CHESS PLAYING ROBOT PROJECT PROPOSAL

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Summary

This project involves the design and construction of a 3D printed robotic arm that can play chess against a human opponent. The robot can analyse the board, move chess pieces and remove them when they have been eliminated. An iris diaphragm gripper will be used to pick up the cylindrical chess pieces and a webcam will be used to detect the position of each piece. The arm, all electronic components and chess AI will be expected to be completed by semester 1. The computer vision component and any additional features such as automatic resetting of the board and LED displays will be expected to be completed by mid-semester 2. The projected cost for all components will be $100-$150.

Design Ideas

Robotic Arm

The robotic arm will be used to move the chess pieces on the board. A basic template can be seen in figure 1. One servo will be used to allow the arm to rotate on its vertical axis while the other three will be used to extend the arm and orient the gripper. The arm will need to be able to reach all squares of a traditional chess board and will be made of 3D printed plastic. If the plastic cannot hold the arm up, sheet metal or acrylic can be used as a substitute. A custom-built power circuit will be constructed to supply enough current to the servo from a 12V DC power adapter. An Arduino Uno will handle the servo control signals, piece detection and chess AI.

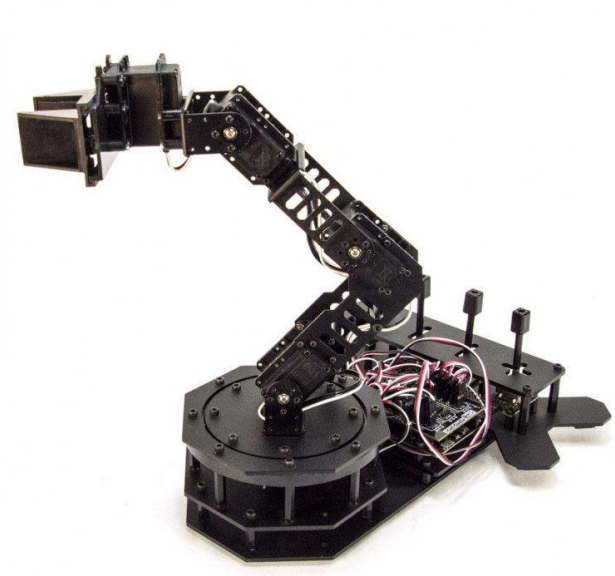

Figure 1. Template for robotic arm design

Source: https://i.all3dp.com/wp-content/uploads/2018/07/26142427/180702-772x772.jpg

Gripper

As most of the chess pieces are cylindrical in shape, a traditional pronged grabber will have difficulty picking up pieces. We can use an iris diaphragm design (figure 2) which can grip the cylindrical chess piece on all sides at once. Another possible gripper design would be to use a small electromagnet; however, the pieces will have to be custom made to ensure proper orientation when it is picked up and released.

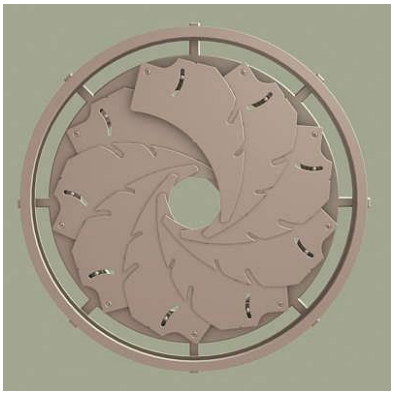

Figure 2. Proposed iris diaphragm design

Source: https://cdn.instructables.com/FI2/X6FI/FIJ3Y8S1/FI2X6FIFIJ3Y8S1.LARGE.jpg

Chess Piece Detection

We can use a webcam to capture images of the board and use computer vision and edge detection to detect each different piece. To make it easier for the computer we can also colour code the top of each piece a different colour. Since the board is stationary, we can mount the camera at a fixed distance above the board. We can then manually allocate pixels to each individual chessboard square, search these regions for a colour and match the colour to a chess piece in a look up table. The goal is to keep the board as traditional as possible so colour coding will only be used if the computer cannot detect the pieces unaided.W

Chess AI

Many chess AI tutorials are available online (e.g. https://medium.freecodecamp.org/simple-chess-ai-step-by-step-1d55a9266977). The piece detection algorithm can feed the state of the board to the chess AI which will determine the optimal move. The chess board has its own coordinate system (A1, A2, A3…) so we can translate the move from chessboard coordinates into points in 3D space for the arm.

