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EECS 373: Ping-Pong Target Practice

Section 1: High Level Description

Our overall project design is a robot that uses cameras to detect an incoming ping pong ball and then move to a calculated position where the ball will arrive at. Players are able to lock that position with a push of a button to ensure it does not move from that spot, allowing for target practice.

A display is used to show the current mode of the game that is being played. A button is used to control the modes, switching when it is pressed, with the display showing the mode change.

There will be 3 different modes to control the paddle that the user can select with the touchscreen display: Automated, Wii control, Joystick control.

Automated: The machine follows the position of the ping pong ball.

Wii Control: Movement of the paddle can be controlled by a Wii remote.

Joystick control: Manually control the movement of the paddle with a joystick.
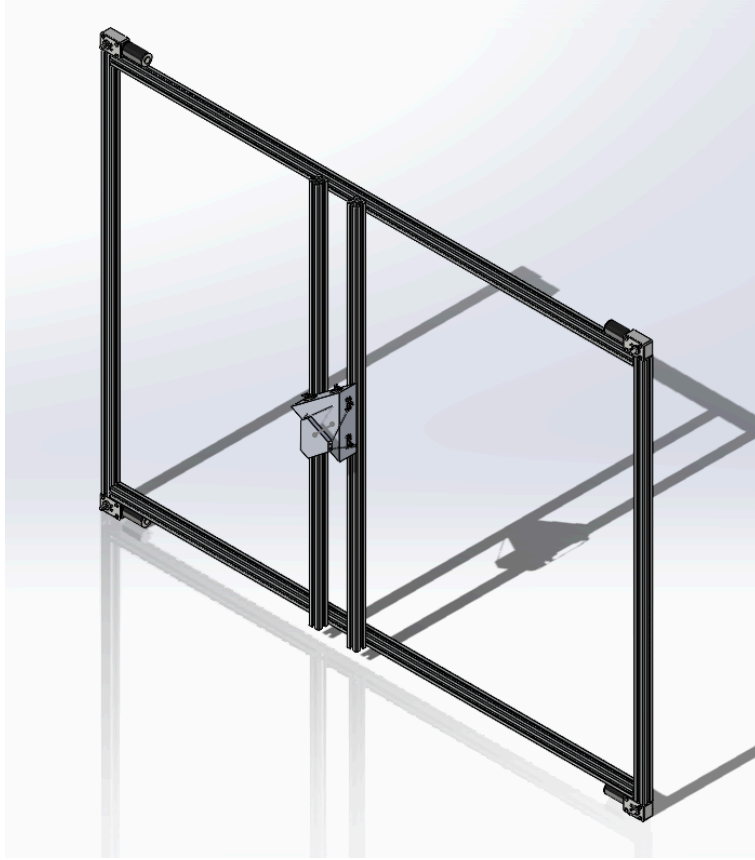
Figure 1. Preliminary mechanical design of gantry for our system featuring 5 degrees of freedom. Some electrical components were incorporated, but chains are still missing.
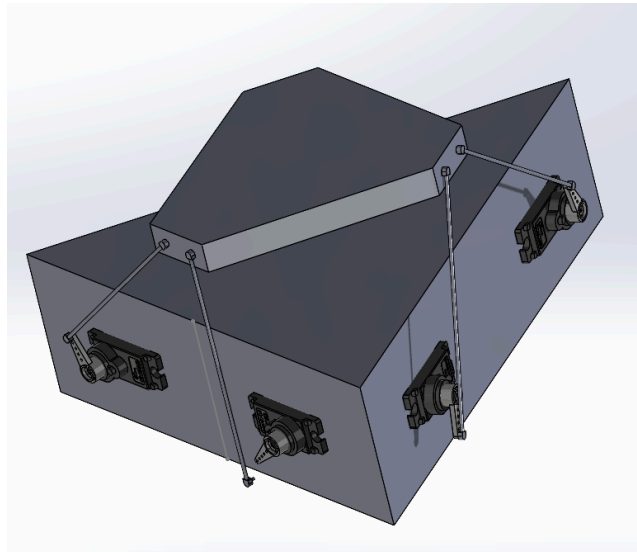

Figure 2. Prototype Stewart Platform design utilized in the above full system CAD. Utilizing 6 hobby servos to give a good range of motion for the system. Top piece will be replaced with a ping pong paddle sized platform.

