An-Najah National University
Faculty of Engineering & Information Technology
Department of Computer Engineering

Graduation Project II

Abullah Shwareb & Majd Basem

Supervisor: Dr. Samer Arandi

Presented in partial fulfillment of the requirements for the Bachelor degree in Computer Engineering.

Sep, 2024

Acknowledgement

In the name of Allah, the Most Gracious, the Most Merciful.
We are filled with gratitude for the blessings that have guided us to complete this hardware project. We express our deep appreciation to the Almighty for bestowing upon us the strength, skills, and understanding necessary for this achievement. Our sincere thanks go to our supervisor, Dr. Samer Arandi, for his invaluable guidance and unwavering support, which significantly shaped the trajectory and success of our project. His expertise and insight have been instrumental in leading us to a result we are proud to present. We are also thankful to the esteemed faculty members of the Computer Engineering Department for their valuable contributions that have enriched our academic journey. Our heartfelt gratitude extends to our families and friends, whose constant encouragement and belief in our abilities have been a source of strength and motivation. Your support has been a pillar throughout this journey. We hope that our efforts and the knowledge we have gained will serve our community and contribute positively to humanity.

Disclaimer

This report was written by students at the Computer Engineering Department, Faculty of Engineering, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Table of Contents

Acknowledgement **I**

Disclaimer **II**

Table of Contents **III**

List of Figures **V**

Abstract **VI**

1 Introduction **1**

1.1 Statement of the problem 1

1.2 Objectives of the work 1

1.3 Scope of the work 1

1.4 Significance of our work 1

1.5 Organization of the report 2

2 Constraints & Earlier coursework **3**

2.1 Constraints 3

2.2 Earlier coursework 3

3 Literature Review **4**

4 Methodology **5**

4.1 Standards and specifications 5

4.2 Hardware components 5

4.3 Hardware implementation 12

4.4 Software implementation 13

5 Results and Discussion **16**

6 Conclusion and Recommendations **17**

References **18**

List of Figures

4.1 Arduino Mega 2560 5
4.2 Arduino Nano 6
4.3 Raspberry pi 4 6
4.4 Stepper motor, H-bridge and YS-DIV268N driver 7
4.5 DC motor 7
4.6 IR sensor 8
4.7 Keypad 8
4.8 I2C 20X4 LCD 8
4.9 RGB Leds 9
4.10 Speakers 9
4.11 Webcam 9
4.12 Power Supply 10
4.13 Step Down Buck Converter Module 10
4.14 SD Card Module 10
4.15 Mechanical Part 11
4.16 Wires 11
4.17 Intercom wires 11
4.18 Full Design 12
4.19 Arduino Mega ASM Chart 14
4.20 Arduino Nano ASM Chart 15

Abstract

Snakes and Ladders, it's a classic board game and is played on a board with numbered squares and features a number of "snakes" and "ladders" connecting certain squares. Players take turns rolling a die and move their game piece accordingly. If a player lands on a square with the bottom of a ladder, they move up to the top of the ladder. If they land on a square with the head of a snake, they slide down to the bottom of the snake. The objective is to be the first to reach the final square, usually number 100. This project presents a hardware implementation of the classic board game Snakes and Ladders, integrating modern technology to automate game play. The system comprises a closed area housing a die, a camera, a Raspberry Pi, an Arduino, and a CNC mechanism with magnets. Players interact with the game by pressing a push button to initiate and stop the shaking of the die. The camera, controlled by the Raspberry Pi, captures the image of the die to recognize its value using image processing algorithms. The recognized value is then transmitted serially to an Arduino, which controls the movement of the player's piece across the board through The CNC mechanism with controlled electro magnet by H-bridge, precisely maneuvers the magnetic player tokens. Additionally, the system features sound and RGB light effects to enhance the gaming experience. This implementation not only automates the traditional game but also introduces an engaging and interactive element, combining the nostalgic charm of Snakes and Ladders with modern technological advancements.

