Team 10

MagiChess

Jack Deguglielmo, Samantha Klein, Weishan Li, Sai Thuta Kyaw

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.

Plan:

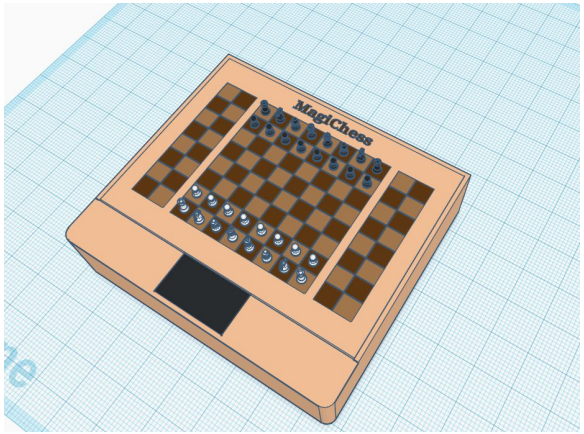
- Sense location of chess pieces on the board
- Interface with LiChess server
- Automate piece moving

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, tutorial
  - Game announcements
  - Highlights previous move
- Provide audio feedback
  - Notification alerts
- Play versus remote opponent
- Playback previous games
- Includes buffer zone to store captured pieces
- Topple the King after checkmate

Preliminary System Specifications (Quantitative)

- Total system dimensions: no larger than 32.5 in x 30 in x 8in (80 cm x 74 cm x 15 cm)
- Speed of XY plotter: 4-5 cm/s
  - Absolute maximum time taken for a move 25s
  - Move pieces under 10s more than half of the time
- Weight: Under 50lbs



CDR Deliverables

Vision statement for our working prototype

Our vision for the working prototype and progress for Magichess includes several key functionalities. We will integrate subsystems described in MDR (LiChess API conversation with physical movement of gantry). We will have a complete assembly and wood frame of our board as well as communication between Pi and (at least) two 328p working as intended.

Proposed CDR Deliverables

Key aspects of our prototype:

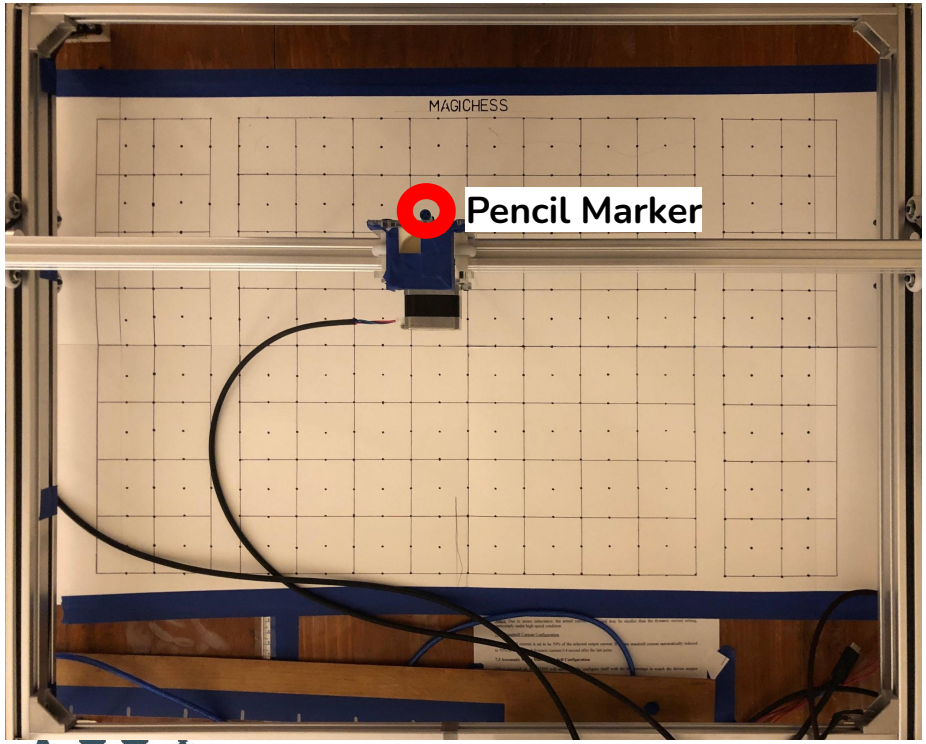
- Completed frame and mechanical assembly of the chessboard and gantry
- System able to detect Chess piece movement made by the user.
- System able to communicate with LiChess the movement made by the user.
- System able to move chess pieces around with Electromagnet and Gantry System with a reasonable success rate.
- Fully functional graphical user interface

