1) Explain how your proposed system is different from the current solution of proposed long term health problem in this regard demonstrate at least three feature which support your system.

We found two existing **posture correction solutions based on hardware**
i) uprightpose, https://www.uprightpose.com/, which is a necklace type wearable that measures leaning and curvature of the back and provide vibratory feedback to the user for posture correction

Ii) ErgoTac, https://arxiv.org/abs/2204.13955, which is an exoskeleton esq wearable that delivers directional vibrations to various body segments, assisting users in achieving optimal postures that minimize the impact of external loads on joints

Following are some features that our system is better than the competitor

- **Optimal Price and performance** (Exoskeletons expensive whereas neckless don't provide full body insight).
- **Purely optical solution** doesn't impart any discomfort as compared to any kind of wearable
- **Rich data insight compared to** uprightpose. Our solution provides in-depth insight.

In contrast, **Po-Go (Posture Good) is a non-invasive, AI-powered solution that provides long-term posture tracking using a webcam and real-time AI analysis.**

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2) How Po-Go Provides a Better Long-Term Health Solution

✅ **Feature 1: Non-Invasive, AI-Based Posture Monitoring**

🔹 **Po-Go does not require any physical device**—it uses **AI-powered computer vision** to monitor posture via a webcam.

🔹 Users can sit naturally without wearing **uncomfortable posture trackers**.

🔹 Unlike **neckbands or back braces**, Po-Go monitors **full-body posture** dynamically.

Why is this better?

- Wearable posture correctors **cause discomfort** and need to be worn for hours.
- **Exoskeletons are expensive** and require extensive training.
- Po-Go **works seamlessly with your existing setup**, detecting poor posture **without requiring physical contact.**

✅ **Feature 2: Personalized Alerts & Long-Term Tracking**

🔹 Po-Go **tracks posture over time** and provides **weekly/monthly insights** using data visualization.

🔹 Users receive **customized alerts** when maintaining bad posture for too long.

🔹 Unlike **basic wearables** that vibrate instantly (often annoying users), Po-Go **adapts to user habits** and only notifies when posture remains incorrect for an extended period.

Why is this better?

- Wearable posture correctors **only give instant feedback** but do not provide **long-term analytics.**

- **AI-based smart chairs** are **not portable**, while Po-Go works on **any desk setup** with a simple webcam.
- Po-Go lets users **review and improve posture trends over time**, ensuring **sustainable posture correction.**

✅ **Feature 3: Cost-Effective & Scalable for Any Workspace**

- 🔹 **No need to buy expensive hardware**—Po-Go works with a standard **webcam and browser**.
- 🔹 **Highly scalable**—it can be used in **corporate offices, schools, and remote work setups.**
- 🔹 **AI-based posture classification** makes it possible to integrate **ergonomic recommendations**, reducing long-term **health risks like back pain & spinal misalignment.**

Why is this better?

- **Wearable devices cost $100-$200**, while Po-Go is **low-cost and accessible to everyone.**
- AI-based ergonomic chairs **cost thousands of dollars** and are **not flexible** for different users.
- Po-Go **provides a software-driven solution** that **scales easily across different environments** without additional cost.

Conclusion: Why Po-Go is the Best Long-Term Posture Tracking Solution

Feature	**Po-Go (Posture Good)**	**Existing Solutions (Neckbands, Exoskeletons, Smart Chairs)**
Comfort	✅ No physical device needed	❌ Requires wearing a tracker or sitting on a specific chair
Full-Body Monitoring	✅ Tracks **full posture dynamically**	❌ Most only track **neck/back posture**
Personalized Alerts	✅ AI-based adaptive alerts	❌ Wearables send **constant vibrations**, which may become annoying
Long-Term Tracking	✅ Weekly/monthly history	❌ Most wearables only provide **instant feedback**
Cost	✅ **Affordable** (software-based)	❌ **Expensive** (Hardware-based solutions cost $100+)
Scalability	✅ Works in any workspace	❌ Not scalable (smart chairs & wearables are limited to individuals)

By offering **AI-powered, non-invasive, cost-effective, and scalable posture monitoring, Po-Go provides a more practical and accessible solution for long-term posture health than current wearable and hardware-based solutions.**

2) Demonstrate the operation of smart posture detection using RGB/ optional thermal cameras with Mediapipe or Tensorflow lite software

Overview

Smart posture detection leverages **computer vision and AI models** to monitor sitting posture in real time. Using an **RGB camera (webcam) or an optional thermal camera**, we can detect body key points, classify postures, and provide alerts when incorrect posture is detected.

