NON-CONTACT CARDIOPULMONARY ASSESSMENT IN-THE- WILD USING IMAGING TECHNIQUES

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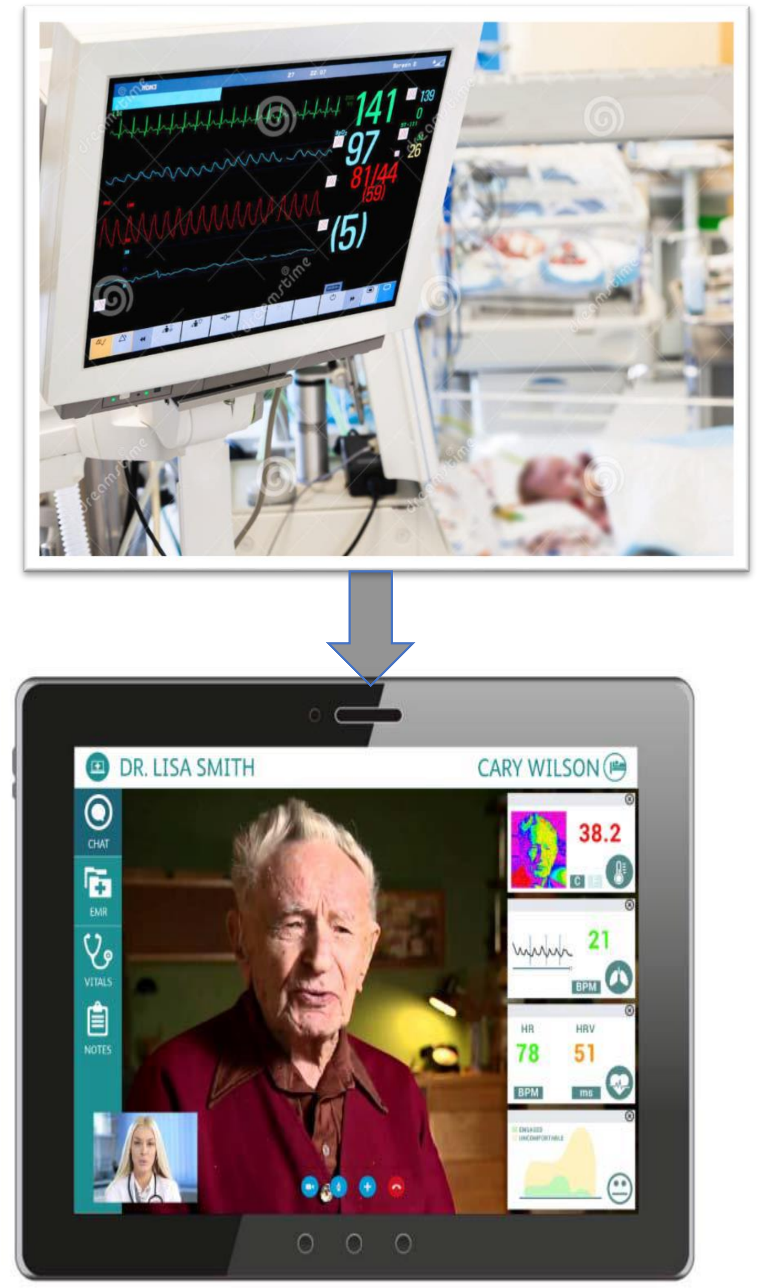
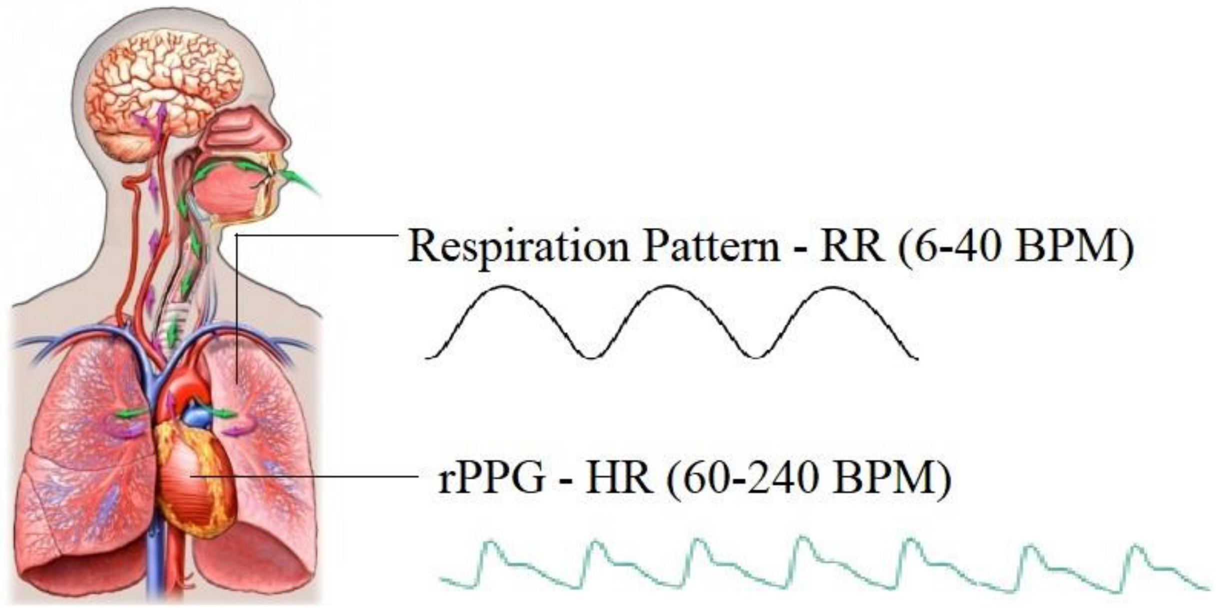
Introduction / Background

