Separating uterine EMG records using sample entropy

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Abstract – in this report we will present the methods and results of our BSIP seminar work, which tasked us with the analysis of EHG recordings using sample entropy.

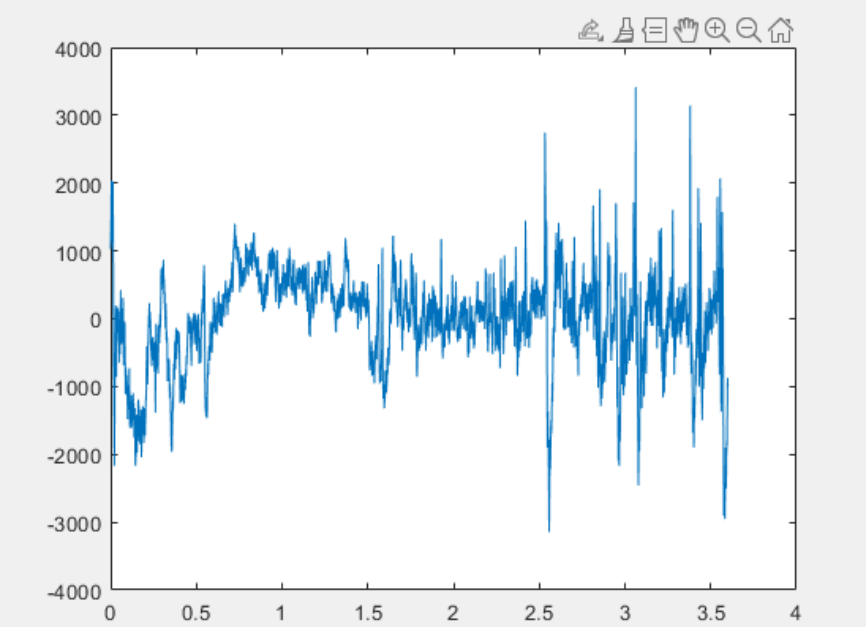
Introduction - Uterine electromyogram (EMG), also termed electrohysterogram (EHG), represents electrical activity of uterus. The EHG signals contain also intervals with increased electrical activity of the uterus. The increased electrical activity is visible in the EHG signals as short bursts with higher signal amplitude. These intervals usually coincide with contractions. The frequency contents of the EHG signal changes during contractions, but the studies have also shown, that the frequency contents of the EHG signals as well as frequency contents of individual contractions within a signal, changes as the labour approaches. Your task is to separate the uterine EMG records using sample entropy. For this purpose use the EMG records of the Term-Preterm EHG DataBase (TPEHG DB). The TPEHG DB is available on the home pages of the Laboratory for biomedical computer systems and imaging or on the PhysioNet web site. To fully complete the assignment you have to satisfy several requirements. You have to write a program which has to accept the name of a record (.dat and .hea files of the database) as a parameter. The program has to open this record and calculate sample entropy for the signal 3 of this record for the chosen preprocessing filter. Take four records, one from each of the four groups (PE: pre-term labour, recorded before 26th week of gestation; PL: pre-term labour, recorded during or after 26th week of gestation; TE: term labour, recorded before 26th week of gestation; and TL: term labour, recorded during or after 26th week of gestation). Study and compare the sample entropy of signals 3 for following four pairs of records: a record from PE and a record from PL; a record from TE and a record from TL; a record from PE and a record from TE; and a record from PL and a record from TL. You also have to calculate, study, and compare the sample entropy of signals 2 and 3 for the chosen preprocessing filter for one of the selected four records. Select those four records which actually contain intervals with increased electrical activity of the uterus. You can extend your study by selecting additional or multiple quadruplets of the records. The program has to calculate sample entropy using the pattern length of m=3 and pattern match margin of r=0.15. Your discussions and conclusions regarding the estimator for records from each of the four groups have to be written into a text (.txt) or document (.pdf) file. The .txt or .pdf file, together with the source of your program has to be submitted during uploading of the assignment.

Methods – For the purpose of this task we used Matlab, which is a professional tool for developing methods for signal processing. We used recordings from the TPEHG DB to succesfully complete our analysis. We wrote a matlab script, which opened 4 records (which were stored in a .mat format). Each recording belonged to a specific group, pre-term early, pre-term late, term early and term late, as was described in the instructions. Before we calculate the sample entropy of the recordings, we used a Butterworth filter to digitally filter the recordings. The Butterworth filter is a type of signal processing filter designed to have a frequency response as flat as possible in the passband. It is also referred to as a maximally flat magnitude filter. The filter was designed as a 4-pole digital filter with a double-pass filtering scheme. We used a bandpass cutoff frequency from 0.3 Hz to 4 Hz. After filtering was done the program calculated the sample entropy. Sample entropy is a modification of approximate

