rPPG Methods

Implementations

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239AS: Computational Imaging

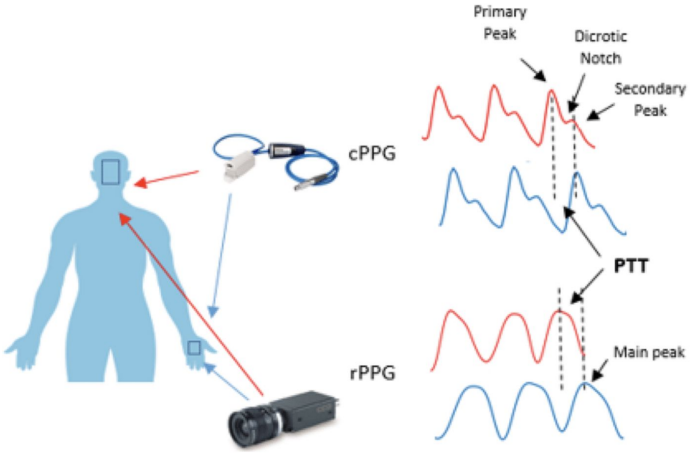
Project Repo: https://github.com/diplav09/239AS

Overview

- Motivation
- What is rPPG?
- Math behind rPPG
- Current Methods
  - Pipeline
  - CHROM, 2SR, POS
  - Heartbeat estimation from Pulse
- Results
- Computational Imaging strategies

Motivation

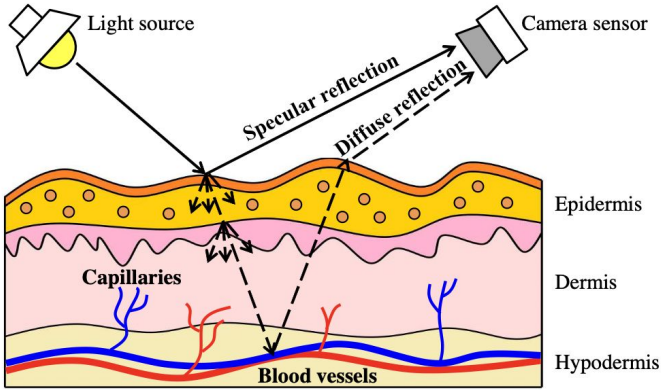
Imparting readily available cameras a capability to sense heartbeats using Signal Processing.



Alweshah, Mohammed, et al. "Journal: Journal of Ambient Intelligence and Humanized Computing, 2019, № 8, p. 3405-3416." Journal of Ambient Intelligence and Humanized Computing 8 (2019): 3405-3416.

What is rPPG?

- Remote Photoplethysmography.
- rPPG is used to extract BVP (blood volume pulse) from the face.
- Operates by looking for subtle colour variations visible on the surface of human skin caused by subdermal light absorption fluctuations from changes in blood volume and content.



Wang, Wenjin, et al. "Algorithmic principles of remote PPG." *IEEE Transactions on Biomedical Engineering* 64.7 (2016): 1479-1491.

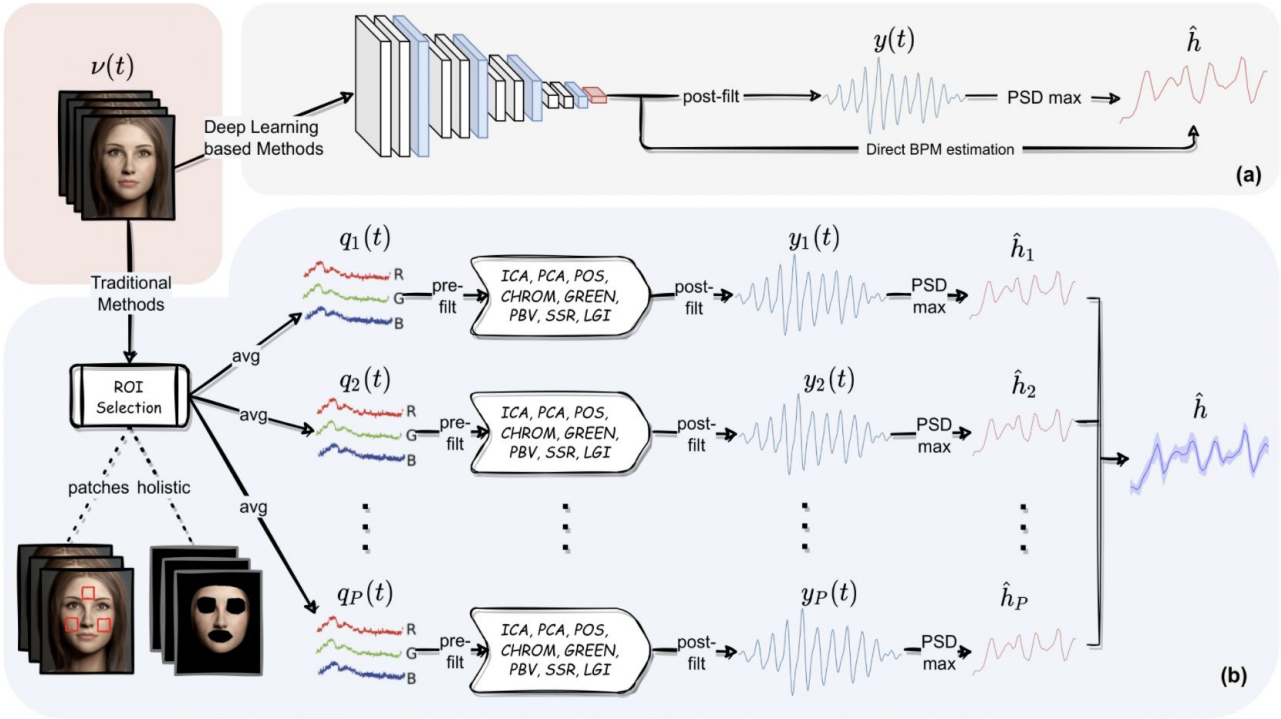
Math behind rPPG!

