POSTURE DETECTION USING QIDK

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TEAM NAME: ENTROPY

Posture Analyzer — Qualcomm QIDK Real-Time Mobile Posture Detection

On-device AI posture monitoring with MediaPipe + custom TensorFlow Lite models for accessible preventive healthcare

1 Problem Statement

- Widespread poor posture causing chronic issues and missed prevention
- Need for continuous, real-time monitoring without special hardware
- Privacy concerns with cloud processing of camera data

2 Motivation & Value

- Preventive healthcare via accessible mobile monitoring
- Immediate feedback: alerts and health recommendations
- Privacy-first: on-device processing to protect user data

3 Methodology & Workflow

- MediaPipe for pose/keypoint extraction
- Custom TensorFlow Lite models for posture classification
- On-device inference; continuous monitoring loop
- Immediate alerts + health recommendations delivered in app

4 Models, Frameworks & Metrics

- MediaPipe and TensorFlow Lite (custom models)
- Parameters: **accuracy**, **latency**, **on-device memory**
- Evaluation: model accuracy, latency, NPU/GPU runtime
- Dataset and preprocessing: pose keypoints, normalization

Problem Statement — Posture Awareness Gap

Real-time posture monitoring with no specialized hardware

Scope: Poor posture affects **80% of adults**, causing back pain, productivity loss, and long-term musculoskeletal risks

Gap: Most users lack real-time awareness and notice issues only after pain develops

Solution: Posture Analyzer app — continuous real-time monitoring via smartphone or external cameras

Features: Intelligent alerts, personalized stretch guidance, progress tracking and analytics

Advantage: No specialized hardware required — enables widespread adoption and early correction

Motivation: Health + On-Device AI

Tackle widespread posture-related costs with private, real-time mobile inference

Health burden: 80% of adults experience back pain in their lifetime; forward head posture adds **10 pounds** pressure per inch

Economic impact: billions in annual treatment costs driven by posture-related conditions

Technology enabler: ubiquity of smartphones plus on-device AI (MediaPipe) and hardware accelerators

Privacy & performance: leverage Hexagon DSP/NPU via NNAPI for real-time, on-device healthcare

Alignment with Qualcomm QIDK: targets QIDK goals by using Hexagon and NNAPI for efficient mobile delivery

Value proposition: scalable, private, real-time posture care delivered directly on user devices

Hexagon NPU Acceleration

[The Critical Unique Feature]

10-100x Faster Inference

Utilizes the dedicated Hexagon 780 DSP/NPU via NNAPI. Far superior to standard CPU execution.

FP16 Precision

Hardware-level optimization for floating-point calculations, essential for mobile AI workloads.

Direct Hardware Access

Provides acceleration capabilities unavailable on MediaTek, Exynos, or generic ARM devices.
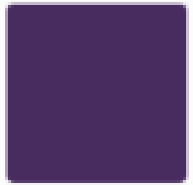
Graphics & Vision

Adreno GPU & Spectra ISP

Adreno GPU Acceleration

Custom architecture with optimized OpenGL ES 3.2 compute shaders and better TFLite delegate support than Mali.

Multi-Camera Architecture

Utilizes Qualcomm Spectra ISP for advanced processing and V4L2 direct access for USB cameras.

Performance Benchmarking

Metrics

Tracks real-time Inference Latency (micro-seconds), Throughput (FPS), and Model Load Time.

Thermal Mgmt

Snapdragon AI Engine automatically balances power/performance to prevent thermal throttling.

The QIDK Advantage

Why this performance is unique to Snapdragon.

< 50ms Inference

Achieves real-time posture detection speeds impossible on CPU-only processing.

Multi-Model Support

Capable of running 3 TFLite models simultaneously without performance degradation.

Sustained Efficiency

High power efficiency ensures consistent performance vs. Generic ARM platforms.

