# Automated Smart Chess System

Trinity College
HARTFORD CONNECTICUT

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## Abstract

The goal of this project is to develop an automated smart chess system that allows a person to play chess against an AI on a physical chessboard. Via the integrated chess AI, the system is able to quickly decide its next move, and through analog Hall effect sensors, it checks for legal and illegal moves. In the event that a person makes an illegal move, this is communicated to the player through a 16-bit LCD. To physically pick up and move chess pieces for the AI to the desired locations without interfering with other pieces on the board, a robotic arm is to be used.

## Background

**Robotic Arm**

- Adopted from SCARA Robot Arm design by Dejan
- 4 Degrees of Freedom
- 3D printed Parts
- Max Length - 310 mm or 12.4 inches
- Programmable with Arduino

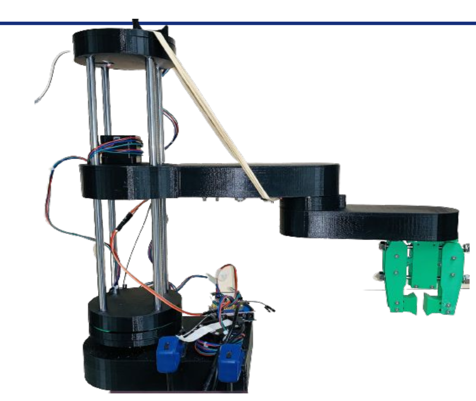


Fig. 1: Initial iteration of Robot arm with rubber band counterbalance

**AI Software: Stockfish**

- Open source chess engine library compatible with python
- Can set engine’s skill level
- Has its own version of the current game
- A move is validated by Python Chess library before passing it to Stockfish

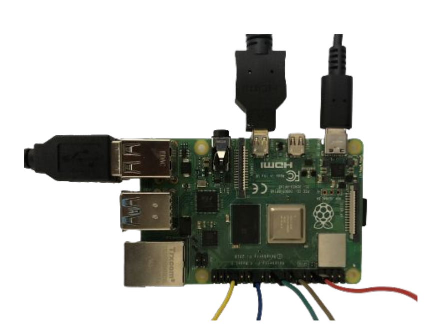


Fig. 2: Raspberry Pi 4B & connections

**Chessboard & Circuit Design**

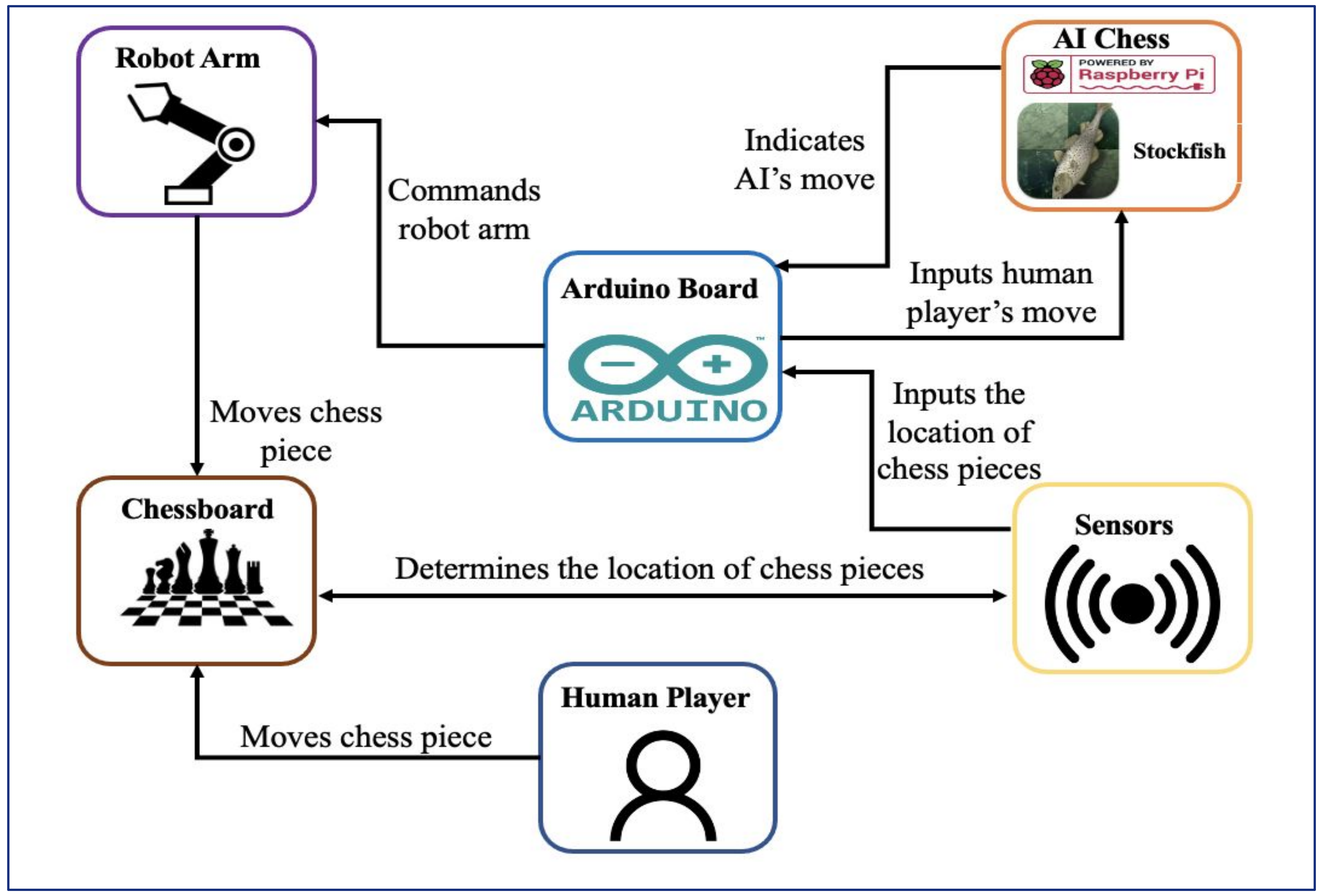
- Wooden chess board
- 8 x 8 - 1.25 inch cubic squares
- 64 Hall effect sensors in each square
  - Analog output: voltage reading
  - Detects polarity
  - Detects magnetic field strength

