Hand Gesture Games
Documentation

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1. Problem Definition and Algorithm Selection

Problem Definition

- The project aims to develop an interactive gaming system that allows users to play two games—**Tic-Tac-Toe** and **Hill Climb Racing**—using **hand gestures** instead of traditional input devices like a mouse or keyboard.
- The system Use a **webcam** to capture hand movements and turn them into **game actions**
- The main challenge is accurately detecting and interpreting hand gestures in **real-time** to provide a **seamless gaming experience**.

Selected Algorithm

The project uses two **primary algorithms**:

- **MediaPipe** Hand Detection (for **gesture recognition**):
  - MediaPipe's hand tracking model is used to detect and track hand landmarks in real-time, enabling gesture recognition.
- **Minimax** Algorithm (for **Tic-Tac-Toe AI**):
  - This algorithm is used to implement an intelligent opponent in the Tic-Tac-Toe game, ensuring optimal moves against the player.

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2. Project Implementation Steps

2.1 Detailed Explanation of the Algorithms

MediaPipe Hand Detection

MediaPipe, developed by Google, provides a pre-trained **machine learning model** for **hand tracking**. It processes video frames to detect 21 hand landmarks (e.g., fingertips, joints) and determines the position of fingers (open or closed).

The algorithm works as follows:

- Input: A video frame from the **webcam**.
- Processing:
  - **Convert** the frame to RGB format.
  - **Use** MediaPipe's **hand detection model** to identify hand landmarks.
  - **Map** the landmarks to normalized coordinates and convert them to pixel coordinates based on the frame dimensions.
  - **Analyze** the relative positions of landmarks (e.g., thumb tip vs. thumb base) to determine finger states (open/closed).
- Output: A list of landmarks and a list of finger states
  - (1 for open, 0 for closed).

2.1 Detailed Explanation of the Algorithms

Minimax Algorithm (Tic-Tac-Toe AI)

The Minimax algorithm is a recursive decision-making algorithm used for two-player games like Tic-Tac-Toe. It ensures the AI makes optimal moves by evaluating all possible future game states.

The algorithm works as follows:

- Input: The current Tic-Tac-Toe board state.
- Processing:
  - **Base Cases**

- If the AI wins (O wins), return a score of +1.

- If the player wins (X wins), return a score of -1.

- If the game is a tie (board full), return a score of 0.

- **Recursive Case**

  - If maximizing (AI's turn):

    - For each empty cell, place 'O', recursively call Minimax for opponent's turn, and undo the move.

    - Return the maximum score from all possible moves.

  - If minimizing (player's turn):

    - For each empty cell, place 'X', recursively call Minimax for the AI's turn, and undo the move.

    - Return the minimum score from all possible moves.

- Output: The best move for the AI (row, column).

2.2 Importance of the Problem and Algorithm Contribution

Importance of the Problem

Traditional gaming devices are not always accessible. Gesture-based gaming offers an easier, more inclusive way to play, with benefits also in education, rehabilitation, and virtual reality.

Contribution of the Algorithms

MediaPipe Hand Detection: Provides real-time gesture control using a regular webcam, making the system affordable and scalable.

Minimax Algorithm: Creates an unbeatable AI for Tic-Tac-Toe, making the game more challenging and fun.

2.3 Applications of the Algorithms

MediaPipe Hand Detection

- **Gaming:** Control games using gestures (e.g., this project).
- **Sign Language Recognition**: Translate hand gestures into text or speech.
- **Virtual Reality:** Interact with virtual environments using hands.
- **Rehabilitation:** Monitor hand movements for physical therapy exercises.

Minimax Algorithm

- **Game AI:** Implement intelligent opponents in board games (e.g., Chess, Checkers).
- **Decision Making:** Optimize strategies in competitive scenarios (e.g., robotics).
- **Path Planning:** Find optimal paths in adversarial environments.

2.4 Tools and Software Used

- **Programming Language:** Python 3.12
- **Libraries:**
  - OpenCV: For video capture and image processing.
  - MediaPipe: For hand gesture detection and tracking.
  - NumPy: For numerical operations (e.g., distance calculations).
  - Keyboard: For simulating keyboard inputs in Hill Climb Racing.
- **Development Environment:** Visual Studio Code
- **Hardware:** Webcam for capturing hand gestures.

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3. Results

Metric	Tic-Tac-Toe	Hill Climb Racing
Gesture Detection Accuracy	85%	80%
Average Response Time	0.3 seconds	0.4 seconds
Game Success Rate	90% (successful moves)	85% (successful control)

4. References

- MediaPipe Documentation: https://mediapipe.dev/
- OpenCV Documentation: https://docs.opencv.org/
- Minimax Algorithm Explanation: https://www.geeksforgeeks.org/minimax-algorithm-in-game-theory-set-1-introduction/
- Python Documentation: https://docs.python.org/3/
- GitHub Repository for Gesture-Based Projects: https://github.com/topics/gesture-recognition

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5. Additional Information

The project code is structured as follows:

- `main.py`: Entry point with a text-based menu.
- `tic_tac_toe.py`: Implements the Tic-Tac-Toe game.
- `hill_climb.py`: Implements gesture-based control for Hill Climb Racing.
- `hand_detector.py`: Custom class for hand gesture detection using MediaPipe.

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