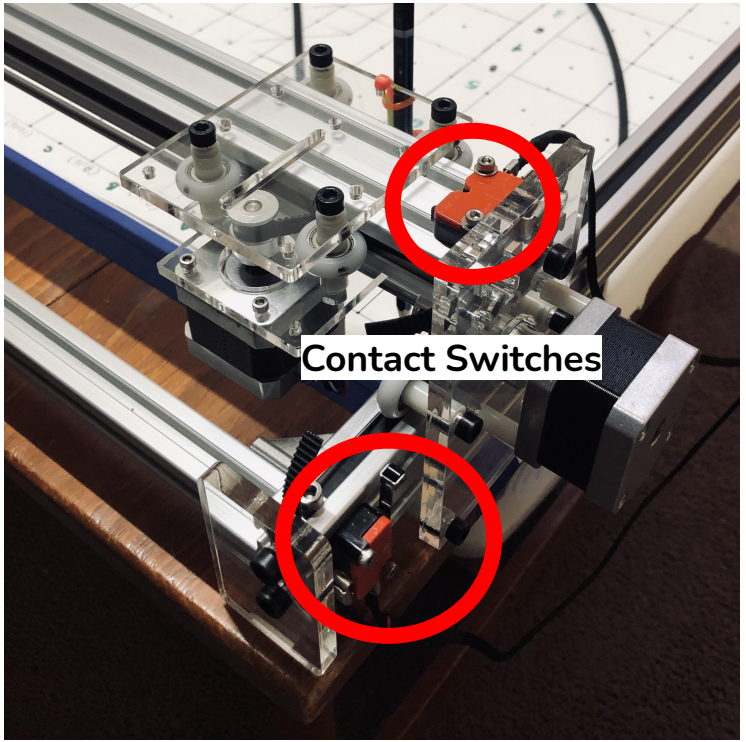
Current Prototype

Left: Soldiered Hall Sensors on Sensor PCB

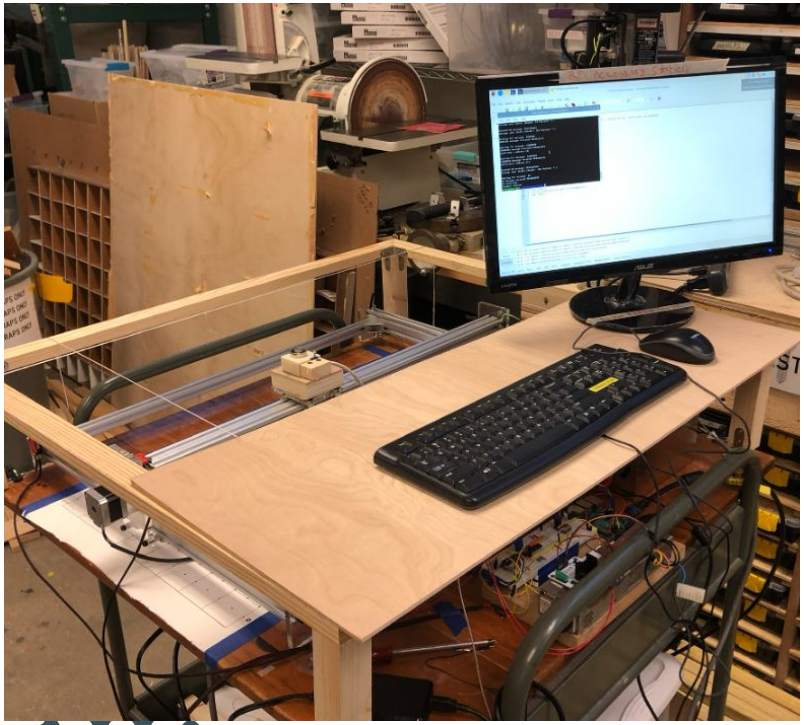
Right: Sensor PCBs setup and wiring. Breadboard Power Rails are used for wire connections only.