Fig. 3: Chess pieces with 3-D printed top and bottom additions

## Key Materials

- Raspberry Pi 4B
- Arduino Uno
- Analog Hall Effect Sensor
- Multiplexer
- Magnets (10 mm dia.)
- Nema 17 Stepper Motor
- 16x2 LCD with I2c
- Arduino CNC Shield
- Servo Motor
- A4988 Stepper Driver
- Limit Switch
- 12V DC Power Supply
- 3D Printer w/ PLA Filament
- Color-Coded Push-Buttons

## System Design




## Results

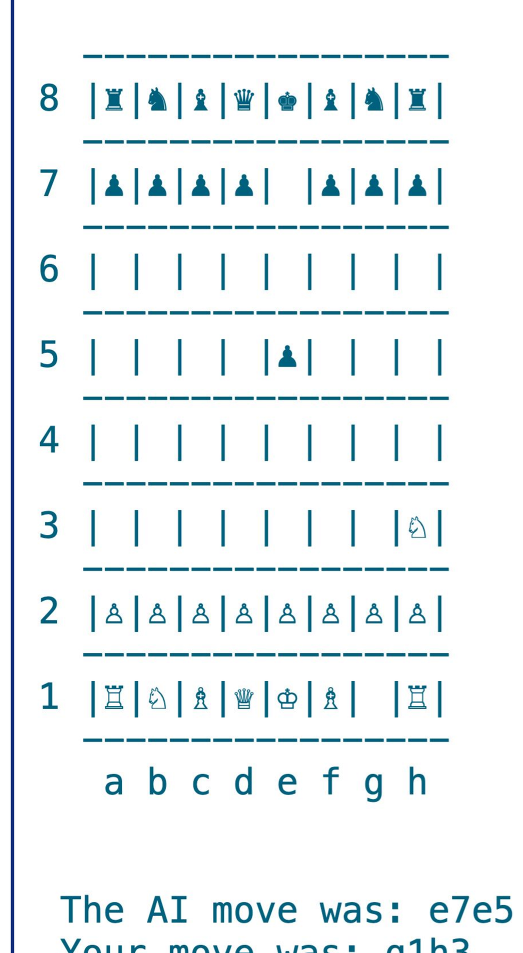



Fig. 4: Screenshot of Virtual chessboard screen indicating the player and the chess engine moves