Chapter 1

Introduction

Snakes and Ladders is a classic board game enjoyed by players all over the world.The game is played on a board with numbered squares arranged in a grid. On the board, you'll find various ladders and snakes that connect different squares. The goal is to move your game piece from the starting square at the bottom to the finishing square at the top, using dice rolls to advance. Ladders help you move up faster, while snakes send you sliding back down.

1.1 Statement of the problem

The disadvantages of the traditional game are that it contains some cheating and deception and is not entertaining. So we moved towards making a three-dimensional model of the game in an entertaining way.

1.2 Objectives of the work

The goal of our project is to create a model of the famous game Snakes and Ladders, which has been known since childhood. Our project works to add an atmosphere of entertainment and play, as it can be placed in public places. The main goal is entertainment.

1.3 Scope of the work

To achieve our project goals, we began by selecting essential hardware components, including a DC motor, stepper motor, Arduino Mega, Arduino Nano, Keypad, Raspberry Pi, and stepper motor drivers. Each system was developed independently: we used Python to program dice recognition, developed code to control CNC coordinates, and integrated sound effects. Finally, we combined all the systems to complete the project.

1.4 Significance of our work

This project offers a solution to cheating in the traditional game while adding a modern style. It has the potential to be installed in public spaces, such as malls, where it can provide a fun and interactive gaming experience for players of all ages.

1.5 Organization of the report

This report begins with addressing the Introduction (Chapter 1), then moves on to addressing constraints, challenges, and relevant coursework that shaped the project (Chapter 2). A literature review (Chapter 3) delves into existing research, establishing a foundation for the project's context. The methodology (Chapter 4) details the systematic approach, development processes, and tools used. Results and Discussion (Chapter 5) are then presented, offering data interpretation and comparisons to benchmarks. The project wraps up with a summary of key findings and potential avenues for future work (Chapter 6).

Chapter 2

Constraints & Earlier coursework

2.1 Constraints

During the project, we faced a few challenges. One of the main issues was the high cost of CNC systems. Another problem was how to manage when two players landed on the same square, as the magnetic setup couldn't handle overlapping pieces easily.

2.2 Earlier coursework

Our university studies played a key role in building the skills we needed for this project. Classes such as Digital Circuits Design I and II, Microcontroller Programming, and Image Processing gave us the practical knowledge to understand how to work with hardware and software. These courses provided us with hands-on experience, which was essential for developing the automated Snakes and Ladders game.

Chapter 3

Literature Review

Automation in traditional board games, like Snakes and Ladders, has increasingly integrated modern hardware and software systems to enhance gameplay. Several projects have employed microcontrollers such as Arduino and Raspberry Pi, combined with CNC systems and image recognition, to automate game mechanics. These projects utilize hardware to eliminate human error and improve user experience. For instance, Rashid et al. (2021) implemented motors and sensors to automate Snakes and Ladders, facilitating automated dice rolls and player movement without manual intervention Rashid et al., 2021. Similarly, software-based designs such as those by Satyamkumarnavneet (2020) used JavaFX to develop multiplayer versions of the game with automated dice simulations and piece movement Satyamkumarnavneet, 2020. Additionally, Laxmi Renjith's (2024) project utilized CNC programming and stepper motors to move game tokens with electromagnets, incorporating gyroscopes and Bluetooth for dice detection Renjith, 2024. These efforts represent the growing trend of merging traditional games with modern technology to create more engaging and error-free experiences for players.

Chapter 4

Methodology

4.1 Standards and specifications

The design and building of the Snakes and Ladders game followed specific guidelines. We chose hardware components based on how easily we could find them, how well they worked together, and how reliable they were. For the microcontrollers, we used standard communication methods. The software was written using Python for the Raspberry Pi and Arduino IDE for the microcontrollers. The CNC system was designed to meet mechanical standards, ensuring smooth movement of the game pieces.