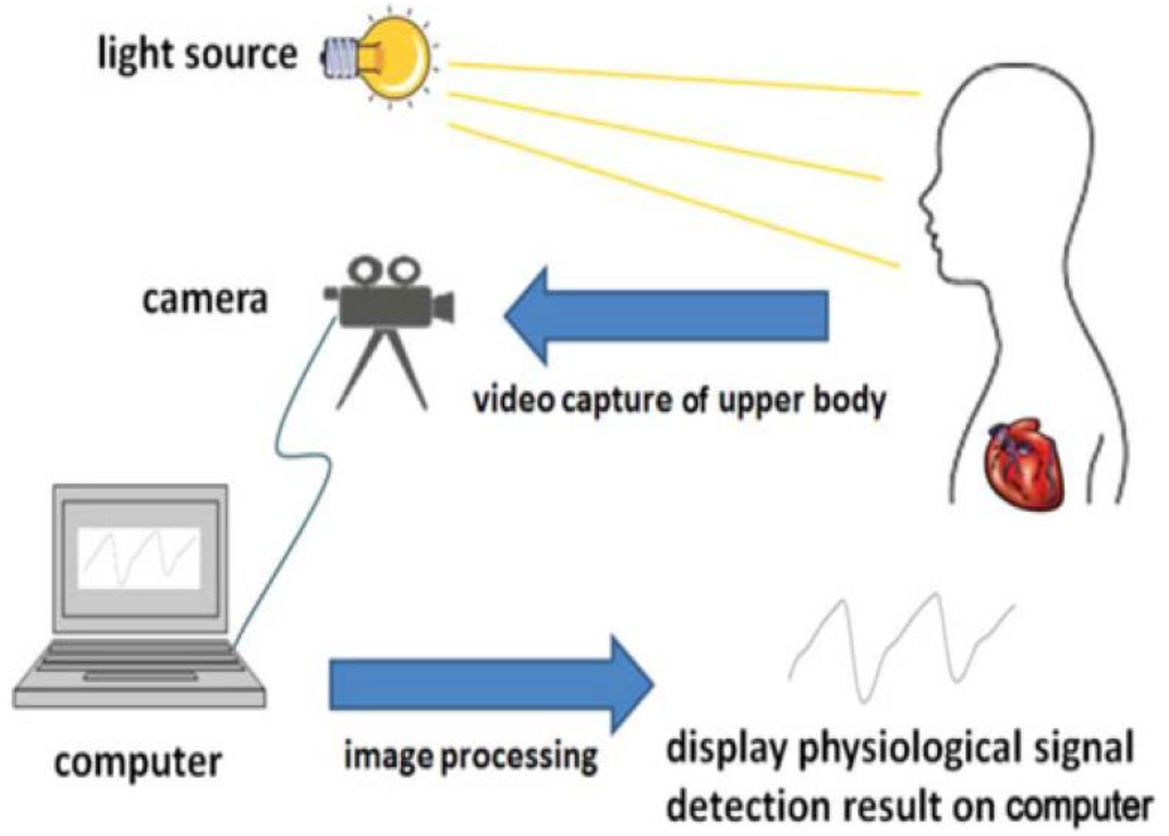
- HR, RR, SpO2, Temp, BP – Routinely measured Cardio-pulmonary vitals.
- Biomarkers for many physical (Cardiac arrest, asthma, sepsis) and psychological ailments (stress, anxiety, aponia).
- Clinical Techniques – Contact, Invasive, Painful, different device for each physiological measure, non-ubiquitous, psychological stress.
- Need for continuous non-contact Monitoring – Non Invasive/contact, Painless, anywhere anytime monitoring, single commodity device.
- Applications – Continuous health assessment (Telemedicine, child/elderly care), Stress Monitoring (office workers, drivers), Sleep Quality, Driver State Assessment, mass health screening etc.



