MagDrop4

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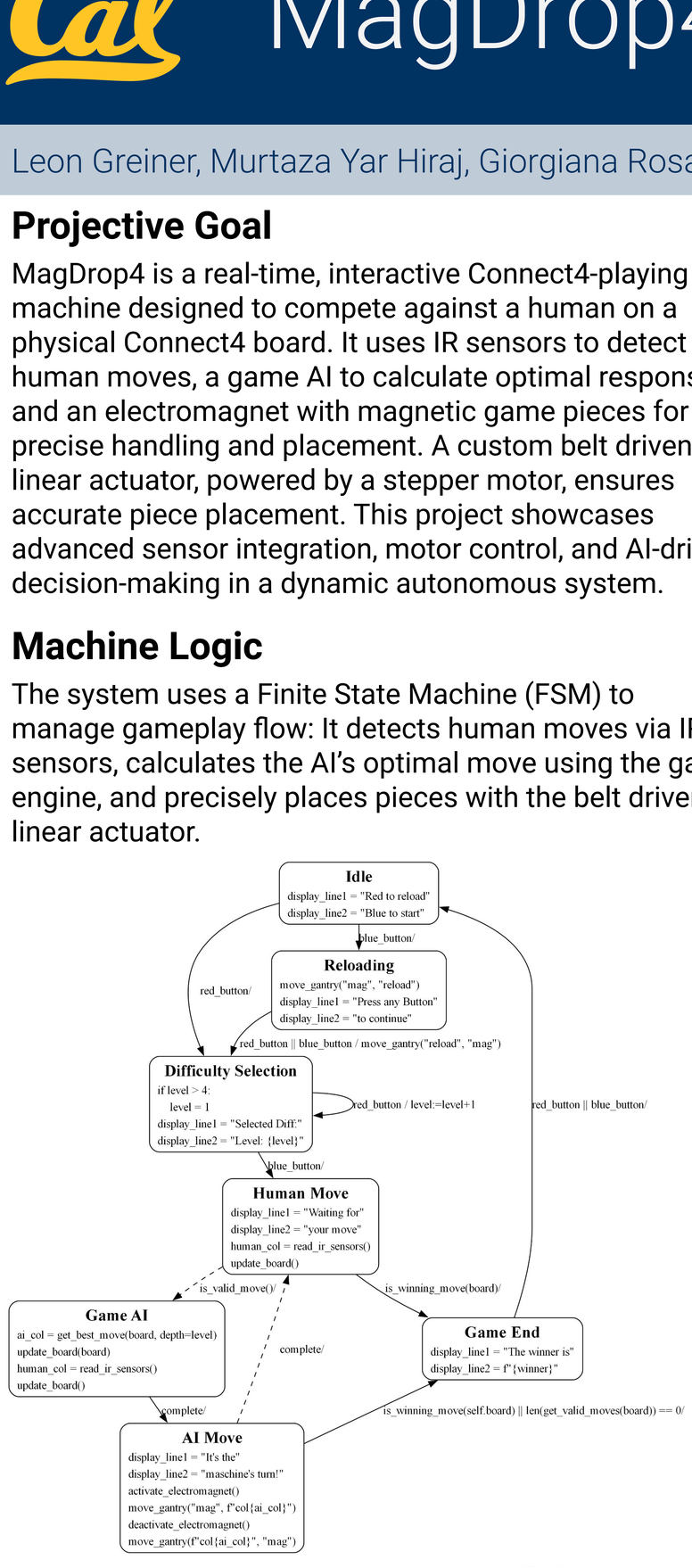
Projective Goal

MagDrop4 is a real-time, interactive Connect4-playing machine designed to compete against a human on a physical Connect4 board. It uses IR sensors to detect human moves, a game AI to calculate optimal responses, and an electromagnet with magnetic game pieces for precise handling and placement. A custom belt driven linear actuator, powered by a stepper motor, ensures accurate piece placement. This project showcases advanced sensor integration, motor control, and AI-driven decision-making in a dynamic autonomous system.

Machine Logic

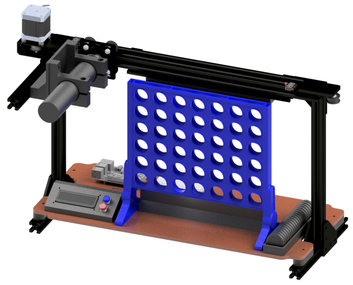
The system uses a Finite State Machine (FSM) to manage gameplay flow: It detects human moves via IR sensors, calculates the AI's optimal move using the game engine, and precisely places pieces with the belt driven linear actuator.



