ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

Chess Express: The Voice-Controlled Moving Chessboard

Team #67

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1 Introduction

1.1 Objective

There are many people who would like to play chess with their friends and family around the world. Currently, one can do this on the web, but unfortunately looking at a screen and using finicky online chess interfaces isn't ideal for many chess players. This particularly hinders the elderly or those with disabilities.

We propose "Chess Express", a voice-controlled, automatically moving chess board. This product would still have the look like a traditional chess board, but be able to be controlled using voice commands, with the pieces automatically moving to reflect the state of the board. This board has WiFi capabilities, so that users can play against any other user in the world, provided that both have an internet connection.

We hope that this product will bring about increased connectivity to the chess community. In particular, we envision "Chess Express" to be able to connect friends across continents as they play games of chess with each other.

1.2 Background

"Chess Express" was initially inspired by *Wizard's Chess*, from *Harry Potter and the Sorcerer's Stone*. In the book and film of the same name, Harry Potter and his best friend, Ron Weasley, play a chess game in which the pieces respond to voice commands, and violently destroy the pieces they are capturing. While our pieces will not destroy others, we were inspired by the hands-free chess game that still had physical, moving pieces.

The project will utilize the attraction between metal feet on the bottom of chess pieces and an electromagnet below the board in order create piece movement. To move the electromagnet, we will use an X-Y plotter, set up with belts and stepper motors, to accurately move the electromagnet directly below the target piece and drag it to its new location.

Speech commands will be implemented through a microphone and speech-processing software on the microprocessor. We will utilize cloud-based speech processing services in order to parse the user's commands. By using proven, cloud-based services from reputable companies, we can better ensure that the user's command is heard correctly.

1.3 High Level Requirements

- Chess Express must be able to accept voice commands consisting of the specific pattern "D2 to D4", in a quiet room with minimal background noise.
- The piece movement system must consistently move the targeted piece to the target destination, without affecting nearby pieces along the path.
- Chess Express must prevent illegal chess moves as well as implement the full chess rule set, allowing for advanced moves such as castling and the "En Passant".

