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A Fuzzy Approach to Term and Preterm Identification Through EHG Signals

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Abstract: A single paragraph of about 200 words maximum. For research articles, abstracts should give a pertinent overview of the work. We strongly encourage authors to use the following style of structured abstracts, but without headings: 1) Background: Place the question addressed in a broad context and highlight the purpose of the study; 2) Methods: Describe briefly the main methods or treatments applied; 3) Results: Summarize the article's main findings; and 4) Conclusion: Indicate the main conclusions or interpretations. The abstract should be an objective representation of the article, it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.

Keywords: Biomedical Instrumentation; Electrohystogram; Uterine Contractions; Fuzzy.)

1. Introduction

Pregnancy is a physiological process that involves anatomic-functional, emotional and psychological changes as result of an increment of hormone that enables compliance with the metabolic demands of the fetus and the mother [1].

Despite being a natural process in women, pregnancy could generate some health complications, constituting a significant proportion of the global burden of maternal mortality and morbidity. That is why to monitor both an adequate adaptation of the women to all the physiological changes as well as the correct development of the fetus are important.

According to the World Health Organization (WHO) complications during pregnancy are a leading cause of death among women of reproductive age. In 2015, the maternal mortality (women death during pregnancy and childbirth, or after them) was 216 per 100.000 live births, representing 303.000 deceases. Virtually all of these deaths occurred in low-income countries but most of them could have been avoided [2]. One of the major complications during pregnancy is preterm labor (less than 37 weeks of gestation). Preterm labor and subsequent preterm birth is the primary cause of neonatal mortality and neurological morbidity in the short and long term. Its frequency varies between 5% and 12% in developed regions of the world, but can be up to 40% in the poorest regions [3].

1.1. Uterine Contractions

Write.

1.2. Tocography

Currently, Tocograph as a part of Cardiotocography (CTG) is used to monitor the strength, duration and frequency of uterine contractions. It is a pressure sensor which picks up the contraction of the uterus and displays it on a graph with the X-axis as time (seconds) and the Y-axis as pressure (mmHg). The sensor is placed at the fundus of the abdomen and is kept in place with the help of a belt. A sample Tocography is shown in Figure 1.

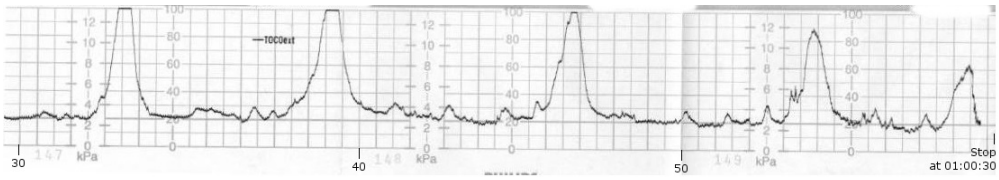

Figure 1. Uterine contractions in Tocography signal.

There are several disadvantages of Tocography. Important among them are:

- Inter and intra-personal variation in interpretation of CTG trace [4].
- Sometimes there is shift (either up or down) in baseline of signal which makes interpretation difficult. This is known as baseline wandering [5].
- Tocodinamometry is not a reliable technique because it is very imprecise. [Dietmar et al, 2009]
- Many different variables affect the measurement of contractions, such as instrument placement, amount of subcutaneous fat, movements of the pregnant woman and uterine wall pressure.

1.3. Electrohisterography

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1.4. Objectives

The purpose of this work is to evaluate the possibility of detect if the pregnant is in labour or not, by means of characterization of the contractions obtained by uterine surface electromyogram (sEMG) on the abdomen of the pregnant woman. The uterine sEMG is called electrohysterogram (EHG). As there is no current published information concerning fuzzy classification of EHG recordings, we propose to investigate, in this study, the potentialities of fuzzy logic to determine a possible separation between labour and non-labour contractions.

2. Materials

In this chapter, the database used to perform the experiment is described. The data used in this work was processed entirely in Matlab 2016 software.

2.1. The Icelandic 16-electrode Electrohysterogram Database

To perform this work, a 16-channel EHG signal database called "The Icelandic 16-electrode Electrohysterogram Database", available from the Physionet repository, was used.

The acquisitions of this database were executed between 2008 and 2010 in the Landspitali University Hospital, Akureyri Hospital and Akureyri Primary Health Care Centre in Iceland. Were performed 122 recordings on 45 pregnant woman, where 32 were measured repeatedly during the same pregnancy and participated in two to seven recordings. Sessions ocurred in the third trimester (112 recordings) and during labor (10 recordings). The database includes simultaneously recorded tocographs, annotations of events and obstetric information on participants. Informed consent was obtained from every participant and the protocol was approved by the National Bioethics Committee in Iceland (VSN 02-006-V4) [6].

