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Virtual Reality Enabled Activity Recognition for Immersive Computing

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Goals

- Recognize human activities using only Meta Quest VR headset built-in sensors.
- Build complete pipeline: data collection → preprocessing → feature extraction → classification
- Evaluate traditional ML vs LLM-based approach with zero training data

Background and Motivation

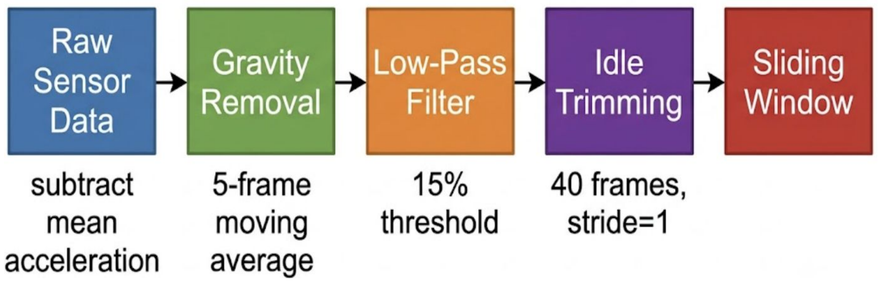
- VR headsets have built-in IMU sensors capturing motion data at 72Hz — always active.
- Current activity recognition requires extra wearables or cameras.
- Our approach uses only the headset's existing sensors for activity recognition

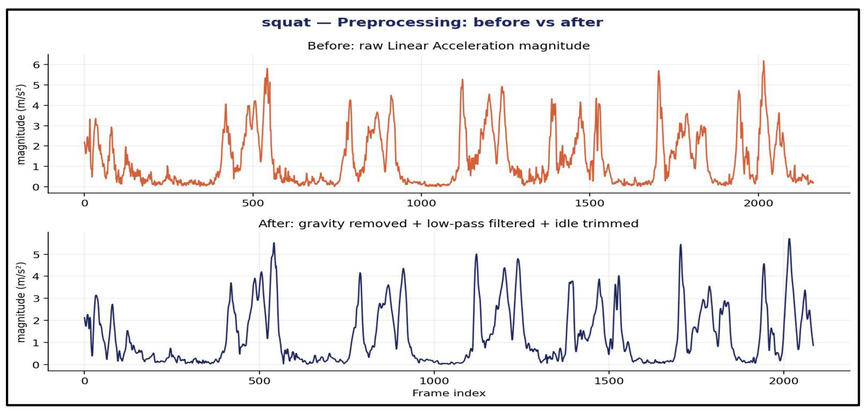
Technologies Used

- Meta Quest VR Headset (HMD + Controllers)
- Android Studio + Meta VrApi SDK (C++)
- ADB (Android Debug Bridge) for data extraction
- Python — scikit-learn, numpy, matplotlib

Methodology

- Sensor data captured at 72Hz from HMD and controllers and give 4 sensor types: Linear Acceleration, Angular Velocity, Linear Velocity, Angular Acceleration
- 12 values per frame (3 axes × 4 sensor types) — two-stream design



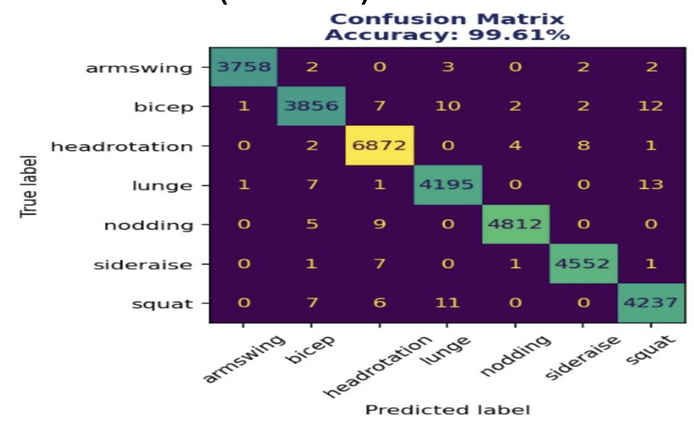


PCA Feature Extraction

- 5 stats (mean, std, min, max, energy) × 12 channels = 60 features per window
- Two-stream PCA: Body → 2 components + Head → 3 components = 5 PCA total

Classifier Comparison

- Two-Stream CNN/MLP — 99.61%
- KNN k=3 (5 PCA) — 95.43%
- Random Forest (5 PCA) —93.91%
- SVM RBF (5 PCA) — 67.07%



Prompt Engineering

- Tested 3 strategies: zero-shot, few-shot, chain of thought
- 55 tests (5 per activity) — **100% accuracy with zero training data**

Gemini LLM achieves 100% accuracy with zero training data outperforming all trained classifiers that required 247,400 labeled windows.

Acknowledgments

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[1] Zhao et al., IEEE VR 2023 — Two-stream 1D CNN for HMD activity recognition
[2] Guo et al., IEEE INFOCOM 2017 — FitCoach: wearable fitness recognition
[3] Xu et al., HotMobile 2024 — Penetrative AI: LLMs for sensor data

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