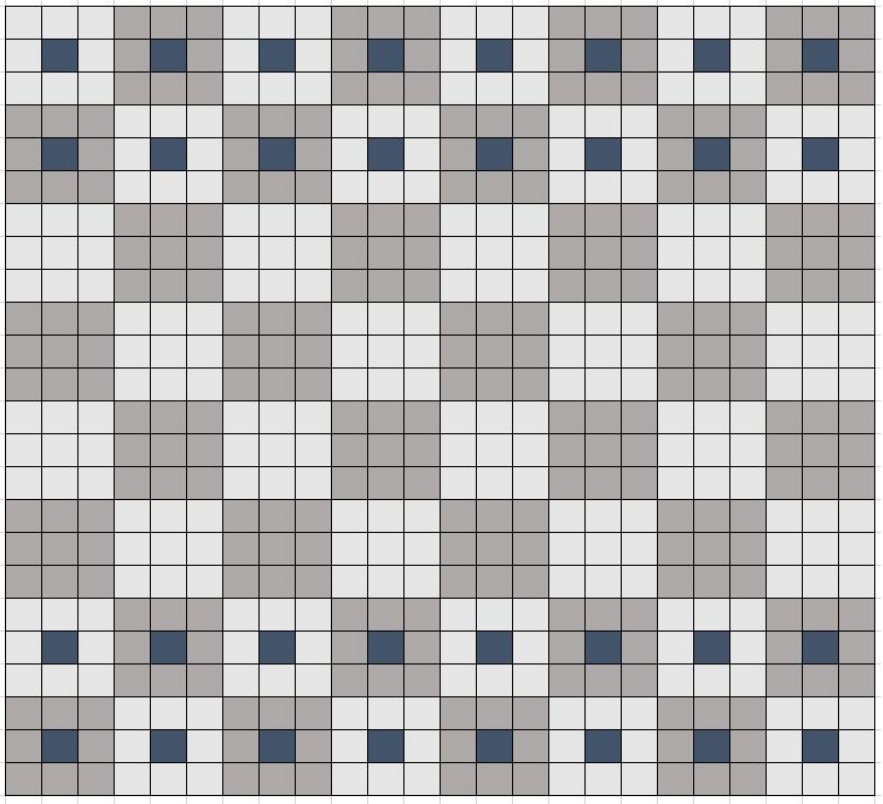
- RFID Antenna Multiplexing testing
- Multiplexing Analog Signals for Hall Sensor input
- Budget Manager

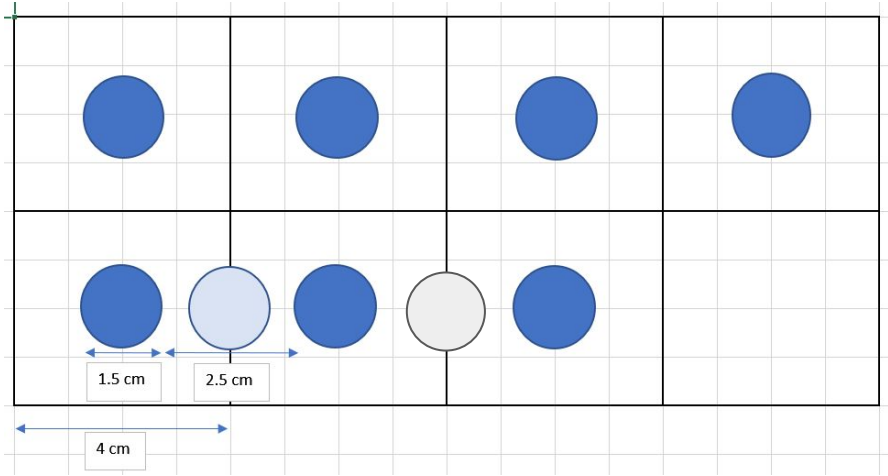
Sai

- Hall Sensor test w/ diff. Magnets
- RFID on system testing
- XY plotter (Gantry) assembly and test
- Team Coordinator

Gantt Chart										
Overarching category	**Task**	Team Member	Sept 21 - Sept 25	Sept 28 - Oct 2	Oct 5 - Oct 9	Oct 12 - Oct 16	Oct 19 - Oct 23	Oct 26 - Oct 30	Nov 2 - Nov 6	Nov 9 - Nov 13
Network/Server Interface	Lichess server + Raspberry Pi integration	Jack								
Display/Touch Interface	Touch GUI design and prototype for RPi display	Wei								
Network/Server Interface	Software interface between GUI and API	Jack,Wei								
Communication Protocol	Communication with RPi SPI, UART, I2C	Jack,Wei								
Path Planning	Path Planning Algorithm	Jack,Wei								
Sensing	RFID antenna multiplexing	Sam								
Sensing	Multiplexing Analog Signals for Hall Sensor input	Sam								
Sensing	Hall Sensor Test with Chess piece	Sai								
Sensing	RFID system test	Sai								
Gantry + Moving	Moving Gantry XY axis Assembly and test	Jack, Wei, Sai								
Moving	Electromagnet switch working	Jack, Wei, Sai								

Thanks for watching!!




1.5 cm
2.5 cm
4 cm