Analysis of electromyogram of uterus (EMG)

Abstract

Our goal was separating uterine EMG records using sample entropy as measure. Our dataset consists of 300 30-minute EMG records [2] and our approach was inspired by an article [1]. We compared records from four groups (TE, TL, PE, PL), described in paragraph *Methods.* Using sample entropy and two-sample Kolmogorov-Smirnov test we showed that there exists difference between pre-term and term delivery in the terms of EMG signals.

Introduction

Analysis of uterine EHG could be really helpful in the case of term and pre-term delivery. EHG records have the potential to show useful signs of possible pre-term delivery which can sometimes be dangerous for the baby. If we could predict high possibility of pre-term delivery, we could act so that we would minimize possible negative consequences.

Methods

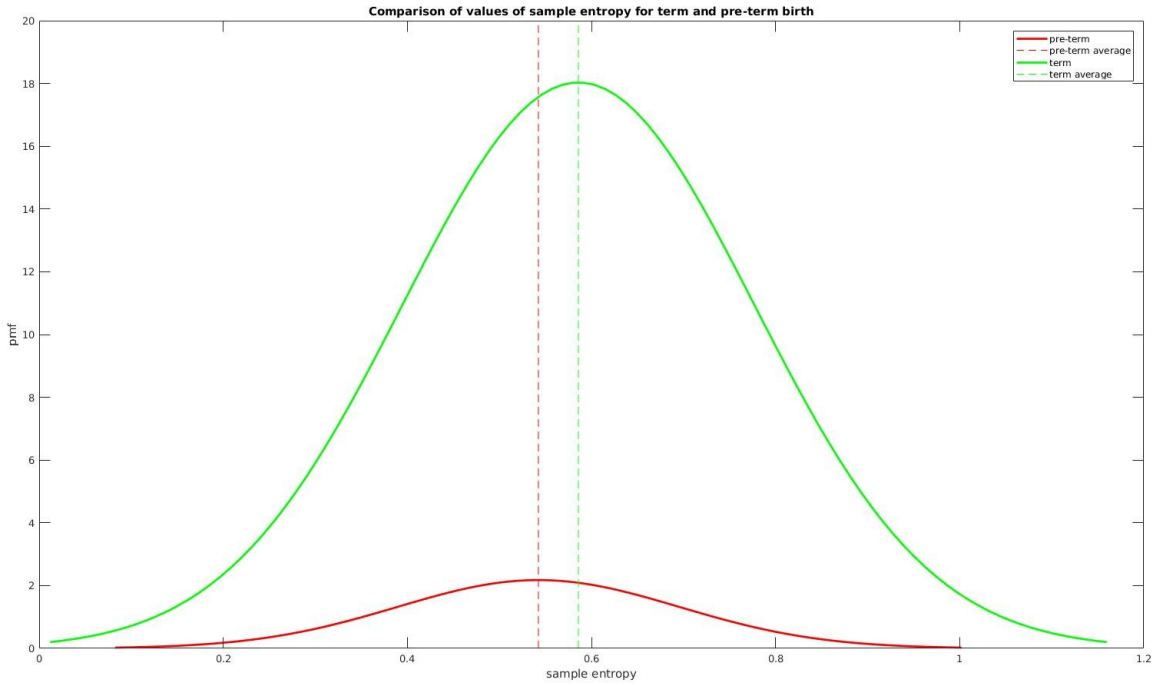
We divided our dataset into four groups: TE – term early, TL – term late, PE – pre-term early, PL – pre-term late. If the EMG measure was done before 26^{th} week of gestation the measure was early, otherwise late. The gestation is pre-term if it happens before 37^{th} week, otherwise we say it is term. For comparing individual records we used sample entropy implementation from PhysioNet [4]. We calculated sample entropy for each record in the dataset and then averaged results from the same groups. Using two-sample Kolmogorov-Smirnov test we rejected the null hypothesis that all samples come from the same distribution.