Methodology — Phased Development & Deployment

From YoloNAS+HRNet prototype to MediaPipe Pose Landmarker + TFLite real-time Android pipeline (33 keypoints, >30 FPS)

Problem: integration and mobile performance limits with **YoloNAS** (detection) + **HRNET** (pose)

Decision: pivot to integrated **MediaPipe Pose Landmarker** (33 keypoints) for simpler pipeline

Models & Framework: **MediaPipe** for landmarking, custom **TensorFlow Lite** classifiers for actions

Workflow: data collection → feature engineering → model training & optimization → Android integration

App: Android app with hardware acceleration, external USB camera support, and benchmarking tools
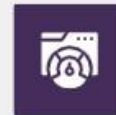
Performance: achieved **>30 FPS**, simplified deployment, robust mobile performance

Parameters considered: **accuracy**, **latency/FPS**, model size, hardware acceleration, cross-device
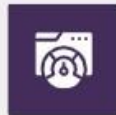
Evaluation: thorough benchmarking across devices and iterative optimization for runtime (NPU/GPU) and accuracy

Summary: phased pivot yielded a single integrated pipeline enabling real-time, deployable solution

Real-time Posture Monitoring Pipeline

From camera capture to analytics: pose detection, classification, quality checks, cloud storage, and user feedback

- Camera Input Manager
  - Unified manager accepts front, back, or USB webcam feeds and routes frames.

- MediaPipe Pose Detection
  - Run MediaPipe pose model extracting **33 keypoints** per frame.

- Feature Extraction
  - Compute geometric features from keypoints for posture analysis.

- Multi-model Classification
  - Ensemble models detect **slouching**, **cross-legged**, and **lean direction**.

- Quality Metrics

- Apply **PDJ** and **OKS** to validate detections and guide processing decisions.

- Intelligent Processing
  - Manage presence detection, slouch timers, and break reminders based on metrics.

- Cloud Storage (Firebase)
  - Upload metrics and analytics (images excluded) to Firebase for persistence.

- Outputs & Feedback
  - Real-time UI with skeleton overlay, alert/stretch notifications, and analytics dashboard.

Parameters Considered for Posture Analysis

Key accuracy, latency, and resource metrics that enable reliable, fast, power-efficient inference
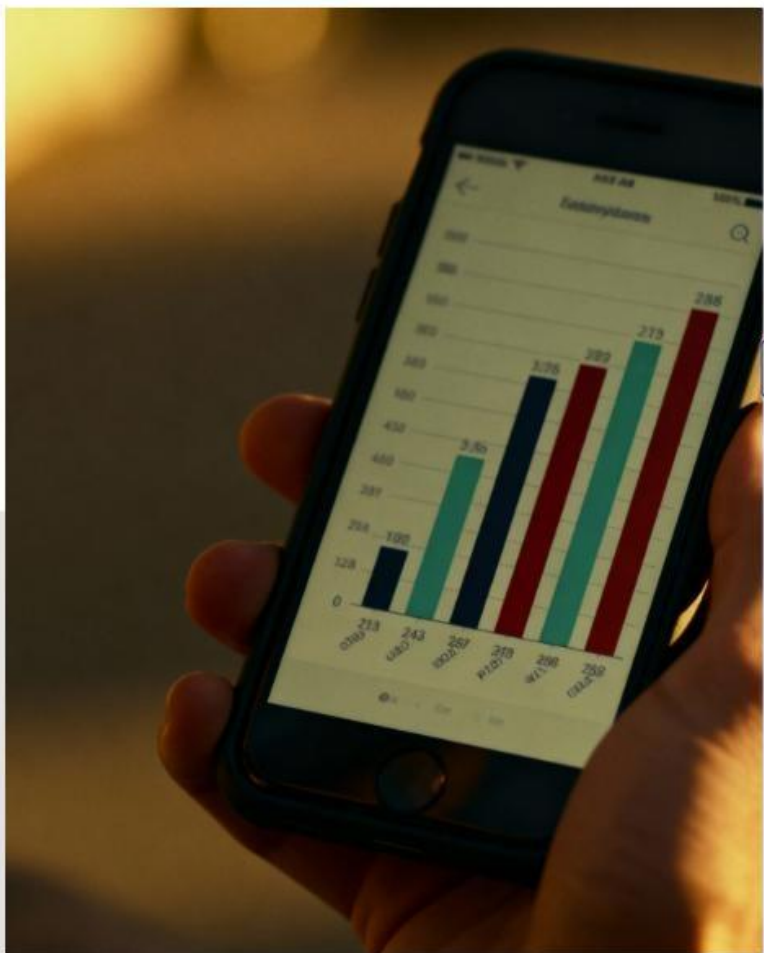
Accuracy & Classification