Problem Statement

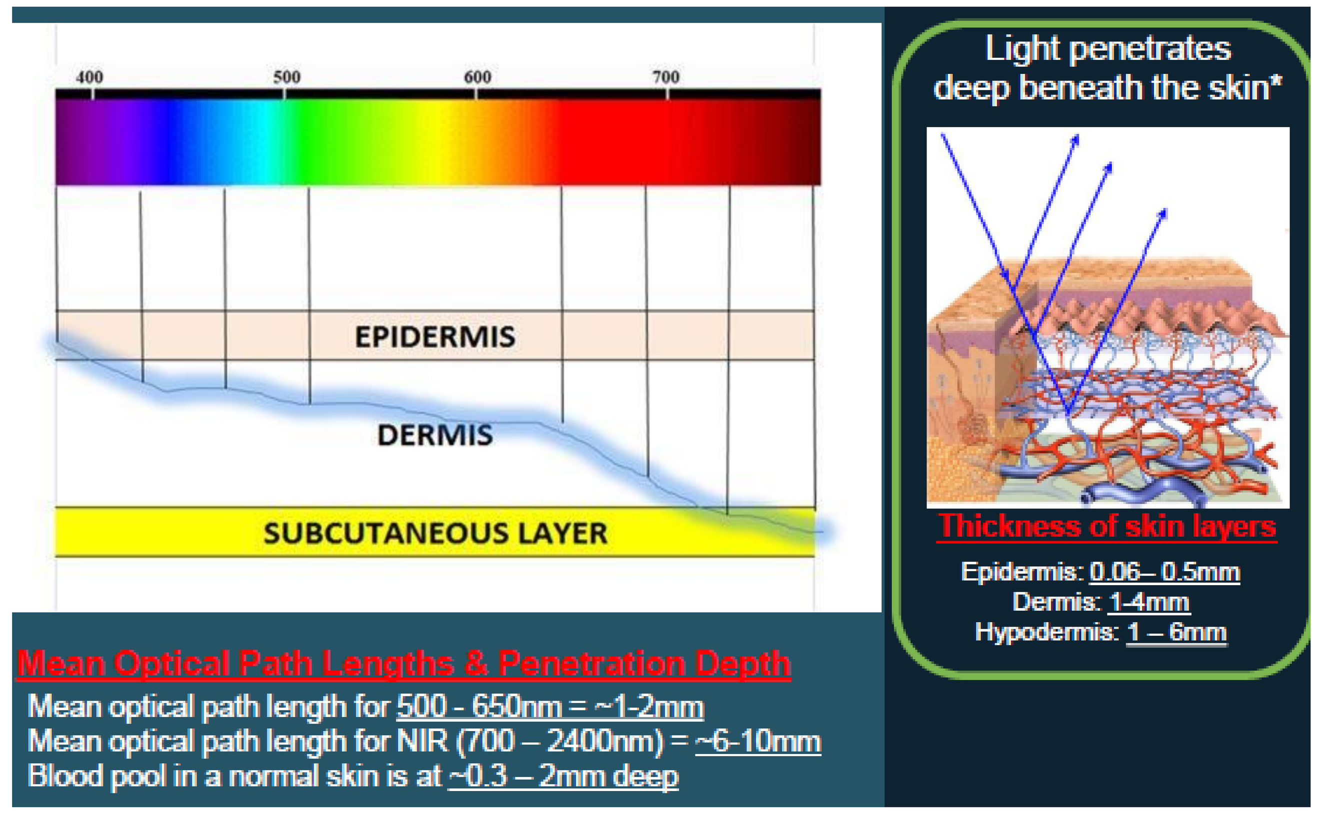
- Estimate human body vitals using imaging techniques via commodity cameras.
- Based on reflectance photometry – measure vitals through changes in the human body surface reflectance – remote photoplethysmography (rPPG).
- HR - frequency of the carrier of rPPG.
- RR - frequency of the modulating signal of rPPG, frequency of resp. pattern through chest movement.
- SpO2 (ratios of amplitudes of rPPG at two bands).
- Temperature – function of surface body temperature measured through thermal camera.
- BP – phase lag between rPPG peaks at two different sites.
- Robust estimation of rPPG, respiration pattern in-the-wild (low/no-light, different skin colors, mobility, distance) using cameras.