🛠 **Technologies Used / proposed:**

- **MediaPipe Pose estimation (TensorFlow)** for real-time **human pose estimation**
- **RGB Cameras** (webcam / IP camera) for input
- **Optional Thermal Cameras** for **temperature-based posture analysis**
- **Edge Processing** using **NPU / Ai accelerators** for more Realtime analysis

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Step-by-Step Operation

1 Capturing Input via RGB or Thermal Camera

- **RGB Cameras (Webcam)** → Capture **real-time video** and process **human pose estimation**
- **Thermal Cameras (Optional)** → Detect **body heat for better detection of subject and analyze pressure points & ergonomic stress**

2 Real-Time Pose Estimation using MediaPipe/TFLite

- The system **detects body landmarks** (shoulders, spine, hips etc) using MediaPipe pose estimation

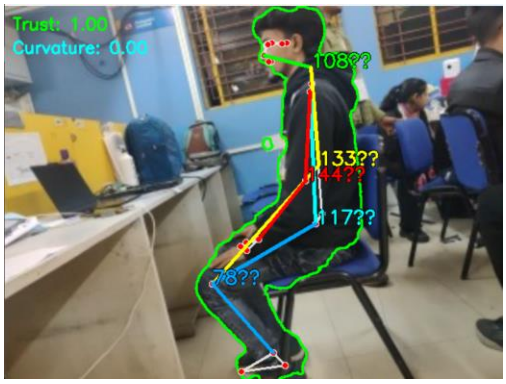
- **Key Landmarks Used for Posture Tracking:**

    - **Spine Alignment** (Head → Neck → Hip)
    - **Shoulder Position** (Shoulder tilt, forward leaning)
    - **Back Curvature** (Straight vs. Slouching)

Landmark Detection

Contour

Angle Calculation



These processing frames won't be available to the end naïve user

    - **Thermal camera** (optional) detects **uneven pressure points**, showing poor posture effects **before discomfort occurs.**

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3 Posture Classification

- **Pose Data from MediaPipe** is fed into a **posture classification function**
- The model detects **Good, Acceptable & Bad Posture** based on the **international standards on working postures and movements ISO 11226 and EN 1005-4 ,** https://www.academia.edu/112422554/International_standards_on_working_postures_and_movements_ISO_11226_and_EN_1005_4
- For seated working, the ISO11226 classifies posture based on the angle formed between the different joints and the curvature / angle of trunk (upper spinal region)

- These are implemented via a simple threshold-based algorithm

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4 Posture Alerts & Feedback System

- If bad posture is **detected for > 20 minutes**, Po-Go triggers:
  🔔 **Notification Alerts** (Pop-ups, Sound, Vibrations)
  📊 **Posture History Logs** (Users can review trends in a dashboard)
  📣 **AI-Based Suggestions** (Stretching reminders, ergonomic advice)

Conclusion

Smart posture detection using RGB and optional thermal cameras, powered by MediaPipe offers an effective solution for real-time posture monitoring. By leveraging AI-driven pose estimation and classification based on international ergonomic standards, the system can detect poor posture and provide timely alerts. With features like real-time analysis, posture history tracking, and AI-driven suggestions, this technology promotes healthier sitting habits, reduces discomfort, and enhances workplace ergonomics.

