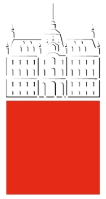
Mobile Sensing: Physiological Signals

Master studies, Winter 2021/2022

Dr Veljko Pejović
Veljko.Pejovic@fri.uni-lj.si



University *of Ljubljana*
Faculty *of Computer and Information Science*

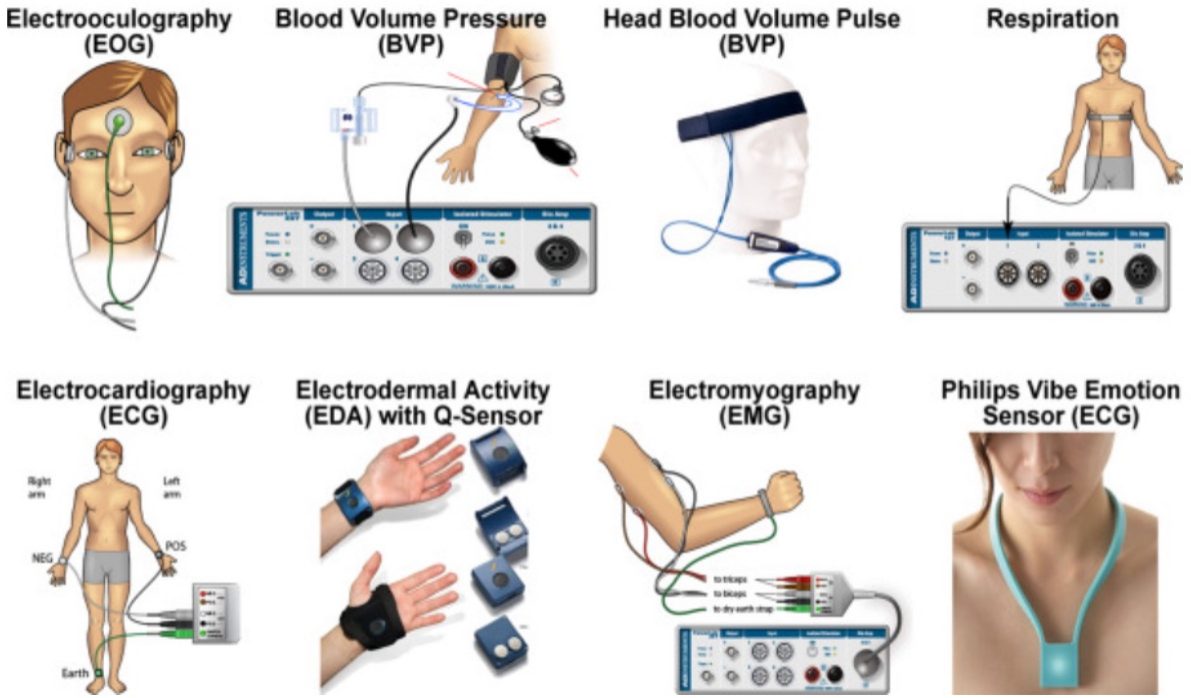
Based on slides by Dr. Martin Gjoreski, IJS

Physiological Signals and Sensors

- Physiological signals
  - Any signal in living beings that can be continually measured and monitored
- Physiological sensors
  - Provide an objective measure of physiological signals

Physiological Signals and Sensors

- Physiological signals

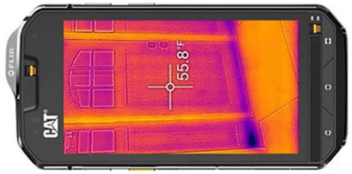


- Physiological sensors

Nonparametric models—signal estimation
Claudio Cobelli, Ewart Carson, in Introduction to Modeling in Physiology and Medicine (Second Edition), 2019

Evolution of Phy-Sensing Equipment

- Specialised devices
  - Sensing, some processing
- Consumer wearables
  - Sensing, some processing, HCI
- Smartphones
  - Sensing, processing, HCI
- Standalone sensors, e.g. thermal camera
  - Sensing, processing, HCI



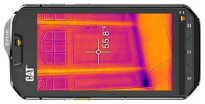
Physiological Sensor Types

- Accelerometer
  - Acceleration, including gravity → orientation
- Gyroscope:
  - Angular velocity
- Photoplethysmogram (PPG):
  - Blood volume pulse → heart activity, blood oxygen, blood pressure

