Spring | 13

Automated Chessboard

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The purpose of this project is to have chessboard that can play against a person autonomously. A microcontroller interacts with the engineered chess surface and individual pieces, detecting human movements, moving the computer AI's pieces at the appropriate time, and determining capture and end-game conditions. A configuration application will allow capture and broadcast individual games and allow the board to be remotely reset.

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I. Problem Statement

Team Automated System of Chess, (TASC), with the objective of making a system that can play chess against a person autonomously for our client and adviser, Joseph Zambreno of the Department of Electrical and Computer Engineering at Iowa State University,. The board will be able to physically move pieces and also be able to detect when the user has moved a piece. The system is intended for display and demonstration purposes.

II. Functional Requirements

After discussion with our client, the following requirements are this projects functional requirements:

- Piece movement system must be unobservable by players and bystanders.
- Base must contain piece movement system such that the system can be revealed.
- Piece movement system must move fluidly, quickly and quietly.
- User interface must allow players to choose AI skill level.
- User interface must allow players to save and reset games.
- User interface must allow players to undo moves.

III. Non-Functional Requirements

After discussion with our client, the following requirements are this projects non-functional requirements:

- Base and pieces must not be overly large.
- User interface must be comparable to computer/game console chess games
- Pieces controlled by AI and piece movement system must move seemingly magically.

IV. Solution/Procedure Statement

In order to produce the automated chessboard we developed a three-part system. The system consists the individual chess piece identification, physical movement of the chess pieces, and the AI and interface to interact with the game. The steps to complete the systems are:

- Chess Piece ID:
    a) Power the chess pieces with inductive power transfer.
    b) Blink an IR LED at a frequency unique to the piece.
    c) Detect and interpret the IR signal.

- Physical Piece Movement:
    a) Develop a frame to provide XY movement for the chess pieces.
    b) Assemble a base to house the project.

- AI and Interface:
    a) Modify the Stockfish chess AI to control piece movement.
    b) Create a touch screen interface to set up and provide an overview of the game.
    c) Coordinate the movement of the chess pieces.

V. *Intended Use and Users*

The chessboard is intended for demonstration (FAN events, TLA users, VEISHEA attendees). The users will be students, faculty, and the general public.

VI. Assumptions and Limitations

Assumptions

- Piece movement method is not observable, but can be revealed at will.
- Players will not knock over chessboard / pieces.
- Players can start a new game.
- Players can choose the AI difficulty level.

Limitations

- Substantial mechanical design, no members have significant mechanical background

Procedure is undefined and has not been done before

VII. Risks

There are a few risks associated with this project.

- **Magnetic fields**
  Magnetic fields generated by the inductive power transmission circuit will interfere with the capacitive touch screen. This could cause the chess board to operate sporadically and not properly respond to user input. To mitigate this risk we can mount the screen in a metal enclosure to help shield it from magnetic interference.

- **Durability**
  The electronics in the chess pieces need to have a robust design, because they will be handled while the rest of the product will be contained or stationary.

VIII. Deliverables

- **Chess Board**
  - A 2’ x 2’ metal enclosure that contains the electronics that control chess piece movement and player interface (servo, stepper motors, motor controllers, LCD screen).
- **Chess Pieces**
  - Hollow plastic chess pieces housing a microcontroller, IR LED, power receiver circuit.
- **Chess Piece Movement System**
  - System that includes the motherboard which is connected to a microcontroller through a UART interface for servo and stepper motor control. It also includes motor controllers to provide current and signals required by the stepper motors.
- **Chess Piece Identification System**
  - System that includes the motherboard connected to a microcontroller that reads the identification signal from each piece using IR detectors.

- **Chess Piece Power Circuit**
    - LC oscillator circuit that sends a 1 MHz signal to the chess pieces to provide power through inductive power transfer.

- **Chess Playing Interface**
    - Touch LCD screen for intuitive game controls.

IX. Proposed Approach

- Provide power to the chess pieces through inductive power transfer
    - This power will be used to power a microcontroller that will blink an IR LED at a unique frequency so that the piece can be identified.

- Detect the pieces with an IR detector in every possibly location for the pieces on the board.
    - Use a microcontroller and multiplexers to scan every spot on the board to detect where each piece is.

- Use the Stockfish chess AI engine to compute the computers next move
    - The Stockfish chess AI engine is fairly resource intensive so a relatively powerful microcontroller (Raspberry Pi) or maybe even an x86 based computer will have to be used to run the chess AI engine in a reasonable amount of time.

- Move the chess pieces via a magnet
    - Use a magnet attached to an XY movement system moved by stepper motors and servos.
    - This system will either have its own microcontroller to control the details of the movement or will also be controlled with the same microcontroller used in the piece detection system.

X. Project Tracking Procedures

- We will have weekly group meetings on Saturday to see what has been accomplished on the project in the previous week and to plan what to do in the following week.
- We will have bi-weekly meetings with our advisor to keep him updated on the state of the project and to make sure the product is meeting his expectations.
- We will post weekly reports to help track the progress of the project and to help keep our advisors and mentors informed on the status of the project.

XI. Statement of Work

[To be formulated after the project has been completed or nearly completed]

XII. Estimated Resource Requirement

- < $1000
- 2x Stepper Motors
- 1x Servo
- 2x2 Plywood

- 4x of 2ft. segments of 1x6 plywood
- 4x 3/8" diameter smooth steel rods
- 2x ¼" diameter #20 threaded rods
- 6x #20 Threaded nuts
- 32 ATTiny9 microcontrollers
- 32x IR LED's
- 96x IR Detectors
- Raspberry Pi? (Possibly a more powerful microcontroller to run the chess AI engine)
- 100' 16 gauge wire
- IR transparent Plexiglas
- Steel ribbon
- Chess pieces (3D printed?)
- 200' magnetic wrapping wire

XIII. Project Timeline

Completed by end of:

- February – Power transfer research
- March – Power transfer prototype
- April – User Interface
- May – Prototype
- September – Chess piece fabrication
- October – Testing
- November – Final product

XIV. Faculty Adviser
Joseph Zambreno
Department of Electrical and Computer Engineering
Iowa State University

V. Team Members
Matt Dresser
Electrical Engineer, Co-Team Leader
Power transfer circuit, chess piece fabrication

Jordan Jacobson
Computer Engineer
LCD screen

Riley Swindell
Computer Engineer, Web Master
Website, User Interface

Allison Thongvanh
Electrical Engineer, Communications Liaison
Base and chess piece movement design

Blake Vermeer
Electrical Engineer, Co-Team Leader
Base and chess piece movement design, power transfer circuit, and piece detection system