Foosbot: A Single Player Table Football

CS-358: Making Intelligent Things — Team Project Proposal

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Description

Table football, also known as foosball or table soccer, is a game based on association football. The objective is to move the ball into the opponent's goal by manipulating rods with figures resembling football players of two opposing teams. This fast-paced game is typically played by 2-4 players, but it is not designed for solo play.

Our project proposes the creation of a Foosball table that can be played by a single player, with the help of an Arduino Uno board. Our vision involves a program executed from a computer connected to the microcontroller, controlling one side of the game, while a human player controls the other side. This system should at least be able to rotate the handles and displace them, considering two axes of movement per pole.

A traditional foosball table is as large as a standard table and has four handles per side. However, for the sake of our project's budget and complexity, the prototype will be based on a smaller version with only two handles per side. This approach will reduce system complexity and improve motor reaction times.

Game Setup

- A red button is placed on one side of the main game surface to activate the game.
- The button can be pressed during the game to stop the action and restart the game.
- Double-clicking the red button stops the game completely.
- A small digital screen shows:
  - Game Instructions
  - Current score while playing

Game Level Selection

The single player can choose their competitor's difficulty level: beginner, intermediate, or advanced.

Player Specification

The player can select their team color and name via the digital screen. When the player scores, a special congratulatory message will be displayed on the screen.

Gameplay Mechanics

Controls

The human player uses keyboard controls or mouse inputs to control the players. Instructions will be provided on how to maneuver.

Game Rules

Standard foosball rules apply.

Game Levels

- **Beginner**: Basic movements with error replacement in shooting skills.
- **Intermediate**: Better positioning, including ball passing between players on the same row.
- **Advanced**: Fast moves, improved tactics based on the human player's actions.

Visuals and Sound

- **Sound**: Hand clap sound effects when the single player scores.
- **Visuals**: Congratulatory messages displayed on the digital screen when the player scores.

Game Flow Parametrics

- **Digital Display**: Displays current score.
- **Red Button**: Controls for resetting, starting, and stopping the game.
- **Match Timer**: A 30-minute counter automatically ends the game.

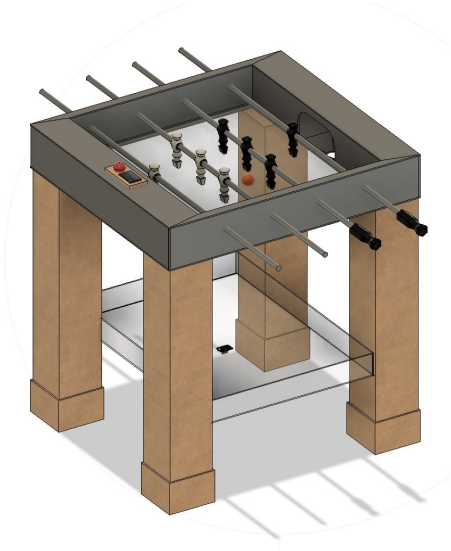

Figure 1: Isometric View of Foosball Table Structure

Figure 2: Top View of the Foosball Table Structure

Figure 3: Side Elevation View of Foosball Table with Players

Technical and Mechanical Details

Ball Vision

A camera is installed underneath the foosball setting, with a transparent surface of the game. The chosen camera model is ESP32-CAM. Due to possible challenges that top-view angle can introduce such as blind spots of the ball positions, we chose a transparent ground system for camera vision.

The ball has a distinct color such as violet for the camera vision to be able to separate it from the object in the camera view.

Image Processing And Motor Control

To accurately detect the players' positions and control their movements during the game, we will use a combination of sensors managed by Arduinos. There will be two key sensors: one attached to the rotation motion motor and an end-stop sensor for the sideways motion of the bar.

The sensor on the rotation motor will track each player's angular position, allowing precise control of their turning movements. Meanwhile, the end-stop sensor will manage the sideways motion of the bar, ensuring that it always starts from a consistent position at the beginning of each game.

The Arduinos will be programmed to interpret data from both sensors, enabling precise adjustments to the players' rotation and sideways motion. This setup will ensure accurate player positioning and smooth movements, providing a consistent and reliable gameplay experience.

Motor Design

The motors controlling the AI-player rods are responsible for two key functionalities: linear motion and rotational motion.