3) Explain how this system performs its activities for eliminating the need for cloud processing with a prototype

Eliminating the Need for Cloud Processing in Smart Posture Detection

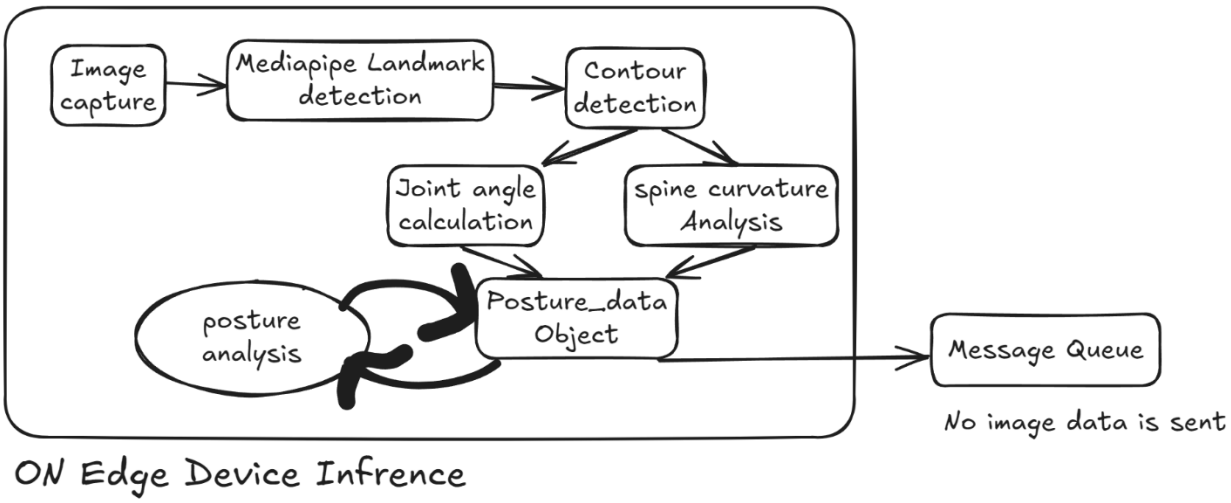
💡 **Overview**

The Po-Go system is designed to work **without cloud dependency**, ensuring **real-time processing, enhanced privacy, and lower latency**. This is achieved by leveraging **on-device AI inference** using lightweight models like **MediaPipe Pose estimation, which is based on the Blazepose algorithm**. By running posture detection locally on **edge devices**, the system eliminates the need for **expensive cloud servers** while maintaining **high efficiency**.

⚙️ **How Po-Go Works Without Cloud Processing**

- **Capturing Data via camera**
- **On-Device AI Processing with MediaPipe, openCV** & helper lib
- **Local Decision-Making for Posture Alerts** / Posture analysis according to ISO:11226
- The final posture and analysis data is sent to server in JSON format
- All analysis and detection is done on the device only

- There is only string-based data communication between device and server, thus reducing privacy problems



Posture analysis workflow (local model)

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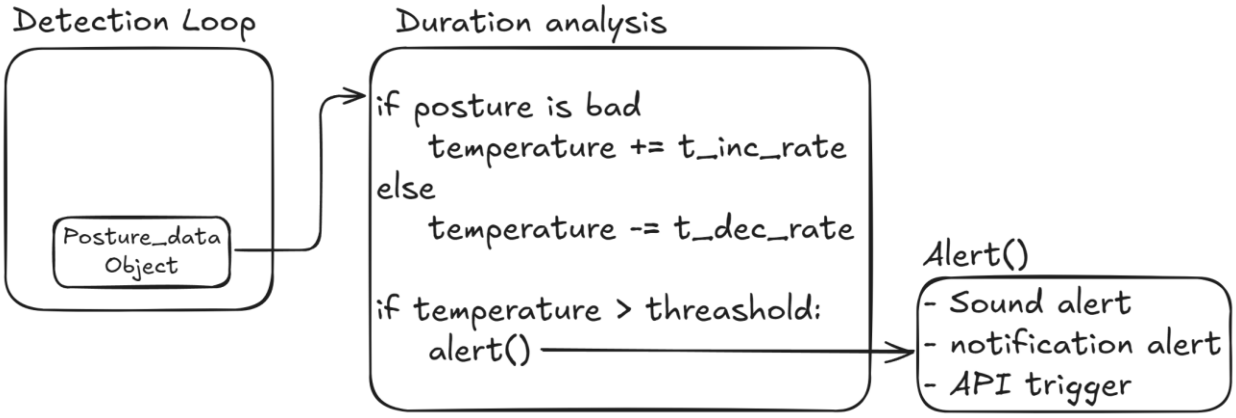
4) Prototype which notifies the user about posture