Physiological Sensor Types

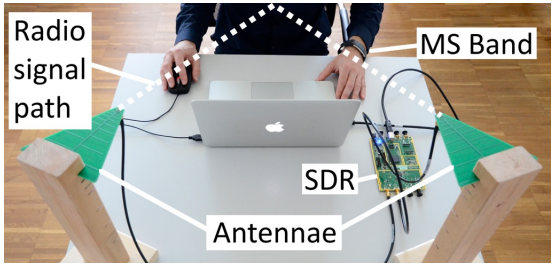
- Electrocardiogram (ECG):
  - Heart activity (richer information than PPG)
- Electromyogram (EMG):
  - Muscle activity
- Galvanic skin response (GSR) / Electrodermal activity (EDA):
  - Skin conductivity → sweating
- Electroencephalogram (EEG):
  - Brain activity





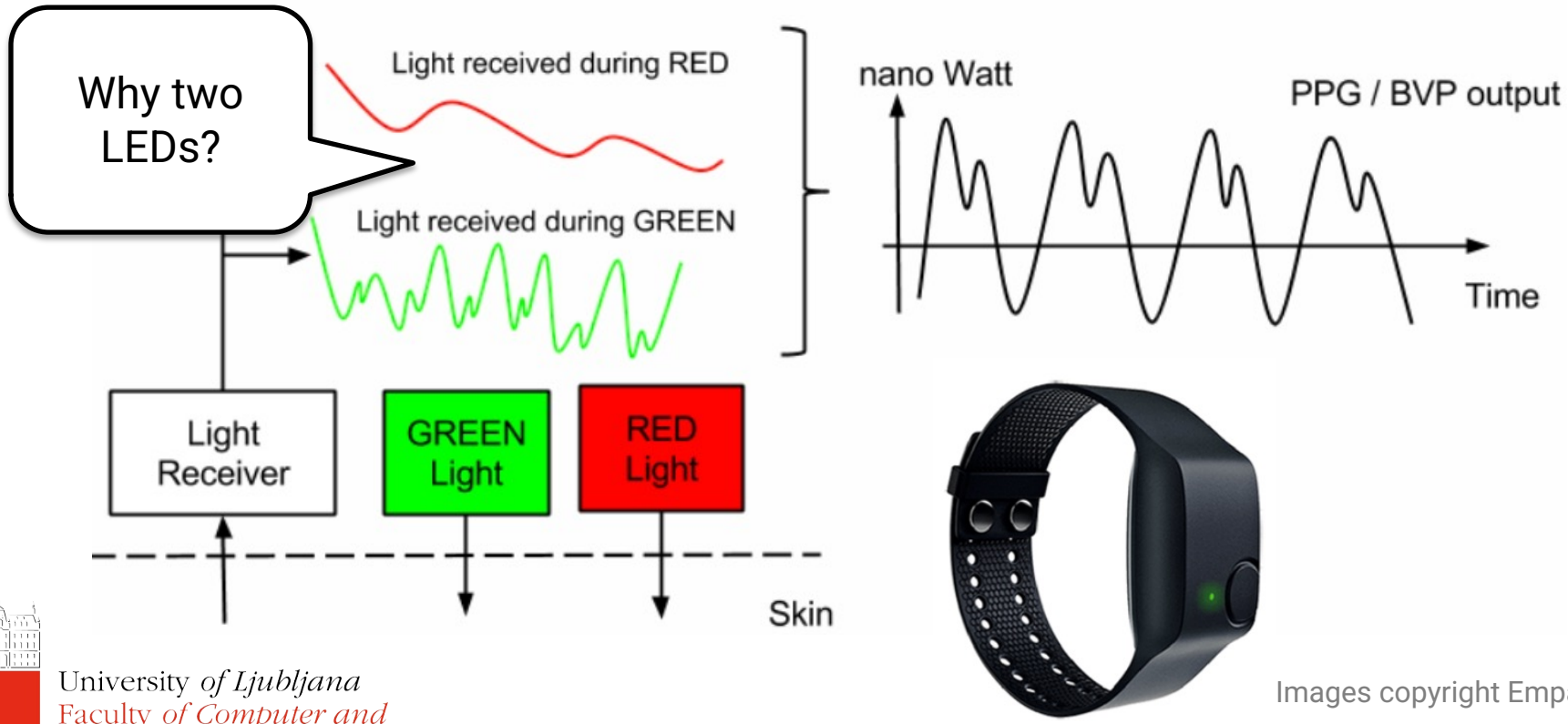
Physiological Sensor Types

- Temperature sensor:
  - Skin/ambient temperature
- Phonocardiogram (PPG):
  - Heart sounds
- (Wireless) ballistocardiograph:
  - Movements related to heart and breathing activity