4.2 Hardware components

In this section we are going to talk about all the hardware components we used, and why we used each one of them:

- **Arduino Mega 2560**
  The Arduino Mega 2560 is a versatile microcontroller board that serves as an extended version of the Arduino Uno. It boasts an ATmega2560 microcontroller at its core, providing a generous array of digital and analog pins, memory, and computational power with 54 digital I/O pins, 16 analog inputs, and a larger flash memory capacity. We initially used the Arduino Uno, but as the number of components increased at each step, we switched to the Arduino Mega 2560. The Arduino Uno's limited number of pins was insufficient for all the components, making the Arduino Mega 2560 the main controller in our system.

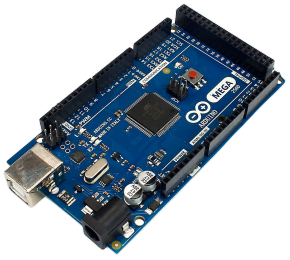


Figure 4.1: Arduino Mega 2560

- **Arduino Nano**
  The Arduino Nano is a compact and versatile board that's designed to be easily used with a breadboard. It's built around the ATmega328 chip (like the Arduino Nano 3.x version) and offers similar capabilities to the Arduino Duemilanove but in a smaller, more convenient form factor. It doesn't include a DC power jack and instead connects via a Mini-B USB cable, making it a bit different from the standard USB connection found on other Arduino boards.

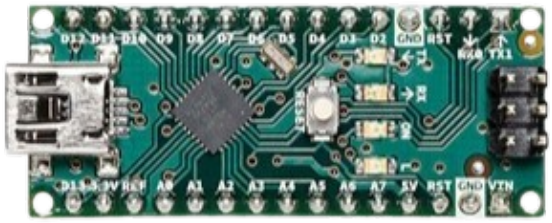


Figure 4.2: Arduino Nano

- **Raspberry pi 4**
  The Raspberry Pi 4 is a small, affordable computer used for a variety of projects. It features a 1.5 GHz 64-bit quad-core ARM Cortex-A72 processor, supports up to 8GB of RAM, and includes dual-band Wi-Fi, Bluetooth 5, and gigabit Ethernet for fast networking. It has two USB 3.0 ports, two USB 2.0 ports, and can connect to two 4K monitors using micro HDMI. It's commonly used for tasks like programming, media centers, and IoT projects, making it versatile for hardware and software development.

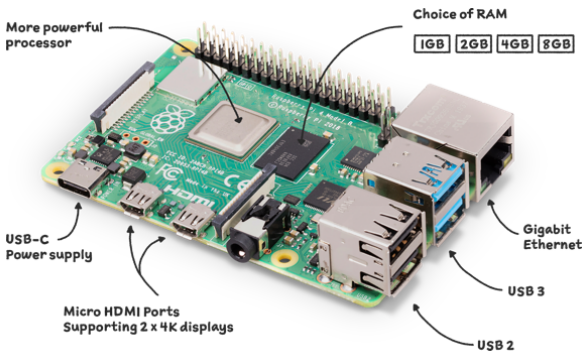
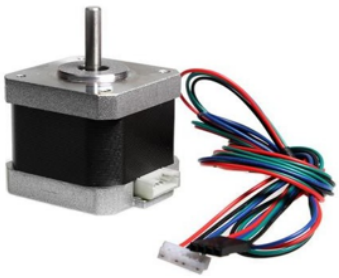


Figure 4.3: Raspberry pi 4

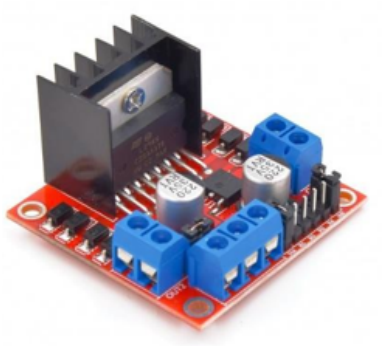
- **Stepper motor**
  A stepper motor is a specialized type of electric motor designed for precise control of angular movements. A stepper motor divides a full rotation into a series of steps, allowing for accurate positioning without the need for feedback mechanisms. It operates by receiving electrical pulses from a controller, causing it to move in discrete steps. They come in different configurations, including bipolar and uni-polar, offering flexibility in terms of torque and speed. The distinct feature of stepper motors

is their ability to maintain position even when power is off, making them well-suited for applications requiring stability and reliability in positioning.

