AN-NAJAH NATIONAL UNIVERSITY

FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

Computer Engineering Department

Graduation Project 2

Ping pong hitter

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Acknowledgment

We are grateful to our supervisor Dr. Abdullah Rashed for his cooperation during semester Also special thanks to all the professors of Computer Engineering Department that were available and helpfully answered every question we had. We found incredible experience and support, which really helped our project a lot. Finally, we would like to thank Dr. Sulaiman Al-Amad for his support in the project idea and College of Sports Finally a massive thanks to our friends, and family. They've been really instrumental in getting us to this point. We are grateful to them.

YoursSincerely

Sama,Manar.

Disclaimer

The author of this report is a student of the Department of Computer Engineering, Faculty of Engineering, An-Najah National University. This report has not been revised or corrected, except for editorial corrections made during the evaluation process, which means that it may contain linguistic and substantive errors. The opinions expressed in this report and any conclusions and recommendations are solely those of the student. An-Najah National University does not accept any responsibility for any consequences that may arise from the use of this report for any purpose other than the original assignment.

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1 . Abstract

The use of modern technology is important in enhancing the performance and growth level of tennis players. Advanced technological tools such as smart sensors and cameras help coaches analyze performances accurately, they can detect any errors in playing style of individual players helping tailor training specifically for their level. This kind of personalized training helps in increasing player effectiveness by enhancing their individual skills using the assessment data as reference.

We develop a training system where an air pump pumps balls fired at set speeds and angles, the width of table are changed by angling tops with trapezoidal shape allowed that re-computed for volatile-time durations determined from bullet ranges chosen by players. If the racket has successfully blocked the ball and how it is determined can be viewed via OAK-D camera. Also on the other side of table LDR sensor and laser sensor are kept that counts point scored by player.

This type of analysis provides the information that coaches need to help players perform better with instant and targeted feedback. He system also allows exact repetition of exercises what increases the level of training and progressions in players throughout time. This results in a higher level of interaction between the player and system while also enhancing training effectiveness by annotating points using smart technologies to evaluate the real-time response of players.

With this technology, personalized and effective training can be provided to every layer individually that helps develop their skills quicker and better.

2 Introduction

1.1 General background

In this project, we propose the development of an intelligent tennis training system with advanced technologies. Normally coaching has little precision because it always depends on trapping and the bait systems, but with modern tools like air pump system, motion sensors(LDR sensor & laser already exist), cameras mounted in OAK-D can track real time about their performance. The system shoots tennis balls at different speeds and angles, mimicking game situations, as sensors monitor the player's strokes as well his or her ability to return shots while on the move. This iterative, data-informed approach ensures that training is both highly focused on the individual requirements of each layer and based in excellence for technical skills as well performance.

1.2 Objectives of the work

This project aims to design a smart platform for tennis training with aiming ball launching automation and implementation of technology like air pumps, OAK-D cameras and specific motion sensors (LDR/laser) to generate dedicated statistics regarding the sports actions. Using a customised and consistent training program, the system is designed to simulate game situations which in turn help develop player skills by monitoring performance and delivering real-time feedback.

1.3 Significance of the Work

Completing the tennis training through modern technology is a specialty of this project. That means more accuracy and personalized training, real-time feedback, persistant practice. The system.

3Methodology

3.1Hardware Components

To ensure accurate and smooth operation, a variety of hardware components were nec- essary for constructing this system. The components employed in building this system include:

- **Arduino Mega 2560**

  Arduino Mega 2560, developed as the primary Logic Control Unit, IPython is a single-board computer and has soon become very popular in different fields in a short time due to its small design and practical utility. The Arduino Mega 2560, which acts as a master control unit, manages the different components through its many I/O applications. The control of the engine blocks NEMA 23 and NEMA 17 is done through the digital I/O pins for precise positioning and motion adjustment. In addition to that, it reads the input given from the infrared sensor through the analog input pins and tells whether or not the ball being in the path is true, and if not so, ot waste the air; otherwise, the air via the air pump channel. The data from the keypad and selector switches are fed into the microcontroller to correct the speed or motion of the motor. Moreover, the PWM pins are exploited as controls for the servo motors. First off, the Arduino Mega manages the entire system by choosing related relays and activating them through the digital input pins that are attached to the analog output pins, each time the air pressure is modified well before the control system sets it, to ensure a perfect setting .