PDJ average 88.5%

OKS average 82.3%

Slouching accuracy 92%

Cross-legged accuracy 88%

Lean direction accuracy 85%

False positives < 7%

Latency & Throughput

CPU latency 50–100ms

NNAPI latency 15–30ms

Supports 30–60 FPS

Storage, Memory & Power

App storage 80MB

Runtime memory 150–250MB

Battery drain 8–20% per hour

NNAPI = most efficient

Dataset Overview — Posture Video Frames

40–50K manually annotated frames; diverse subjects and controlled splits for robust training

Size: 40,000–50,000 manually annotated video frames collected over 3–4 months

Subjects: ages 18–60 across varied lighting, backgrounds, camera angles, and body types

Frame distribution: 12,000 **good posture**, 15,000 **slouching**, 8,000 **cross-legged**, 10,000 **lean**

Augmentation: rotation, scaling, brightness/contrast, noise, blur simulations

Split: 70% training, 15% validation, 15% testing for robust generalization

Summary: **balanced, diverse, and augmented** dataset sized for reliable posture model training

Data Pre-processing → Post-processing → Alerts & Analytics

Clear pipeline from frame standardization and MediaPipe keypoints to temporal filtering, notifications, and Firebase logging

- Frame Standardization
  - Resize frames, enforce RGB, correct orientation for consistent input
- MediaPipe Keypoint Detection
  - Detect 33 keypoints; apply visibility filter (threshold <0.5)
- Geometric Feature Extraction
  - Compute angles/distances from keypoints for model-ready features
- Normalization
  - Apply Z-score normalization to geometric features

- Model Inference
  - Run models and produce softmax probability outputs
- Temporal Filtering
  - Smooth probabilities with a moving average over 5 frames
- Multi-Model Fusion
  - Combine model outputs for robust decisioning
- Presence-Aware Logic
  - Pause processing when user absent to save resources

- Notifications
 - Slouch alert at 2.5 minutes; break reminder at 27 minutes
- Logging & Analytics
  - Metrics logged to Firebase every 2 seconds; visualized in time dashboards

App Workflow: Continuous Posture Monitoring

From launch and permissions to real-time detection, timers, logging, and dashboard analytics

- App Launch & Permissions
  - User opens app and grants camera/notification permissions to enable live monitoring.

- Main Screen — Live Feed
  - Real-time camera feed displayed for continuous posture analysis.

- MediaPipe Detection
  - Pose landmarks extracted from the live camera via MediaPipe.

- Posture Classification
  - Classify posture states (slouch/neutral) using the trained model.

- Quality Metric Calculations
  - Compute metrics (posture score, duration, confidence) for analytics.

- Presence Detection
  - Detect user active/away state to control monitoring and timers.

- Timer Management
  - Track slouch intervals and break timers for intelligent alerts.

- Logging to Firebase
  - Send events, metrics, and timestamps to Firebase for persistence.

- Dashboard Analytics
  - Update dashboard with aggregated insights and data-driven feedback.
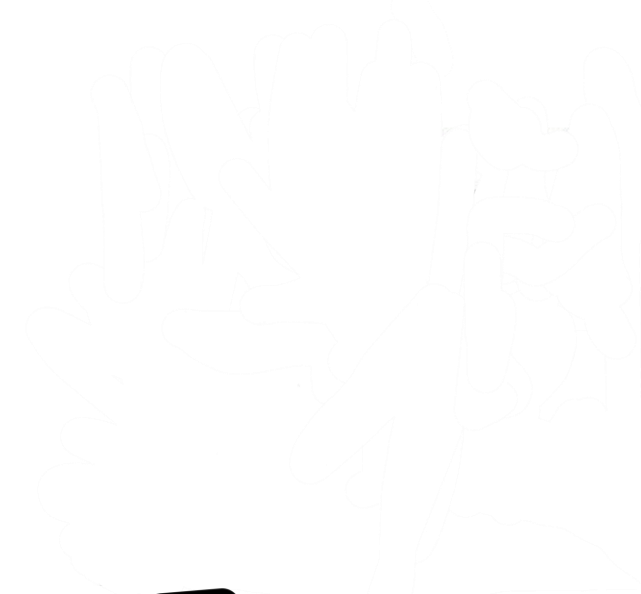
Android App Functionalities — Real-time Posture Monitoring

