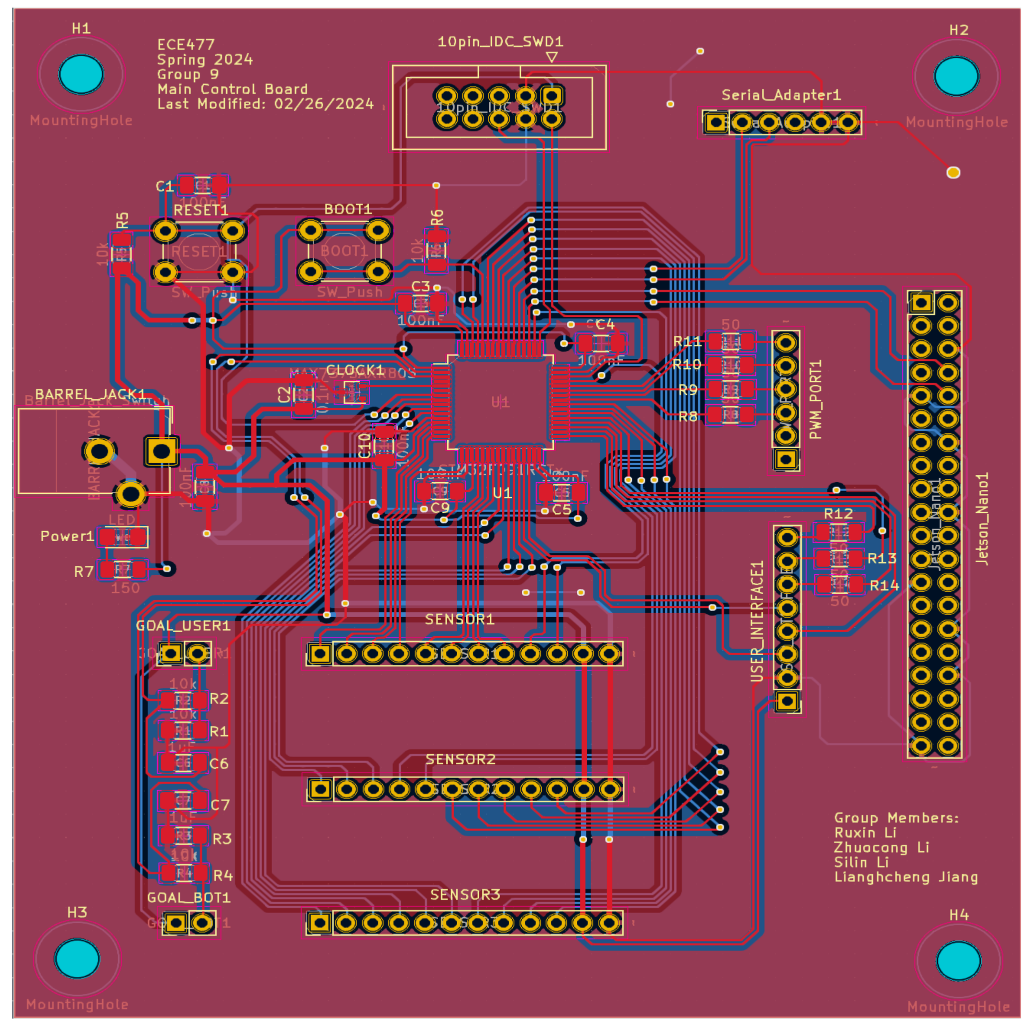
PURDUE UNIVERSITY

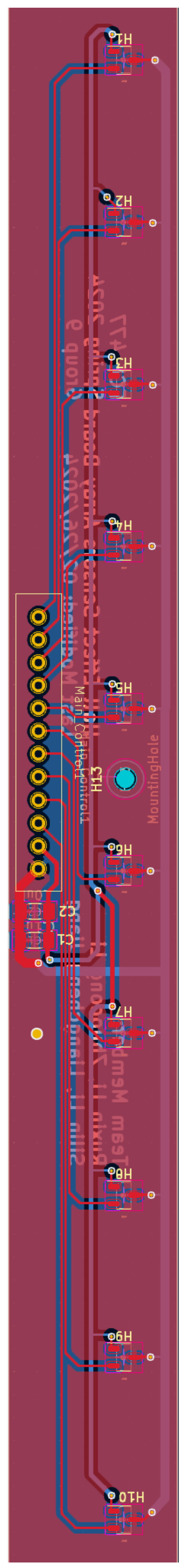
CYBER BALL

OVERVIEW

CyberBall Showdown - this innovative product allows you to hone your skills against an automated robotic opponent that tracks the ball, computes trajectories, and manipulates the rods with high accuracy and rapid response. It integrates a high-speed camera, a Jetson Nano Developer Kit, digital hall effect sensors, a microcontroller, and servo motors. CyberBall features an intuitive OLED display and keypad that lets you easily start, pause, or reset games with the push of a button. It also features a built-in pressure sensor that automatically detects when goals are scored.