Figure 1: Arduino Mega 2560.

- **NEMA 23 stepper motor:**

  Function: Controls horizontal movement (left and right) according to the width of the table.

  How it works: The stepper motor rotates in steps, allowing precise control of position. The direction and amplitude of the movement are determined by pulses sent by ArduinoMega accurate timing.

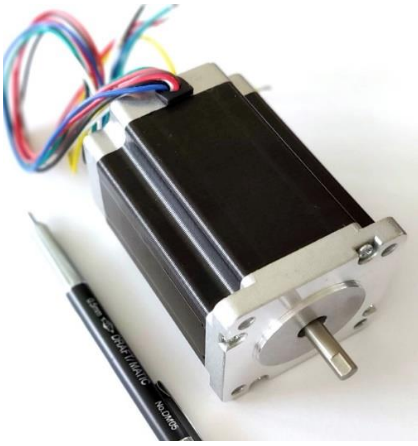


Figure 2: 12V NEMA 23 Stepper Motor

- ## NEMA 17 Stepper Motor with Gearbox:

Function: Controls vertical movement (up and down)

depending on the height of the table.Working

Principle: Almost like NEMA 23, but the gearbox is. [The machine] moves with more power and accuracy both upwards and downwards because of the use of gearings, similar to NEMA 23, if the table is higher and also in the vertical settings.

Figure 3: 12V NEMA17 stepper motor with gearbox.

- ## 2Switches

Function: The switch controls the stepper motors from the digital-output circuit; thesinemaster said that one source of error could be a wrong EMF connection or an exchanged step direction of the MCU. When the corresponding switch is hit, a signal is sent to the Arduino Mega, and every step of the corresponding NEMA 17 and NEMA 23 motors is set to the initial position (NEMA 23 motors in the horizontal position and NEMA 17 motor in the vertical position).

Figure 4: 5A Micro limit switch with roller

- **Keypad**

Function: The keypad enables users to input the desired table width and motor speed. Working Principle: The Arduino Mega reads the key presses and utilizes the values to adapt the motor settings and behavior accordingly. The input from the keypad dictates the movement of themotors as per the user's specifications.

Figure 5: 4×4 Matrix Membrane Keypad

- **IR sensor**

Position Detection of the BallIn the database of an IR sensor, the ball's right placement can be checked to confirm the ball is correctly positioned for release. The IR sensor sends an invisible light beam, and when the ball is where it should be, the light is reflected back to the sensor. This difference in the sensor reading is reported by the Arduino Mega to the air pump, which then starts, getting ready to throw the ball.

Figure 6 : IR Sensors

- **Servo motor**

the Arduino Mega to the air pump, which then starts, getting ready to throw the ball.

Ball Release ControlThe release mechanism for the relative is actuated by a servomotor, which is the "slave" of the Arduino board. The servo motor is in charge of either opening or closing the release mechanism depending on the ball's location. With the control angle of the servo, the system ensures that the ball is launched with high precision, which is error-free.

Figure 7: MG995 High Speed Servo Motor (180 Degree)

- **4-Relay Module**

Air Speed ControlThe fans are regulated by the air pump's relays. A single Arduino Mega board is connected to each of the relays, to which the board will either be turned on or turned off depending if the user had chosen the speed already. Through the usage of different speeds, the Arduino winds up the suitable relay so that the air pump's power is regulated, thus ensuring the ball is shot with the correct force.

Figure 7: 4 Channel 5V Relay Module

- **SOLENOID VALVE**

In the Air Speed Selection paragraph, the term is the user can specify the speed of the air in which the ball gets launched through 4 sped selectors. Each selector on the switch pegboard is directly attached to a separate relay while its position determines which of the controlled air pumps speeds via each of the relay which is switched on. It should point out that the Arduino Mega chip is responsible for reading the positions of the switches and powering up the relay with the most similar of them to the actual set launching speed of ball.