Prior Art

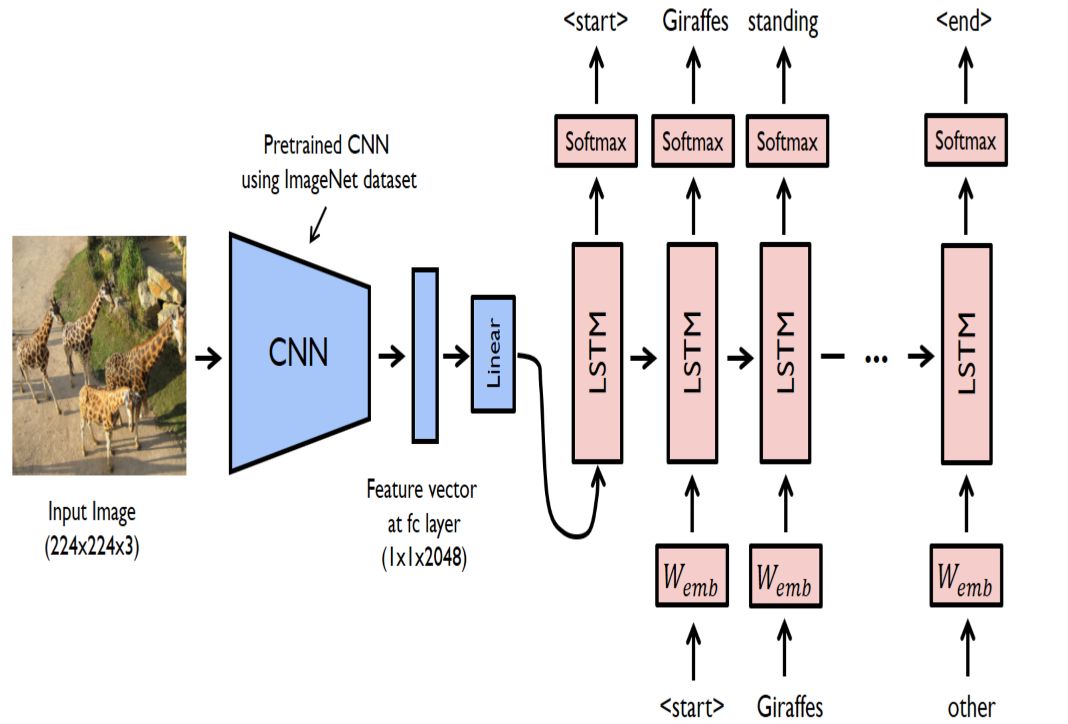
- Mostly techniques from Signal, Image Processing and Computer Vision – considerable progress made
- ROI (manual selection on forehead, skin-pixel extraction, max SNR regions), Pixel transformation (Chrominance/reflectance models, PCA and eigen decomposition), Pixel aggregation (naive averaging, bandpass filters)
- Depends critically on ROI Specific
- Lack of generalization across multiple skin complexions - subject dependent parameters
- Algorithms are specific for each vital
- Sensitivity to Illumination/Lighting Conditions and Spectra of Light used (does not work with low-lights)
- Sensitive to distance/angles between subject and camera
- Motion, Noise in Images can severely deteriorate estimates
- Yet to reach clinical grade performance



Technical Proposal

- Light penetrates deep enough – subtle change in skin color related to cardiac and respiratory cycles
- Higher the wavelength – deeper the penetration (for skin)
- Physiological signals are ultra-low frequency – HR (max 5 Hz), RR (max 1.5 Hz).
- Modern cameras can easily sample at 30 Hz – possible to fully recover these signals.
- Respiration – manifests as chest motion – can recover from optical flow computations
- SpO2 – measuring rPPG at two wavelengths – Cameras have three
- Temperature – measured from IR cameras
- BP – rPPG at two sites
- Relation between Physiological markers and reflectance of wavelength very complex

- Propose to use end-to-end (From image to the signal) DNNs to estimate the entire physiological signals (not one rate measure)
- Extract multiple vitals at one go (multi-task learning)
- Model all phases (ROI selection, pixel space decomposition, aggregation, filtering) of rPPG estimation with CNNs + RNNs
- Implicit and non-linear modelling of the inherent dependencies



- Current State of the art – uses Red/Green Channels of RGB cameras
- Near Infrared spectrum (650-1350nm) optimal for remote monitoring – maximal penetration depth – penetration till subcutaneous tissue
- Potential to solve Illumination Sensitivity, skin color independent, robust to region of interest
- Work without ambient light – suits multiple applications (ADAS, sleep monitoring)
- Propose to integrate non-contact assessments obtain psychological meta-information such as stress, wakefulness, anxiety etc. that correlates with HR, RR
- Propose to experiment with specialized hardware – hyperspectral/high-speed/single-pixel cameras