BodyTrack

Real-Time Posture Evaluation Using Biomechanics & Machine Learning

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The Problem: **Unsafe Training Without Supervision**

Strength training is more popular than ever. But while access to equipment has grown, access to expert supervision hasn't.

Most people train alone, without knowing if their posture is right - and mistakes go unnoticed.

Incorrect posture during exercises can lead to:

- Muscle imbalances that affect progress
- Joint stress and long-term injuries
- Ineffective workouts with little improvement

Current fitness apps do not offer real-time posture correction.
Most users only realize their mistakes when it's too late - after pain or injury occurs.

What Exists Today – and Why It's Not Enough

There are many fitness apps and smart devices on the market today. **None of them provide real-time posture correction using only a smartphone.**

Existing solutions include:

- **Training apps** like Nike Training Club or Freeletics – offer workouts, but **no form tracking**
- **Devices like Mirror or Peloton Guide** – provide camera-based feedback, but are **expensive and require special hardware**
- **Apps like Kaia Health** – focus on therapy, not full-body strength exercises

These tools are useful, but they don't solve the **core problem:** helping people correct form **in real time**, during strength exercises, without buying new equipment.

Our Goal:
Real-Time Posture Correction for Everyone

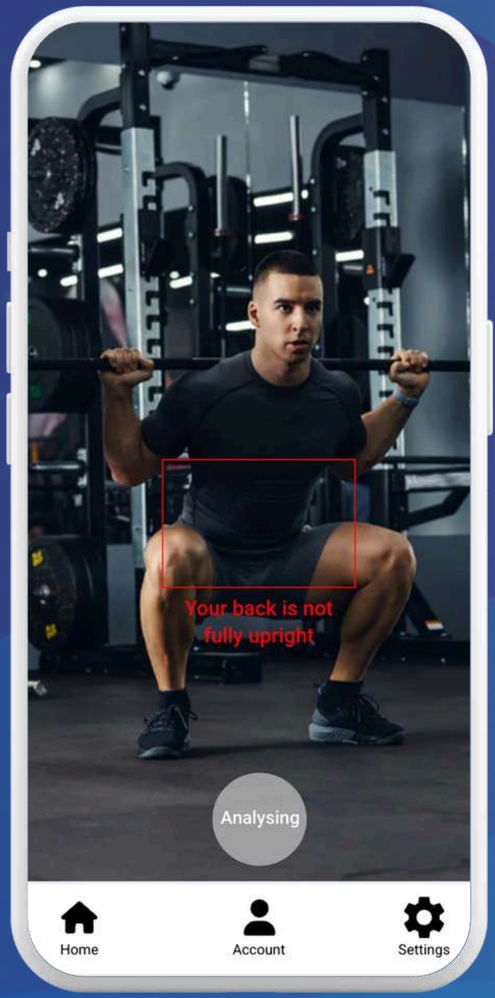
BodyTrack is an Android-based app that helps users improve their exercise technique — safely, effectively, and independently.

Our mission:

Deliver **real-time feedback** on posture and joint alignment

Use only the **smartphone's camera** — no external hardware needed

Make smart coaching **accessible to anyone**, anywhere



We aim to reduce injuries, improve performance, and help users train confidently — just like having a personal coach in your pocket.

System Architecture:
Lightweight Client, Smart Server

BodyTrack combines **real-time posture correction** with a modular **client–server architecture**.

The system is built with 3 key layers:

Input Layer (Client):

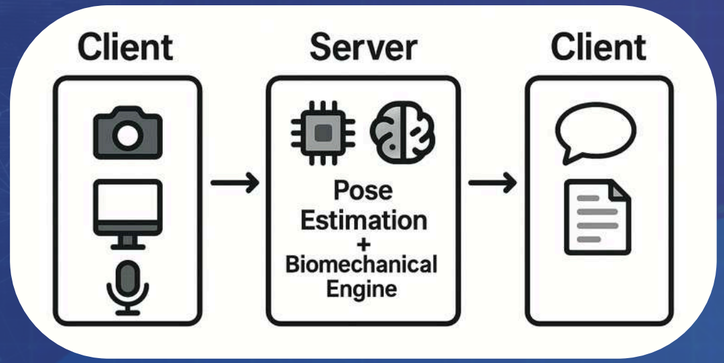
- Captures live video frames from the phone's camera and sends them to the server.

Analysis Layer (Server):

- Detects joint positions using pose estimation (MediaPipe Pose).
- Calculates joint angles and movement phases.
- Compares posture to biomechanical models and detects errors.