Figure 8:PAKET SOLENOID VALVE 5/2 WAY 1/4 INCH 3BARIS BARANG SESUAI FOTO

- **Air hose**

Figure 9: Air hose

- **LCD with I2C module**

We utilized a 20x4 LCD display in the project to get in touch with the users by displaying instructions, options, and the status update at every step of the process. In order to simplify the connections, we picked an I2C serial interface adapter which accommodates the LCD be controlled by two wires instead of the previous six wires, thereby simplifying the setup with the microcontroller.

Figure 10: LCD with I2C module

- **HY-DIV268N Stepper Motor Driver**

  We used this motor to control the direction of its rotation and the number of steps it takes. Additionally, we monitored the frequency and current reaching the motor to ensure proper operation.

Figure 11: HY-DIV268N Stepper Motor Driver

- ## Power supply

In this project we used a computer power supply that supplies 5, 3,3 a nd 12 volts to the pumps.

Figure 12: power supply 12VOLT

- ## 5V power supply-3A

Due to the high demand and pressure on the PC power supply

This ensures that all components receive consistent and adequate power.

Figure 13: 5V power supply-3A

- **Wires used in a project**

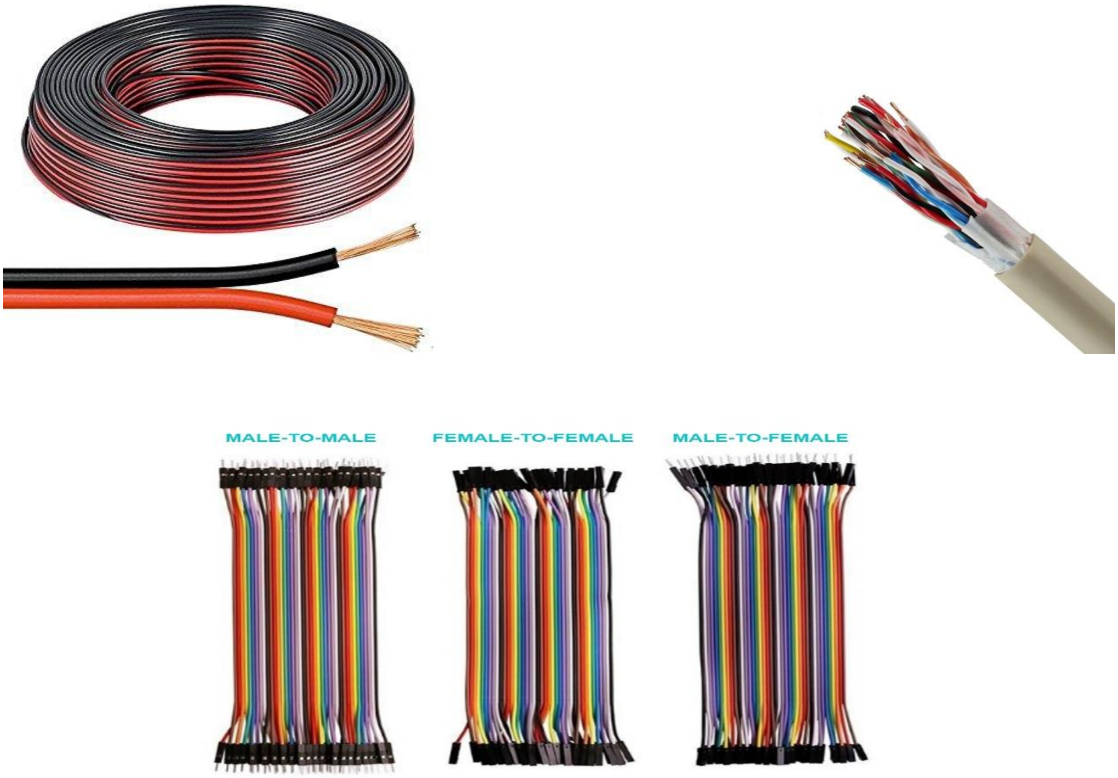


Figure 14:Wires

- **12 LDR module**

An LDR, or photoresistor, is a sensor that alters its resistance by the amount of light that falls on it. Its resistance goes down when light shines and increases in darkness. In this project, the LDR can detect whenever a tennis ball gets in the way of a laser beam, telling the player that he has indeed made a successful return.