In our project, we used 1 * Nema 17 stepper motor for x-axis and 2 * Nema 17 stepper motors for y-axis to cover whole space.



((a)) Stepper Motor NEMA17



((b)) H-bridge L298N

((c)) YS-DIV268N driver

Figure 4.4: Stepper motor, H-bridge and YS-DIV268N driver

- **DC motor**
  A DC motor is an electric motor that turns electrical energy into movement using magnetic fields. It works based on Faraday's law, which says that a current running through a wire in a magnetic field will produce a force. In a DC motor, this force makes the motor's shaft spin. We used it in our project to rotate the dice.

Figure 4.5: DC motor

- **IR sensor**
  An Infrared (IR) sensor is a type of electronic device designed to detect and respond to infrared radiation. An IR sensor can detect the presence or absence of an object by emitting infrared light and measuring the reflection or absorption of this light by the object.

Figure 4.6: IR sensor

- **Keypad**
  We have used a keypad and interfaced it to make system more interactive, through it the user can start the game, end the game, stop the dice of rotating itc..

Figure 4.7: Keypad

- **I2C 20X4 LCD**
  This LCD display module has a screen that shows 4 lines of 20 characters each, plus room for up to 8 additional characters or symbols. You can control it using 6 digital or analog inputs, and it works with either a 4-bit or 8-bit microcontroller.

Figure 4.8: I2C 20X4 LCD

- **RGB Leds**
  RGB stands for Red, Green, and Blue. RGB lighting is a specific type of LED light where the unit combines these three colors. By adjusting the intensity of each color, RGB LEDs can create a wide spectrum of colors, including white light. This is done through a process known as additive color mixing.

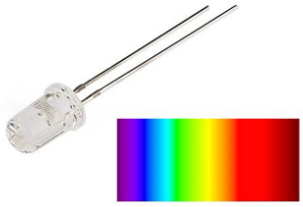


Figure 4.9: RGB Leds

- **Speakers**
  omputer speakers, also known as multimedia speakers, are designed primarily for use with computers. However, they're versatile enough to work with other audio devices, like MP3 players, as well.

Figure 4.10: Speakers

- **Webcam**
  A webcam is a video camera designed for recording or streaming to a computer or network. It is mainly used for video calls, live streaming, social media, and security purposes. Webcams can either be built into a computer or function as external devices. They are typically connected via USB or wireless protocols. We used it in our project to capture the state of the dice.

Figure 4.11: Webcam

- **Power Supply**

Figure 4.12: Power Supply

- **LM2596 Step Down Buck Converter Module**
  A buck converter also known as step-down converter is a DC to DC converter which decreases voltage, while increasing current, from its input (supply) to its output (load). We used it in our project to reduce the 12 volts taken from power supply to 5 volts in order to distribute it to the rest of the system parts.

Figure 4.13: Step Down Buck Converter Module

- **SD Card Module**
  The SD Card Module is a breakout board that lets you read from and write to SD cards using a microcontroller, like an Arduino. You can easily insert a standard SD card directly into the board, but if you want to use a microSD card, you'll need an adapter. In our project, we used the SD Card Module to store the music.