Previous Prototype



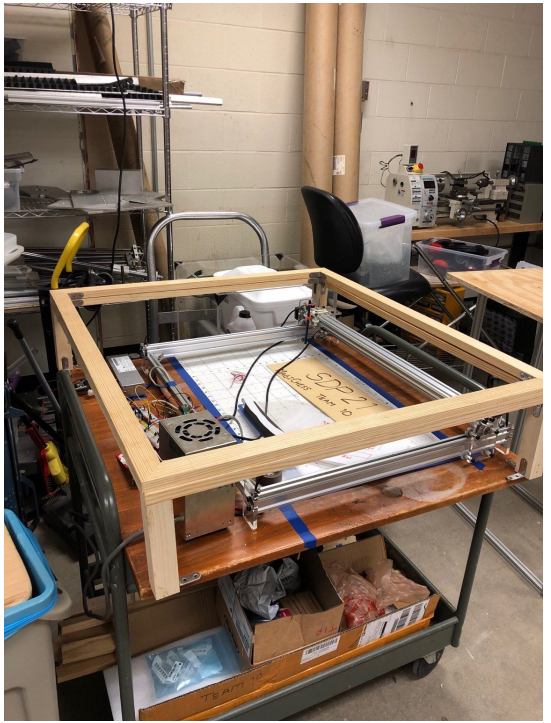


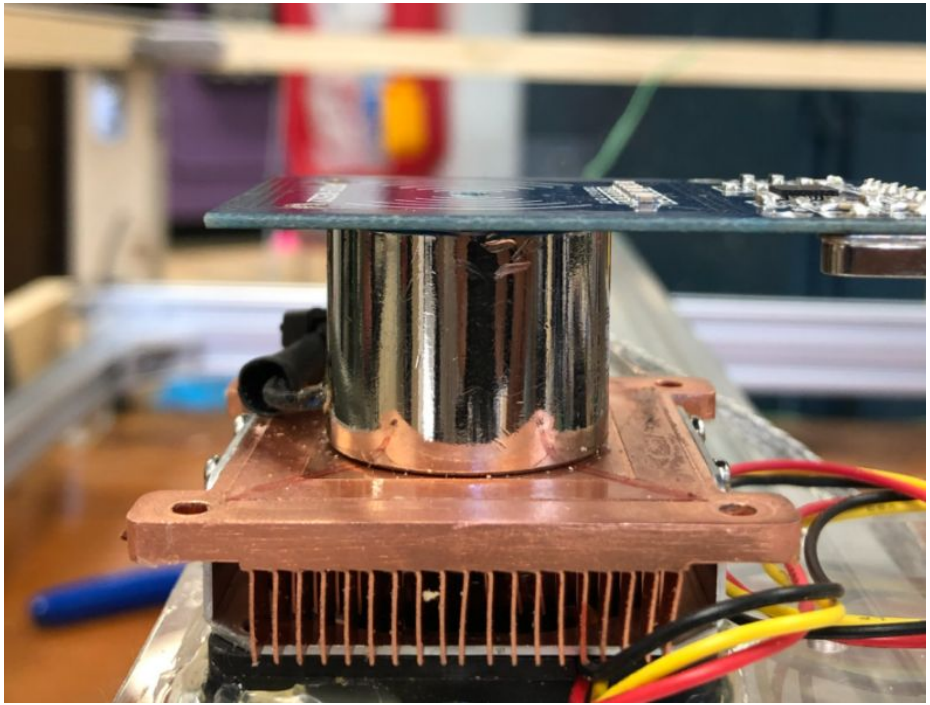
Current Prototype



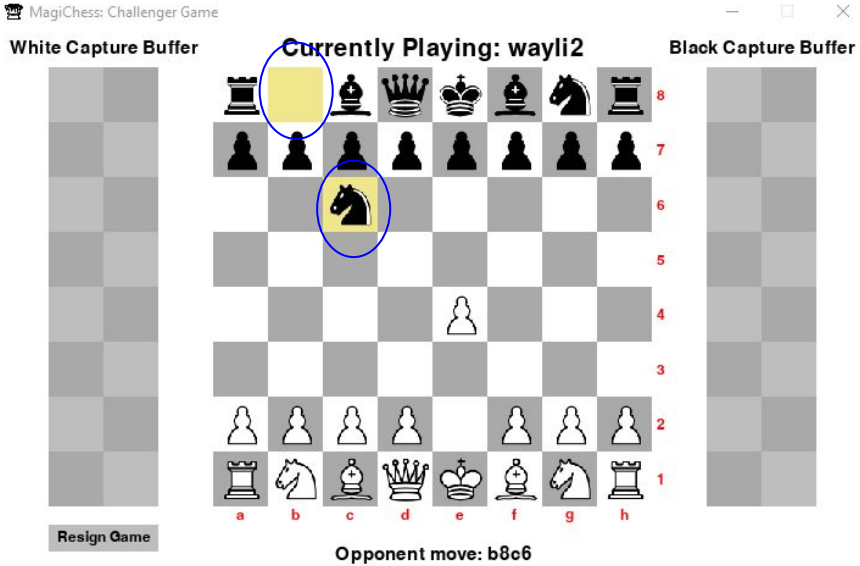
Left: MagiChess frame, electromagnet and monitors for testing