Figure 15: LDR module

- ## 12 Laser module

A finely-tailored module laser sparkles a sharpened light beam on the table in a company of the LDR to form the detection system. The moment the tennis ball transports through the beam, its light is blocked and the LDR perceives this disruption. This installation reliably monitors on time and evaluates the quality of the ball's delivery.

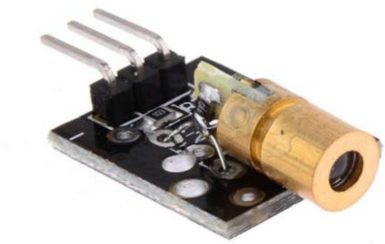


Figure 15:laser module

- **Smooth rod**

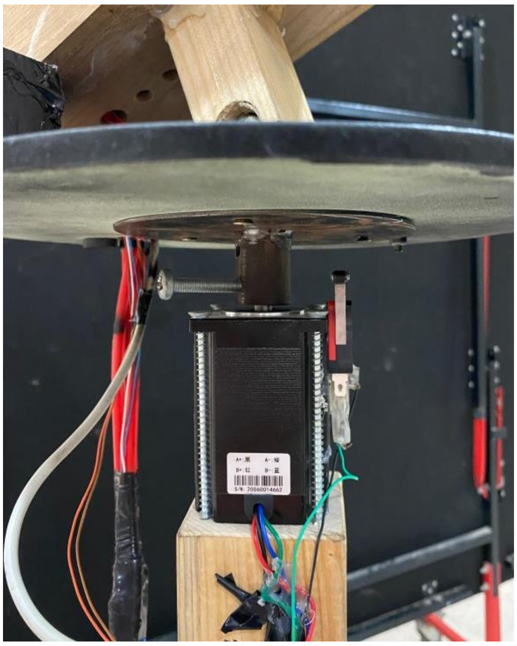
Figure 16:smooth rod

- **ESP**

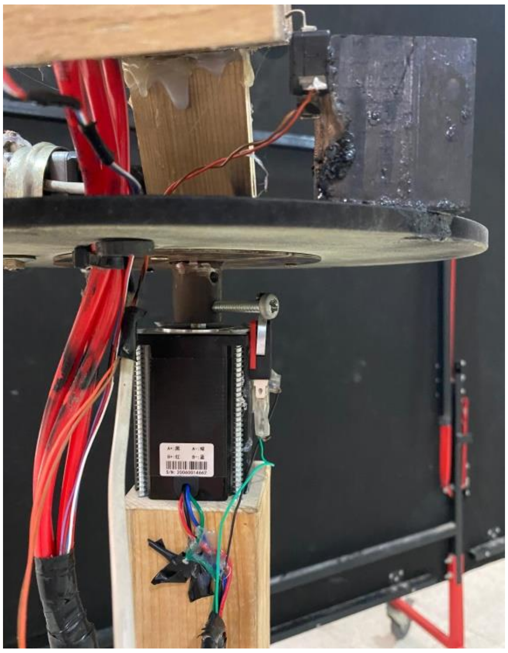
- **OAK-D camera**

3.2 Mechanism of Action

- the hitter takes the home position:
- When the project starts, the NEMA 23 stepper motor (located on the X-axis) moves in a circular and continuous manner until it reaches the location of the first switch and changes its value from here, taking the starting point for this motor.