Results

In the table below we can see that calculated sample entropy depends on the signal (channel) that is given as input. For the same preprocessing Butterworth filter sample entropies turn out to be quite different. We used 4 records to compare results, one record from each type of measure. From the results we can conclude that signal 2 has higher sample entropy in TE and PE, which means that is higher for early measures (before 26^{th} week of gestation). On the other hand, signal 3 has higher sample entropy in the case of late measures (after 26^{th} week).

record number (type of measure)	*sample entropy (signal 2, filtered 0.08 – 4 Hz)*	*sample entropy (signal 3, filtered 0.08 – 4 Hz)*
1021 (TE)	0.243	0.199
1022 (TL)	0.282	0.564
546 (PE)	0.450	0.350
1007 (PL)	0.331	0.453

On the image below we see comparison of sample entropies between term and pre-term delivery. Averages of both are marked with vertical dashed lines.



In the appendix there are four more similar plots, showing four relations between groups: PE – PL, TE – TL, TE – PE, TL – PL.

Two-sample Kolmogorov-Smirnov test showed results presented in the table below. In the pairs TE – TL and TE – PE p-value is very small, indicating that samples from these two group pairs are not coming from the same distribution. TE – PE pair is very interesting since it indicates that if measure was performed early, we can differ term and pre-term delivery relating to sample entropy.

samples from 2 groups	*p-value*
PE – PL	0.742
TE – TL	0.009
TE – PE	0.013
TL – PL	0.761

Discussion

We could observe that there exists differences between EMG records of term and pre-term gestation. To maybe even further improve results and be able to distinguish between groups even more clearly, we could used some other measure instead of sample entropy. Besides, it would be interesting to use personal data about women and compare term and pre-term deliveries according to their age and lifestyle.

References

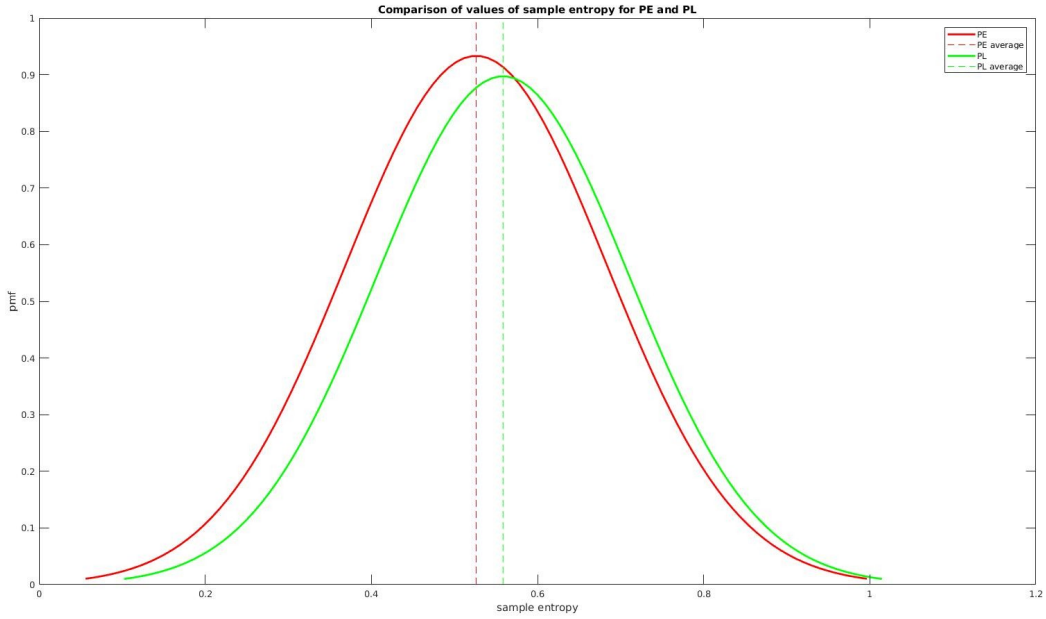
[1] Gašper Fele-Žorž, Gorazd Kavšek, Živa Novak-Antolič and Franc Jager. A comparison of various linear and non-linear signal processing techniques to separate uterine EMG records of term and pre-term delivery groups. Medical & Biological Engineering & Computing, 46(9):911-922 (2008)