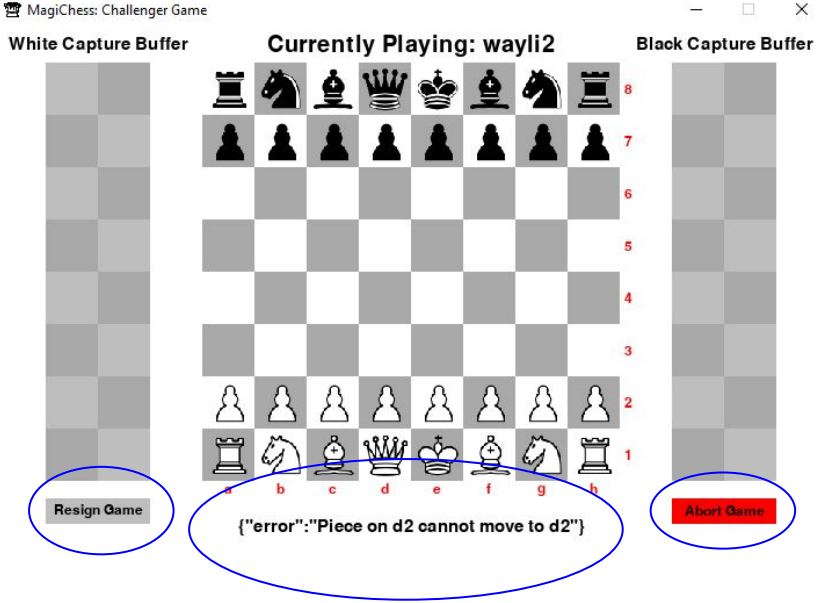
Right: MagiChess Frame and Gantry



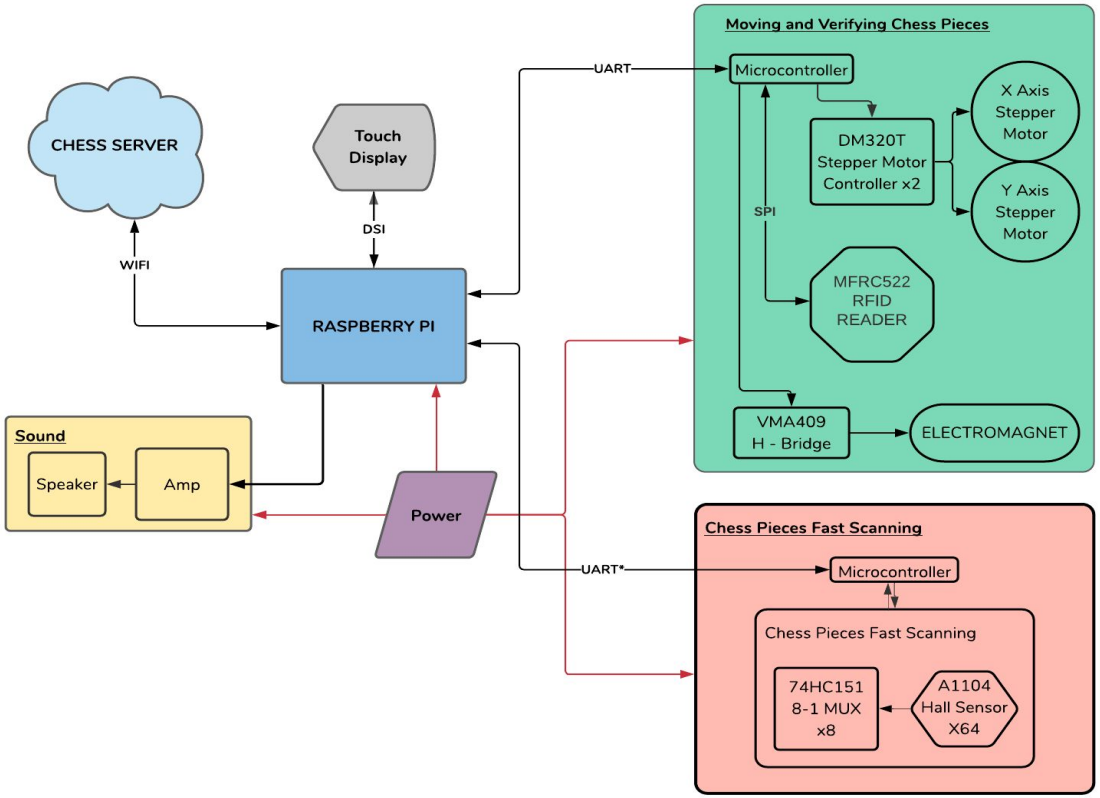


Quick GUI Updates

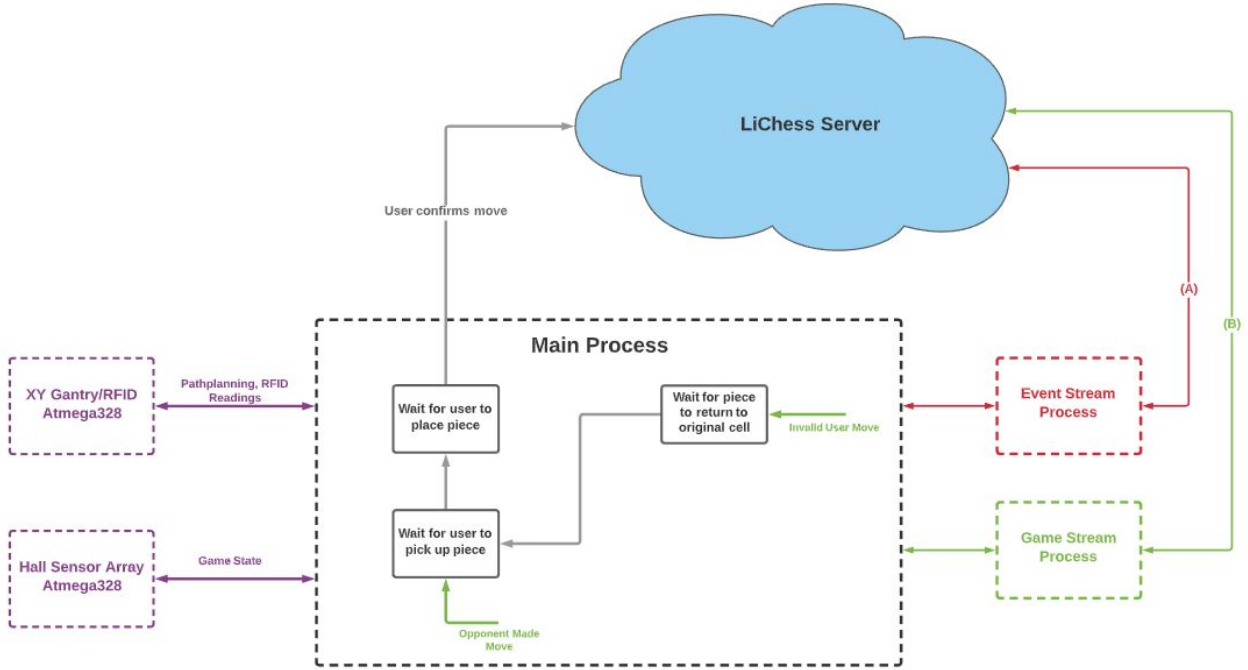




System Block Diagram



Software Diagram - Game State



(A) gameStart, challengeDeclined, ...

(B) gameState, chatLine, ...

Pi to Gantry Communication

UART Data Packet Description

8 bit UART Data Packet								
Bit	7	6	5	4	3	2	1	0
Data	**TYP2**	**TYP1**	**TYP0**	**DAT4**	**DAT3**	**DAT2**	**DAT1**	**DAT0**
Initial Value	X	X	X	X	X	X	X	X

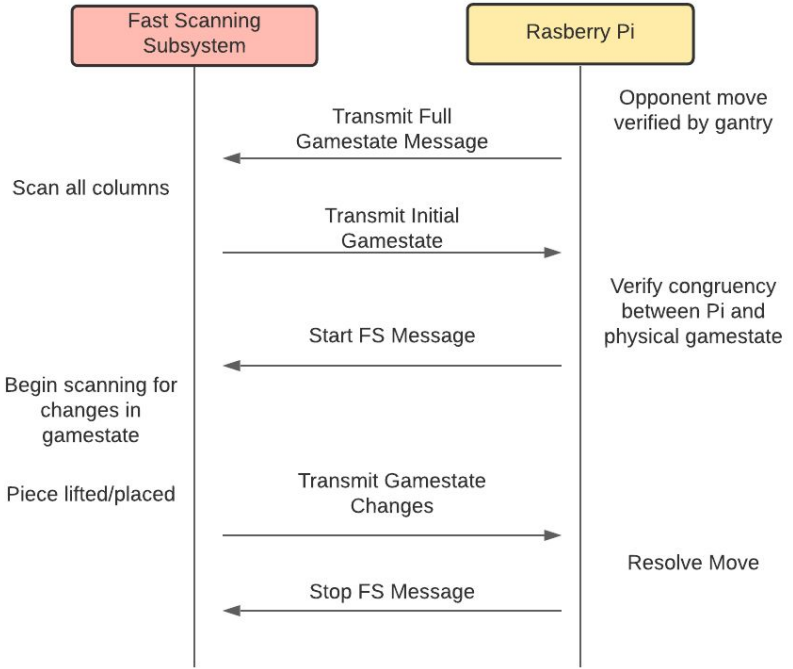
No.	TYP2	TYP1	TYP0	TYPE/CATEGORY
0	0	0	0	N/A
1	0	0	1	X - Axis Address
2	0	1	0	Y - Axis Address
3	0	1	1	RFID Value Return
4	1	0	0	ELECTROMAGNET CONTROL
5	1	0	1	GO
6	1	1	0	ARRIVED
7	1	1	1	ELSE

Link to Document

Pi to Fast Scanning Communication

Bit	7	6	5	4	3	2	1	0
BYTE0	**TYP4**	**TYP3**	**TYP2**	**TYP1**	**TYP0**	**COL2**	**COL1**	**COL0**

Bit	7	6	5	4	3	2	1	0
BYTE1	**DAT7**	**DAT6**	**DAT5**	**DAT4**	**DAT3**	**DAT2**	**DAT1**	**DAT0**



Demos for Integrated System

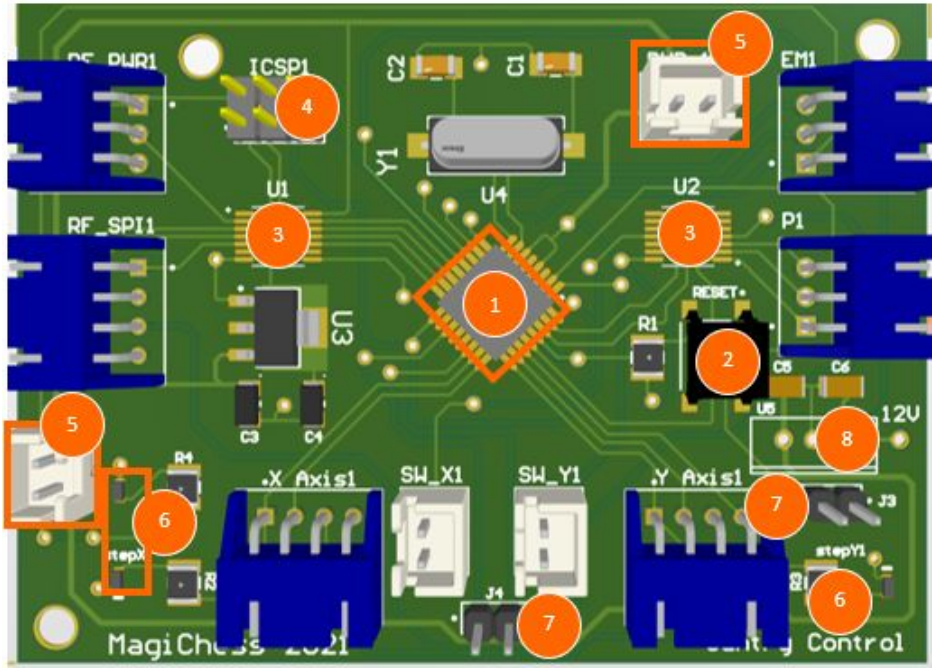
1. Raspberry Pi and Gantry Making Moves
    a. Initial Homing using Contact Switches
    b. Send Address and Go command