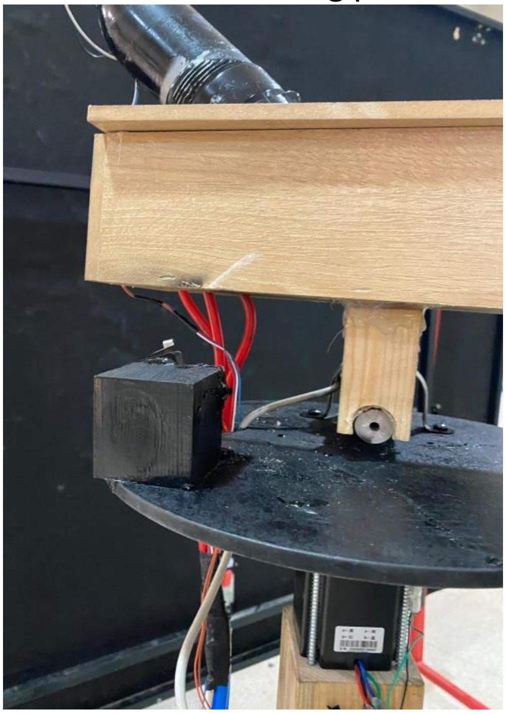


Before



After

- The NEMA 17 stepper motor with gear(located on the Y-axis) moves backward in a circular and continuous manner until it reaches the switch and takes the starting point.



Before

After

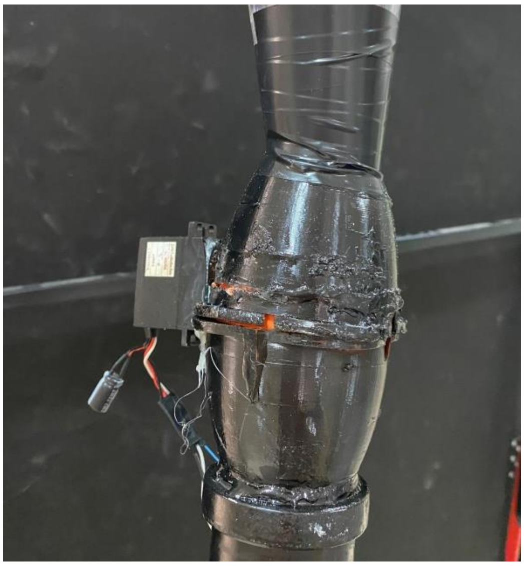
- When the hitter reaches his initial position, the LCD displays options for displaying the table, which are: a=1.5 m, b=1 m, c=2 m, d=2.5 m
The player can then choose the display using the keypad (choose A, B, C or D).

- Then the LCD displays options for the air strike level from 1 to 7.

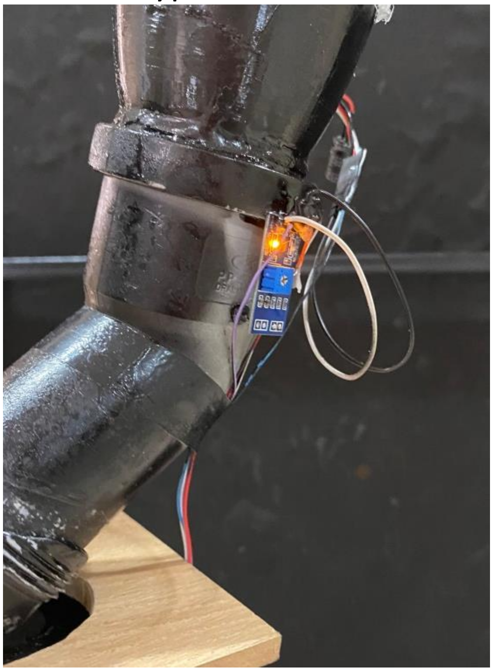
So here he controls the force of the air that passes over the ball when hitting it (meaning he controls the force and range of the ball on the table)
The command is confirmed by pressing #
If * is pressed, the process is completed and the motors are moved to their original positions.

- When pressing # , The X and Y values are stored according to the width you have chosen , So that while the hitter is running, the NEMA 23 stepper motor moves with the X value in both directions (left and right) , And the NEMA 17 moves with the gearbox with the Y value in both directions (up and down)
(until it covers the required area of the table)
And the movement of these two motors continues until the end of the entire process.

