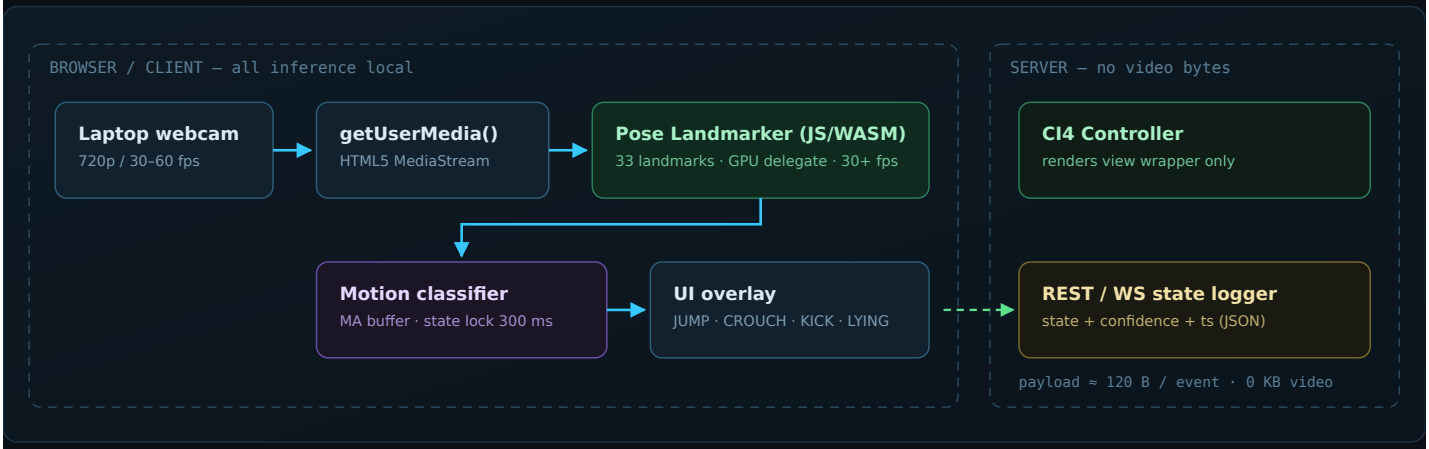
TECHNICAL ARCHITECTURE · MOTION DETECTION SPECIFICATION

# MediaPipe Pose Landmarker + CodeIgniter 4 Integration

Client-side pose inference with a thin CI4 view layer — no video ever leaves the browser.

MediaPipe Pose Landmarker (33 landmarks) | CodeIgniter 4 | WebAssembly + GPU delegate | 30+ FPS · <25 ms inference

## 01 System architecture & flow




The CI4 controller renders a clean view wrapper and never proxies frames. Only state events cross the network boundary — privacy by design, and bandwidth stays flat regardless of session length.

## 02 Movement classification logic & thresholds

| Movement | Signal | Rule | Edge handling |
|---|---|---|---|
| **Jump** | Hip ΔY (23/24) + ankle ΔY (27/28) | Vertical velocity over a rolling 5-frame window: `v = (y_hip(t) − y_hip(t−5)) / 5` Trigger when `\|v\| > 0.045 · body_height` and hip returns within 10 frames. | If ankles leave frame: hip-only mode — Δy_hip > 6% of torso length, ankles ignored. |
| **Crouch** | Hip–knee–ankle interior angle | Angle at knee (25/26) between hip (23/24) and ankle (27/28): `θ = angle(hip − knee, ankle − knee)` Trigger when `θ < 120°` **and** hip y > baseline + 0.03. | Baseline calibrated from 60 frames of standing (median hip y). |
| **Kick** | Ankle radial displacement | `d = \|ankle_x − pelvis_x\| / shoulder_width` Trigger when `d > 1.15` while the opposite ankle stays within 0.35 · shoulder_width of its rest x. | Rejects walk cycles: requires anchor-leg stability for ≥ 4 frames. |
| **Lying down** | Torso vector vs vertical | `t = shoulderMid − hipMid` `φ = atan2(t.x, −t.y)` (0° = upright) Trigger when `\|φ\| > 60°` sustained for 10 frames. | Also fires when the whole body drops below the frame's lower third. |

## 03 Noise filtering & state handling

| Stage | Parameter | Purpose |
|---|---|---|
| **Moving average buffer** | `5–10 frames, per-landmark, per-axis` | Kills single-frame landmark jitter (MediaPipe noise ≈ 1–2 px at 720p). |
| **Velocity smoothing** | `EMA α = 0.4 on Δy before thresholding` | Prevents a fast arm swing from registering as a jump. |
| **Debounce / state lock** | `300 ms after a state fires` | Stops flicker between JUMP and CROUCH on landing. |
| **Hysteresis** | `enter 0.045 · exit 0.030` | A state does not end the instant the value dips below the entry threshold. |
| **Confidence gate** | `landmark visibility ≥ 0.5` | Low-confidence joints are excluded, not averaged in. |

`JUMP DETECTED` `CROUCH DETECTED` `KICK DETECTED` `LYING DOWN DETECTED` `NO MOVEMENT DETECTED`

### STATE MACHINE

- One active state at a time; priority: LYING > KICK > CROUCH > JUMP.
- State lock 300 ms after entry — no re-entry until the lock expires.
- Exit requires the metric to cross the hysteresis floor (not the entry threshold).
- No landmark confidence ≥ 0.5 for 1 s → falls back to `NO MOVEMENT DETECTED`.

### PERFORMANCE BUDGET

- Inference: 12–22 ms per frame (WebGL delegate, 720p).
- Classifier + smoothing: < 2 ms per frame.
- Frame budget: 33 ms @ 30 FPS — headroom kept for rendering.
- Memory: ~28 MB model (lite) / ~30 MB WASM heap.
- Server: 1 view route + 1 JSON endpoint, no queue, no worker.