PPG Analyzer 9800FX

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The team!

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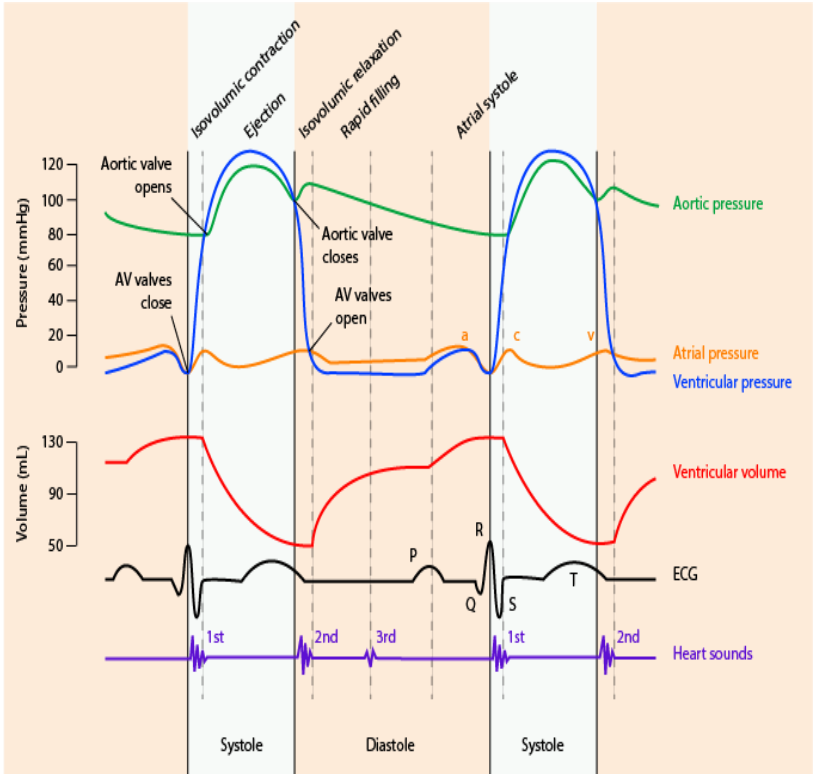
- Mirva Reijonen – born in 1990, has a bachelor in Chemical engineering, currently in student exchange in Czech Republic
- Miloš Kaćanski Ing. – born in 1989, got his degree in Biochemical engineering, currently part of CEMACUBE programme

PPG

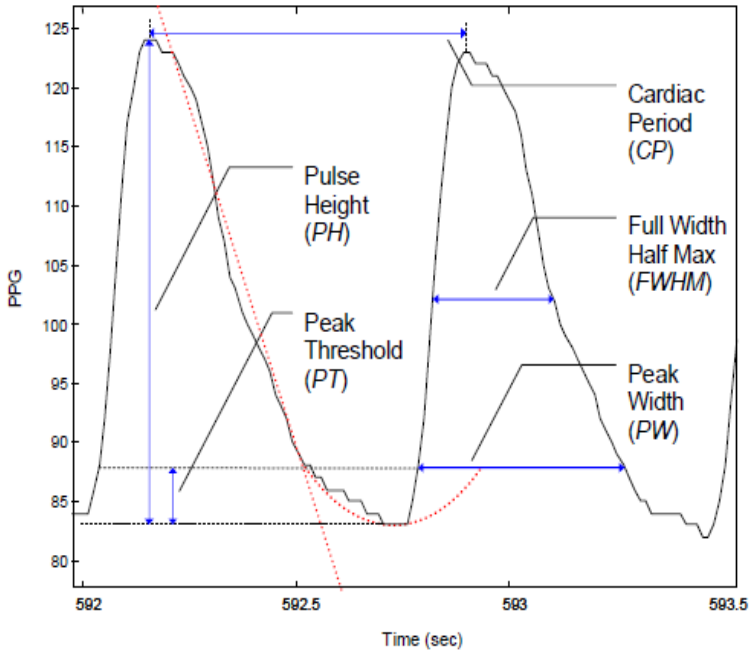
Photoplethysmography (PPG) is an optical measurement technique that can be used to detect blood volume changes in the microvascular bed of tissue



Structure of the PPG Signal

Parameters in the PPG signal

- **PH:** pulse height or pulse amplitude
- **CP:** cardiac period
- **FWHM**: full width half max
- **PW**: peak width
- **PT**: peak threshold



- **Information in the PPG**
  - **Heart rate:** $\frac{60}{CP}$ in beats per minute
  - **Blood pressure:**
    - $p_1 - p_2 \cdot PTT$ (e.g. p_1 = 246, p_2 = 0.4, PTT=315ms)
    - $p_1 \cdot e^{p_2 \cdot PH} + p_3 \cdot e^{p_4 \cdot PH}$ (e.g. $p_1 = 105, p_2 = -4, p_3 = 0.2, p_4 = 18$)
  - **Respiration:** using low frequency respiratory induced intensity variations and PPT
  - **Arterial stiffness:** $\frac{c}{a}$
  - **Vascular aging:** $\frac{b-c-d-e}{a}$