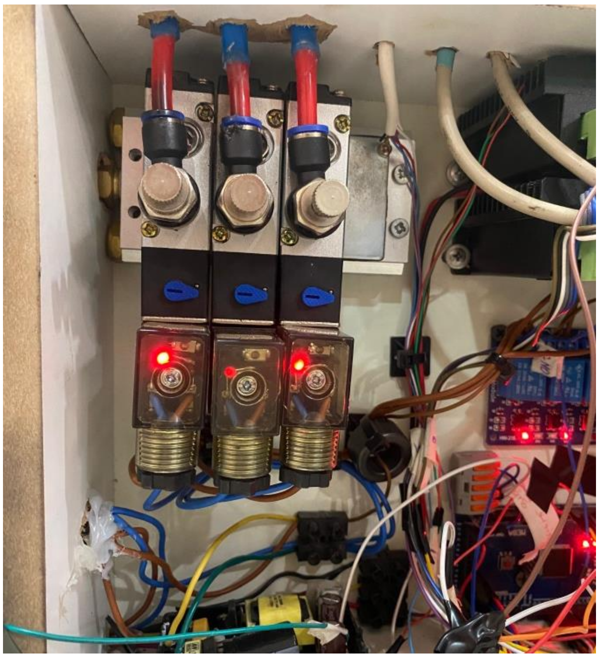
- Then the servo motor located at the end of the ball basket moves so that only one ball is allowed to pass.



- The ball move and cuts the sensor , it gives a signal to the relay to open so that air is pumped from the selectors depending on the power that the player chose from the keypad.

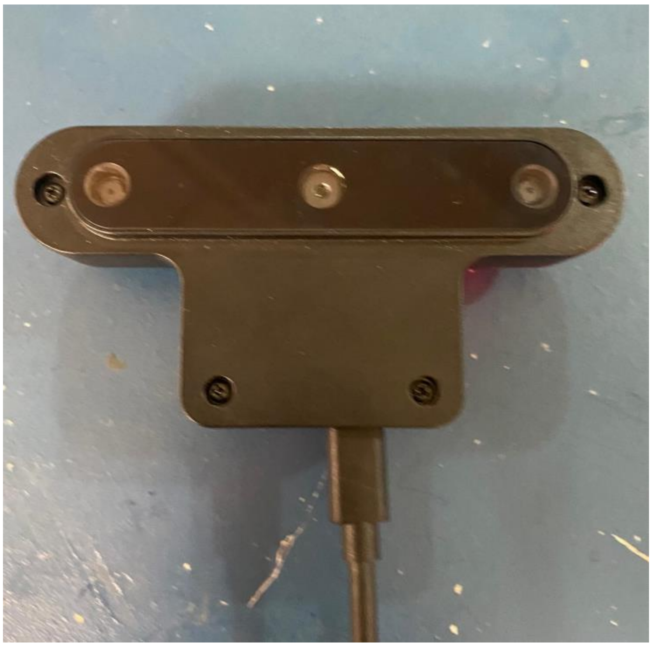


If he chooses 1 ➔ that the first selector is allowed to pump air.
If 2 ➔ allows the second selector.
If 3➔ It allows both the first and second together.
If 4 ➔ allows the third selector.
If 5➔ It allows both the first and third together.
If 6➔ It allows both the second and third together.
If 7 ➔ It allows all the selectors together.



- This process is repeated and the selectors are opened to pump the ball at each signal from the sensor.
  Where the movement of the motors with the servo and selectors becomes together , With each step movement of the X-motor, the servo is opened and a ball passes and is pumped directly.

- When the balls reach the table, the player blocks them. There is a OAK-D camera that monitors his performance with the movement of the racket and the ball and calculates the number of balls the player blocks until the end of the round.



On the edges of the table there is a set of LDR sensors equipped with lasers through which we can determine the playing area within which the player must block the ball.
At the beginning of the round, two motors move both the sensors and the laser until they reach the initial position (where each of them moves to the end of the table until each of them reaches the key and changes its value).
Then both motors begin to move with us to determine the required playing area, moving from the first area to the second and then the third.