Final Assembly

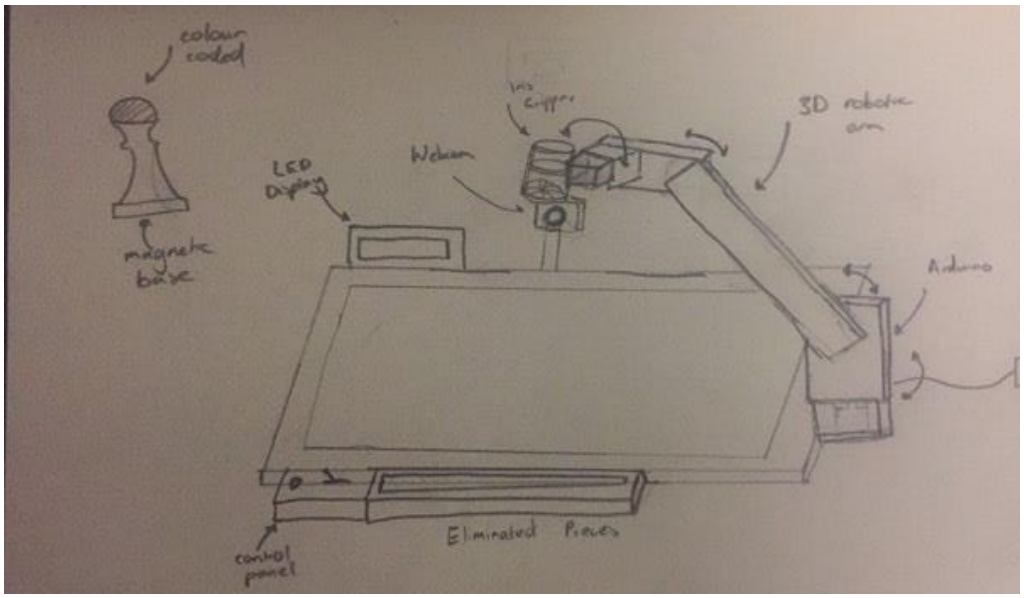

Figure 3. Sketch of final assembly

Timeline

Semester 1

Week	Task to be completed
2	Finalise a robot arm design, order servos, begin modelling parts
3	Modelling arm.
4	Modelling arm. Print parts.
5	Adjust design and reprint if necessary. Finish power module for servos.
6	Adjust design and reprint if necessary. Make sure all electronics are working.
7	Model gripper, print and attach to arm.
8	Program arm to move to a point in 3D space.
9	Program arm to move to each square on the chessboard.
10	Program arm to pick up pieces, move and release.
11	Code Chess AI
12	Add different difficulties to Chess AI

Mid-Year Break: By mid-year break, it is expected that the arm be completed and be able to move and release pieces properly. If not done, the entirety of the break will be working on the arm so that we can focus on coding piece detection and testing in semester 2. If the arm is working, begin work on computer vision section of the project.

Semester 2

Week	Task to be completed
1	Work on computer vision algorithm
2	Computer vision algorithm
3	Computer vision algorithm
4	Add additional features such as a start game button, switch to determine if the robot starts first, indicators, speed chess…etc
5	Assemble final product
6	Testing and revising
7	Testing
8	Testing
9	Work on project documentation
10	Work on project documentation
11	Spark Night

Projected Costs

Part	Expected Cost
Arm servos (15kg/cm torque) x4	~$30-35
Arduino Uno	$10
Breadboard, Resistors, Transistors…etc	$10
Gripper servo	$3
Webcam	$15
3D printed parts	$10-15
Chessboard and pieces	$30
Total Cost	**$118**