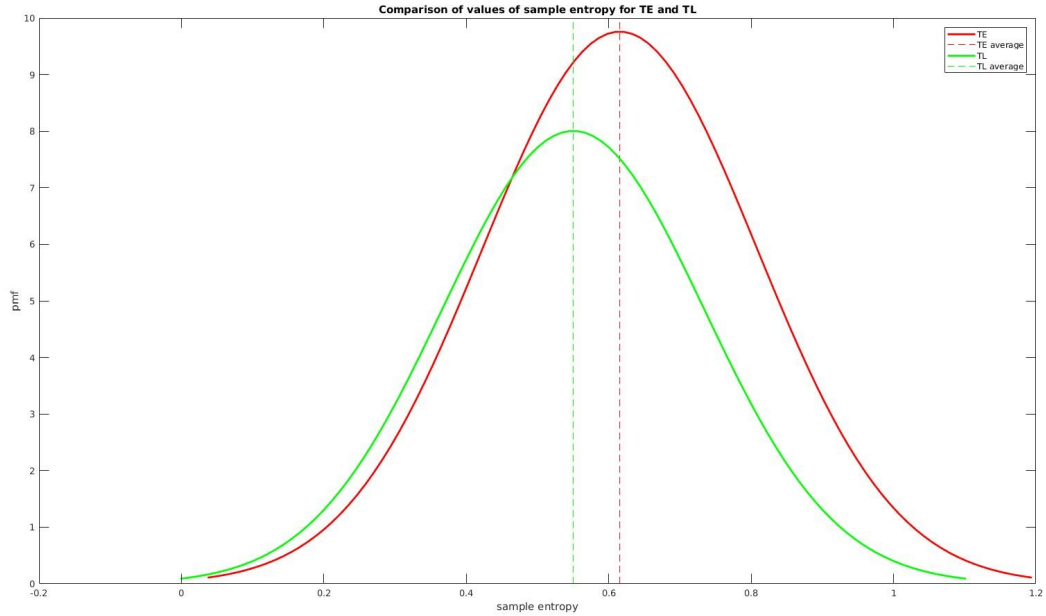
[2] Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng C-K, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. Circulation 101(23):e215-e220 [Circulation Electronic Pages; http://circ.ahajournals.org/content/101/23/e215]; 2000 (June 13).

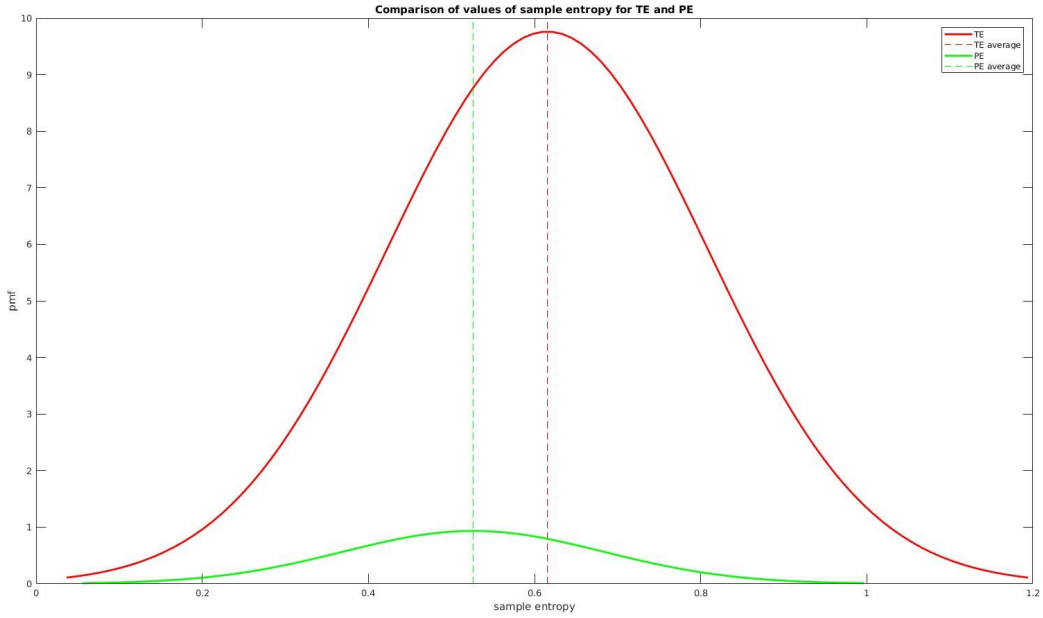
[3] Franc Jager and Žiga Pirnar (online). Biomedical signal and image processing. (cited 18. 01. 2019). Accesible at: https://ucilnica.fri.uni-lj.si/course/view.php?id=151.

