Project Scope: Real-time Stabilization and 3D Reconstruction of Hand Gestures and Finger Movement Traces Using LED-Equipped Gloves

This project aims to develop a mobile app that captures, stabilizes, and smooths hand gestures and finger movement traces in real-time using LED-equipped gloves and a phone's rolling shutter camera. The app will employ image processing techniques for refining hand movements and finger traces, integrating machine learning algorithms for recognition, and ensuring privacy by filtering irrelevant data. After achieving 3D reconstruction of the movements, the project will extend to integrate the visualized movements into a virtual reality (VR) space. The project is divided into the following key components:

1. LED Gloves: Understanding and Setup

Objective: Familiarize with the hardware and software functionality of the LED gloves provided by Dr. Zhang.
Tasks:

- Meet with Dr. Zhang or his graduate students in the lab to understand glove features.
- Learn how to operate, control, and integrate the LED gloves with the mobile app.
- Document hardware/software specifications and ensure compatibility with the app.

2. Basic Mobile App Development

Objective: Build the foundational mobile app that can access the camera feed in real-time.
Tasks:

- Design a user-friendly interface with basic app functionality (start/stop tracking, camera access).
- Integrate Android Camera2 API to capture the live camera feed.

3. Image Processing

Objective: Pre-process and post-process camera feed data to focus on tracking hand gestures and finger movement traces while eliminating noise and irrelevant data.
Tasks:

- Implement image denoising techniques to minimize interference from ambient light.
- Develop algorithms to enhance the visibility and track the finger movement traces created by the LED gloves under various and potentially challenging lighting conditions.
- Filter out background and irrelevant data for privacy protection.
- Focus on improving the precision and smoothness of captured hand gestures and finger traces to ensure fluid representation.

4. Machine Learning Integration

Objective: Apply machine learning techniques to refine the accuracy and smoothness of finger movement traces and recognize hand gestures formed by the user.
Tasks:

- Train ML models to smooth raw movement data and predict missing points in finger traces.
- Implement gesture recognition models to detect predefined hand movements or letter formations created by the fingers.
- Optimize the models for real-time performance on mobile devices while maintaining smooth and accurate hand gesture recognition.

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5. 3D Simulation and Movement Trace Display

Objective: Create a 3D simulation to display the reconstructed hand gestures and finger movement traces in real-time, incorporating the refined data from image processing and machine learning.
Tasks:

- Use OpenGL ES or similar 3D rendering libraries to visualize the traced finger movements.
- Ensure the 3D simulation accurately reflects smooth hand movements and finger traces with minimized jitter and noise.
- Provide real-time feedback to the user by visualizing both raw and processed hand gestures and finger traces.

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6. VR Integration for Movement Trace Visualization

Objective: Expand the project to integrate the 3D hand gesture and finger movement trace visualization into a virtual reality (VR) space, either within the mobile app or through a dedicated VR headset.
Tasks:

- Research and select a suitable VR platform (e.g., mobile VR or a standalone VR headset).
- Modify the 3D simulation to work in a VR environment, ensuring accurate depth and perspective tracking for a fully immersive experience.
- Implement VR controls for interaction within the VR space, allowing users to interact with the virtual environment using their hand gestures and finger traces.
- Optimize the VR experience to maintain real-time performance while using the refined movement traces from the LED gloves.
- Explore potential applications for the VR space, such as interactive games, training simulations, or gesture-based controls.

Deliverables

- Operational LED glove control.
- A mobile app with real-time camera feed access.
- Image processing algorithms for LED glove-based movement trace tracking.
- Machine learning models for hand gesture and finger movement trace recognition.
- Real-time 3D visualization of finger movement traces.
- Full VR integration of hand gesture and finger trace visualization in an immersive space.
- **Long-term Goal**: Research and develop further implementations or potential applications of this technology, exploring its use in fields such as interactive gaming, VR-based training, gesture-based controls, or other innovative areas.