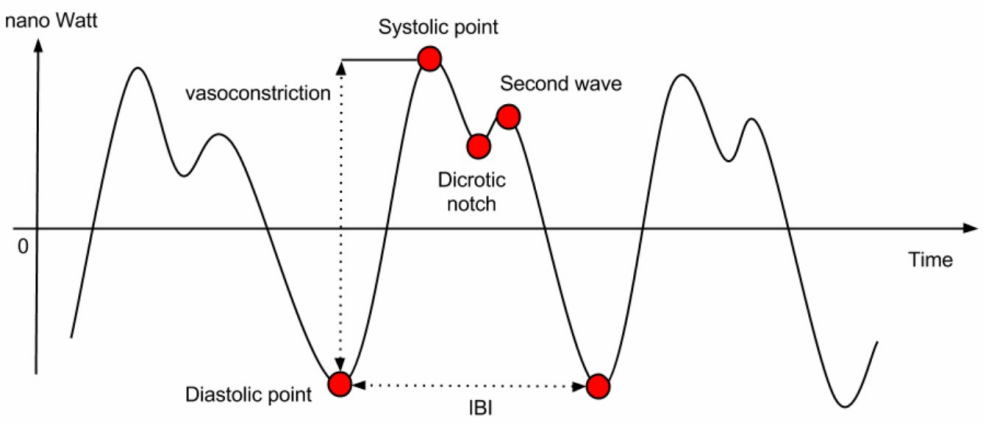
Example Signal – BVP

- Light absorption
  - Light is better absorbed by blood than by other tissue
  - Different light wavelengths, different absorption



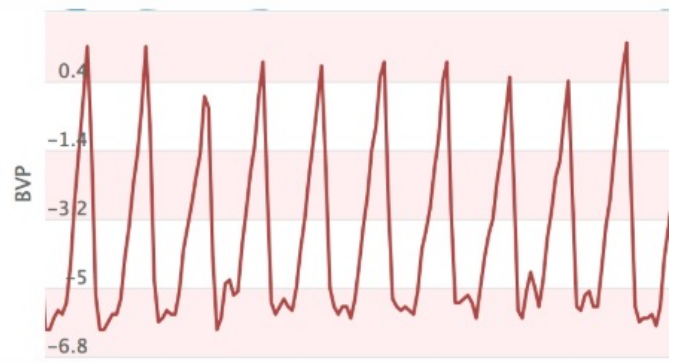
Example Signal – BVP

- BVP signal in theory



- BVP signal in practice

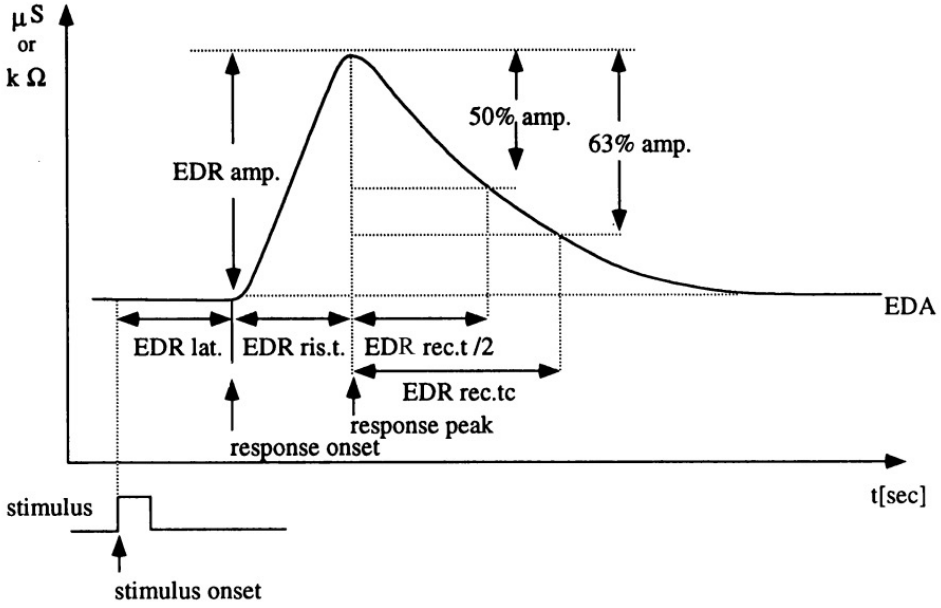
noisy example (first few seconds)



clean example (stable signal)