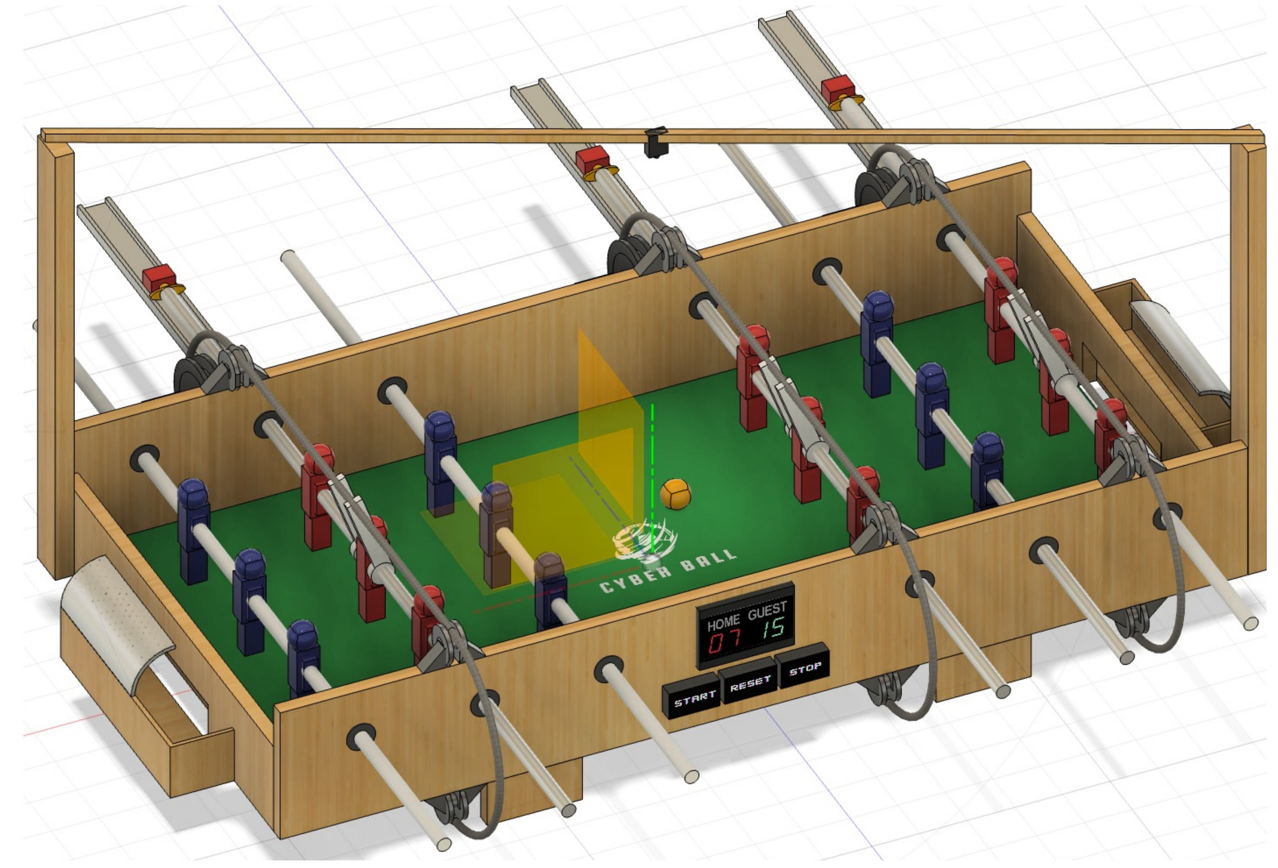
PCB Design



Our design features two essential PCBs: the main PCB, which houses the microcontroller, and the Hall effect sensor array PCB.