Notification workflow

1. **Detection Loop**: Continuously monitors posture data from an input source (e.g., an RGB or thermal camera).
2. **Duration Analysis**:
    - If bad posture is detected, a temperature-like variable increases at a set rate (t_inc_rate).
    - If posture improves, the variable decreases (t_dec_rate).
    - When this variable exceeds a defined threshold, an alert is triggered.
3. **Alert System**: If poor posture persists beyond the threshold, the system generates:
    - **Sound alerts**
    - **Notification alerts**
    - **API triggers** for further automation.

This workflow ensures real-time monitoring and proactive posture correction.

TASK-2

1. How does your proposed system avoid any security oriented problem? Explain properly.

   Ans:-

   How Po-Go Ensures Security & Avoids Security-Oriented Problems

   Po-Go is designed to prioritize user privacy, data security, and system integrity while providing an AI-powered posture monitoring experience. Unlike traditional cloud-based posture detection systems, Po-Go employs on-device processing, encrypted data storage, and secure communication protocols to eliminate potential security threats.

🔐 1. Eliminating Cloud Processing – Local AI for Privacy Protection

🔸 *Traditional cloud-based solutions* send posture data, images, and videos to external servers for processing. This creates privacy risks as sensitive data can be exposed, intercepted, or misused.

✅ Po-Go Solution:

- Utilizes TensorFlow Lite & MediaPipe for on-device AI processing (no cloud dependency).
- Processes posture detection in real-time directly on the ESP32, Raspberry Pi, or Jetson Nano.
- Prevents data leaks & unauthorized access by keeping all computations local.

🚀 Advantage: Eliminates hacking risks, third-party surveillance, and network-based attacks common in cloud-based solutions.

🛡️ 2. Secure Communication – Encrypted Data Transmission

🔸 *Risk:* Many IoT posture detectors use unencrypted Bluetooth/WiFi for transmitting posture data, making them vulnerable to man-in-the-middle (MITM) attacks and data interception.

✅ Po-Go Solution:

- Uses SSL/TLS encryption for secure WiFi-based communication.
- If user notifications (SMS alerts) are sent via an API, HTTPS-based API calls are used to prevent interception.
- MQTT with TLS ensures secure real-time posture alerts when using IoT message protocols.

🚀 Advantage: Prevents unauthorized posture data interception and ensures only authenticated devices can receive posture notifications.

🔑 3. Strong Authentication & Role-Based Access Control (RBAC)

🔸 *Risk:* Many posture monitoring systems lack secure login mechanisms, making them vulnerable to unauthorized access.

✅ Po-Go Solution:

- Implements JWT-based authentication for secure user login.
- Uses Role-Based Access Control (RBAC):
    - User Role: Can access only personal posture history.
    - Admin Role: Can manage settings but cannot view user data.
- Multi-Factor Authentication (MFA) can be enabled for extra security.

🚀 Advantage: Prevents unauthorized device access and protects personal posture data from misuse.

🛠️ 4. Data Anonymization & Minimal Data Collection

🔸 *Risk:* Many smart posture devices store personal information without anonymization, exposing users to potential data breaches.

✅ Po-Go Solution:

- No Personally Identifiable Information (PII) is stored.
- Posture data is anonymized before being logged.
- Users can delete their posture data whenever they want.

🚀 Advantage: Even in the event of a security breach, no sensitive personal information can be exploited.

📶 5. Secure Firmware & Software Updates

🔸 *Risk:* IoT devices without secure update mechanisms are vulnerable to malware injections and remote exploits.

✅ Po-Go Solution:

- Implements OTA (Over-the-Air) updates with signature verification.
- Only signed firmware updates from Po-Go's official source are allowed.
- Prevents unauthorized firmware modifications that could compromise security.

🚀 Advantage: Protects Po-Go devices from malicious software injections.

🚀 Key Takeaways: Why Po-Go is Secure?

