Programming Exercise 1 - ECG & Respiration

Digital Biomarkers

2024/08/29

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Python script template:	`L1-ecg-RR-intervals-template.py`
Data set:	`apnea-ecg-a01er-data.csv`
Data source:	`https://physionet.org/content/apnea-ecg/1.0.0/`
Data description	`http://ecg.mit.edu/george/publications/apnea-ecg-cinc-2000.pdf`

Background

It is known from physiology that the heart rate and ECG amplitudes are correlated to the respiration activity of a subject. In this exercise, we apply basic methods to explore this dependencies.

We use an ECG signal recorded in parallel to a nasal flow signal from physionet (see Fig. 1). The nasal flow signal was recorded with a thermal flow sensor, showing high temperature values on expiration (see Fig. 2).

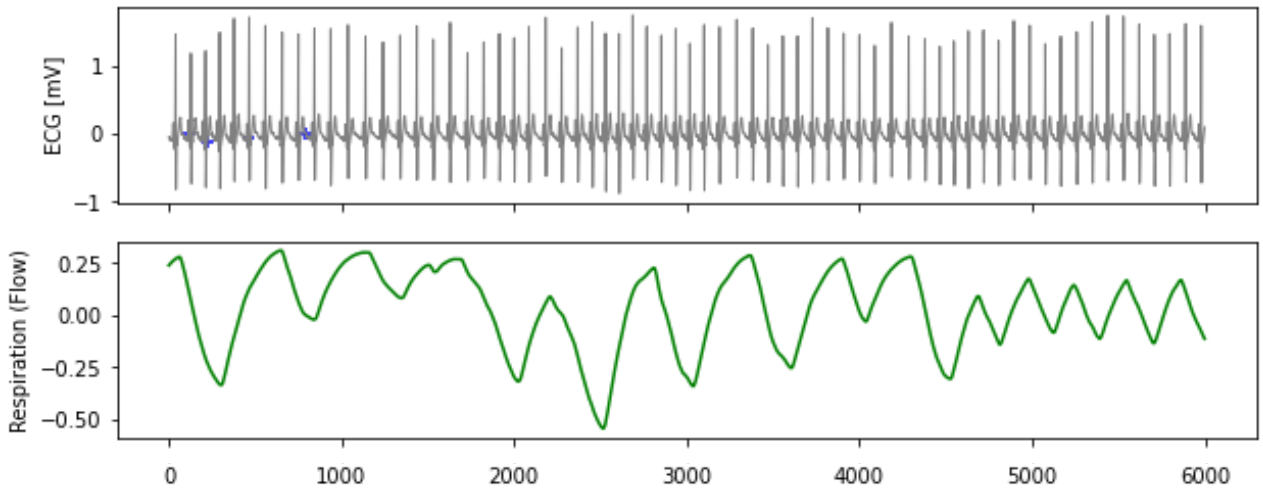

Figure 1: The upper plot shows an ECG signal recorded at a sampling rate of $f_s = 100\,\text{Hz}$. The lower plot shows the air flow recorded with a thermal nasal respiration sensor.

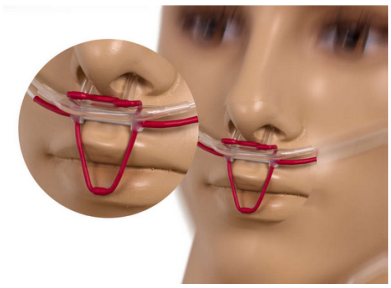

Figure 2: Example of a thermal flow sensor covering nose and mouth.

Programming Exercise 1-1: ECG RR Intervals

Running the template script, plots the ECG signal (grey) and respiratory flow (green) as shown above.

Tasks:

a) An R wave in an ECG signal is the center, positive peak of a QRS complex. Detect the positions of each R wave in the provided signal using `find_peaks(...)` from `scipy.signal`. (See `**to do 1**` in the template code).

b) Calculate the R-R intervals from the detected R peaks, i.e., the time between two consecutive R's and extract the amplitude of each R peak. See `**to do 2**`.

Programming Exercise 1-2: ECG vs. Breathing

Continue from the previous exercise. It is known from physiology that R-R intervals as well as the QRS peak amplitudes are correlated to subjects breathing activity. Check if this is also observable in the provided data set.

a) Append a scatter plot in `**to do 3**` displaying

   i) R-R interval vs. Respiration,

   ii) R peak amplitude [mV] vs. Respiration,

b) Add a linear regression line to each scatter plot and print the R-value (correlation coefficient) of the correlations. (See the Python functions `linregression` from `scipy.stats` for more details.)

c) Briefly check in literature for the connection between ECG and respiration.

Hint: Note that the connection between ECG and respiration is dependent on subject health state and age. Therefore, it might not be visible in every data set.