Figure 3. Gif showing the operation of a Stewart Platform.

Key Functional Components:
- **Computer Vision Ball Detection**
    - We will use a camera to track the ball's trajectory
    - Image processing (OpenCV) to track ball's position and
    - Interrupts utilized to drive frame capture and processing
- **Motion Control System**
    - Using Stepper motors with chains, which move the paddle vertically and horizontally
    - Stewart platform to control the paddle's orientation to ensure an optimal rally back
    - Use of a button to stop all motors from moving to lock a position(Toggleable)
- **Embedded system integration**
    - An STM32 microcontroller will be used to handle motor control, sensors, and communication with the system receiving the visual data
    - An STM32 microcontroller(L432KC) also used to handle Wii Remote control
- **Structural features**
    - 80/20 aluminum framing

I/O inputs:
- Cameras for ball tracking
- Limit switches to ensure safety and home positioning
- Feedback from motors on positioning
- Button to select control mode

- Wii remote data
- PS2 controller data
- Button to stop the movement of the paddle to lock in place

I/O outputs:
- PWM signals to the DC motors for the X/Y axis control
- PWM signals to the servo motor to flip the Ping Pong Paddle
- Screen output control (Outputs current mode it is on)

Key Implementation Challenges:
- Real-time ball trajectory calculations
- High-speed motor control for intercepting the ball
- Accurate Paddle positioning
- Power management for multiple motors
- IR LEDs suitable for the IR Camera being used
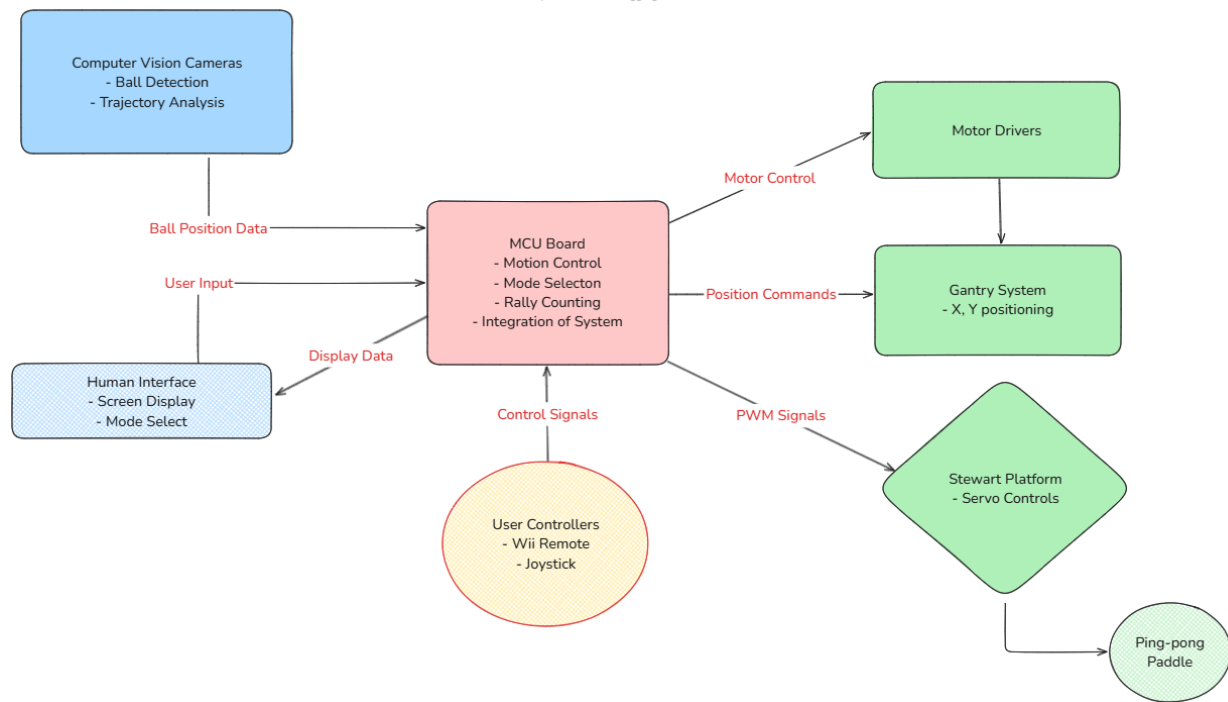
Section 2: Functional Diagram

