ECE 445

Team 23

9/16/21

The Auto Board

Rafal Czech, Nicholas Rappe, Kevin Villanueva

TA: Dean Biskup

Introduction

Problem:

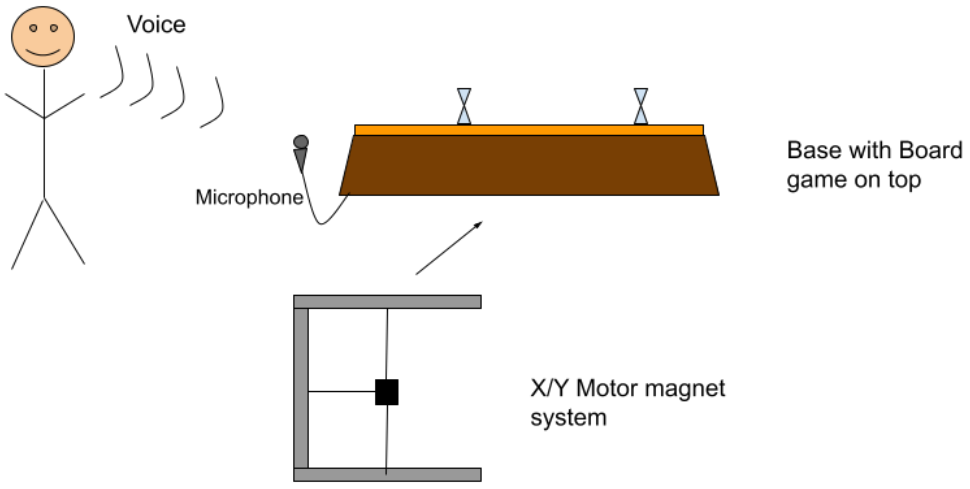
People with physical disabilities can find difficulty when participating in family game night. Anyone with restrictive moving or difficulty of control can struggle to move the many pieces on some of the most famous board games like Checkers, Sorry!, Chutes and Ladders, Monopoly, and many others. Those with disabilities can feel alienated when having to rely on others to assist in participating in games like these. In nursing homes alone, almost one quarter of the elderly 85 and older are disabled with many more having limited movement.

Solution:

Our product would be the solution to this problem. Our idea consists of a physical base of which your favorite board games can be placed on top with its pieces. From then it would accept the players voice commands to move those pieces and play the game. For example, if a player says, “d2 to e3” for checkers or “move player 2 up the ladder” for Chutes and Ladders, the associated piece would move across the board accordingly. This would allow people with disabilities to then be able to participate regardless of their physical ailments.

We would accomplish this by having an electromagnet tool attached to stepper motors and a grid structure that allows us to control the location of the electromagnet and whether it should attract the piece above. All of which is controlled by the users voice and our circuitry, which would consist of a microcontroller and microphone to provide the appropriate signals to the motors and magnet.

Visual Aid:



High-level requirements list:

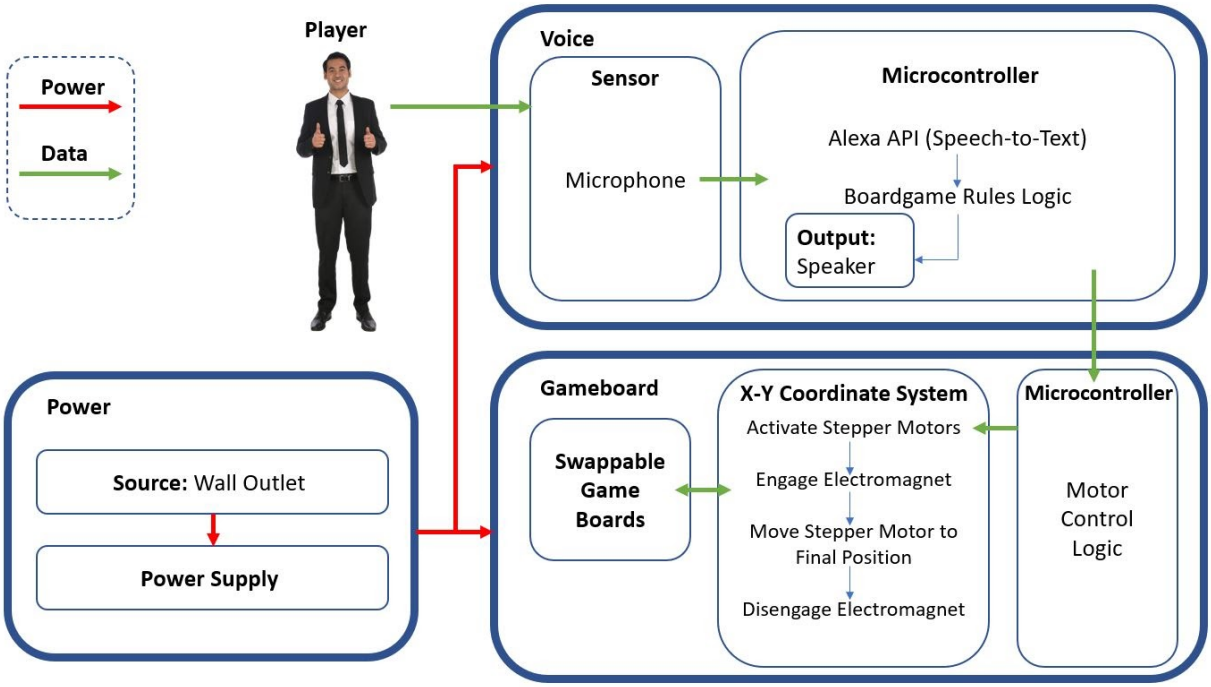
1) The final product must have self moving pieces so that after the initial set up the players will not be required to touch the board again to play the game chosen.