Linear motion refers to the movement of the rod along the x-axis on the playing field, primarily used for blocking incoming shots or passing the ball to one of the AI players on the same row. The precision and accuracy of this movement are achieved using stepper motors, which are driven by A4988 motor drivers. These motor drivers not only provide fine control over the rod's positioning but also supply the necessary power for the actuation, since the motors cannot be powered directly from the controller.

Rotational motion can be described as the actuation of the angular coordinate in a polar system with a fixed radius, where the rod rotates about a point offset along the x-axis rather than moving along the y-axis. This motion allows the AI players to perform actions such as kicking or blocking, reacting to the ball's direction by rotating quickly. The Racestar 3536 motors are employed for this task, delivering high torque to enable fast and powerful rotational movement. These motors are also controlled by suitable motor drivers to ensure they receive adequate power for their operation.

For sensor feedback:

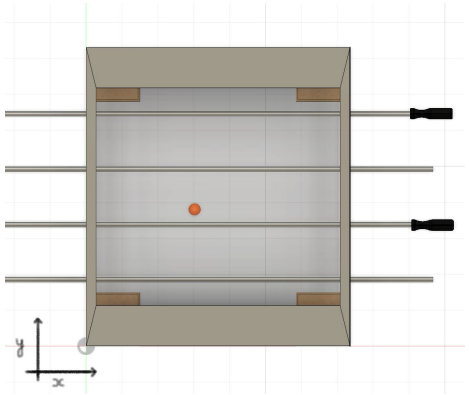

Figure 4: Top View with the Description of the Axis Structure

Rotary Incremental Encoders are attached to each motor to provide precise data on the angular position of the rods, ensuring that rotational movements are responsive and accurate in real time. End Stop sensors detect the maximum and minimum travel positions of the rods during linear motion, ensuring smooth operation and preventing the rods from moving out of bounds.

Regarding the mechanical design that allows the rods to move sideways and rotate, there are two components. The first one allows the rods to move sideways, and the second on allows them to rotate. As a model, the CAD files exhibit the intended mechanism:

- To move sideways: the idea is to use a cylinder that wraps around the rod without any friction on it and can push or pull against rings that are stuck to the rods
- To rotate: the original idea was to wrap a long gear around the rod and rotate it, however as it would imply technical difficulties another idea would be to use only two small gears far apart and connect them with small rods to allow the gear to rotate. Again, another idea would be to attach the motor to the end of the rod.

Risk Assessment

- **User Experience Risk**: The AI player's movements at different levels may seem robotic and unrealistic.
- **Technical Risk**: The response time of AI players may not be quick enough.
- **Electronics and Wiring Risk**: Risks include short circuits, unique ground levels, and motor-related risks such as back EMF, magnetic interference, and blunt trauma, as described in the course manual.

Figure 5: Side Part Design

- **Lighting Conditions**: The performance of color-based tracking can be sensitive to changes in lighting conditions, which could cause the color detection to fail. Calibration of thresholds may be necessary if lighting changes significantly.
- **Occlusion**: If the ball or player feet overlap or occlude each other, it may be difficult for the camera to distinguish between them, especially if they have similar colors.

Previous Projects

Automated Baby-Foot Table - Instructables

Babyfoot Upgrade Report - EPFL

Babyfoot 2020 Report - EPFL

Robopong 2024 Report - EPFL

Bill of Materials

You can also find the Bill of materials here in google Docs. The total cost is **240.45 CHF**.