1. Raspberry Pi and Fast Scanning Hall Sensors Detecting movement.

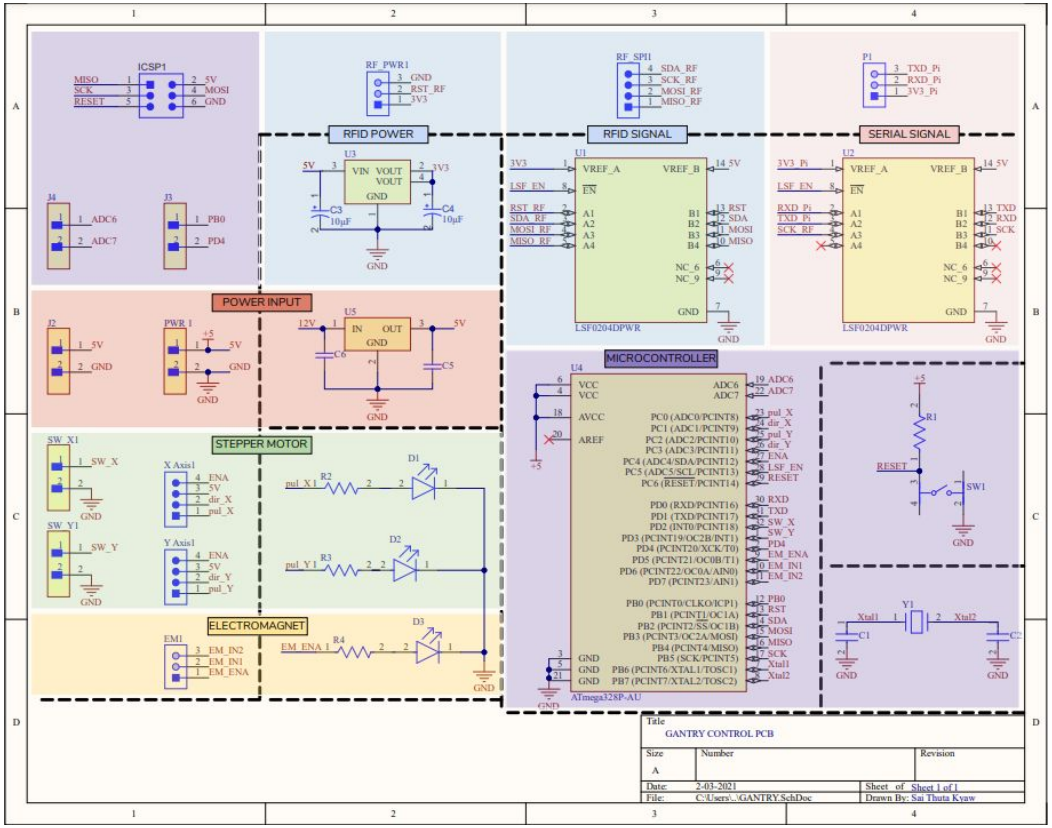
CDR Deliverables

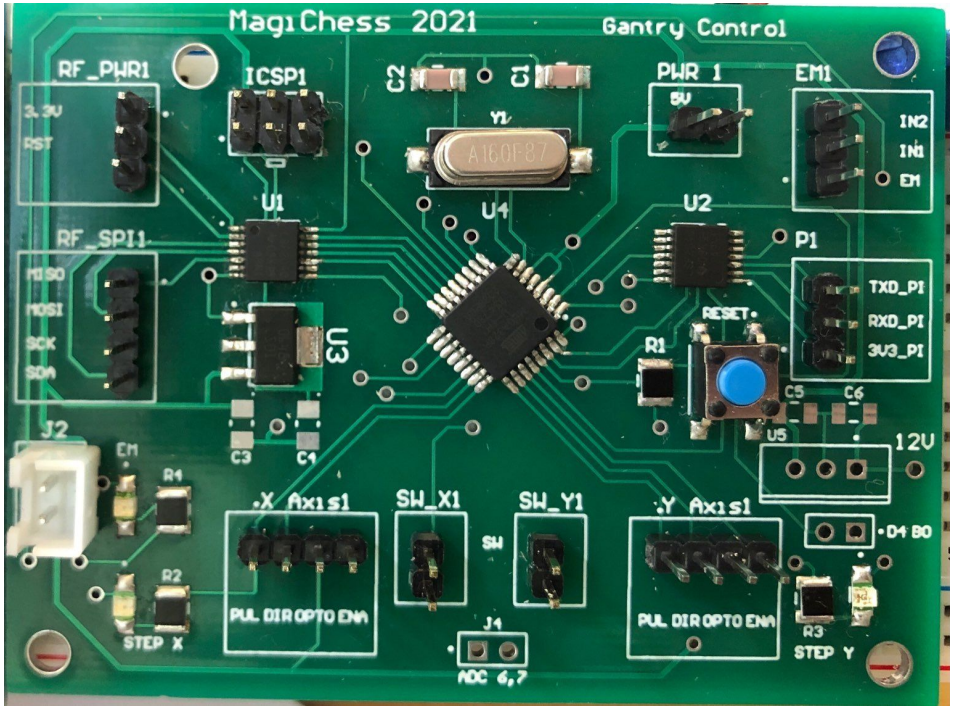
- ✓ System able to communicate with LiChess the movement made by the user.
- ❑ System able to detect chess piece movement made by the user
- ✓ System able to move chess pieces around with Electromagnet and Gantry System with a reasonable success rate.
- ✓ Fully functional graphical user interface
  - Audio Integrated
  - Optimized for touch display and added features
- Completed frame and mechanical assembly of the chessboard and gantry
  - Wooden frame as seen in the current prototype
  - Upgrading from wood to Aluminium and CAD frame model shown below