2 Design

2.1 Block Diagram

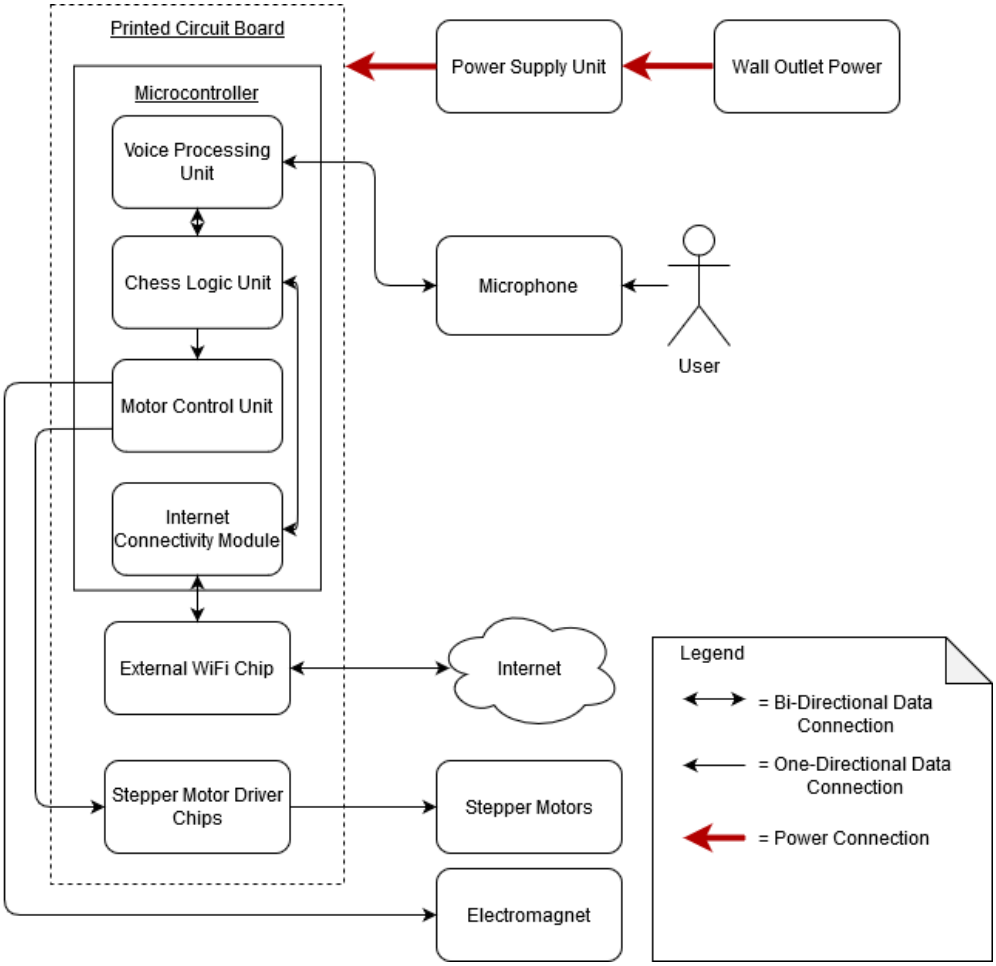

Figure 1: Block Diagram of Chess Express

Figure 1 shows the proposed block diagram for Chess Express. In particular, the components on the Printed Circuit Board (PCB) are grouped together. In general, the user will interface with Chess Express through voice commands through the microphone, which the microprocessor will then turn into software commands to the stepper motors and electromagnet through the Motor Control Unit.

2.2 Physical Design

The physical design of Chess Express uses a system of 3 stepper motors, belts, and tracks to move the electromagnet within an X-Y coordinate system. Each square on the chess board is 2.5 inches wide, creating a total board area of 20×20 inches. Since the X-Y plotter system has to extend beyond the entire board area, the size of entire product is 24×28 inches.

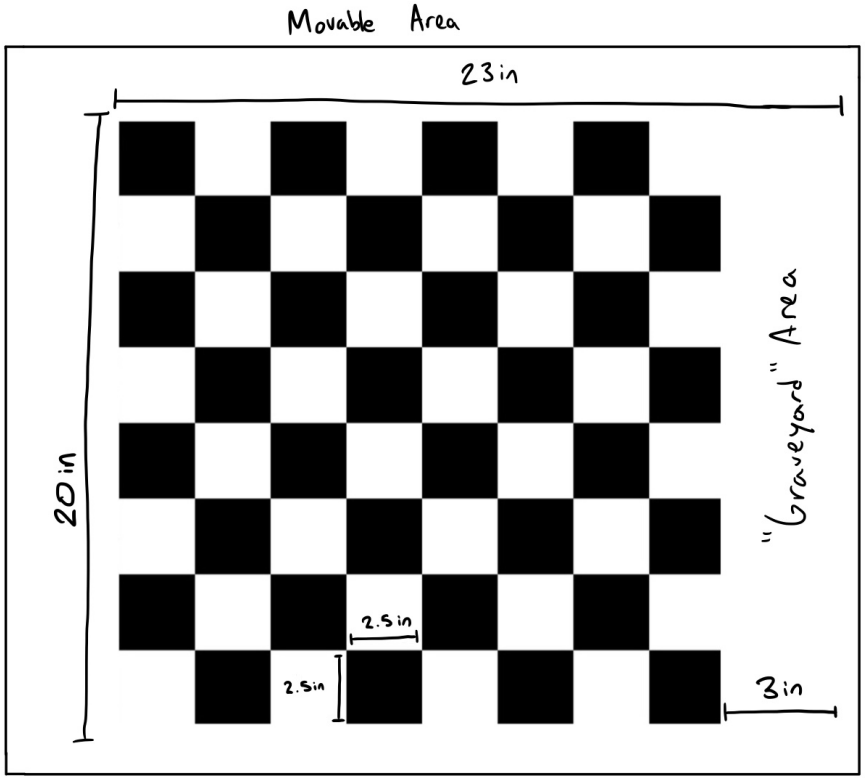

Figure 2: Dimensions of the Chess Board Area

2.3 Power Supply Unit

The Power Supply Unit (PSU) provides power to the PCB as well as all the peripheral devices (microphone, motors, electromagnet, etc.) The input to the PSU is 110V AC, as we plan to have Chess Express be plugged into a standard wall outlet.