Example Signal – EDA

- Sweat glands react to a stimulus
  - How many peaks are present in the signal
  - How fast a peak appears
  - …
- However, sweat glands also react to:
  - Temperature
  - Food you eat
  - Smoking

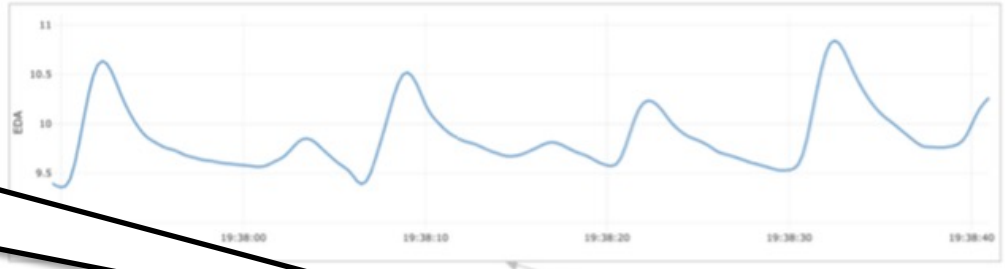


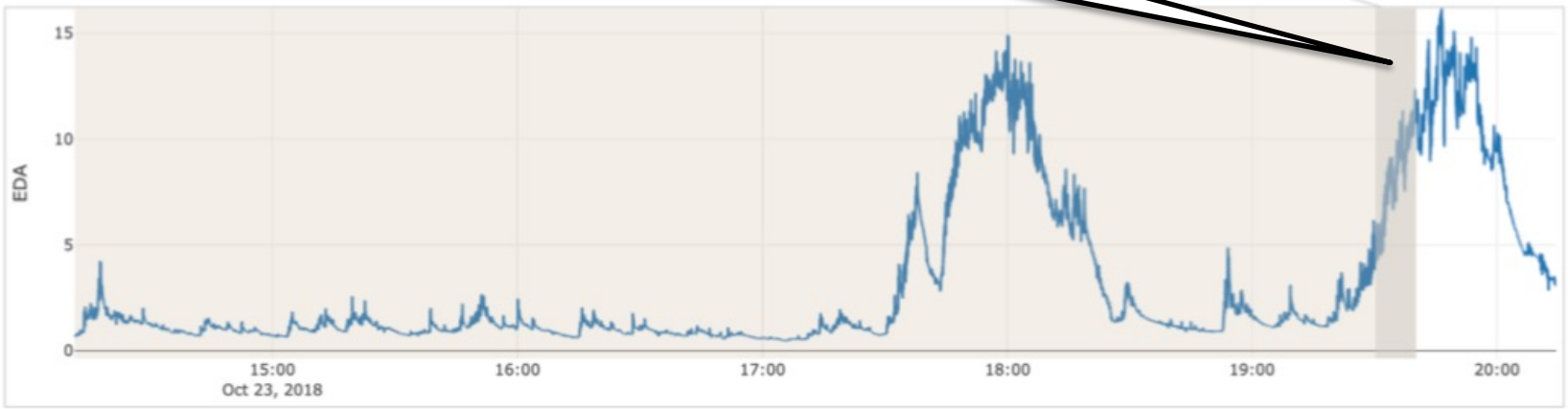
Boucsein, W., 2012. Electrodermal activity. Springer Science & Business Media.

Example Signal – EDA

- Real life EDA signal

Turns out that this correlates with acceleration – a user is exercising?