Live monitoring, intelligent alerts, camera & acceleration management, dashboard analytics, and on-device privacy

Monitoring: live camera feed with skeleton overlay; status panel shows runtime, **PDJ/OKS** scores, and user status

Classification: posture, leg position, and lean direction results displayed in real time

Alerts: slouch timer with **2.5-minute** countdown and break reminders after **27 minutes**; includes stretch suggestion videos

Presence detection: active (green) vs away (orange) to optimize alerts and battery

Camera management: seamless switching among front, back, and USB webcams

Hardware acceleration: dynamic switch between CPU, GPU, and **NNAPI** without restarts

Dashboard: comprehensive analytics with trend visualizations and runtime metrics

Privacy: on-device processing; only metric-only logging (no raw video uploaded)

Model Results — Accurate Posture Detection

Comparison of classification metrics across three models; system weighted accuracy ~88%

Model	Accuracy	Precision	Recall	F1-score
Slouching detection	90%	94%	92%	92%
Cross-legged detection	86%	92%	90%	92%
Lean direction	89%	93%	85%	88%
Overall system (weighted)	88%	—	—	—

Automatic Weekly PPT Generation & Email Reports

- The system automatically collects and stores posture data throughout the week (good posture time, bad posture time, number of corrections, common mistakes, etc.).

- At the end of every week, it analyzes all the recorded data in depth and generates a professional PowerPoint report, without any manual effort from the user.

- The PPT Includes weekly posture statistics, graphs, trends, and personalized insights about the user 's sitting habits and psture quality.

- The generated PPT is automatically sent to the user's registered email ID, so they can easily track their progress and share the report if needed (for doctors, trainers, or ergonomics evaluation).