Type	**Name**	**Shop**	**Qte.**	**Price per Piece** (CHF)	**Total Price** (CHF)
Motor + Driver	17HS4401 + A4988	CS-358	2	15	30
Motor	Racerstar 3536	CS-358	2	15	30
Motor Driver	b-g431b-esc1	CS-358	2	18	36
Sensors	End Stop Sensor	https://www.bastelgarage.ch/optischer-endschalter-lichtschranke-mit-kabel	4	3.50	14
Motor Sensors	CUI AMT-102-V Rotary Incremental Encoder	CS-358	2	21	42
Camera	ESP32-CAM	CS-358	1	4	4
USB Isolator	USB Isolator	CS-358	1	15	15
Power Supply	78 W, 12 V, 6,5 A Power supply	https://www.reichelt.com/ch/fr/bloc-d-alimentation-de-table-78-w-12-v-6-5-a-vt-3240-p215629.html	1	18.90	18.90
Plug	Power Supply Plug	https://www.distrelec.ch/fr/jack-de-puissance-prise-femelle-angle-droit-x6-3mm-cliff-fc681465/p/14205870	1	2.25	2.25
Converter	Step Down Converter	https://www.reichelt.com/ch/fr/cartes-de-d-veloppement-r-gulateur-de-tension-20-w-convertiss-debo-dcdc-20w-p233018.html	2	4.53	9.06
Belts	GT2 6mm belt, **1m**	https://www.bastelgarage.ch/gt2-riemen-6mm	2	3.90	7.80
LEDs	LED Strip, WS2813, **1m**, 5V, 1.8A, 9W	https://www.distrelec.ch/en/led-strip-ws2813-1m-5v-8a-9w-rgb-seeed-studio-104020108/p/30121593	1	6.70	6.70
Button	Red Button	https://www.reichelt.com/ch/fr/shop/produit/bouton_d_arcade_rouge-317435	1	1.29	1.29
Screen	Small Screen	https://www.reichelt.com/ch/fr/shop/produit/cartes_de_developpement_-_cran_e-ink_2_7_noir_blanc-224220	1	19.95	19.95
Ball	Orange Ball	https://andysbillard.ch/FB-Tischfussball-Ball-hart-orange	1	3.50	3.50

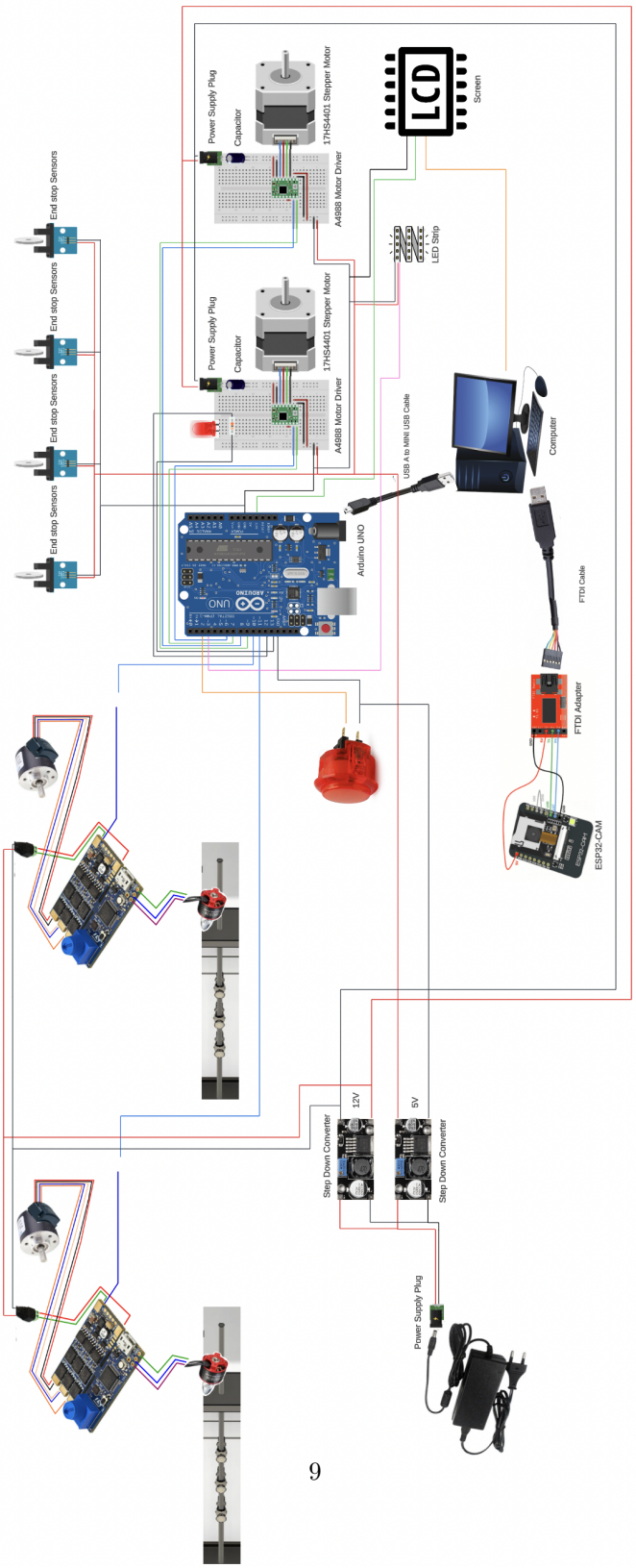

Figure 6: Electronics Design