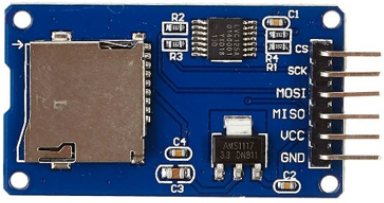
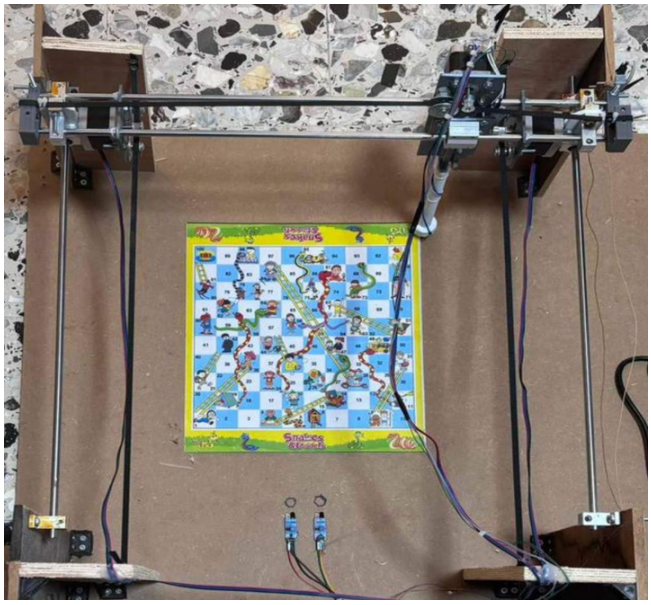


Figure 4.14: SD Card Module

- **Mechanical Part**
  The mechanical part contains stainless steel rods, Biel, timing belt and 3d printed parts.



((a)) Stainless steel rods, 3d printed parts and biel

((b)) Timing belt

Figure 4.15: Mechanical Part

- **Wires**
  We used different types of wires: male-to-female, male-to-male and female-to-female.

Figure 4.16: Wires

- **Intercom wires**
  We used them to make the final connections for all components.

Figure 4.17: Intercom wires

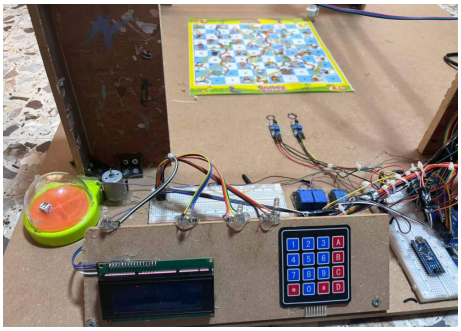
4.3 Hardware implementation

The system consists of three main parts: the CNC mechanism, the Raspberry Pi with camera, and the user interface.

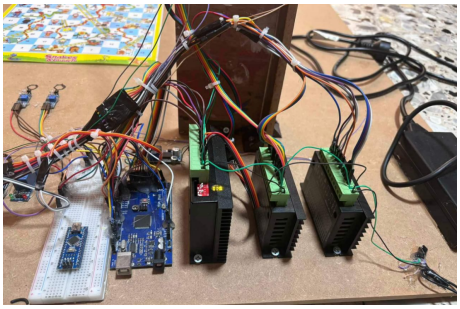
We first set up the CNC system by 3D printing parts and installing motors to move along the x and y axes. This helped position the magnet, allowing it to move and center on the board.

For the Raspberry Pi, we used Python to process images from a camera that records the dice roll by detecting and counting circles. The result is sent to the Arduino, which controls lighting and sound based on the game state.