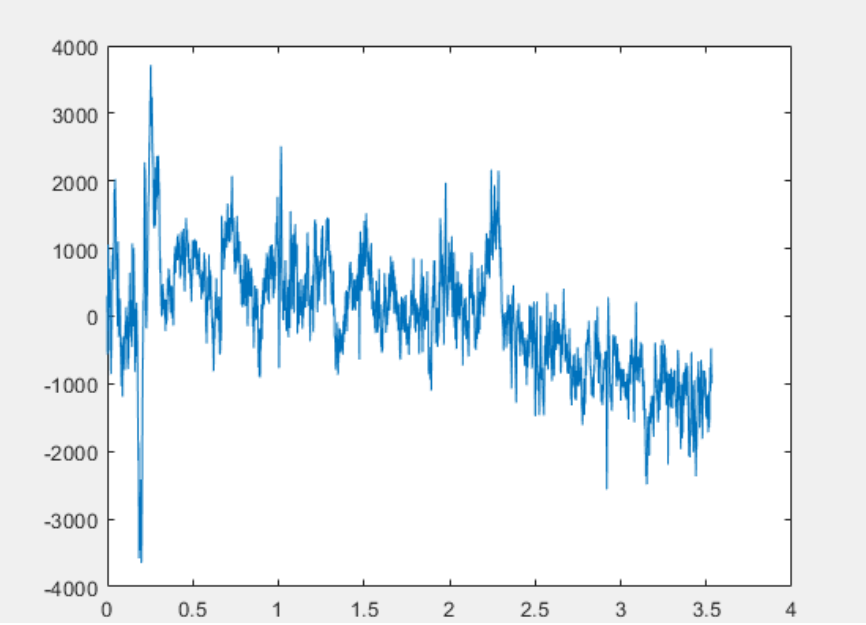
entropy, used for assessing the complexity of physiological time-series signals, and diagnosing diseased states. If the sample entropy is high, that means the time series is less predictable than one, with a lower sample entropy. Our program calculates the sample entropy of the recordings with a pattern length of m=3 and pattern match margin of r = 0.15, as specified in the instructions. After this, we will calculate the sample entropy for another quadruplet of recordings and compare the results.

Results

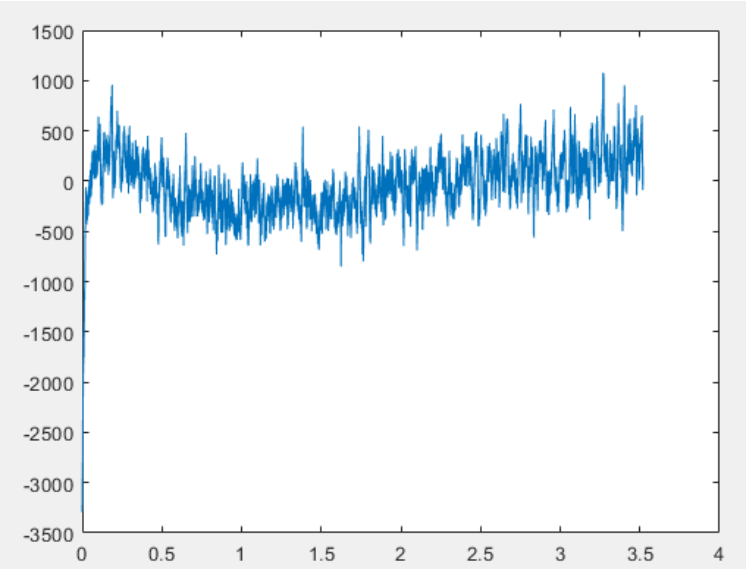
In this chapter we will present the results with graphs and calculated results.



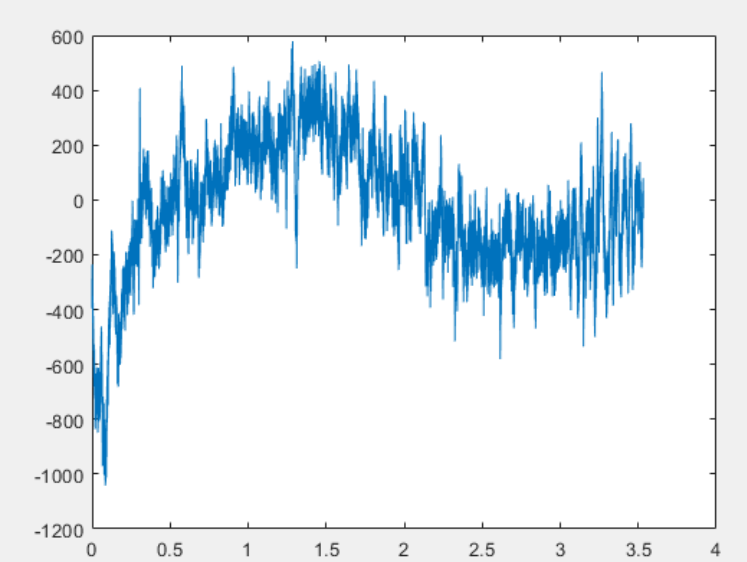
Slika 1 Pre-term labour, early



Slika 2 Pre-term labour, late



Slika 3 Term labour, early



Slika 4 Term labour, late

Sample entropy (quadruplet: 1302, 1202, 1116, 1027)

- SE PE (3rd signal) - 1.2842
- SE PL (3rd signal) - 1.3520
- SE TE (3rd signal) - 2.2128
- SE TL (3rd signal) - 2.1118
- SE PE (2nd signal) - 1.8593

Sample entropy (quadruplet: 1203, 1007, 1118, 1022)

- SE PE (3rd signal) - 1.5805
- SE PL (3rd signal) - 1.2150
- SE TE (3rd signal) - 1.9926
- SE TL (3rd signal) – 1.6447
- SE PE (2nd signal) - 1.0367

- Average SE of pre-term: 1.3579
- Average SE of term: 1.9905

Discussion - The average sample entropy of pre-term recordings is much lower than the sample entropy of term recordings. This means that the predictability of pre-term recordings is much higher, because the power spectrum already moved to lower frequencies which corresponds to lower sample entropy values.

We also calculated the 2nd signal values of PE (pre-term early) recordings, which were generally low. This means that they have a high predictability.

Perhaps we could have expanded the research and calculated the values in quadruplets for the entire database, so we could see if there are any visible patterns in the values. The only pattern we have extracted from our study is that pre-term sample entropy is lower than term sample entropy.

References

[1] TPEHG DB, available on: https://physionet.org/content/tpehgdb/1.0.1/

[2] Sample entropy, available on: https://en.wikipedia.org/wiki/Sample_entropy

[3] Butterworth filter, available on: https://en.wikipedia.org/wiki/Butterworth_filter