QUALCOMM Pineapple for arm64 - Inference Times
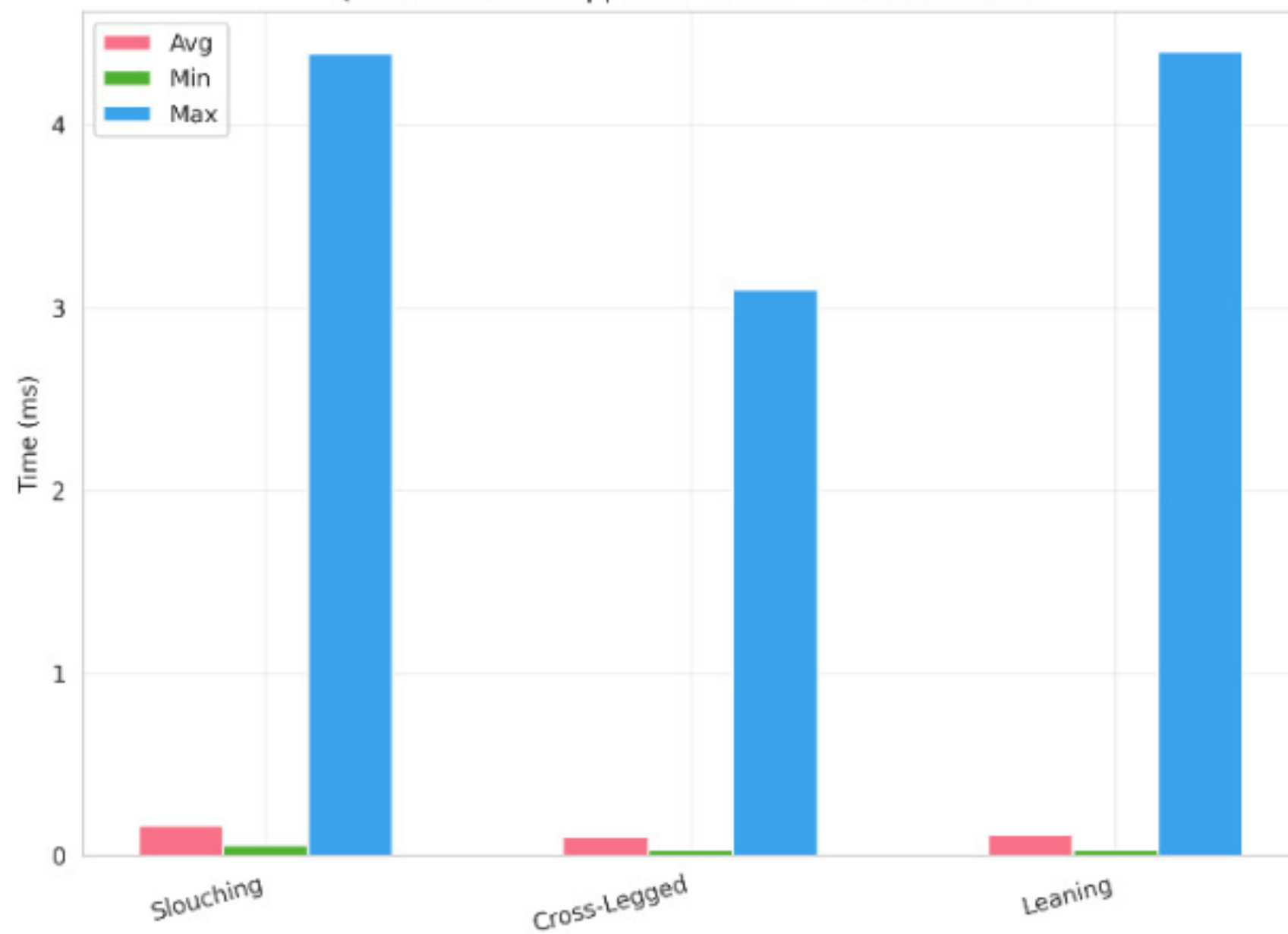
realme RMX3853 - Inference Times