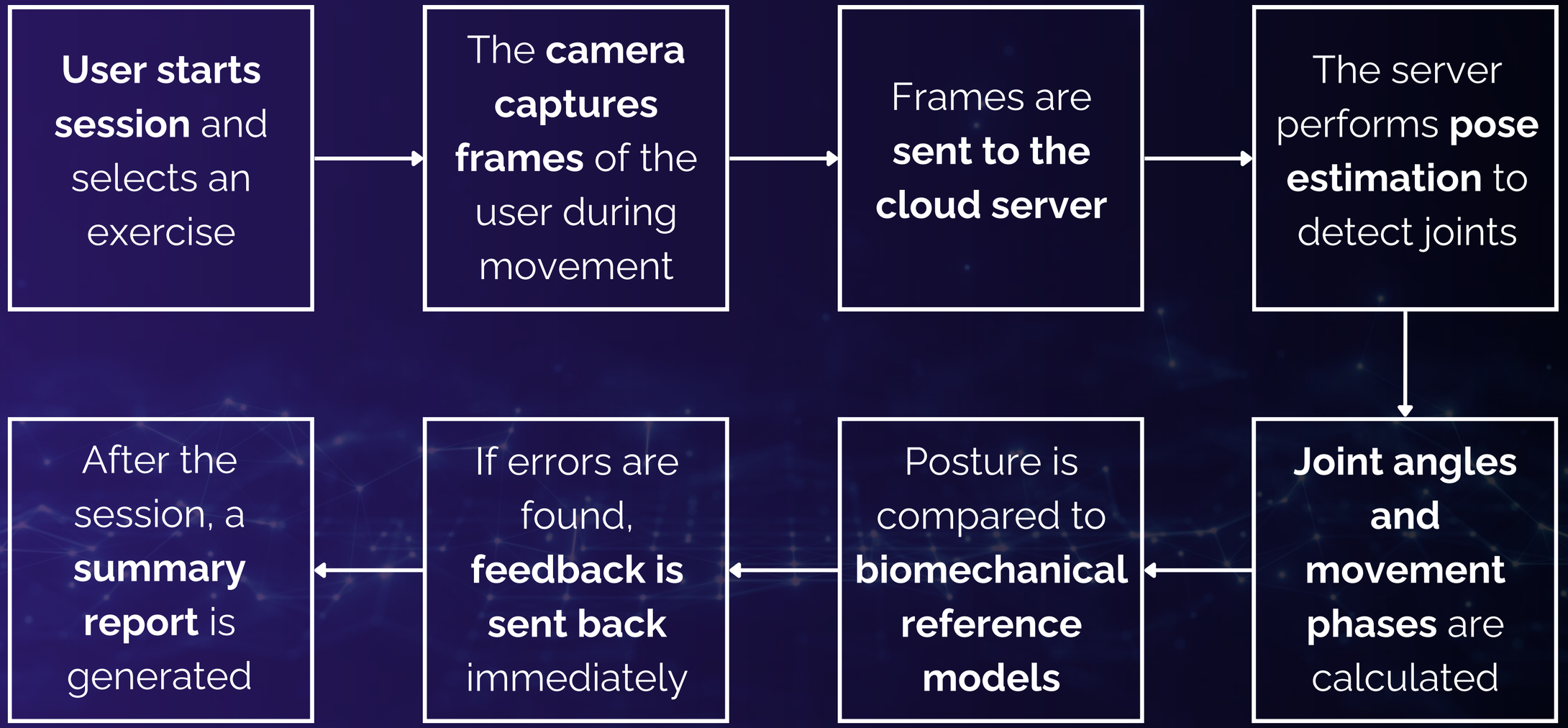
Presentation Layer (Client):

- Displays real-time feedback via text, visuals, and audio cues.
- Shows session summaries after the workout.



This architecture keeps the app **lightweight and responsive**, all smart analysis **runs remotely on the server** and it is easy to **update posture logic** and add exercises in the future.

How Data Moves: From Camera to Correction



This flow happens continuously during training — allowing **live corrections**.