A $4x4$ reusable monopolar Ag/AgCl electrodes with a 13.0mm outer diameter and an 8.0mm inner diameter were used for the recordings. An alignment frame, a double sided hypoallergenic adhesive sheet and a silicone backing were designed and manufactured to enable a standardized electrode setup with a 17.5mm distance between adjacent electrode centers. The electrode numbering scheme, as seen when looking at the abdomen of the participant, can be seen in Figure 2.

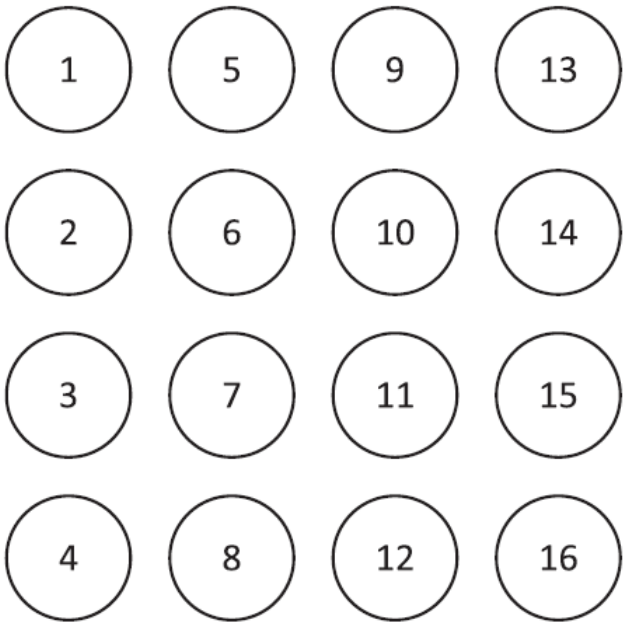

Figure 2. The electrode numbering scheme, as seen when looking at the abdomen of the participant.

A tocodynamometer was also attached to the abdomen during recordings. For pregnancy recordings, the participants were seated in recliner chairs and a support, such as a small pillow, was positioned under the right side of the participants to prevent potential aortocaval compression syndrome. For labor recordings, the participants were lying on their beds in the maternity wards and the researcher did not try to affect their positioning. A photo of the setup during a recording can be seen Figure 3.

Figure 3. Electrode grid diposed on pacient's abdomen.

The measurements of EHG were performed using a sixteen channel multi-purpose physiological signal recorder (Embla A10), most commonly used for investigating sleep disorders. An anti-aliasing filter with a high cut-off frequency of 100 Hz was used but no high pass filter was used. The signal sampling rate was 200 Hz and the signal was digitized to 16 bits. [6].

3. Methods

The signals from the base were analyzed graphically and a series of processing were identified to use the signals in a classification system. After the processing, characteristics of the segmented signals were extracted and used to identify labor.

3.1. Signal Analysis

To obtain knowledge of the behavior of the database signals, graphs of the 16 channels were generated, which can be visualized in the Figure 4. Cada canal foi plotado com um offset, a fim de melhorar a visualização de todos os canais.