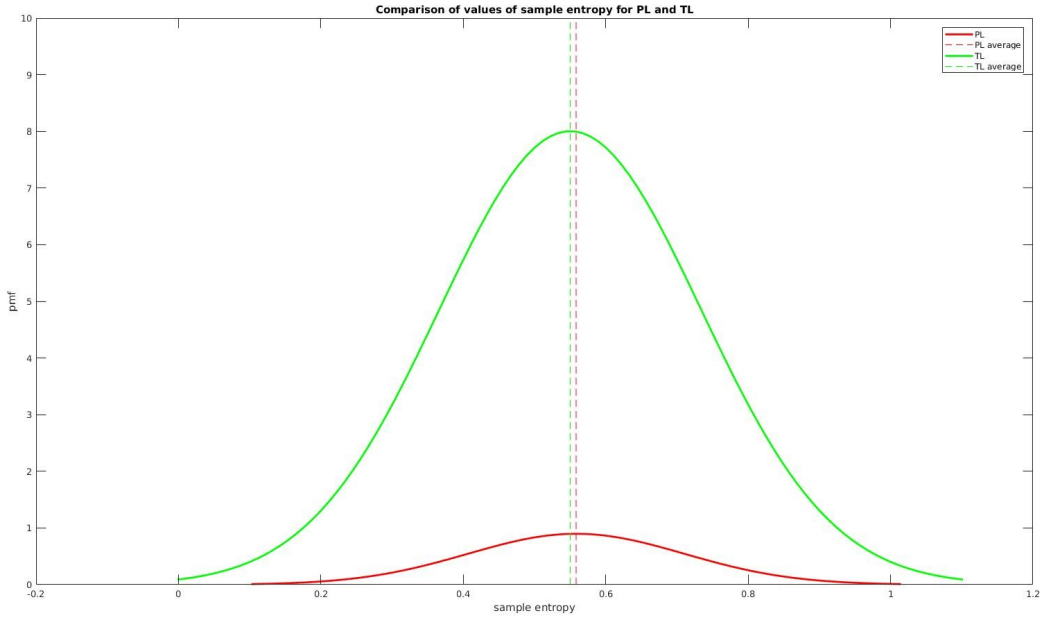
[4] PhysioNet (online). (cited 18. 01. 2019). Accesible at: https://www.physionet.org/physiotools/sampen/matlab/1.1-1/sampen.m

Appendix


Comparison of values of sample entropy for PE and PL
PE
PE average
PL
PL average
pmf
sample entropy
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.2
0.4
0.6
0.8
1.2


Comparison of values of sample entropy for TE and TL
TE
TE average
TL
TL average
pmf
sample entropy
0
1
2
3
4
5
6
7
8
9
10
-0.2
0
0.2
0.4
0.6
0.8
1
1.2


Comparison of values of sample entropy for TE and PE
TE
TE average
PE
PE average
pmf
sample entropy
0
1
2
3
4
5
6
7
8
9
10
0
0.2
0.4
0.6
0.8
1
1.2


Comparison of values of sample entropy for PL and TL
PL
PL average
TL
TL average
pmf
sample entropy
0
1
2
3
4
5
6
7
8
9
10
-0.2
0
0.2
0.4
0.6
0.8
1
1.2