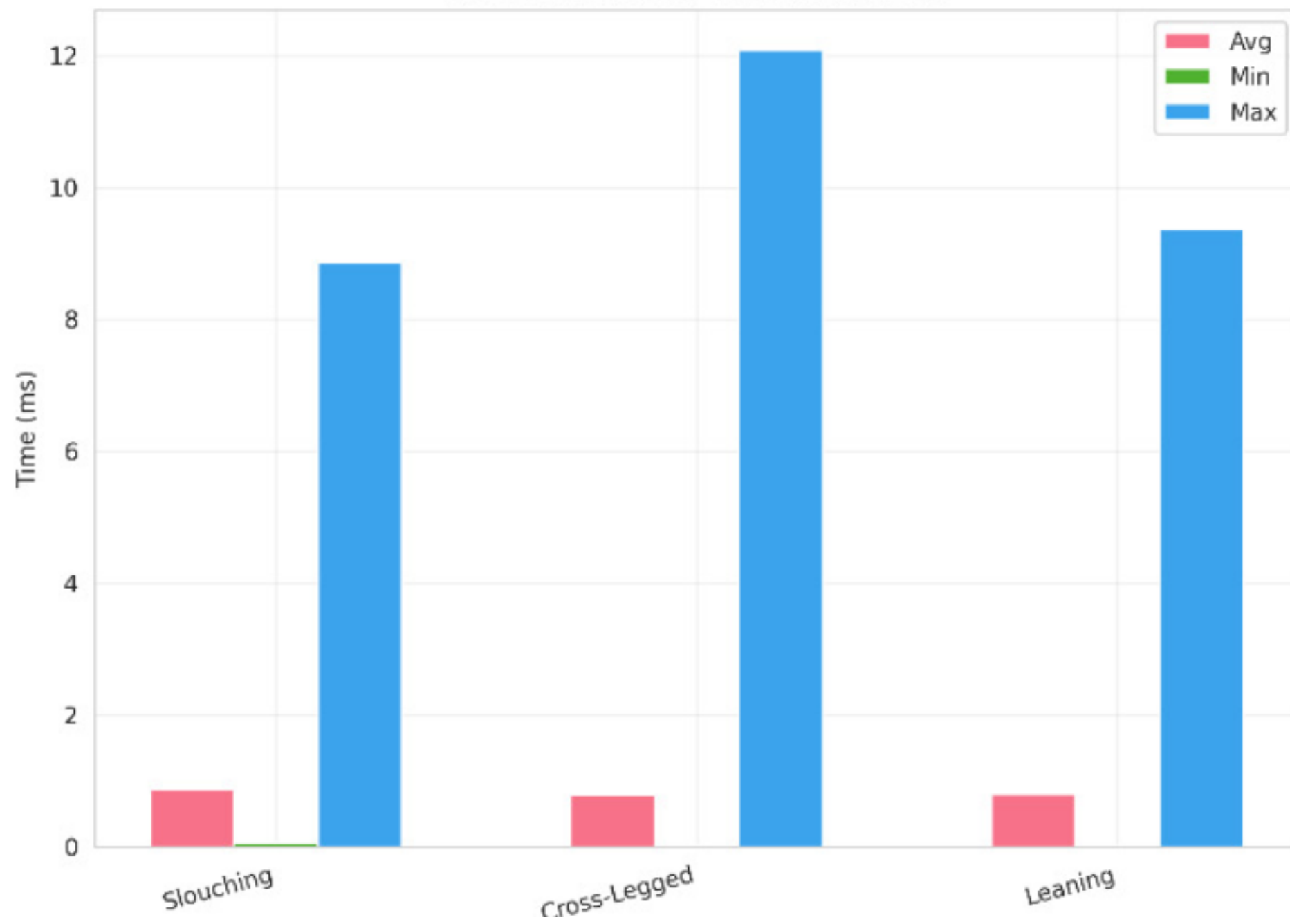
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