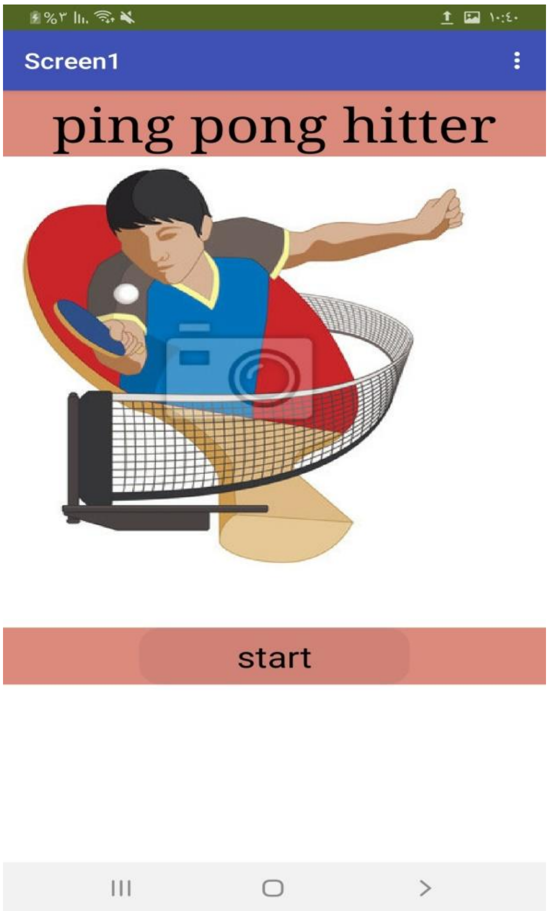
In each round, the number of balls that reach the player in this area is calculated to calculate the evaluation at the end .

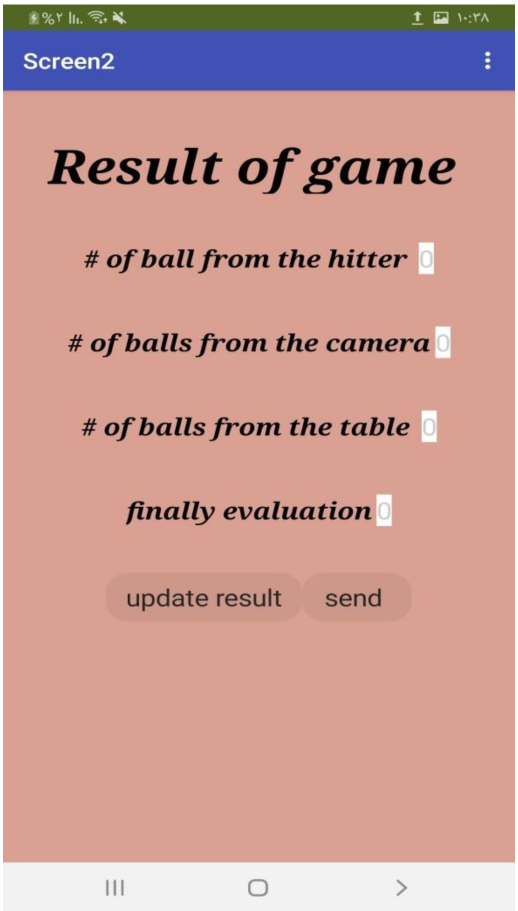
- Application

We created an application on the App Inventor to receive the result of the player's correct points and display the final evaluation of his performance

This screen displays the number of balls that are hit in the game and the number of balls that the player blocked is displayed (the value from the camera) and the number of balls that were sent to the required area and the correct way is displayed

Finally, according to the sent values, the player's evaluation result is displayed





3.3 Constraints

In my project, which involves controlling motors, detecting ball movement, and launching the ball using an air pump, several challenges could affect system performance or make implementation more difficult. Here are some potential constraints:

1. **Ball Detection Accuracy**
   - **Sensor Limitations:** The LDR and laser sensors may have difficulty accurately detecting the ball, especially if it moves quickly or if external lighting interferes with the sensors' performance.
   - **Response Delay:** LDRs can be slow to respond, which might result in missed detections when the ball moves too fast.

