Prediction of Term and Preterm Conditions from Uterine Surface Electromyography using Time-Frequency Image based Texture Features

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Introduction
Preterm labor is the leading cause of neonatal mortality and long-term morbidity. The World Health Organization estimated that 15 million babies are born preterm every year. The early detection of preterm labor could enable efficient medical intervention to prolong a pregnancy period closer to the predicted delivery term.

Hypothesis
Uterine surface Electromyography (EMG) is a non-invasive technique which records the electrical activity of uterus muscles during contraction. It has high sensitivity in the detection of preterm labor signs. In this work, an attempt has been made to differentiate term (pregnancy duration > 37 weeks) and preterm (pregnancy duration ≤ 37 weeks) conditions using texture representation of the time-frequency (t-f) images obtained from the uterine EMG signals.

Methods
The signals for analysis are obtained from the Term-Preterm ElectroHysteroGram database of PhysioNet. The database comprises of 300 uterine EMG signals, each recorded from 3 channels. The signals are preprocessed using 4-pole digital Butterworth filters with three different cut-off frequencies namely 0.08-4 Hz, 0.03-3 Hz and 0.03-4 Hz. From the preprocessed signals, time-frequency spectrum is computed using Short Time Fourier Transform. Texture features namely Local Binary Pattern (LBP) and its variant, uniform LBP, are extracted from the t-f images. Support Vector machine (SVM) is trained with the extracted features and the performance of the classifier is analyzed.

Results
The representative uterine EMG recordings of term and preterm delivery are shown in Figure 1. The amplitude of the recorded signals are found to be subject dependent and observed to be higher in term condition. Figure 2 shows a representative spectrogram of uterine EMG signals for term and preterm conditions. It is observed that, during term conditions, the texture pattern exhibits more variations compared to preterm conditions. In order to discriminate these texture patterns, the spectrogram of uterine EMG signals is considered as t-f images and features such as LBP and its variant namely, uniform LBP features are extracted. These features are fed to SVM classifier and the corresponding performance metrics is shown in Table 1. It is observed that the Butterworth filter with cut-off frequency 0.3-3 Hz have better performance in all the considered channels. Uniform LBP features extracted from the third channel achieves relatively better discrimination accuracy of 93.33%.

Figure 1

![Figure 1](image-url)
Conclusion
The results show that the time-frequency image based texture features extracted from the uterine EMG signals recorded from the electrodes placed below the navel (channel 3) are able to differentiate term and preterm condition effectively. Since an accurate detection of preterm labor is crucial to increase the chance of survival rate for both mother and the infant, this framework can be used to predict the preterm and term delivery of pregnant women.

Statement of Impact
The existing methods used for the diagnosis of preterm are subjective and inaccurate. Analyzing the changes in uterine EMG signals using the texture features extracted from the time-frequency images helps in an objective and accurate detection of preterm.

Keywords
preterm delivery, uterine electromyography, short time fourier transform, time-frequency image, local binary pattern, Support vector machine