The project

Digital filtering of a raw PPG signal

Extraction of PH (pulse height) and PP (peak-to-peak) values from a filtered PPG signal

MAP estimation using PH

Fourier transform of PP intervals and estimation of HF and LF

Implementation in Matlab, if possible with an interactive GUI

- User should be able to import the raw signal import from a Biopac text export
- User should be able to enter the sampling frequency,
- User should be able to filter the raw signal
- User should be able to execute PP, PH, MAP, LF, HF computation
- User should be able to display plots of the raw signal for a given start and end timestamp
- *User should be able to display plots of PP, PH, MAP over the time for a given start and end timestamp and display the value of LF and HF*

The signal

- Data for project design was:
  - From a superficialy healthy subject treated with Czech culture for last nine months, with some interuptions
  - Recorded by Biopack SS4LA plethysmograph transducer
  - Exported into text file with Biopack student lab PRO software
  - Analysed in Mathlab, version 2011a

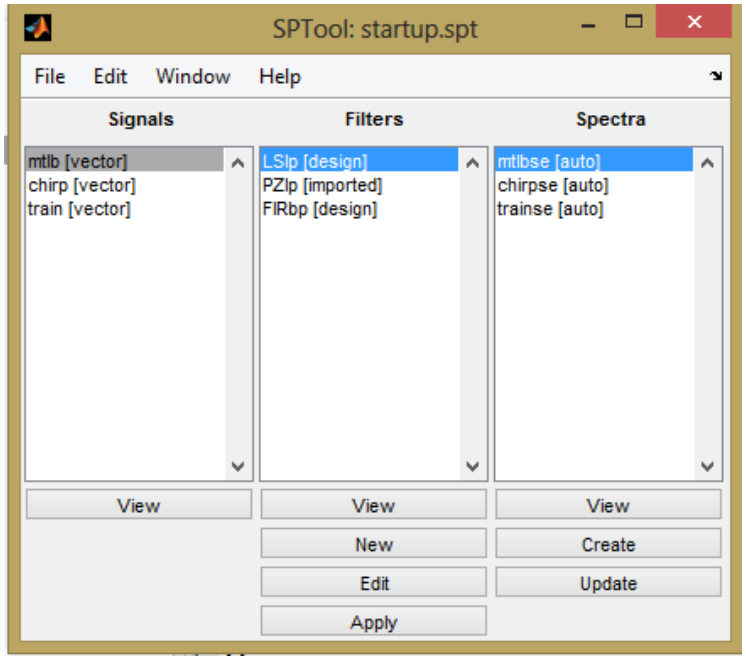
Heart rate estimation

- Filtering with a strong FIR low pass filter
  - FIR for linear phase characteristics
- Peak detection
- Removal of small intervalls
  - Lower than 0.6 mean interval
- Determination of mean Heart rate

Digital filtering of a raw PPG signal

FIR low pass (experimentaly determined values using Sptool):

- Passband Frequency= 1
- Stopband Frequency= 12
- Passband Ripple= 0.057
- Stopband Attenuation= 0.003
- Density Factor= 20



Extraction of PH (pulse height) and PP (peak-to-peak) values from a filtered PPG signal

- Using the filtered data
- Peak detection using minimal peak distance
  - Minimal peak distance intelligently set after heart rate
- Intervals are determined for PP interval
- For Pulse height:
  - Peak detection of negative signal
  - Positive and negative peaks are sorted
  - Difference between peak values are calculated
  - Removal of all even data

MAP estimation using PH

- $p_1 \cdot e^{p_2 \cdot PH} + p_3 \cdot e^{p_4 \cdot PH}$ (e.g. $p_1 = 105, p_2 = -4, p_3 = 0.2, p_4 = 18$)

*Using mean peak height

Fourier transform of PP intervals and estimation of HF and LF

- Doubling of Fs
- Fast Fourier transform of peak to peak intervals
- Interpolation of the amplitude spectrum
- Integration of HF and LF intervals
  - LF: 0.04 – 0.15 Hz
  - HF: 0.15 – 0.5 Hz

Implementation in Matlab

[sound of Matlab opening]

Discussion

- Strengths:
  - Every physician can use it without background knowledge
  - Low number of mathematical operations -> Fast
  - Easily user-adaptable
  - User can evaluate peak detection
- Possible improvements
  - Program is not compatibility-tested with different operating systems and Matlab versions
  - Parameters are set after 1 PPG data set, validation with other sets required
  - Stand-alone program
  - Added functions: HR, PA, MAP, Amplitude spectrum over a user-defined interval

Questions?