

Ultimate Chess



Team B1: Anoushka Tiwari, Demi Lee, Yoorae Kim

Application Area

- Enjoy physical chess during pandemic
- Help the elderly who aren't comfortable with apps still enjoy chess
- Learn to be better at chess from practicing chess with AI
- Areas Covered:
 - Signals, Software, Circuits



Requirements

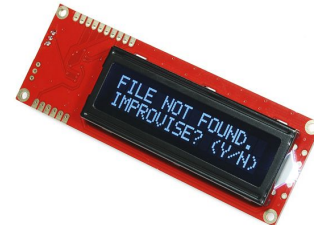
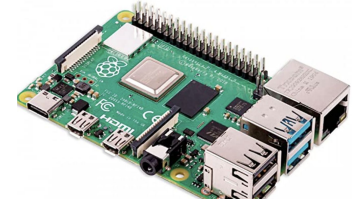
- Low move latency (< 24 sec)
- High move detection accuracy (> 99%)
- Accurate illegal move detection (100%)

Solution Approach

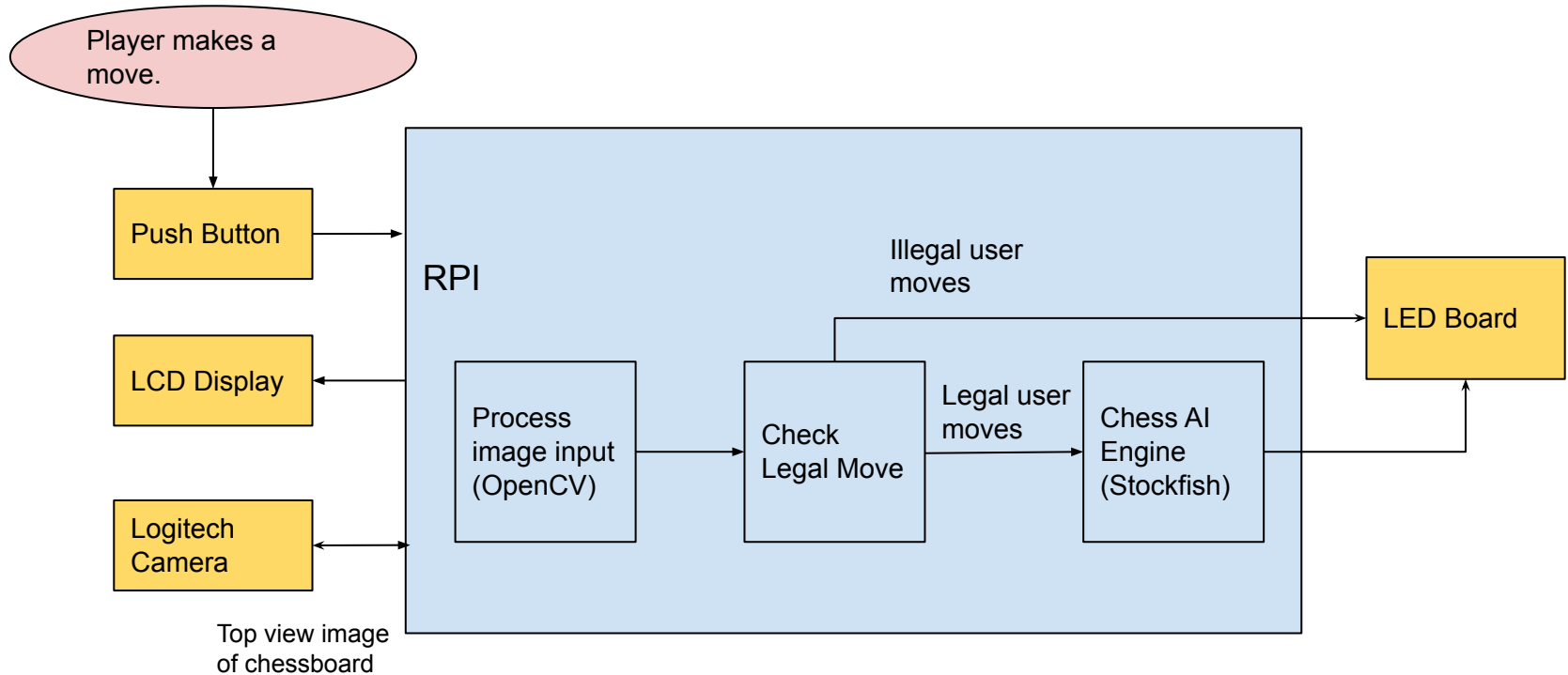
- Computer Vision
 - Webcam placed on top of the chessboard
 - Detect player's move using OpenCV
- Software
 - Check if player's move is valid or not by implementing chess game logic
 - Use existing chess AI engine to come up with next move
- Hardware
 - Display AI's move using LEDs
 - Player presses push button after making their move
 - Signals camera to take picture of board
 - LCD display keeps track of total time each player takes for their moves

Components

Chess pieces	\$24.64
Logitech C270	\$26.92
Raspberry Pi	Capstone Inventory
LED Strips	\$22.88
5V Power Supply	\$21.99
Push Button	\$5.95
LCD Display	\$10.99
Acrylic/Wooden Sheets	\$50 (estimate)
Total	\$160