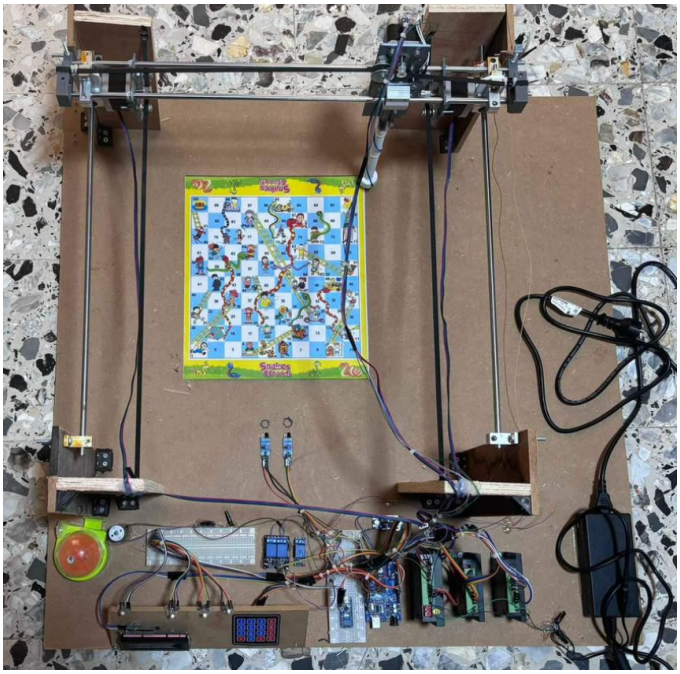
The game includes a screen and keypad, where the player selects their character and starts from the beginning. The motor rotates to shake the dice, and the player presses a button to stop it. The Arduino calculates the player's move and checks if they land on the same spot as another player—if so, they must roll again. If not, the system checks for snakes or ladders based on pre-programmed coordinates, and the turn passes to the next player. The same process repeats for the second player.



((a))



((b))



((c))

Figure 4.18: Full Design

4.4 Software implementation

The game will start at initial state which user can set basic settings like starting player then if the user starts the game from the keypad the dice will be shake until current player presses on keypad to stop shaking then the controller waits for raspberry pi to send dice value after applying image processing techniques to detect dice based on circles detection's then the result sent serially to Arduino if the new value for player is the same position for other player it will retry for the current player, if the value is greater than 100 so the layer will be at last row and will lose his turn until get exact difference to get on 100 to win other wise the machine will get player die and transmit it to new position and checks if new position is ladder or snake then will notify players for that and move the player to new position and toggle the current player and this will continue until one of player wins the game or stop the game from keypad, at each state of the game the Arduino sends serial commands to Arduino nano which will play music based on current situation of the game, also there is a beautiful rgb leds for better experience. See figures 4.19 and 4.20.