Security Feature	Po-Go's Approach	Advantage
On-Device AI	TensorFlow Lite / MediaPipe	Prevents cloud-based data leaks
Encrypted Communication	SSL/TLS + MQTT	Blocks MITM attacks & unauthorized access

Security Feature	Po-Go's Approach	Advantage
Authentication & Access Control	JWT, RBAC, MFA	Ensures only authorized users access data
Minimal Data Storage	Anonymized data logging	Eliminates PII exposure in case of breaches
Secure Firmware Updates	OTA with signature verification	Protects against malicious firmware attacks

Conclusion: Po-Go is designed with a privacy-first approach, eliminating common IoT security risks while maintaining efficient posture tracking. Let me know if you need more details!

2. Specify training dataset, testing dataset and feature matrix for ML.

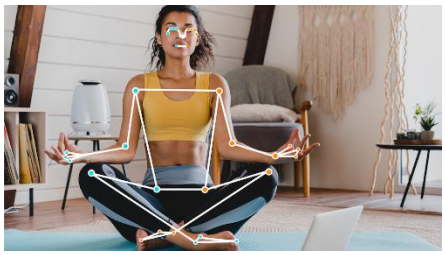
Ans:-

MediaPipe Pose is a machine learning solution developed by Google for high-fidelity body pose tracking. It infers 33 3D landmarks and provides a background segmentation mask from RGB video frames. This technology is particularly useful in applications such as physical exercise quantification, sign language recognition, and full-body gesture control.

Training and Testing Datasets:

The specific datasets used for training and testing MediaPipe Pose models are not publicly disclosed by Google. However, the evaluation of these models is conducted using validation datasets representing different activities, including Yoga, Dance, and High-Intensity Interval Training (HIIT). Each image in these datasets contains a single person located 2-4 meters from the camera. For consistency with other solutions, evaluations are performed on 17 keypoints following the COCO topology.

Feature Matrix:



The feature matrix in MediaPipe Pose consists of 33 3D landmarks that correspond to key points on the human body. These landmarks include positions such as the shoulders, elbows, wrists, hips, knees, and ankles. The model predicts the location of these landmarks in both image coordinates and 3D world coordinates, enabling detailed analysis of human posture and movement.

https://ai.google.dev/edge/mediapipe/solutions/vision/pose_landmarker

Learning Method:

MediaPipe Pose employs supervised learning methods in its development. The models are trained on annotated datasets where the positions of body joints are labeled. This supervised approach allows the model to learn the relationships between input images and the corresponding body landmark positions.

Model Type / Architecture:

The architecture of MediaPipe Pose utilizes a two-step detector-tracker machine learning pipeline. Initially, a detector locates the person or pose region-of-interest (ROI) within the frame. Subsequently, a tracker predicts the pose landmarks and segmentation mask within the ROI using the cropped frame as input. For video use cases, the detector is invoked only as needed, such as for the first frame or when the tracker can no longer identify the body pose in the previous frame. For other frames, the pipeline derives the ROI from the previous frame's pose landmarks.

The pose detection model is inspired by the lightweight BlazeFace model used in MediaPipe Face Detection. It explicitly predicts two additional virtual keypoints that describe the human body center, rotation, and scale as a circle. The pose landmark model, known as BlazePose GHUM 3D, predicts the location of 33 pose landmarks and can optionally predict a full-body segmentation mask represented as a two-class segmentation (human or background).

In summary, MediaPipe Pose is a supervised machine learning solution that uses a two-step detector-tracker architecture to predict 33 3D body landmarks. While specific training datasets are not publicly disclosed, the model is evaluated on validation datasets representing various activities to ensure its effectiveness across different use cases.

Refrence:

https://github.com/google-ai-edge/mediapipe/blob/master/docs/solutions/pose.md

https://ai.google.dev/edge/mediapipe/solutions/vision/pose_landmarker

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3. Bluetooth-Based Alert System (Concept)

1. BLE Connection to a Wearable Device (Vibration Alert)
    - Po-Go can connect via HC-05 or HM-10 BLE module to a lightweight vibrating wristband or neckband.
    - If bad posture is detected for too long, a gentle vibration alerts the user.