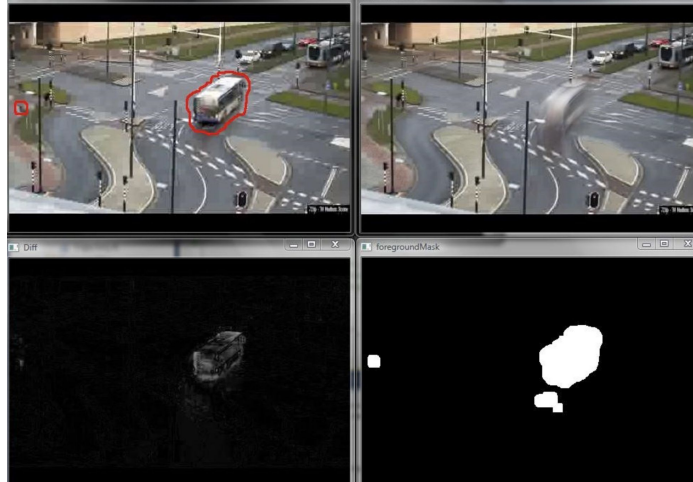


System Overview



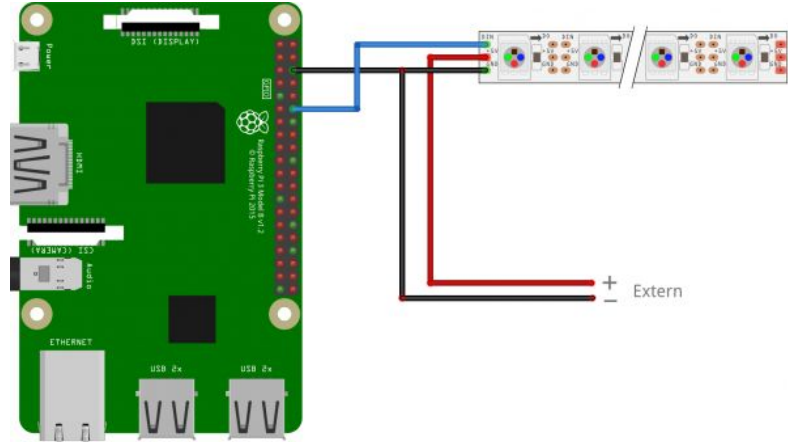
Implementation - Image processing

- Detect edges of 64 squares on a chessboard, convert them into coordinates
 - Canny edge detection (OpenCV)
- Detect user move
 - Change detection & background subtraction algorithm (Open CV)



Implementation - LEDs

- 8x8 LED matrix under chessboard
- WS2812B RGB LED Strip
 - Individually programmable LEDs
 - Rpi_ws281x library
 - 5V power supply adapter



(Source: [tutorials-raspberrypi.com](https://www.tutorials-raspberrypi.com))

Implementation - Software

- Implement chess game logic to check if player's move is valid or invalid
 - Only valid position changes
 - If there is a check, must try to save the king
- Generate AI's move corresponding to user input (Stockfish chess engine)



Metrics

AREA	TESTING STRATEGY	METRIC
CV	Compare the internal board representation to the actual board	99% accuracy
CV + AI move latency	Use a timer to measure average time it takes for the LEDs to light up after player moves	< 24 s
Valid chess game	Make invalid moves to see if the software catches it. Make valid moves to ensure no false positives	100% accuracy
LEDs	Visually confirm that the right LEDs light up	100% accuracy

Risk Factors and Mitigation approach

- CV not being accurate on difference in chess board
 - Possible causes: inconsistent lighting and user's hand included in a photo
 - Mitigation approach: include a simple lighting system and a front-end button user can push after finishing the move
- CV + AI engine creating a latency bottleneck
 - Using an efficient AI engine like Stockfish with medium difficulty setting
 - Downscaling the image before applying CV processing
- Edge detection on chessboard squares
 - Mitigation approach: Use contrasting alternating colors for each block

Schedule

Tasks	10/4 - 10/10	10/11-10/17	10/18-10/24	10/25-10/31	11/1-11/7	11/8-11/14	11/15-11/21	11/22-11/28	11/29-12/5
Computer Vision									
Camera Setup	Anoushka								
Board Detection	Anoushka & Yoorae	Anoushka & Yoorae							
Move Detection		Anoushka & Yoorae	Anoushka & Yoorae						
Optimization for Speed				Anoushka & Yoorae	Anoushka & Yoorae	Anoushka & Yoorae			
Design chessboard									
Laser cut chessboard	Demi	Demi							
LED Purchase	Demi								
LED circuit design		Demi							
Chessboard / LED Construction		Demi	Demi						
RPI testing			Demi						
Game Software									
Implement chess game logic	Yoorae								
Integration									
Integration CV / Chessboard			Everyone	Everyone					
AI Integration			Everyone	Everyone	Everyone				
Class stuff									
Proposal presentation (Anoushka)									
Design presentation (Yoorae)									
Midpoint demo						Everyone			
Final report							Everyone	Everyone	
Final presentation & demo									Demi
User Interface (Optional)									
Basic website framing			Yoorae						
Display current board in real time with AJAX			Yoorae	Yoorae	Yoorae				
AWS upload				Yoorae	Yoorae				

Anoushka
Demi
Yoorae
Anoushka & Yoorae
Everyone