Stress detector

Requirements

- Pretrained models
  - └ facial landmarks
  - └ Remote PPG / Pulse Extraction

The full form of **rPPG** is **remote photoplethysmography**.

It is a non-invasive optical technique that uses a standard digital camera (like those found in smartphones or webcams) to measure physiological signals, such as heart rate, heart rate variability, respiration rate, and blood oxygen saturation, without any physical contact.

How it Works

The technology works by detecting subtle, heartbeat-induced color variations on the surface of the skin that are invisible to the human eye. The rhythmic flow of arterial blood causes periodic changes in light absorption and reflection from the skin. Advanced computer vision and signal processing algorithms analyze these tiny color changes in the red, green, and blue (RGB) color channels of the video frames to extract a reliable pulse signal.

O/P] Stress Index (0 – 100)
(with real time graphs)

System Overview

Video Input (Video / webcam)
↓
face detection + facial landmarks
↓
rPPG Signal Extraction (H.R.)
↓
Physiological feature Engg.
↓
Stress Index (0 – 100)
↓
Real time graphs
(plotly / matplotlib)
↓
Model Evaluation (with GTV)

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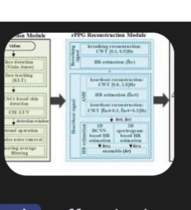
① face detection

- Mediapipe
  - └ Stable in Real-time
  - └ 468 Landmarks
  - └ fast on both CPU / GPU.

Why not DLib
- └ C++ bindings
- └ 68-point landmarks

② RPPG Extraction

- Vitallens-python (best)
  (Works upon API)
- CHROM Method

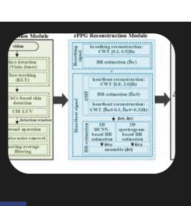


The **CHROM Method** (Chrominance-based) in rPPG (remote Photoplethysmography) is a robust algorithm that extracts heart rate signals by transforming RGB video data into orthogonal chrominance signals, effectively separating pulsing blood volume changes from lighting noise and motion artifacts, by using ratios of color channels to create a stable, pulse-indicating signal, offering better performance than single-channel methods like GREEN under varied conditions.

How CHROM Works

1. **Input**: Takes RGB (Red, Green, Blue) video frames from a standard camera.
2. **Transformation**: Creates two new orthogonal color signals, $X_{CHROM}(t)$ and $Y_{CHROM}(t)$, from the R, G, B signals, designed to highlight blood volume changes.
3. **Signal Extraction**: Calculates the final rPPG signal using a formula like $rPPG(t) = X_{CHROM}(t) - \alpha Y_{CHROM}(t)$, where α normalizes the signals.
4. **Noise Reduction**: This approach inherently removes much of the ambient lighting noise and motion artifacts that plague simpler methods, as it focuses on the *relative* color changes (chrominance) rather than absolute intensity.

- POS Method



The **POS (Plane-Orthogonal-to-Skin) method** is a key algorithm in **rPPG (remote Photoplethysmography)**, used to extract heart rate from video by projecting RGB skin signals onto a plane perpendicular to the skin's color direction, effectively filtering out lighting/motion noise to isolate the subtle blood pulse signals for more accurate, contactless health monitoring, outperforming simpler methods like the green-channel in challenging real-world scenarios.

How it Works (Simplified)

1. **Input:** Raw Red, Green, Blue (RGB) video frames of a person's face or skin.
2. **Skin Tone Vector:** Identifies the dominant "skin tone" direction in the RGB color space.
3. **Orthogonal Projection:** Projects the RGB pixel data onto a plane that is mathematically *perpendicular* (orthogonal) to this skin tone vector.
4. **Signal Separation:** This projection effectively removes variations due to overall brightness changes (lighting, shadows) and motion, leaving primarily the chromatic (color) changes caused by blood flow.
5. **Pulse Extraction:** The resulting 2D signals are combined into a 1D signal, filtered (bandpass), and analyzed to find the heart rate.

Disadvantages of CHROM & POS
- Sensitivity of Motion
- Varying Lighting Conditions
- Skin-tone dependency
- Inaccurate

- I'll use pre-trained weights for RPPG extraction

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③ Physiological feature Engg.

[Stress ≅ Heart Rate (x)]

We need to compute HRV (Heart Rate Variability) fet.

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④ Facial stress Cues

- EAR (Eye Aspect Ratio) – Stress / fatigue
- Blink Rate (↑) ≅ Stress Rate (↑)
- Brow distance (Tension)
- Mouth Tension (Jaw clenching)

Stress Index Equation

$$S.I. = w_1 * HR_{norm} + w_2 * (LF/HF)_{norm} + w_3 * (1 - RMSSD_{norm}) + w_4 * BlinkR_{norm} + w_5 * FacialTension_{norm}$$

where, $\sum_{i=1}^{5} w_i = 1$

- HR_{norm}
  Heart Rate (normalised)

$$= \frac{HR - HR_{min}}{HR_{max} - HR_{min}}$$

Bound (50BPM – 120BPM)

- $(LF/HF)_{norm}$
  Low frequency to High frequency Power Ratio (normalized)

$$= \frac{LF/HF - (LF/HF)_{min}}{(LF/HF)_{max} - (LF/HF)_{min}}$$

Bound (0.5 – 4.0)

- $(1 - RMSSD_{norm})$
  Root mean Square of succ. differences

$$= \sqrt{\frac{1}{N-1} \sum_{i=1}^{N-1} (RR_{i+1} - RR_i)^2}$$

- Blink Rate

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

detection Criterion
$EAR <$ Threshold

$$BR_{norm} = \frac{BR - BR_{min}}{BR_{max} - BR_{min}}$$

- Facial Tension

$$= \frac{d_{brow} + d_{jaw} + d_{lip}}{3}$$

$$FT_{norm} = \frac{FT - FT_{min}}{FT_{max} - FT_{min}}$$

- Weights
  According to feature imp.

why normalised?
→ Because all stress-related features are measured in different units, ranges and scales, combining them directly would produce a biased and physiologically meaningless stress index.

x