1. Gantry Control PCB

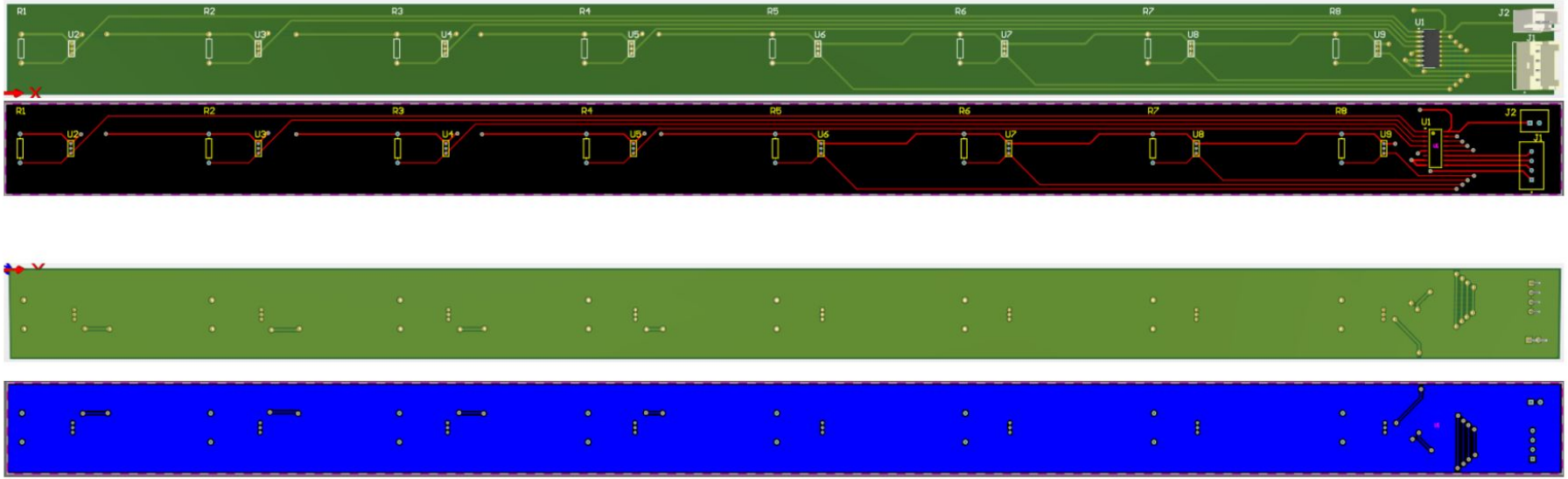


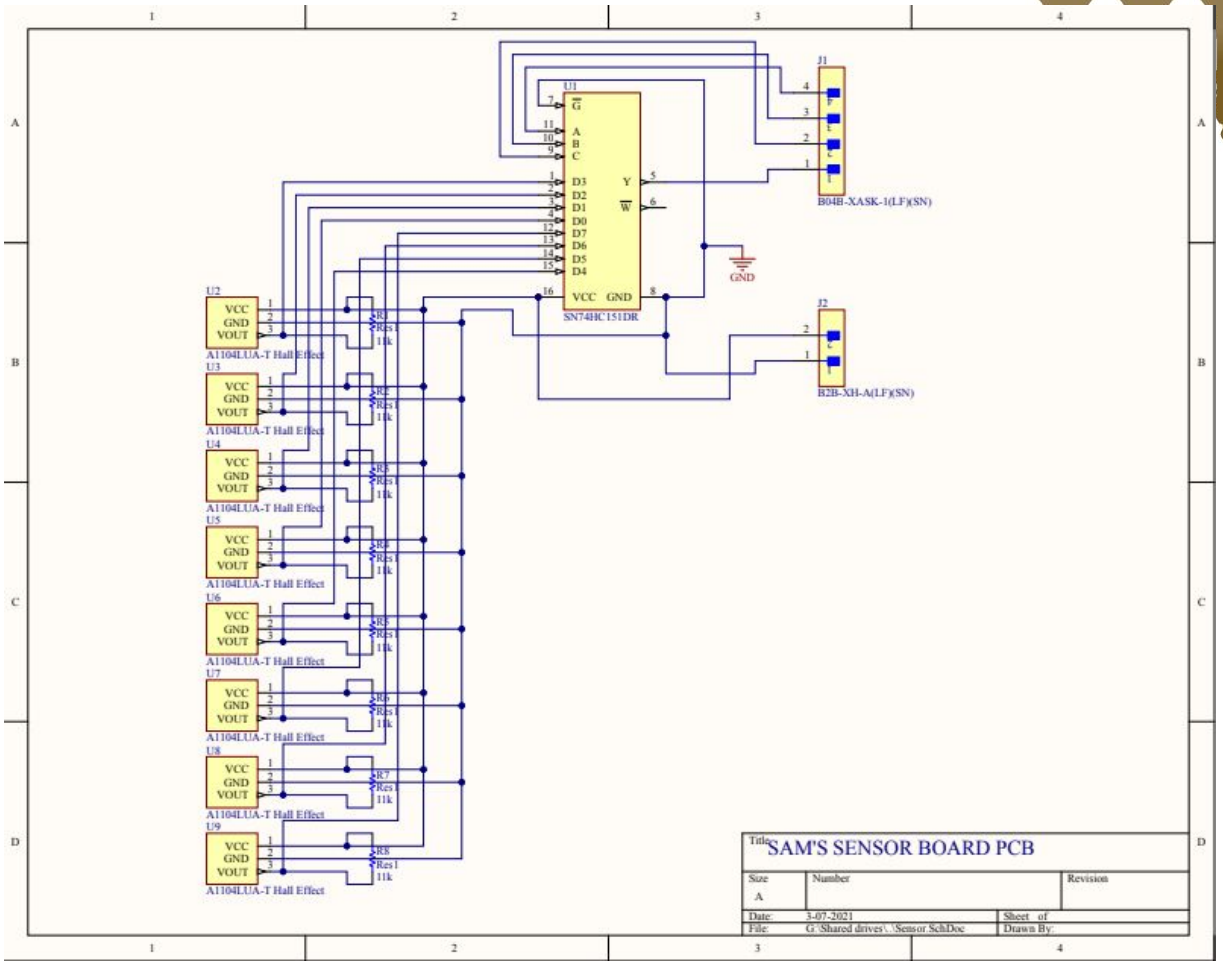
1. Microcontroller
2. Reset Button
3. Level Shifters
4. ICSP Port
5. Power Ports
6. Status LEDs + Resistors
7. Extra Ports
8. 12V Power Input