Figure 4. Functional Diagram of System
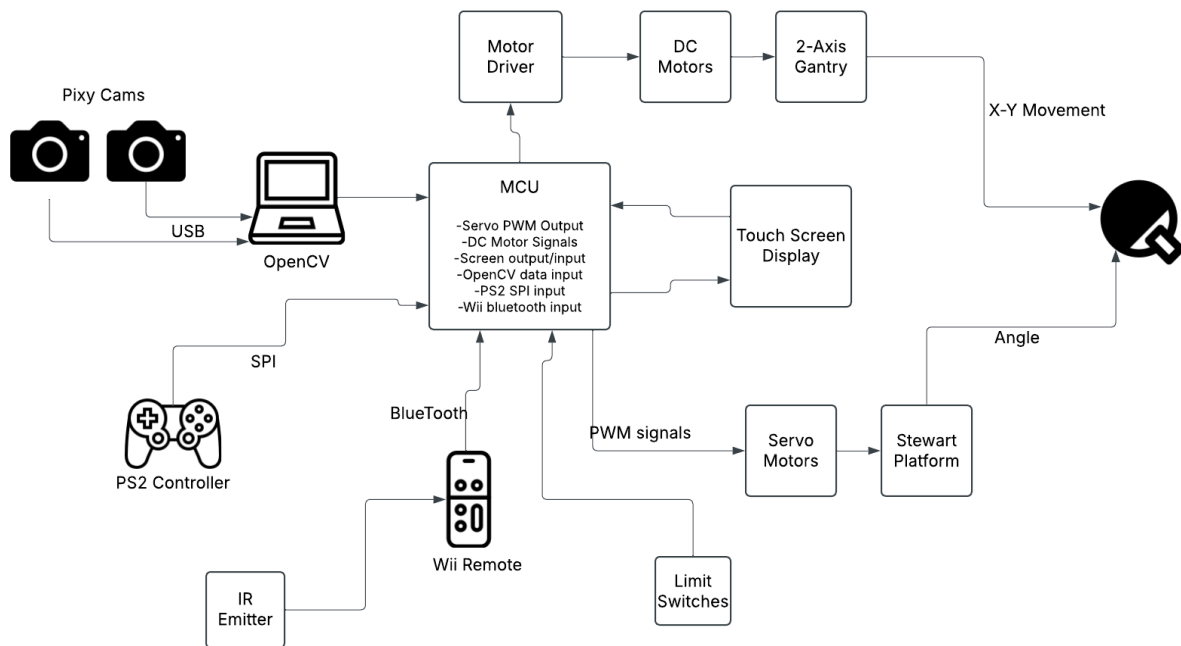
Section 3: Component Diagram

Figure 5. Component Diagram of system

Section 4: Component List

1. Stepper Motors **(For X/Y axis movement)**
2. Servo Motor
   a. High torque servos with ball bearings
   b. 180 degrees of rotation
3. Ping-pong paddle

4. Ping-pong ball
5. Ping-pong table
6. Camera
7. Power supply unit (Or a device that can power the system)
8. Chain/belt system for X/Y movement
9. LCD screen
10. Wii Remote
11. PS2 controller

Stock:
1. Raspberry Pi Camera
2. Servos
3. SPI Display
4. Stepper Motors (3x)
5. Nucleo l432kc
6. Bluetooth module

Non-Stock:
1. Ping-pong paddle
2. Ping-pong ball
3. Ping-pong table
4. Wii remote
   a. IR emitter
   b. Accelerometer
5. PS2 controller
6. Gantry
   a. 80/20 aluminum
   b. Chains

References:

Mechanics of Table Tennis:
https://protabletennis.net/book/export/html/210

https://www.amazon.com/NX4024T032-Resistive-Compatible-Raspberry-Suitable/dp/B0BBT576JK/ref=asc_df_B0BBT576JK?mcid=2e24115a1bb63369a2a8612596a2348b&hvocijid=6717852405584003605-B0BBT576JK-&hvexpln=73&tag=hyprod-20&linkCode=df0&hvadid=730434177080&hvpos=&hvnetw=g&hvrand=6717852405584003605&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9016855&hvtargid=pla-2281435177818&th=1

PS2 Controller:
https://store.curiousinventor.com/guides/PS2/