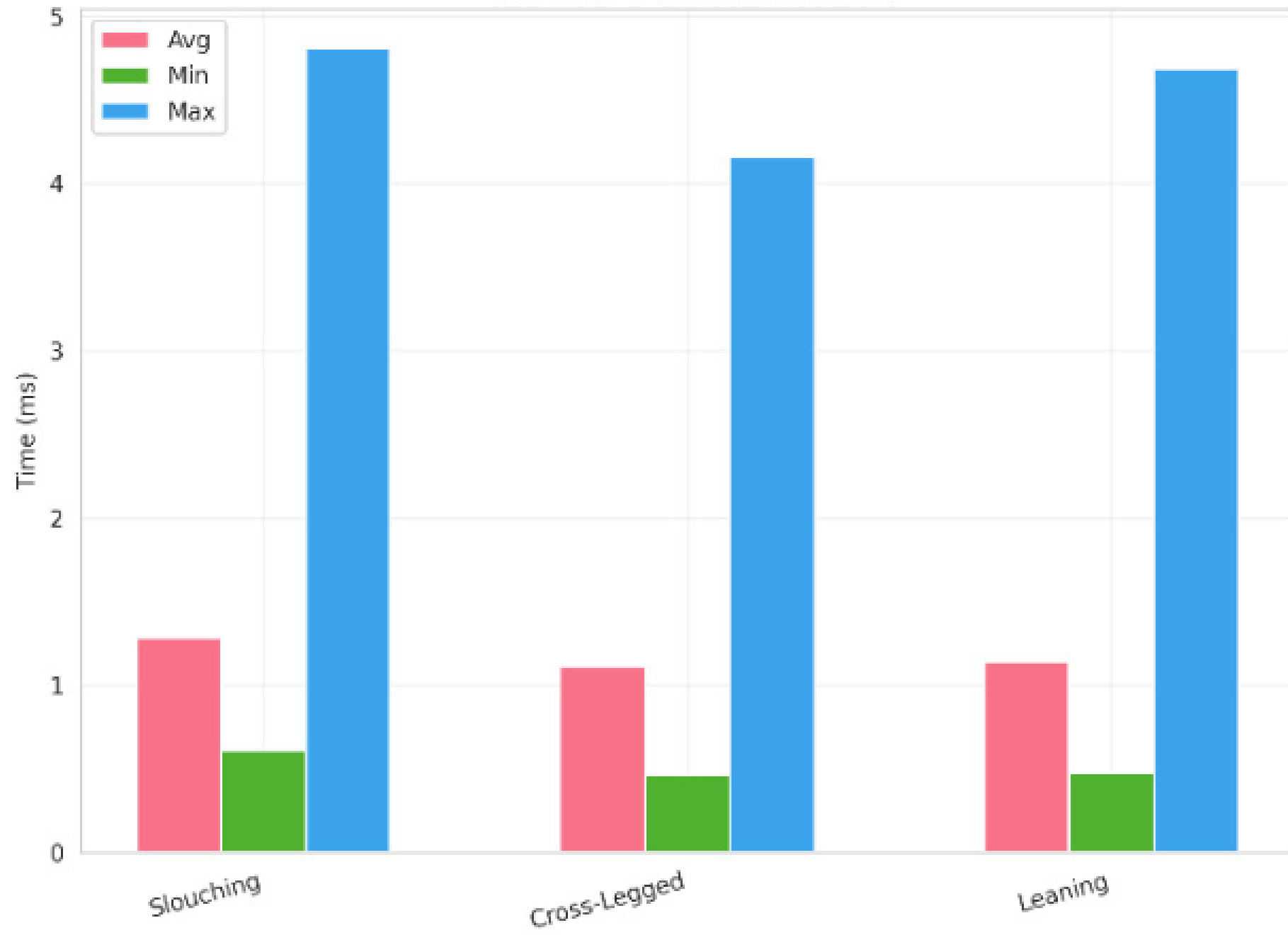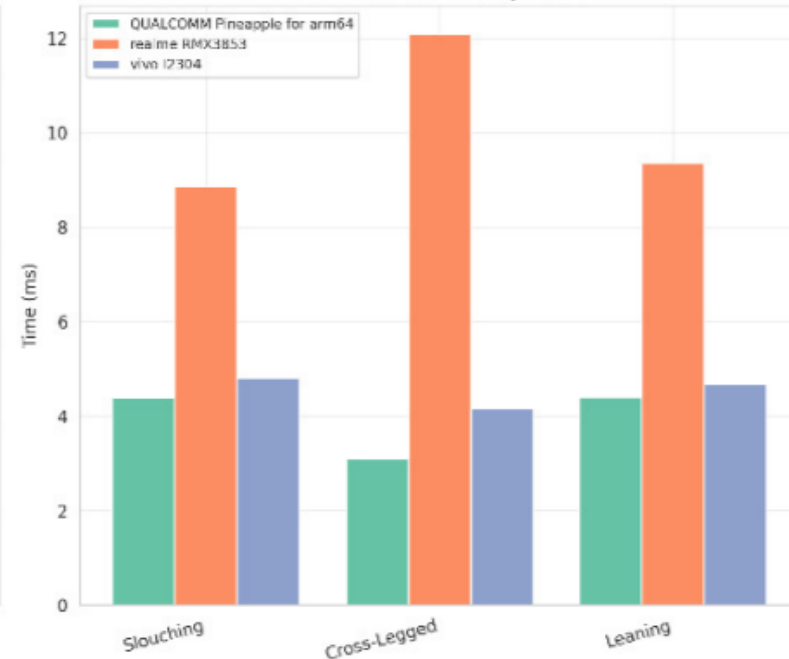
Average Inference Time Heatmap: Device vs Model