2) The product must be able to take the player's speech as input for all moves in the game.

3) The final product must be able to support multiple games (2 games).

Design

Block Diagram:



Subsystem Overview:

- **Sensor:** The microphone will be used to collect the player's voice data. The player will be speaking their commands and moves.
- **Microcontroller:** Voice data is then sent to the Alex API (speech-to-text program) so that the player's commands can be used within our board game rules logic. The board game rules logic will be able to accurately determine if the move is allowed and possible. The next step is sending the data to the motor control logic which will determine how to move the stepper motors and what exact path they will take. This is one of the most

important steps because it will depend on if the move is legal, and what pieces might be in the way on different paths.

- **X-Y Coordinate System:** The first step here is to activate the stepper motors based on where the piece being moved is. Once the stepper motors arrive at that location, the electromagnet will be activated and the piece will be “selected” for movement. The stepper motor will then take the most clear path (determined by the motor control logic), to move the piece to its final destination before disengaging the electromagnet.
- **Swappable Game Boards:** The idea here is that we will be able to swap the board out for others and therefore have multiple different game modes to play. This will make the product expandable in the future and will give many options to the players.
- **Power:** The system will be powered using a wall outlet and will be stepped down to 12V using a premade power supply block.
- **Output:** A speaker will be used for speaking commands back to the player to ensure that a move will be made correctly. This will provide as a means of feedback other than visually seeing the piece moving.

Subsystem Requirements:

- **Sensor:** The microphone is extremely important for the voice commands. It must be able to send clear audio signals to the microcontroller in order for voice commands to be used.
- **MicroController:** The microcontroller is the most important subsystem to the overall design. The main purpose is to translate the audio signals into voice commands using Alexas Speech to Text api, then convert these commands into Motor control logic. In order for this to be possible the microcontroller needs to have a constant connection to the internet in order to communicate with the alexa api. If the microcontroller is unable to connect to the internet then the board will not be able to function properly. The microcontroller also needs to communicate with the speaker in order to communicate with the user playing. While the user experience would not be as enjoyable the board would still be able to function. The final way that the microcontroller interfaces with other subsystems is its communication with the X-Y Coordinate system. It must send the correct signals to each motor so that they can move fluidly and to the exact position the piece is at. If this feature fails then the board will not be able to function properly.
- **X-Y Coordinate System:** The Coordinate system is another subsystem that if removed the subsystem would fail to function. In order to make sure it functions correctly, it will need to receive consistent power from the power supply along with signals from the Microcontroller.
- **Power:** The power subsystem must be able to take power from the wall and step it down to both 12V and 5V to be sent to the other subsystems. If this subsystem fails to distribute consistent power the Board will fail to operate.

- **Swappable Boards**: This subsystem is necessary in order for our product to be modular. The board will still be able to function if only one of the boards can be used. The swappable board tops must be connected to the board securely and also must be able to allow the electromagnet to connect to the magnets in the pieces on the boards.

Tolerance Analysis:

An aspect of our project that poses a risk to it working properly is the ability to use an electromagnet to grab onto magnetic pieces on the top of the board and pull them across the board. The material that we have decided to make the board out of is ⅛ inch polycarbonate sheeting. As of now we have tested using a Neodymium magnet and a piece of metal on the other side of the board. We were able to smoothly slide the magnet across one side of the board, and see the metal slide with magnet on the other side. In order to confirm that there will be a strong connection between the piece and the electromagnet, we will be using a neodymium magnet in the pieces and a 12v 25N electromagnet under the board. The neodymium magnet will have the pole opposite to the electromagnets facing down so that they will attract once the electromagnet is turned on. This method will double the force that is pulling the magnets together as they will both be pulling on each other.

Ethics and Safety

Ethics:

In the name of ethics, we recognize two potential problems with our product. First being our use of already trademarked games. The issue would arise that the making of any profits with the use of a trademark item would be illegal. Although this won't be a problem for the purposes of this class in the near future as we won't be making any money or using the product commercially, we vow to uphold the standards as outlined in point 4 of the IEEE Code of Ethics.

Additionally players may have a problem with their voice data being used and stored. While our product will not store any of the speech data, there is the possibility of speech data being stored by an outside party's speech processing service/software. The exact details will be known to the patrons of the product. We will approach this in accordance with points 5 and 7 of the IEEE Code of Ethics.

Safety:

In the name of safety, we recognise three potential safety issues that could arise. First would be the use of power while developing the product. This issue is connected with any circuitry use as improper safety measures and faulty equipment/parts could lead to fires, burns, electrical shocks, or worse. To avoid any and all injuries we will

uphold all the standards listed in the safety manual and training provided in the senior design lab.

The next safety concern is associated with the use of motors while developing the product. The motors by themselves do not have sensors that can detect human fingers and hands. This could lead to crushed extremities if uncareful in the close area around the motor. Due to this some rules will be put in place to prevent all injuries. The motor must not be in use outside of the lab, unattended, or by anyone without a safety training certificate. The motor must also not be used with a greater voltage than its rated. This safety concern is mostly for the users as the final product will be enclosed.

The last safety issue we must take great care with is the use of the electromagnet. While the force we predict it will have is low enough not to pose a threat, the magnetic field created could still pose a danger to users with internal medical devices. Especially since our target audience is of greater age. We predict the threat to be very low and we will still proceed in accordance with point 1 and 9 of the IEEE Code of Ethics.

Citations

https://aspe.hhs.gov/reports/disabled-elderly-their-use-long-term-care

https://www.ieee.org/about/corporate/governance/p7-8.html