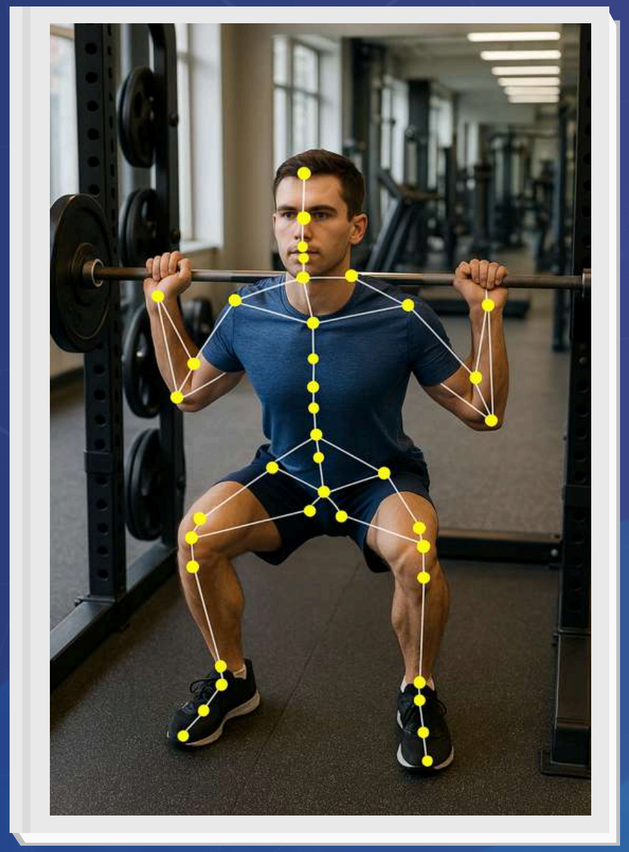
Pose Estimation – Powered by MediaPipe

BodyTrack uses **MediaPipe Pose**, a real-time pose estimation framework developed by Google.

- Detects **33 body landmarks** (e.g., shoulders, elbows, hips, knees, ankles)
- Uses a **two-stage pipeline:**

  → First, detects the person's region of interest

  → Then uses a **CNN-based regression model** to estimate joint coordinates
- Outputs **(x, y) position + visibility confidence** per joint
- Provides **smooth, stable tracking** using built-in filtering
- Runs in the **Python backend**, enabilng efficient cloud-based processing
- Supports both **2D and approximate 3D** (Z-Axis) tracking



This pose data is the foundation for calculating angles and detecting posture errors **in real time**.

Understanding Movement – Joint Angles and Biomechanical Rules

After detecting body joints, BodyTrack uses biomechanical analysis to measure how the body moves during exercise:

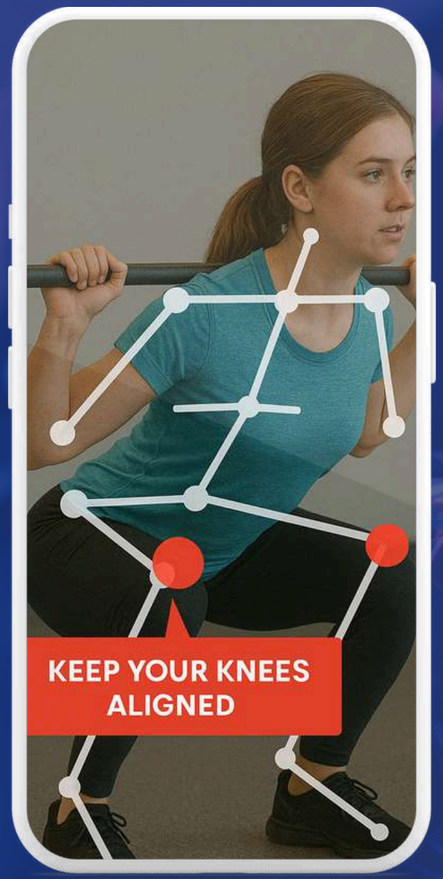
- It **calculates joint angles** using simple vector math:
  - Knee angle: between hip, knee, and ankle
  - Back angle: between shoulder, hip, and vertical line
- It **tracks movement phases** — like going down, bottom position, and going up — based on how angles change over time.
- For each exercise, there's a **reference model** with expected angle ranges, based on professional biomechanics guidelines.
- All calculations use **NumPy and vector math in Python**, frame by frame on the server.
- **Tolerance thresholds** are also added to handle natural differences between users, avoiding over-reaction to small variations.

Detecting Posture Errors and Giving Real-Time Feedback

After analyzing joint angles and movement phases, BodyTrack uses **defined biomechanical rules** to detect mistakes.

Each exercise includes a set of error conditions (e.g., insufficient depth, asymmetry, unstable movement)

These are implemented as decision trees that compare real-time values to thresholds



Errors are identified the moment they happen — frame by frame

The system sends audio cues, visual overlays, or both, to correct the user instantly

Feedback is clear, timely, and designed to **guide correction during the rep**, not after.

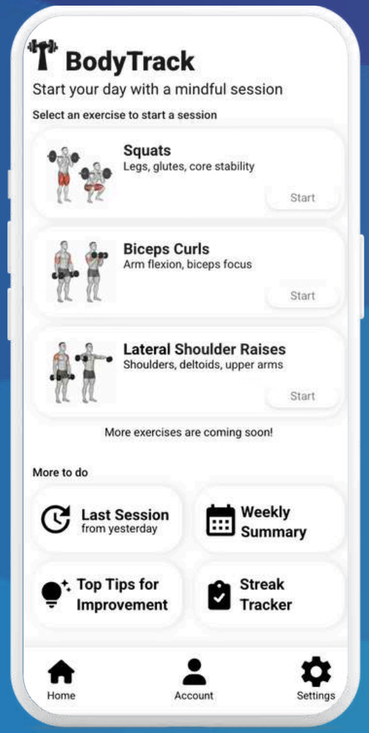
Designed for Clarity – The BodyTrack User Interface