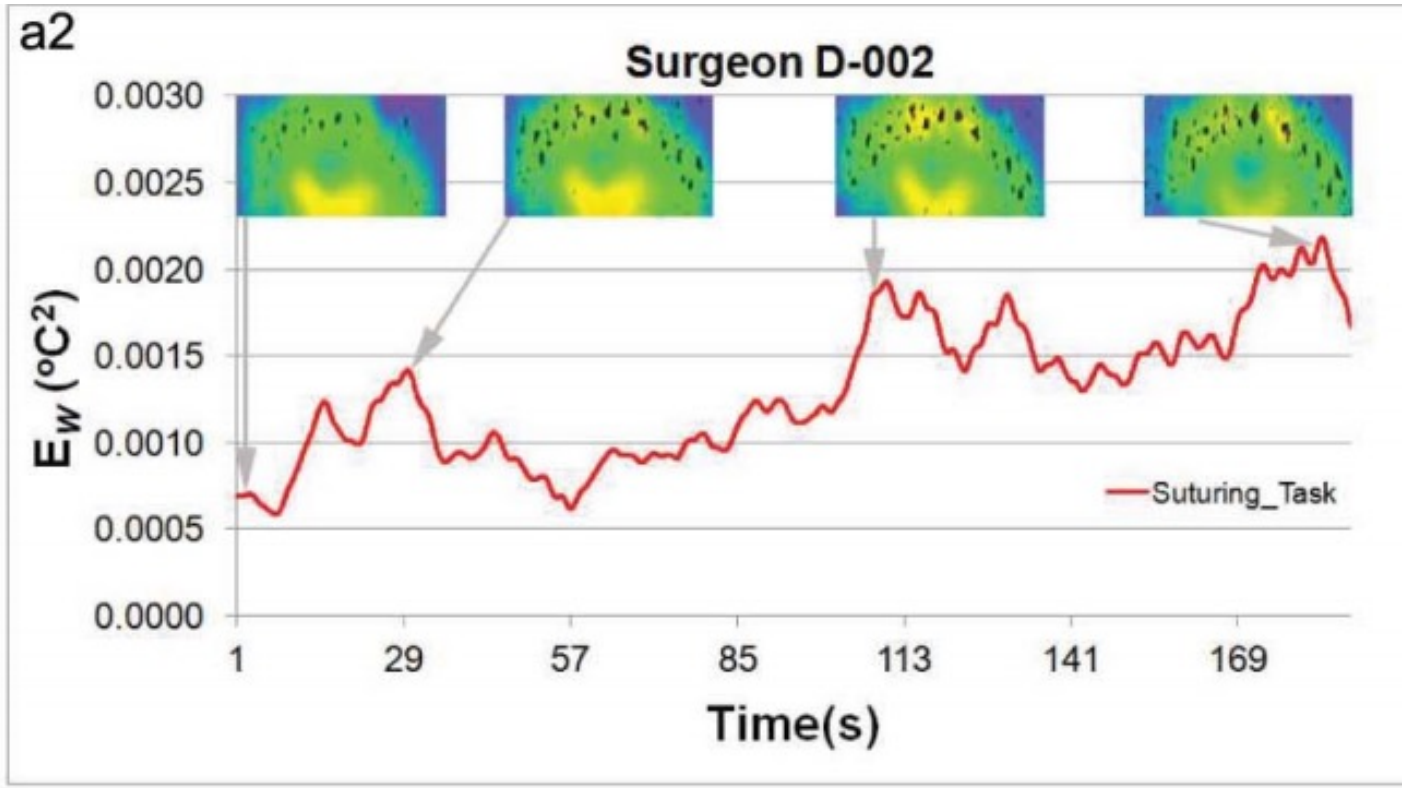
Gashi et al., 2020. Detection of Artifacts in Ambulatory Electrodermal Activity Data

Example Signal – Nasal Perspiration from Thermal Imaging

Pavlidis, I et al. . "Dissecting driver behaviors under cognitive, emotional, sensorimotor, and mixed stressors." Scientific Reports 6 (2016).

Example Signal – Nasal Perspiration from Thermal Imaging

- Nasal “cooling” related to stressful situations



Shastri, Dvijesh, Manos Papadakis, Panagiotis Tsiamyrtzis, Barbara Bass, and Ioannis Pavlidis. "Perinasal imaging of physiological stress and its affective potential." IEEE Transactions on Affective Computing 3, no. 3 (2012): 366-378.

Practical Issues with Physiological Signal Sampling using Wearables

- Battery charge
  - Wearables need to be recharged daily at least
- Processing power
  - Commercial wearables cannot run standard deep learning algorithms – use compression techniques!
- Accuracy and noise
  - Low-quality sensors
  - Placement issues – EDA sensor needs tight contact
  - Impact of outside factors