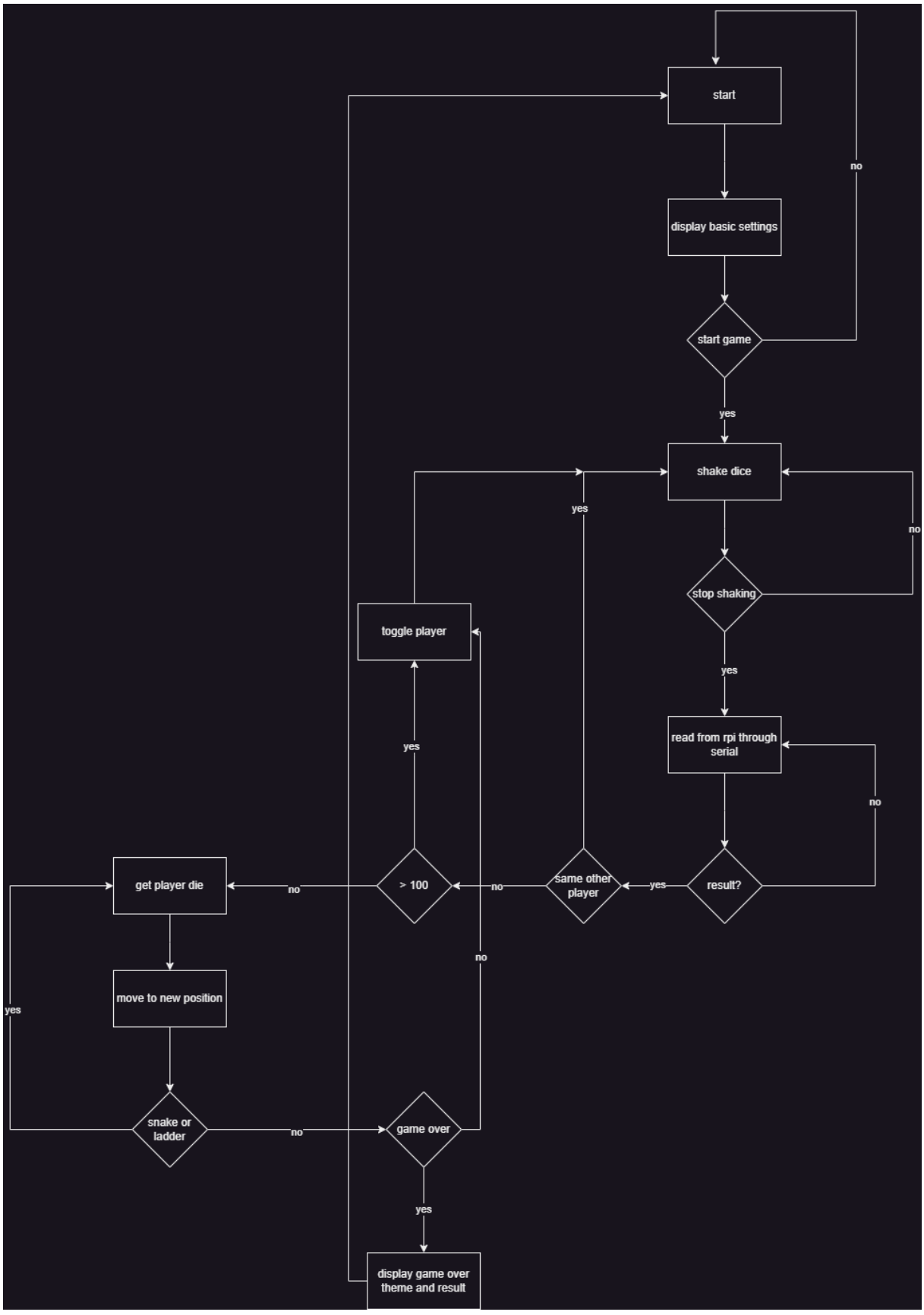


Figure 4.19: Arduino Mega ASM Chart

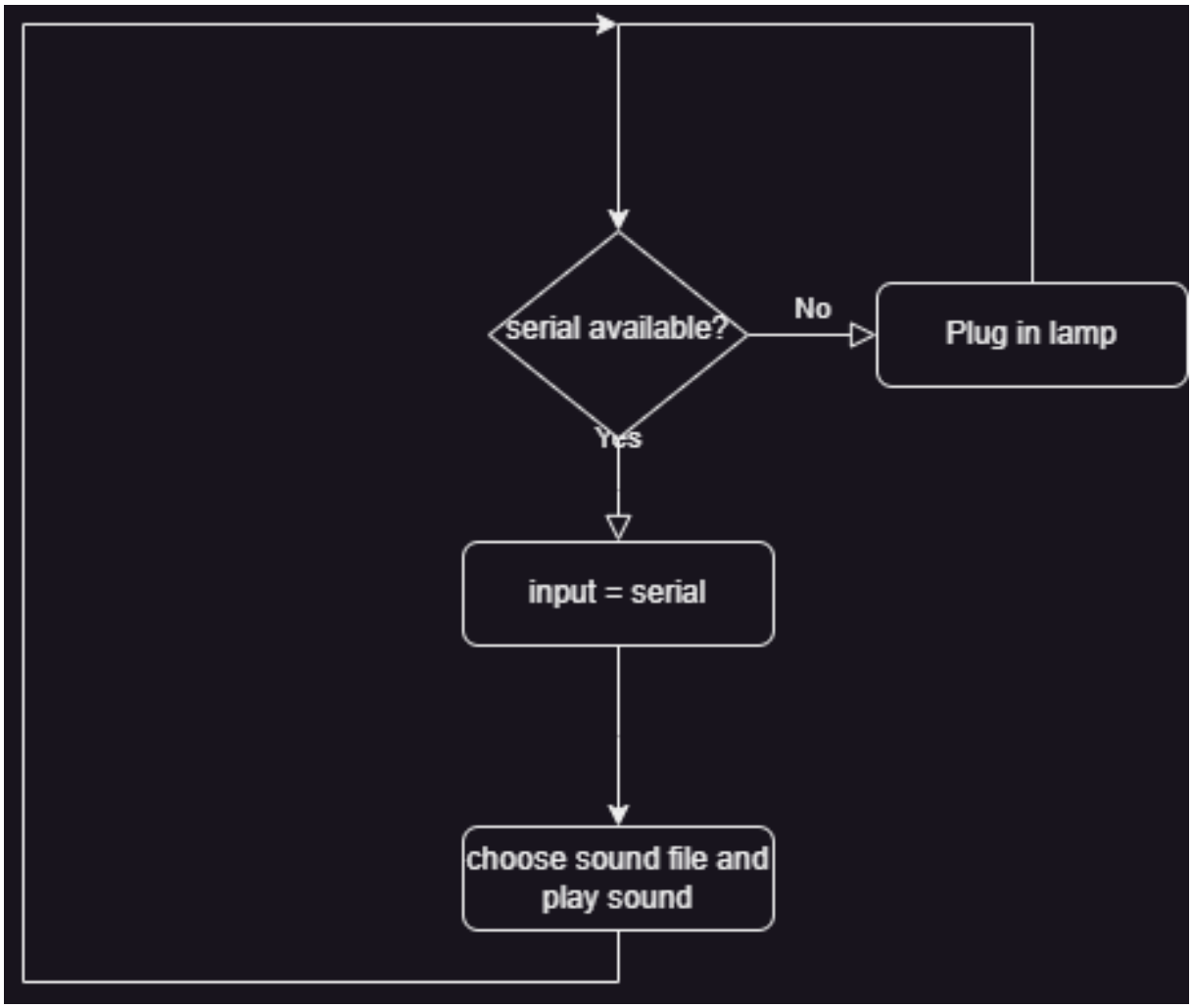


Figure 4.20: Arduino Nano ASM Chart

Chapter 5

Results and Discussion

Our project successfully automated the classic "Snakes and Ladders" game using modern technology. The hardware components, like the Arduino, Raspberry Pi, motors, and sensors, worked together to move game pieces automatically. The Raspberry Pi's camera recognized the dice rolls, and the Arduino controlled the movement of the pieces. The system eliminated cheating, making the game fair.

There were some challenges, like adjusting the camera to properly detect the die and ensuring the CNC mechanism placed the pieces accurately. However, these issues were resolved with adjustments to the software and hardware. The lights and sounds added to the experience, making the game fun and interactive.

While the project achieved its goal, some limitations included difficulties when two players landed on the same square due to the magnet system. Also, adding a feature to return pieces to the starting point every time they hit a snake was challenging because of cost and complexity.

Chapter 6

Conclusion and Recommendations

The project successfully created an automated version of "Snakes and Ladders" that made the game fair and more enjoyable. The system combined various hardware and software components to achieve this, making it suitable for public spaces like malls.

For future improvements, we recommend:

- Adding new control modes, such as voice command control, to make the interaction more intuitive.
- Improving the CNC mechanics, so it moves smoothly without needing to return to the starting point after each move.
- Adding a mobile system for remote control.
- Adding a paid system to play for money.
- Enhancing the magnet system to better handle cases where two players land on the same square.
- Adding more user-friendly features, like touchscreens or voice commands, to make the game easier to play.
- Improving the system to handle more players and adding extra gameplay options to make it even more engaging.

In conclusion, this project showed that it's possible to combine old games with new technology to create a fun and fair experience.

References

- Satyamkumarnavneet. (2020). Snakes and ladders game using java & javafx [Available at: https://github.com/Satyamkumarnavneet/Snake-and-Ladder-Game].
- Rashid, A., Khan, M., & Bashir, F. (2021). Automation of traditional board games using microcontroller systems. *International Journal of Embedded Systems*, *45*(1), 67–78.
- Renjith, L. (2024). Automated snakes and ladders game using cnc and microcontrollers [Available at: https://fabacademy.org/2024/labs/kochi/students/laxmi-renjith/snake&ladder.html].