The main PCB is responsible for operating the microcontroller and facilitating its connection to other system components. We selected the STM32F091RCT6 microcontroller for our design, programmed via a 10-pin ST-Link clone IDC connector. It receives power through a 3.3V DC input via a barrel jack. For UART communication with the Jetson Nano, the main PCB includes a 40-pin IDC port on its right side. The main PCB includes pin headers to connect with the Hall effect sensor array boards, user interface, power supply board, and servos.

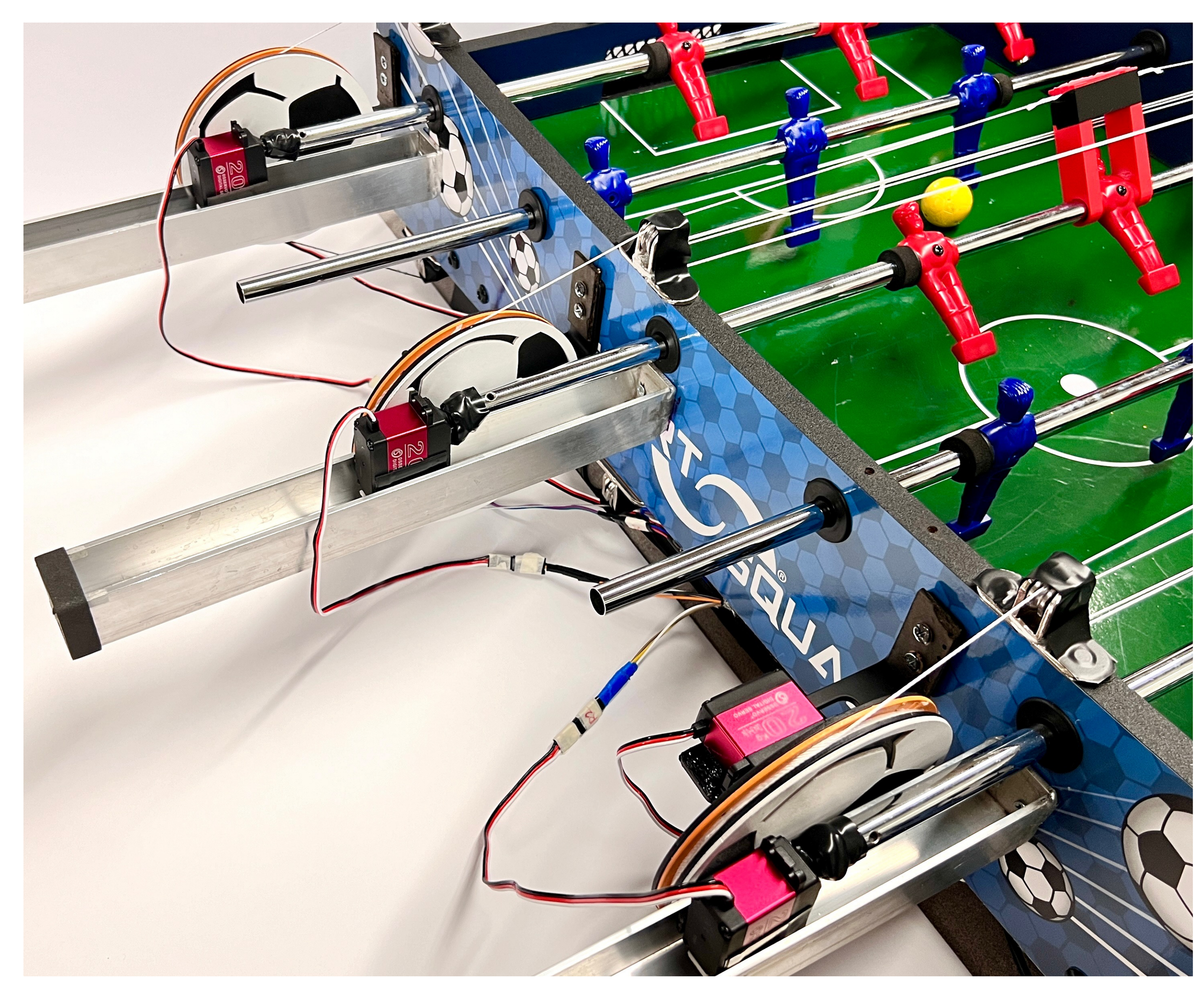
The system incorporates three Hall effect sensor arrays, each mounted below a rod to accurately detect players' position. Each board is decoupled with two capacitors and features ten Si7201 digital Hall effect sensors, spaced 2 cm apart. This arrangement allows for the precise measurement of rod position to within 1 cm, utilizing the digital Hall effect sensor arrays.