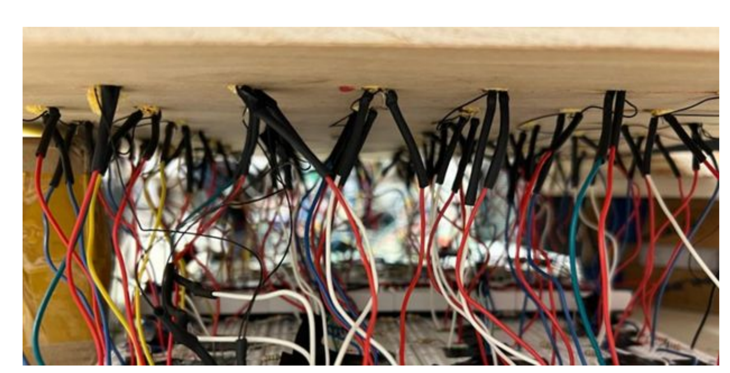


Fig. 5: Side view of the chessboard circuit using Hall effect sensors

The chessboard shown in Fig. 5 successfully takes analog voltage readings of all 64 sensors, distinguishes a white piece from a black piece, tracks any move made on the board, identifies a castling move, and identifies a capture move. This subsystem satisfies all the requirements for it to be functioning.

Fig. 6: Final prototype of Robot Arm

**Robot Arm limitations**

- Rigidity of the base joint, defined as the X-axis, does not allow for precise rotation due to the weight and friction.
- Arm operational at set acceleration rates less than 30 steps per second squared.
- At operating speed, time taken to capture a piece is about 4 minutes.

## Final Prototype

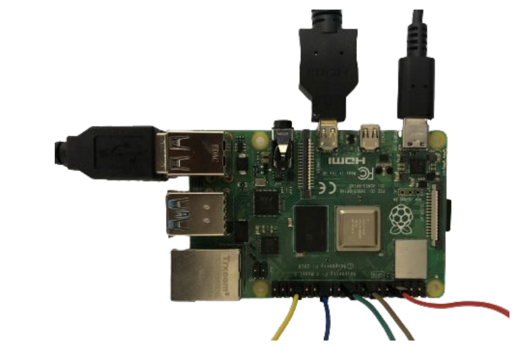


Fig. 7 : Raspberry Pi & Connections

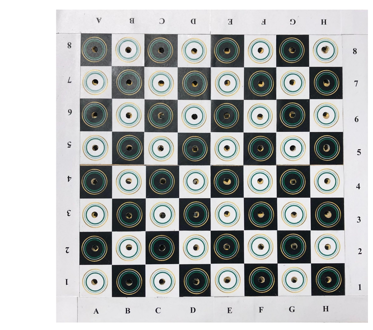


Fig. 8: Smart Chessboard with integrated sensors and circuit

The system consists of a chessboard where the circuit designed on a breadboard is connected, encapsulated, and paired with a user interface that is integrated on their side of the board for easy accessibility. There are 5 push-buttons and an LCD display for feedback. As for the opponent, the robotic arm is positioned on the opposite side of the chessboard.

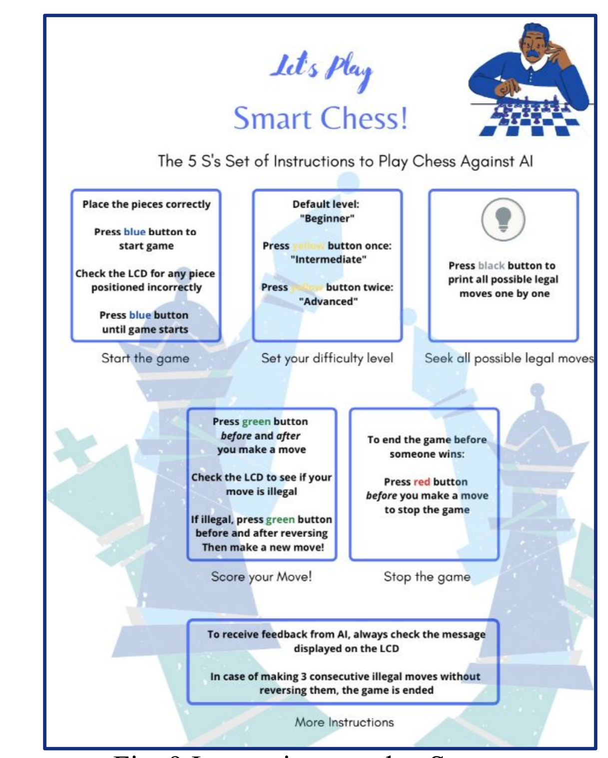



Fig. 9:Instructions to play Smart Chess

## Conclusions

The system was successful in detecting the chess pieces and moves, checking for legal/illegal moves, and in notifying a player when an illegal move has been made. Using the Hall effect sensors with the designed circuit in conjunction with an Arduino Uno to physically map the chessboard, and via serial communication between the Raspberry Pi and Arduino Uno, the system was able to play a complete physical game of chess against a human opponent. Although the robotic arm was not very precise in picking up chess pieces, it offers one of many future improvements to the system, which would allow the AI to physically make a move without human intervention.

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