ICSP1
RF_PWR1
RF_SPI1
P1
RFID POWER
RFID SIGNAL
SERIAL SIGNAL
POWER INPUT
STEPPER MOTOR
ELECTROMAGNET
MICROCONTROLLER
U1
U2
U3
U4
U5
LSF0204DPWR
ATmega328P-AU
GANTRY CONTROL PCB
Date: 2-03-2021
File: C:\Users\..\GANTRY.SchDoc
Drawn By: Sai Thuta Kyaw

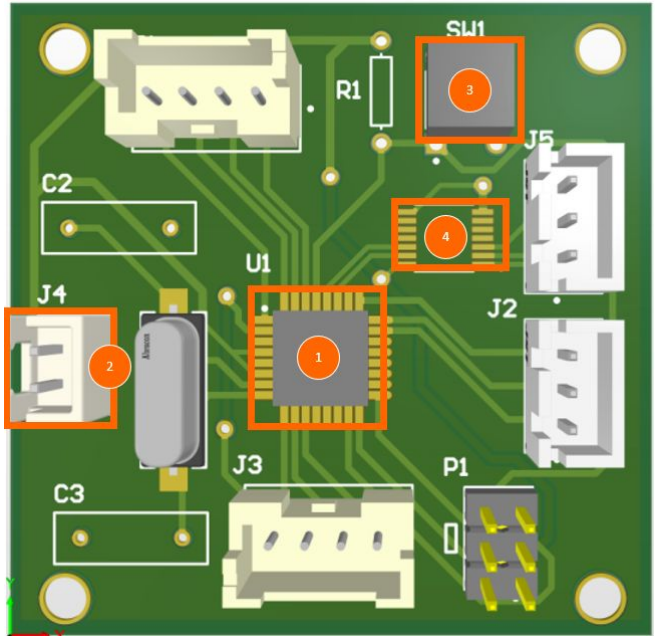

MagiChess 2021
Gantry Control
RF_PWR1
3.3V
RST
ICSP1
C2
C3
Y1
A160F87
PWR 1
5V
EM1
IN2
IN1
EM
U1
U4
U2
P1
RF_SPI1
MISO
MOSI
SCK
SDA
U3
TXD_PI
RXD_PI
3V3_PI
RESET
R1
C5
C6
U5
12V
J2
EM
R4
C3
C1
X Axis1
SW_X1
SW_Y1
Y Axis1
D4 80
SW
R2
PUL DIR OPTO ENA
PUL DIR OPTO ENA
R3
STEP X
STEP Y
J4
ADC 6,7