$$\mathbf{C_k}(t) = I(t) \cdot \big(\mathbf{v_s}(t) + \mathbf{v_d}(t)\big) + \mathbf{v_n}(t)$$

$$\mathbf{C_k}(t) = I_0 \cdot \big(1 + i(t)\big) \cdot \big(\mathbf{u_c} \cdot c_0 + \mathbf{u_s} \cdot s(t) + \mathbf{u_p} \cdot p(t)\big) + \mathbf{v_n}(t)$$

Goal: Extract ***p(t)*** from $\boldsymbol{C_k(t)}$

rPPG Pipeline



https://github.com/phuselab/pyVHR

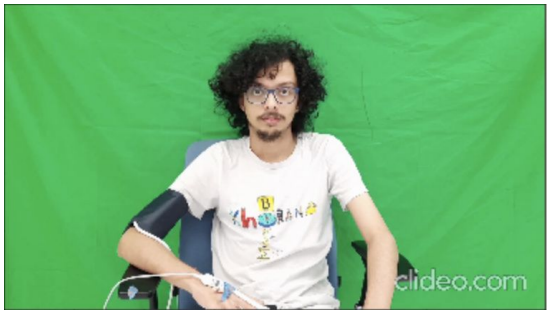
Algorithms

CHROM	2SR	POS
This method removes noise caused by light reflection through color difference channel normalization using Normalized skin tone which is assumed to be same for all under white light.	Obtain a subspace of skin pixels and does averaging in that subspace. To take into account spatial distribution of skin pixels. PPG contribution is measured using the temporal relation between two subspaces of consecutive frames such as instantaneous rotation and scaling	Computes a plane orthogonal to temporally normalized RGB skin tone subject to orthogonal basis. Robust to both distortions in motion and stationary scenes due to better alpha tuning and reduces specular noise.

Heartbeat estimation from Pulse

- Obtained clean pulse waveform is passed through Band Pass Filter (0.7 - 3.5) Hz. Power spectral density (PSD) is then computed.
- 5 Highest peaks in PSD are chosen.
- Peak with highest combined fundamental and second harmonic power corresponds to the final heart-rate.

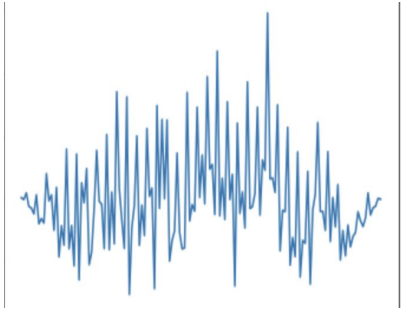
Results



Input Frame

After Face Detection

After eye removal



Obtained BVP Signal

Results

Comparison of Avg. Heart Rates with baselines.

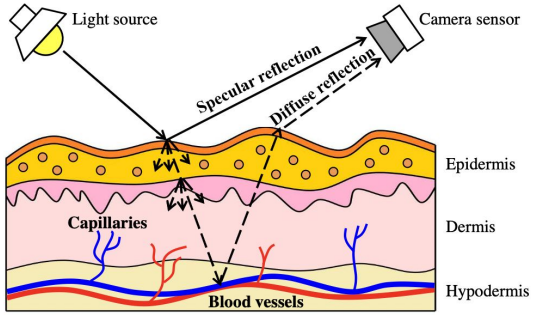
Algorithm	Set1	Set2
CHROM	67.5	82.3
2SR	80.84	83.1
POS	71.93	95.34

Ground Truth	73.39	87.16

Window Size = 1.6 * 30(fps)
Stride = 30

Computational Imaging Strategies

- Need to capture light that travels past the epidermis and dermis layer to reach the blood vessel and capture variations in that.
- Estimate visual artifact due to subsurface scattering
- Use active illumination techniques such as Laser Speckle Contrast Imaging which penetrate skin deeper.
- Direct and global separation and use global component to measure the signal intensity.



Computational Imaging Strategies contd..

- Increase Exposure time/ reduce frame rate to maximise rPPG SNR ratio.
- Have high spectral sensitivity for higher wavelength to capture diffused component of light.
- Adjust aperture value of the camera for constant brightness value regardless of the frame rate for different lighting conditions.