2. Localized Audio-Visual Alerts
    - Bluetooth Speakers can emit sound notifications when posture is bad.
    - LED Indicator (RGB Light Alert via smart home appliances):
        - Green: Good Posture
        - Yellow: Slight Deviation
        - Red: Incorrect Posture for >20 min

✅ Advantages of Bluetooth Connectivity:

- Low Power Consumption: Ideal for battery-powered wearables.
- Instant Feedback: Vibration alerts provide immediate correction cues.
- No Internet Dependency: Works offline, ensuring privacy & security.

Q) Accuracy of mediapipe

Ans:-

Core Finding:

The accuracy of Mediapipe Pose is highly dependent on the camera's viewing angle and the type of physical exercise being performed. High accuracy can be achieved under optimal conditions, but it quickly decreases when conditions are less favorable.

Key Results and Supporting Data:

- Viewing Angle Matters:
    - Estimations were significantly more accurate when the camera had a direct view of the subject.
    - If the camera's viewing angle is off then the pose estimation becomes less accurate and more difficult
- Type of action Matters:
    - Error increases if the landmarks are closer together
- Relative Dimensions
    - The relative dimentions are not consistant over time meaning they have significant error.
- 3D Pose data accuracy is at 30 mm RMSE when done through a well set up stereo camera, using the the left camera and right camera and using epipolar geometry.
- Mediapipe Pose Accuracy Summary
    - Mediapipe Pose is a computationally efficient pose estimation tool, but its accuracy is highly influenced by the environment. For optimal accuracy, use a frontal or side camera view. In one study, 3D pose RMSE reached approximately 30.1mm when using the left camera and right camera to create epipolar geometry.
    -

Q. Why should choose PO-GO instead of other posture detector? show comparison.

Ans:-

Here's a detailed comparative analysis of Po-Go (Posture Good) versus existing posture detection solutions like Upright GO 2 and the ErgoTac Directional Vibrotactile Feedback

Interface (DVFI). This analysis highlights why Po-Go is more cost-effective, user-friendly, and technologically advanced.

Why Po-Go (Posture Good) is a Better Posture Detection Solution

Feature	Po-Go (Posture Good)	Wearable Sensors (e.g., Upright GO 2)	Haptic Feedback Systems (DVFI)
Hardware	None (Uses Existing Camera)	Requires Wearable Device	Requires Multiple Devices
User Comfort	Non-Intrusive	Potentially Uncomfortable	Potentially Bulky
Cost	Software-Based (Lower)	High (Device + Adhesives)	High (Multiple Components)
Maintenance	Minimal	Charging, Adhesive Replacement	Battery Replacement, Calibration
Data Analytics	AI-Driven, Detailed	Limited	Real-Time Correction Only
Customization	Adaptive (Machine Learning)	Fixed Sensitivity	Standardized Feedback
Setup	Easy (Install & Enable Camera)	Complex (Device Placement, Pairing)	Complex (Sensor Alignment)
Environmental Impact	Eco-Friendly (Leverages Existing)	High (Adhesives, Device Replacement)	High (Multiple Components, Batteries)

Why Po-Go is the Superior Choice

1. More Affordable & Accessible

Unlike Upright GO 2 ($99.95) and DVFI (which requires multiple sensors), Po-Go eliminates extra costs by using existing webcams and AI software. This makes it accessible to students, professionals, and businesses without a significant investment.

2. No Wearables = More Comfort

Po-Go provides continuous posture monitoring without requiring stick-on devices, straps, or bulky wearables. Unlike Upright GO 2, which can cause skin irritation, or DVFI, which requires multiple vibrating sensors, Po-Go is completely non-intrusive.

3. Advanced AI & Analytics

Po-Go offers real-time posture tracking, historical data, and behavior analytics, making it more intelligent and insightful than the limited real-time feedback provided by Upright GO 2 and DVFI.

4. More Sustainable & Low Maintenance

Wearable devices need charging, replacements, and recalibration over time. Po-Go is a one-time software setup with zero maintenance and no additional hardware waste, making it the most eco-friendly option.

5. Easy Setup & Universal Compatibility

Unlike Upright GO 2, which requires a physical attachment and mobile pairing, or DVFI, which involves multiple sensors, Po-Go works instantly with any laptop, PC, or smartphone equipped with a camera.