Requirement: This PSU must be able to provide $2.5A$ *at* $12V$ *DC continuously to the system.*

2.4 Motor Control Unit

The Motor Control Unit (MCU) controls the movement of the electromagnet below the board. Two sets of motors enable the movement of the electromagnet. One set of two stepper motors allows for movement in the X direction, while another single stepper motor controls movement in the Y direction. The MCU will also control the powering of the electromagnet. Figure 3 shows a diagram of this system. The two parallel tracks in black move the red track along the X axis, while the red track moves the electromagnet to the correct Y position.

Requirement 1: The MCU must be able to move the electromagnet to the inputted location within 10 seconds from any initial position.

Requirement 2: The MCU must have a mechanism to re-calibrate the location of the motors, should external factors affect the motors' locations.

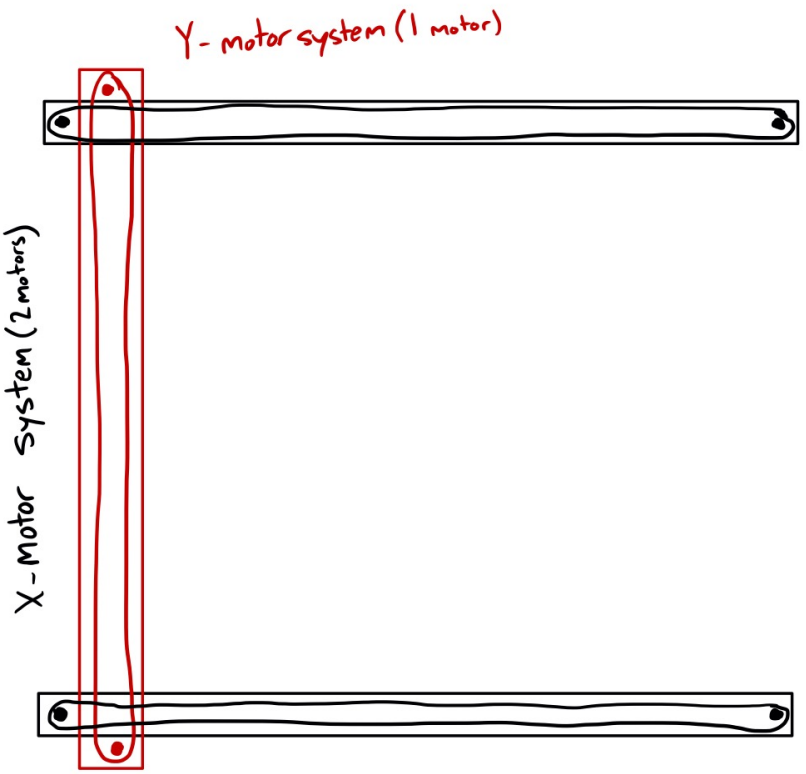

Figure 3: Diagram of Motor X-Y Plotter System

2.5 Voice Processing Unit

The Voice Processing Unit (VPU) takes input from a microphone and uses speech processing software to parse the user's command into specific chess piece movements. The chess logic unit would then use use that command as input and relay to the user whether their intended move is accepted.

Requirement: The VPU must be able to accurately parse voice commands of the pattern "D2 to D4", in a quiet room with minimal background noise in accordance with our High Level Requirements.