2. **Motor Power and Motion Response**
   - **Torque Limitations:** Stepper motors like NEMA 23 and NEMA 17 might not provide enough torque for fast or stable movement if the mechanical loads are too heavy or complicated.
   - **Vibrations and Inaccuracy:** Improper motor mounting or operating motors at high speeds can cause vibrations, reducing movement accuracy.
3. **Power Supply**
   - **High Power Demand:** Running stepper motors, servo motors, air pumps, and sensors all at once requires a stable and substantial power supply. Power fluctuations could disrupt the system.
   - **Heat Management:** High power usage can cause components like motors or relays to overheat, potentially affecting their performance and lifespan.
4. **Response Time**
   - **Processing Delays:** The Arduino Mega 2560 might not process data quickly enough, leading to delays between detecting the ball and responding with motor actions, which could impact accuracy.

- **Parallel Execution:** Managing multiple tasks at the same time (motor control, ball sensing, air pump operation) adds complexity and requires efficient coordination.

5. **Wiring and Compatibility**
   - **Wiring Complexity:** Connecting multiple sensors, motors, and components to the Arduino Mega can result in a complex wiring setup, increasing the chances of errors or incorrect connections.
   - **Signal Interference:** Signals placed too closely together may interfere with each other, potentially affecting sensor readings or motor performance.
6. **Programming and Coordination**
   - **Synchronized Movements:** Programming the motors to move in sync based on sensor data can be challenging, especially when adjusting speeds and directions on the fly.
   - **Program Complexity:** As the project grows with more motors, sensors, and controls, the code becomes more complex, which increases the likelihood of bugs or errors.
7. **Environmental Factors**
   - **Ambient Light:** External lighting could interfere with the LDR and laser sensors, making it harder to detect the ball accurately.
   - **Temperature Variations:** Temperature changes can impact the performance of the motors and sensors, especially in extreme conditions.
8. **Mechanical Constraints**
   - **Friction in Moving Parts:** Mechanical issues like excessive friction or vibrations can affect movement precision, leading to inaccuracies in the system.
   - **Motor Stability:** Poor motor mounting or inadequate mechanical design can result in unstable or erratic motor behavior, reducing the precision of the system.

4. Results and Discussion

The key purpose of the project is to effectively modernize the tennis coaching through the use of technologically-enabled improvements in accuracy and immediate feedback. Here’s the tech it works with:High Specificity: The hardware is equipped with sensors that detect if the player is actually able to successfully return the ball back. Additionally, it has a built-in camera that verifies if the player hits the ball. This, in turn, results in more accurate scoring.Instant Feedback Loop: More Efficient Training: The setup modifies exercises to the abilities of particular students making use of facts and thus makes every session quicker and more productive.Tasks are pretty automatic; the balls are catapulted out at varying speeds and the device provides players with prompt feedback concerning how they are doing, thereby enabling them to enhance their skills more effectively.Issues: Even though, there are some drawbacks to the application. For example, sensors not perceiving balls perfectly and motors not being quick enough are some of the problems. Also, the setup also requires continuous power supply, and external factors like light intensity may affect its performance.

5. Conclusion

This experiment demonstrates how integrating technology into tennis training improves accuracy in tracking player performance and ball movement. The LDR and laser sensors ensure precise scoring by detecting whether the ball was successfully returned, while the OAK-D camera provides real-time feedback on the player's ability to hit the ball. Automating the ball launch and delivering detailed performance insights allow players to focus on specific areas for improvement. By seamlessly combining advanced sensors with mechanical control, this project offers an effective and efficient solution for enhancing tennis training.

6. Recommendations

Enhancing Sensor Accuracy: To avoid most missed readings with moving objects, think about making the use of better sensors or very fast sensors. This will lead to a better accuracy of the diagnostics you will run.
Optimizing Ball Trajectory: Implement machine learning algorithms to the ball’s speed and angle on the basis of the player's capability that will then help you to play better. This program will be like a tailored dress that can be a perfect fit for each individual.
Data-Driven Performance Analytics: Utilize tools which will give you information about the players which has been collected from different sessions; hence, you could use the authentic information to make them alone perform their weaknesses and the like. These statistics are instrumental in developing aimed training techniques.
Scalability: Enhance the system by adding different ways of training such as the use of varied court sizes or players applying different techniques. In this way, we can have a finer training experience.
Improving the User Interface: Come up with an even more user-friendly interface that coaches and players can quickly get into and thus be able to modify the parameters like ball speed and direction within the training. This system will be more accessible and productive for everyone.

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