Dynamic System Design

The dynamics of the system contain two dimensions. For the rotational aspect, each rod has a high torque servo motor attached. These motors are continuously signaled on a constant frequency PWM, which allows the figures on the rods to maintain a swaying, kicking motion. For lateral movement, a structure of cables and pulleys transfers the angular momentum generated by a high-speed servo motor to the linear motion of the rod. An MCU generates the PWM signal that activates the transistor channels between the servo and the DC source to make the servo rotate to the desired angle. This angular displacement pulls the cable attached to the rod, moving it horizontally.

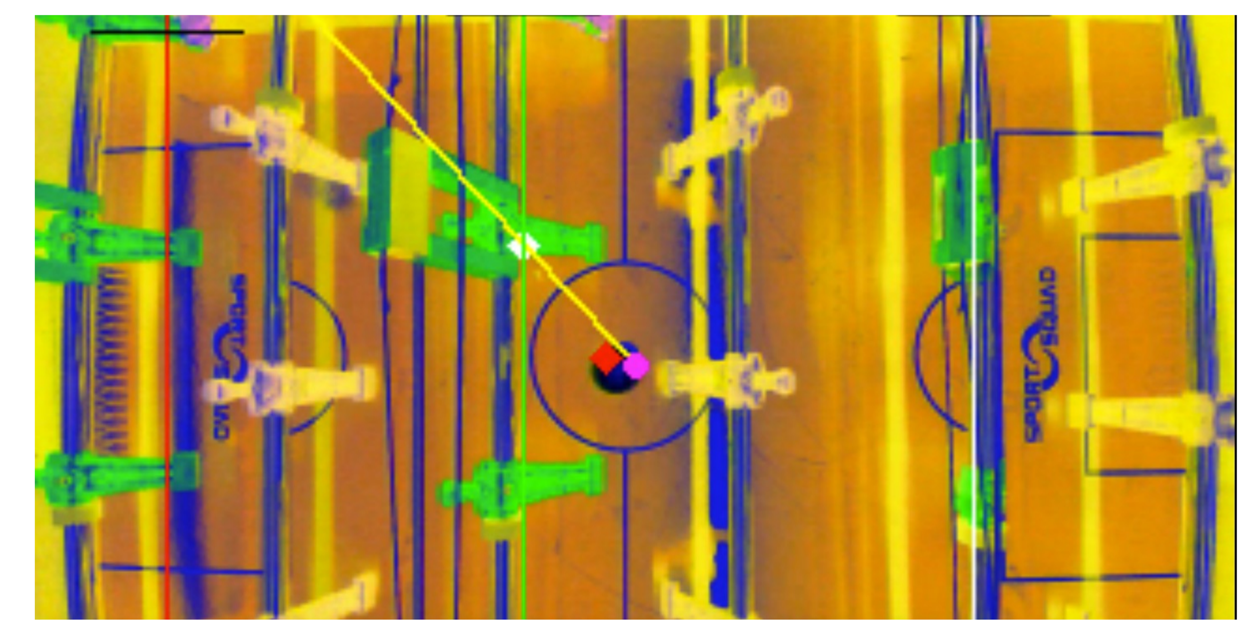
The OLED display communicates with the MCU with the SPI protocol and can be used to display the scores and user command options. The keypad (button array) communicates with the MCU through GPIO to send commands including start (power-on), re-start, and pause.



Software Design

A Jetson Nano developer kit serves as the computational core of the system. Thus, we can leverage its GPU computational resources to run Computer Vision algorithms. A high-speed camera captures the images of the foosball table and sends them to the Nano developer kit by USB protocol and GStreamer pipeline with v4l2. Jetson Nano Developer Kit runs the Min-Max Location algorithm to track the unique color of the ball.

To predict the trajectory of the ball, we introduce the extended Kalman filter to perform the task, which automatically handles the observation noise. Then, Jetson Nano calculates the intercepts of the predicted trajectory and the defense rods. Jetson Nano then updates the dedicated MCU on the intercepts via UART. The updates perform at each frame at an FPS of 90.



Resources

Want to make your own CyberBall? Sure! It is all open-sourced. Check our homepages!

Home Page

GitHub Repo

CONTRIBUTORS:

Ruxin Li
Zhuocong Li
Silin Li
Liangcheng Jiang