2. Sensor Board PCB

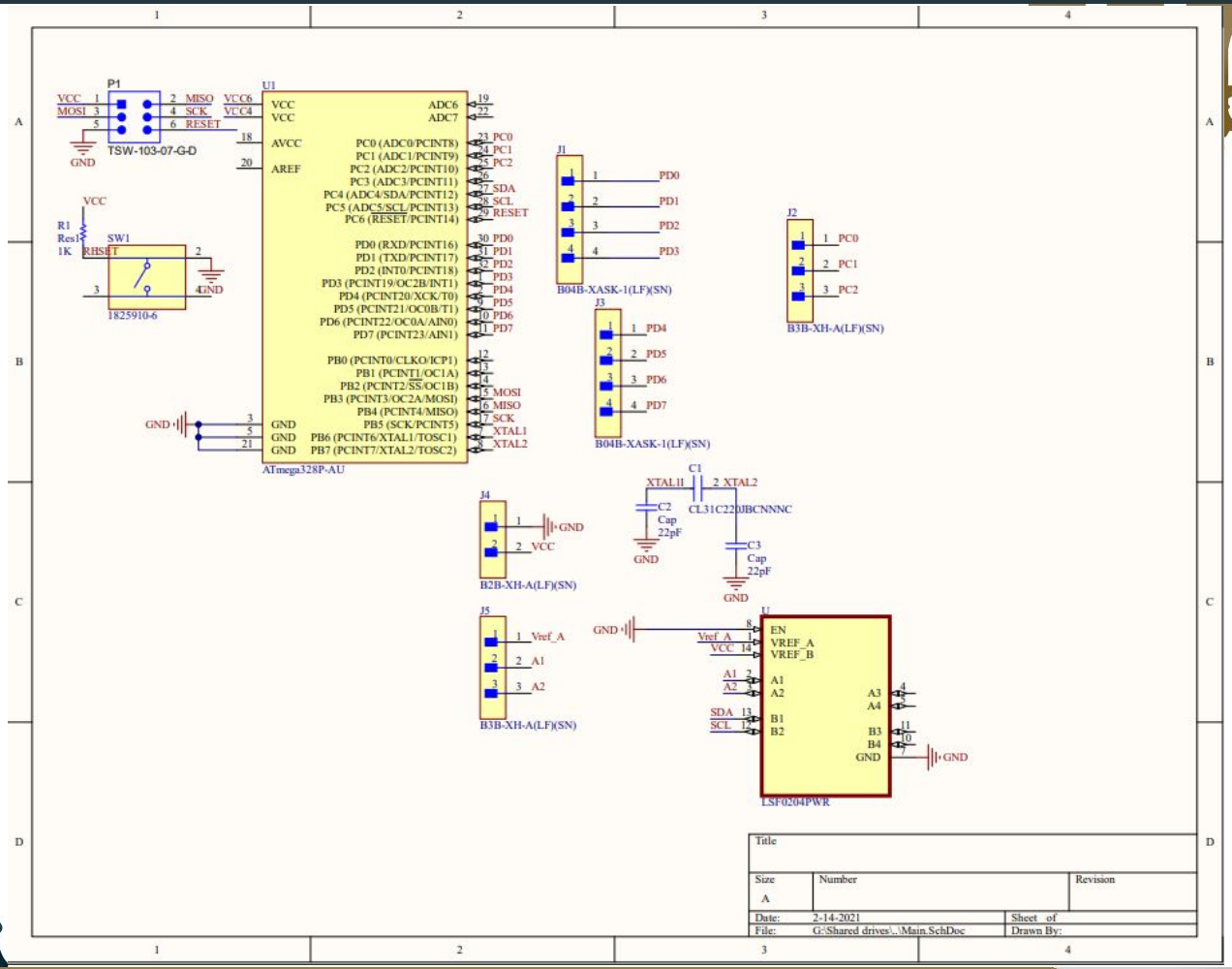



U1
SN74HC151DR
J1
B04B-XASK-1(LF)(SN)
J2
B2B-XH-A(LF)(SN)
GND
U2
U3
U4
U5
U6
U7
U8
U9
A1104LUA-T Hall Effect
R1
R2
R3
R4
R5
R6
R7
R8
Res1
11k
Title
SAM'S SENSOR BOARD PCB
Size
A
Number
Revision
Date: 3-07-2021
Sheet of
File: G:\Shared drives\...\Sensor.SchDoc
Drawn By:

3. Sensor Control PCB

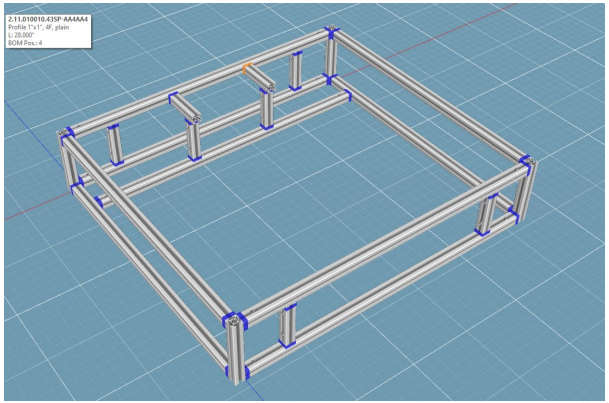


1. Microcontroller
2. Power Input
3. Reset Button
4. Level Shifter


P1
TSW-103-07-G-D
U1
ATmega328P-AU
SW1
1825910-6
R1
Res1
1K
RESET
J1
B04B-XASK-1(LF)(SN)
J2
B3B-XH-A(LF)(SN)
J3
B04B-XASK-1(LF)(SN)
J4
B2B-XH-A(LF)(SN)
J5
B3B-XH-A(LF)(SN)
C1
CL31C220JBCNNNC
C2
Cap
22pF
C3
Cap
22pF
U
LSF0204PWR
Title
Size
A
Number
Revision
Date: 2-14-2021
Sheet of
File: G:\Shared drives\...\Main.SchDoc
Drawn By:

FPR Plan

- Migrate from wood to aluminium extrusion frame with plywood + plexiglass sides.
- Finish frame assembly before 10th April
- 3D-Print Chess pieces with velvet bottoms and embedded magnet
- Migrate from header pins to JST connectors
- Order new PCB to minimize wiring sensor boards



Plans for Testing Prototype

- Stress test gantry with simulated game play for 4 hours
- Stress test hall sensors with real game play
- Play socially-distanced chess with strangers
- Test and record failures to perform root cause analysis

Testing timing

Pi saves the “distance” for average and max move for a typical game

Use mathematical modeling to calculate the timings

Plans for Hardening Prototype

- Retrying failed moves certain number of time
- Add option for User intervention to correct the physical gamestate
- Occasionally resetting the gantry
- Monitor thermals

Plans for FPR Demo

Play a game over the internet

Responsibilities post CDR

Jack

- Raspberry Pi interfaces with 328Ps
- Analysis of gantry move time
- Replay/resume/reset game
- Altium Lead

Weishan

- Refine and add features to GUI
- Improve and debug communication between Pi and 328p's
- Replayable Games

Sam

- Evaluate the use of other protocols over software UART
- Refine Fast Scanning
- Budget Manager

Sai

- Final Frame Assembly
- Testing and Hardening Movement
- Team Coordinator

Total Spendings Pre MDR

Items Purchased (Digikey)	Cost ($)
16QFN breakout board	12
P25/20 Electromagnet	9.95
13MHz NFC antenna (10)	12.32
Tariff for NFC antenna	1.23
32QFN Breakout board	5.95
AH3564 Hall Sensors (5)	3.58
Tariff for Hall Sensors	0.36
PE4244 RF switches (4)	4.8
TI7960 RFID reader 32QFN (3)	14.46
At88RF RFID tag (10)	8.6
AT88RF RFID reader (5)	9.85
USPS Shipping	4.99

Items Purchased (AliExpress)	Cost ($)
Gantry	162.34

Items Purchased (eBay)	Cost ($)
36QFN breakout board (5)	9.25
USPS Shipping	5.15

Total Spent	264.83
Remainding	235.17

Total Spending Pre CDR

Gantt Chart After CDR

Task	Team Member	Mar 28 - Apr 3	Apr 4 - Apr 10	Apr 11 - Apr 17	Apr 18 - Apr 24	Apr 25 - May 1
Bug Fix	Jack					
Training/Replay	Jack					
Bug Fix	Wei					
Training/Replay	Wei					
System Integration	Sam					
Bug Fix	Sam					
Final Frame Assembly	Sai					
System Integration	Sai					

External Links

Team Website

All Demo Videos Playlist

Github Repo

Thank You

Additional Slides

Resolving Moves from Hall Sensor Matrix

- How are we resolving moves?
  - Normal
    - Data received from initial state - 0b11000011
    - Data received from user move - 0b11000101
  - Capturing
  - Edge cases like castling/en passant

Determining User's Piece Promotion

- How do we determine which piece a user promotes to?

  Option 1: User input to select promotion piece + autonomously exchange pieces

  Option 2: User input to select promotion piece + prompt user to exchange pieces

  Option 3: Use RFID to identify the type of piece exchanged

Replay Games/Resume Game in Progress

- FPR

Move Time

- What are the components of move delay?

Transmission Delay of Move	Path Planning	Transmission Delay of Path	Gantry Movement (to start cell)	Electromagnet Charging	Gantry Movement (to dest cell)

Analysis/Plan for Assessing move time

- Update?