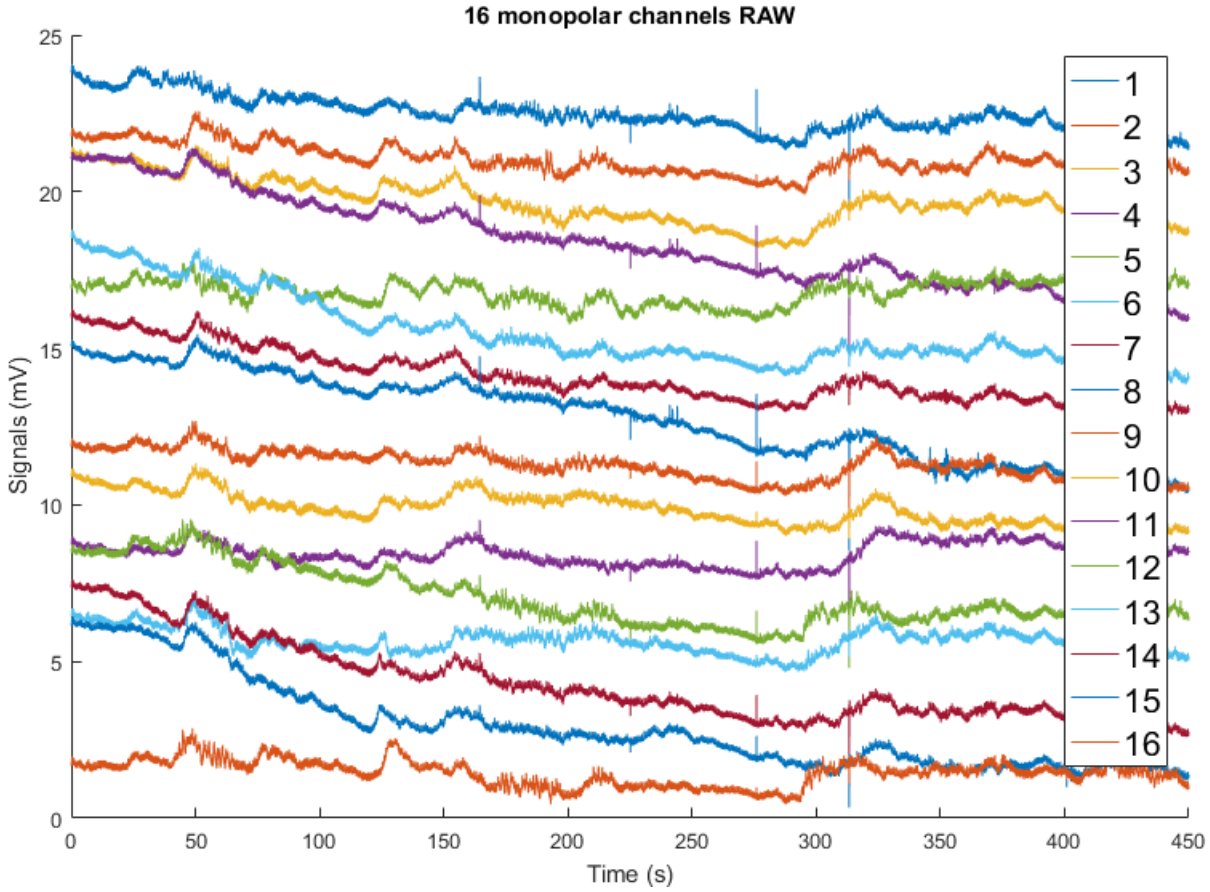

Figure 4. The 16 raw channels.

In the figure 4, a very different behavior is observed in the signals compared to what is typically acquired with electromyography. This behavior occurs because the frequency band of the equipment used is DC up to 100Hz. The DC level of the signal varies without a standard, which can be verified in the decay of the signal baseline. There are also regions in the signs that resemble the waveform of muscle contractions obtained with electromyography. For example, the channel 16, between 50 and 75 seconds, it is possible to check this behavior.

O nível de ruído desses sinais é muito grande, o que é esperado em aquisições realizadas em configuração monopolar. Processamentos e filtragens são necessários para melhorar a qualidade dos sinais.

3.2. Pre-Processing

3.2.1. Filtering

The selection of digital filters to remove noise from signals before the processing may greatly influence the results. A band-pass filter is needed. Uterine EMG signals are filtered in order to exclude most components of motion, respiration and cardiac signals, which yields a narrow 'uterinespecific' band of 0.34–1.00 Hz [11].

3.3. EMG Features

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3.4. Segmentation

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3.5. The Fuzzy Logic

Unlike in the boolean logic, in the fuzzy logic the variables can assume more than 2 values (true and false). That is, it can work in the concept where the truth can range between the completely true to completely false [10]

4. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

4.1. Subsection

4.1.1. Subsubsection

Bulleted lists look like this:

- First bullet
- Second bullet
- Third bullet

Numbered lists can be added as follows:

1. First item
2. Second item
3. Third item

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4.2. Figures, Tables and Schemes

All figures and tables should be cited in the main text as Figure 1, Table 1, etc.

Table 1. This is a table caption. Tables should be placed in the main text near to the first time they are cited.

Title 1	Title 2	Title 3
entry 1	data	data
entry 2	data	data

4.3. Formatting of Mathematical Components

This is an example of an equation:

$$\mathbb{S} \tag{1}$$

Please punctuate equations as regular text. Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

Theorem 1. *Example text of a theorem.*

The text continues here. Proofs must be formatted as follows:

Proof of Theorem 1. Text of the proof. Note that the phrase 'of Theorem 1' is optional if it is clear which theorem is being referred to. □

The text continues here.

5. Discussion

Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

6. Conclusions

This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

Conflicts of Interest: The authors declare no conflict of interest.

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