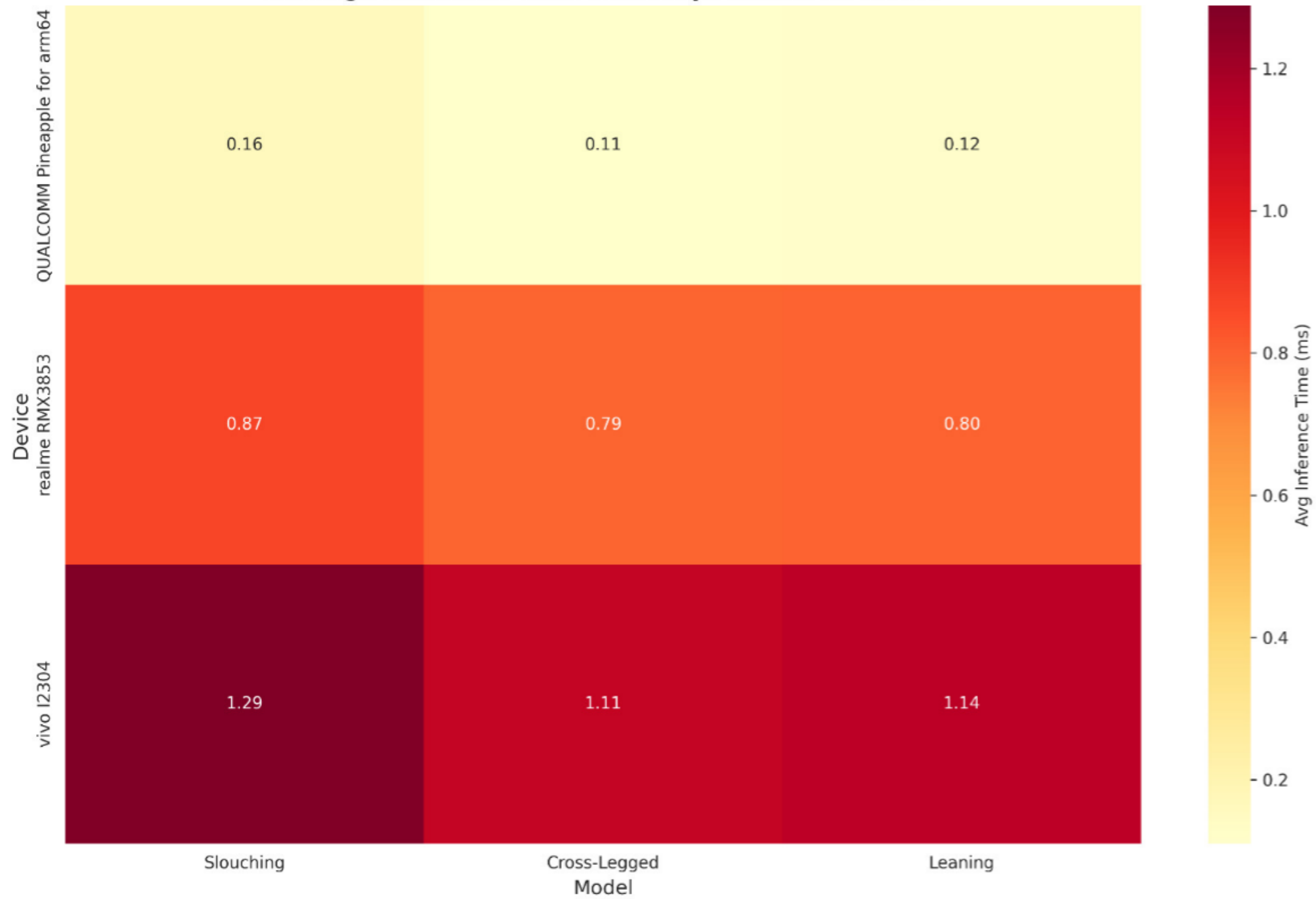
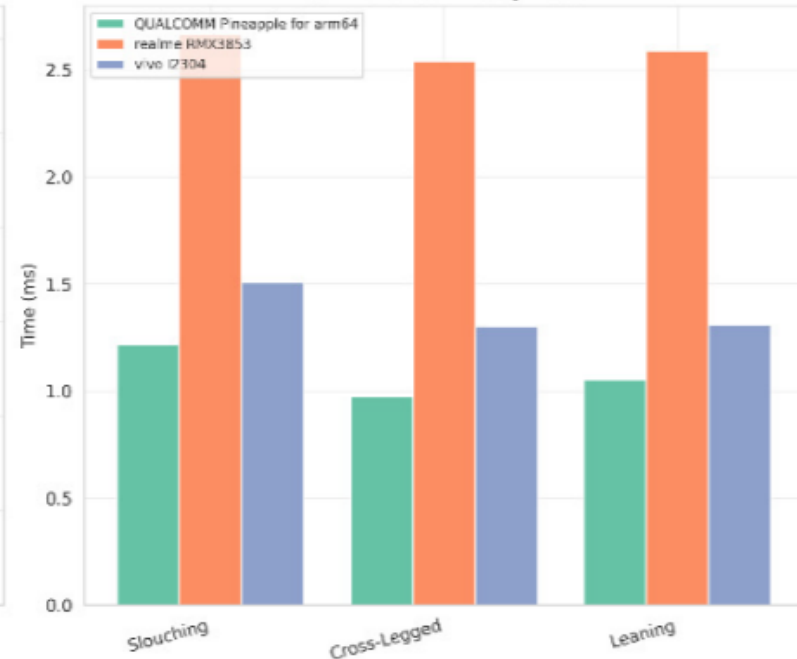Device Performance Comparison Across Models