2.6 Internet Connectivity Unit

The Internet Connectivity Unit (ICU) consists of the ESP-32 WiFi chip as well as software on the microcontroller in order to interface with that chip. The Internet Connectivity Unit will allow Chess Express to communicate with other Chess Express boards over the internet to enable online play.

Requirement 1: The ICU must use a WiFi chip that can communicate over IEEE 802.11 b/g/n.

Requirement 2: The ICU must use a WiFi chip that is able to communicate with the microprocessor over both SPI and UART.

2.7 Chess Logic Unit

The Chess Logic Unit (CLU) is the primary processing unit for Chess Express. It takes, as inputs, some chess board piece movements and processes them in the context of a game of chess, relaying back to the user whether the move is legal and accepted or otherwise. The CLU also would handle the starting of games as well as the ending of games, and be able to recognize checks and checkmates.

Requirement 1: The CLU must be able prevent illegal moves as specified by the chess rule set.

Requirement 2: The CLU must correctly relay a series of movement commands to the MCU in order to accurately perform the requested chess move, given that it is legal.

2.8 Risk Analysis

The VPU presents the greatest risk to the successful completion of this project. The main issue is the complexity of the software behind this subsystem. The process of parsing through a stream of audio data is complex. Incorrect processing can result in the wrong commands being read from the user, which would then corrupt the game currently being played. The requirements for the VPU to work are relatively simple, so that the audio processing can be designed to fulfill a specific purpose, which may eliminate the risk of wrong commands resulting in illegal or wrong moves.

Another potential issue with the VPU is the presence of loud background noise. In the event that the game is being played in an environment like a crowded room, the speech in the background can be picked up as inputs which may cause the user's inputs to be corrupted. Some mitigating elements can be made to eliminate more ambient noise, like filters in either the circuit design or the software, but a much louder noise may result in errors that ruin the functionality of the device.

In order to achieve the desired functionality for this project, these major potential issues with the VPU must be solved in order to create a seamless user experience.

3 Ethics and Safety

3.1 Ethics

Due to the use of speech as an input in the project, users may be concerned with the privacy implications of storing their speech data on cloud servers. While Chess Express will not store any of the speech data, since we will be utilizing cloud-based speech-processing companies, there is the possibility of speech data being stored by our third-party partners. The exact details of the data collection will be disclosed to users in a clear and concise manner.

Additionally, we plan to make both the software and hardware design of Chess Express open-source, such that the public may benefit from the design knowledge gained throughout this project, as well as accept criticism and suggestions of our technical work, in accordance with points 5 and 7 of the IEEE Code of Ethics [1].

3.2 Safety

There are several safety considerations in this project. One of the main concerns is the possibility of injury due to the moving parts of the project, namely, the X-Y plotter system with servo motors. Since the servos do not have sensors that detect human hands, it is possible for developers to have injury when working with prototypes of the product if care is not taken to keep extremities out of the movable X-Y area while the prototype is operational. Our concern is mostly for the students working on this project, as a final product would have the X-Y plotter system enclosed in a case so that the user would not be able to put their hands into dangerous locations.

Another safety concern originates from the electromagnet. In this project, we plan to use an electromagnet with a holding force of > 30 kg. While the strength of the magnet is severely diminished through the chess board itself, the magnetic field created could still pose a danger to users with pacemakers or implantable cardioverter defibrillators (ICDs). This danger would only occur one with a pacemaker or ICD brought the device within 6 inches of the electromagnet itself [2], so in the final product we will ensure that proper disclosure of the magnetic components are included in the User Manual. This is in accordance with point 1 of the IEEE Code of Ethics: "to hold paramount the safety, health, and welfare of the public..."[1].

References

[1] IEEE. (2016). IEEE Code of Ethics, [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html (visited on 02/08/2020).

[2] A. H. Association. (Sep. 2016). Devices That May Interfere with ICDs and Pacemakers, [Online]. Available: https://www.heart.org/en/health-topics/arrhythmia/prevention--treatment-of-arrhythmia/devices-that-may-interfere-with-icds-and-pacemakers (visited on 02/12/2020).