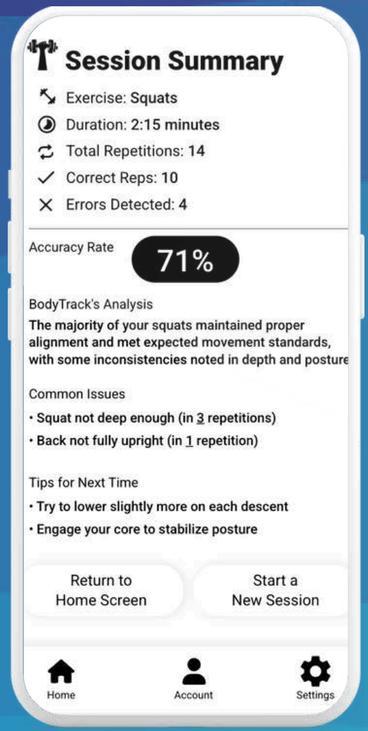
BodyTrack was designed to feel like a **real coach** — without distractions or complexity.

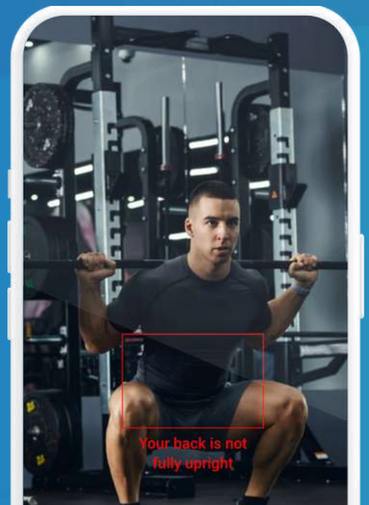
- **Minimal setup:** Select exercise, position the phone, start training
- **Live visual overlays:** Pose skeleton + joint highlights
- **Real-time cues:** Audio alerts when posture errors are detected
- **Session summary:** After each set – rep count, detected issues, improvement tips

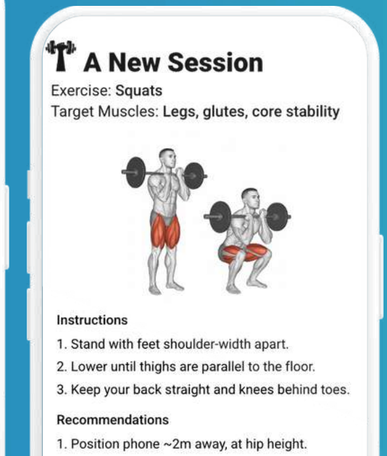
We wanted to create a **clear design**

in order to achieve **better focus & better training**









From Concept to Code – Technologies and Implementation

Mobile App - Client Side

- Built with **Kotlin** in Android Studio
- UI with **Jetpack Compose**
- Camera input via **CameraX API**
- Feedback via **Android Text-to-Speech (TTS)**
- Displays **real-time alerts** from the server

Cloud Server - Backend

- Developed using **Python** (Flask or FastAPI)
- **MediaPipe Pose** for joint detection
- **NumPy + vector math** for joint angle calcs
- **Custom logic engine** for posture validation
- Returns feedback in real time via JSON

Architecture

- **Client-server model:** All analysis and models run remotely
- **HTTPS communication** for speed and security
- System designed to be **modular and expandable**

Planned Verification – Accuracy & Responsiveness

We structured a detailed verification plan to evaluate accuracy, timing, and usability across all components. Once implementation is complete, we will test:

1) **Camera & Input Handling**
   - Real-time frame capture using CameraX
   - Performance on mid-range Android devices

2) **Pose Estimation & Joint Angles**
   - MediaPipe landmark accuracy
   - Angle calculations tested with known postures

3) **Feedback Responsiveness**
   - Measure delay between motion and feedback
   - Target response time: < 1 second

4) **Summary Reports**
   - Accuracy of rep counting and error classification
   - Compare against expert evaluations

5) **User Experience**
   - Test under different lighting and positioning
   - Handle poor visibility, signal loss, and app flow

Strengths and Challenges of BodyTrack

Advantages

- **Real-time posture feedback** using only a smartphone – no external hardware
- Combines **pose estimation + biomechanics + audio coaching**
- Modular and scalable: easy to add new exercises
- Encourages **safe and independent training**
- Lightweight, works on **mid-range Android devices**

Limitations

- Requires **full-body visibility** and decent lighting
- Real-time feedback depends on **internet connection**
- Feedback logic currently based on **rule-based thresholds**
- Supports only a **limited set of exercises** in the current phase
- Verification and model tuning are **still pending**

Thank You!