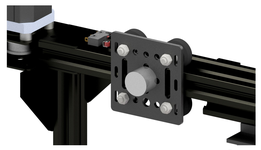
Simplified illustration of the Systems FSM

Mechanical Design

The main structure is built from standard aluminum profiles, which also serve as the guide rail for the gantry cart of the linear actuator. The baseplate is precision laser-cut from plywood. Numerous components, including mountings, the magazine, and game discs, are 3D-printed using PLA. The magazine uses a spring mechanism to continuously push the game discs toward the grabbing point..



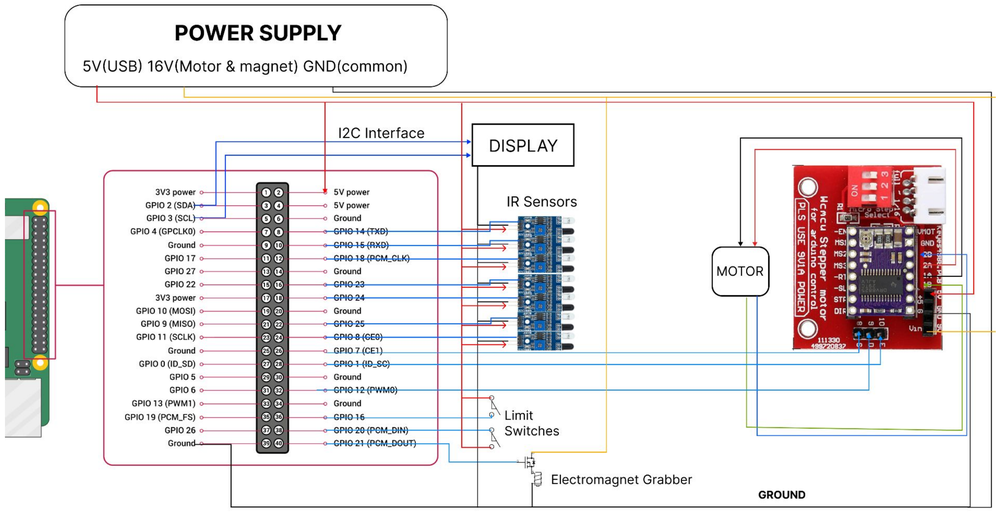
Disc Magazine



Gantry Cart with Electromagnet

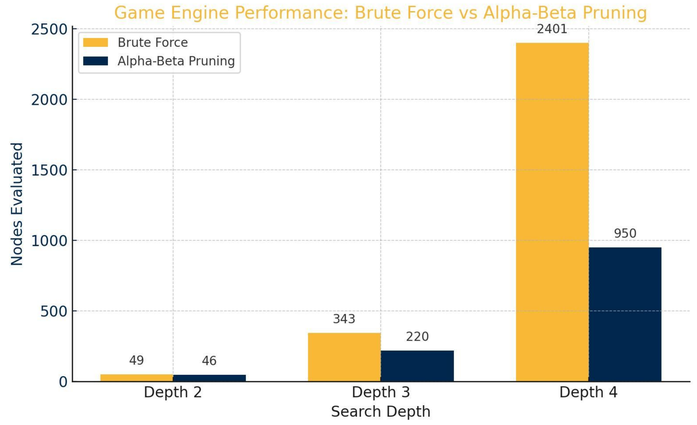
Electrical Design

The electrical system is built around a Raspberry Pi 3+, handling motor control, sensor inputs, and display output. Power is supplied via 5V and 16V lines, with an I2C interface managing the display and the stepper motor controlled by a DRV8825 motor driver, connected via an extension board to the Raspberry. Furthermore, we use an N-channel logic-level MOSFET to control the 16V electromagnet via a GPIO pin.



Game Engine

The game engine uses a Minimax algorithm enhanced with Alpha-Beta Pruning to optimize the AI's moves efficiently. A heuristic evaluates board states by scoring windows with 4, 3, and 2 AI pieces as (+100, +10, +5), penalizing opponent windows as (-100, -8, 0), and prioritizing central play.



System Integration and Results

The final system delivers real-time interaction, accurate gameplay execution, and competitive AI performance, showcasing the success of combining precision mechanics, sensor integration, and advanced algorithms. The gantry cart completes its cycle in <5 secs: detecting human play, computing the AI's move, placing a piece, and resetting for the next turn. This highlights the system's speed and seamless integration.