Abstract—Preterm birth is the major complication during pregnancies. The timely prediction of preterm birth can decrease the infant mortality, morbidity as well as the economic costs. This study aimed to predict the premature births using Electrohysterogram (EHG). EHG is a non-invasive diagnostic technique, which measures the electrical activity responsible for the uterine contractions. The abdominal signals were acquired using Ag-AgCl electrodes in a bipolar configuration and the EHG was obtained by bandpass-filtering in the range of .34-1Hz. certain signal features are extracted for classification, linear and binary SVM classifiers are used. The result showed that it is possible to predict the preterm birth with an accuracy of 66.67%, specificity of 83.34% and sensitivity of 50%.

Keywords— EHG, Preterm contractions, Bandpass filtering, Linear classifier, Binary SVM classifier.

I. INTRODUCTION

Preterm delivery (delivery prior to the completion of 37 weeks of gestation) is the major problem towards the modern obstetrics. It increases the infant mortality and morbidity. It is the most prominent contributor of infant deaths. Studies reported that more than thousands of infants die daily due to the preterm complications. To lower the preterm rate patients determined to be at high risk should be monitored. The timely prediction can improve the effectiveness of the required treatment (use of tocolytics). EHG is the mostly used technique to predict and detect premature birth. Electrical activity responsible for the mechanical contractions of uterus muscle recorded externally on pregnant woman is termed uterine ElectroMyoGraphy(EMG) or ElectroHysteroGraphy(EHG) [2] [3] [4].

Efforts have been made to mitigate the effects of preterm births. Predicting or diagnosing preterm labor before it occurs is generating a great interest because of its importance. EHG signal results from the propagation of electrical activity and gives the potential difference between the electrodes.

However, the ultimate aim of the EHG signal studies is to achieve an ambulatory monitoring system for the risky pregnancies able to alert if premature pregnancy threats occurs. In this study we used a three channel EHG signal which is bandpass filtered by using third order Butterworth bandpass filter, which is undergone with the feature extraction and classification process. The selection of an appropriate features and classifiers generally involves a trial and error process. This is practiced with the aim of obtaining better performance.

II. MATERIAL

In this study the EHG records were downloaded from physionet database included in the Term-Preterm EHG Database (TPEHGDB). This records are collected from 1997 to 2005 at the department of obstetrics and gynecology, medical center Ljubljana [1].
Records are collected from general population as well as the patients admitted at the hospital. One record per pregnancy is retained.

The EHG signals are collected from the surface of the abdomen using four AgCl electrodes. The electrodes are placed in two horizontal rows, spaced 7 cm apart shown in fig2 [1] [5]. Each record is a composition of three channel signals.

- Signal 1-E2-E1 (First channel)
- Signal 2-E2-E3 (Second channel)
- Signal 3- E4-E3 (Third channel)

Three channel signals are of 30 minute duration. Prior to sampling the signal are filtered using Butterworth bandpass filter ranging from 0.1 to 5 Hz. The sampling frequency is 20 Hz and the resolution of the scanning system is 16 bits with the amplitude range of ±2.5Mv.

In this study we used the EHG signals which are recorded during or after the 26th weeks of gestation. 119 records from pregnancies whose deliveries were in term and 19 recordings from pregnancies which ended prematurely.

**III. METHOD**

The EHG data processing for the prediction of preterm labor mainly consists of three steps: Preprocessing, Feature extraction and Classification.

**Fig.2.Block diagram for the preterm birth prediction using EHG.**
3.1. Preprocessing.
The EHG signals are contaminated by different noises like respirational, abdominal EMG, and ECG components. To remove the noises the signals must be preprocessed, so the three channel signals are preprocessed by using a third order Butterworth bandpass filter in the range of .34-1Hz.

3.2. Feature Extraction.
The features like Root mean square (RMS), Standard deviation (SD), Mean absolute deviation (MAD), variance, and entropy are calculated from the preprocessed data.

3.2.1. Root Mean Square (RMS).
The RMS value is calculated for every \( j \)th contractions. RMS of a \( j \)th contraction is calculated using the equation,

\[
RMS_j = \frac{\sum_{i=1}^{T_{ij}F_s} X_i^2}{C}
\]

Where,

\[
C = (T_{ij} + T_{Dj})F_s
\]

\( T_{Sj} \) is the time of \( j \)th contraction,\( T_{Dj} \) is the duration and \( F_s \) sampling frequency.

3.2.2. Variance.
Variance is the expectation of the squared deviation of a random variable from its mean. The variance of a random variable \( X \) is the expected value of the squared deviation from the mean of \( X \),

\[
Var(X) = E[(X - \mu)^2]
\]

3.2.2. Standard Deviation (SD).
Standard deviation is a measure used to quantify the amount of variation of a set of data values or square root of its variance.

\[
SD = \frac{\sum_{i=1}^{n} |X_i - Mean(X)|}{n-1}
\]

3.2.3. Mean Absolute Deviation (MAD).
The MAD of a dataset is the average of the absolute deviations from a central point. The MAD of a set \( x_1, x_2, \ldots, x_n \) is,

\[
MAD = \frac{1}{n} \sum_{i=1}^{n} |X_i - Mean(X)|
\]

3.3. Classification.
The goal of objects classification is to use an objects characteristics or features to identify which group is belongs to. A linear classifier making a classification decisions based on the value of a linear combinations of characteristics.

Support Vector Machine (SVM) are supervised learning models that analyze data used for classification. SVM constructs a hyperplane or set of hyperplanes in a high or infinite dimensional space, which can be used for classification.
IV. RESULTS

Three channel EHG signal is preprocessed to remove the noises using a third order Butterworth bandpass filter in the frequency range of 0.34-1 Hz, shown in figure 3.

![Input signal before and after preprocessing.](image1)

In the feature extraction step, RMS, Standard deviation, Variance, MAD are calculated. Evaluated the feature wise performance for linear and binary SVM classifier (Table 1&2). The result shows that Mean absolute deviation (MAD) and variance together give an accuracy greater than the others. Binary SVM classifier gives an accuracy of 66.7% is greater than the accuracy of linear classifier 58.4% shown in fig 4.

![Feature wise performance analysis.](image2)

<table>
<thead>
<tr>
<th>Features</th>
<th>Accuracy</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS</td>
<td>41.67%</td>
<td>33.34%</td>
<td>50%</td>
</tr>
<tr>
<td>SD</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Variance</td>
<td>50%</td>
<td>66.7%</td>
<td>33.34%</td>
</tr>
<tr>
<td>MAD and Variance</td>
<td>58.4%</td>
<td>83.4%</td>
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Table 1. Feature wise performance evaluation using linear classifier.

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Table 2. Feature wise performance evaluation using SVM classifier.
V. CONCLUSION
Preterm birth is a challenging and complex real world problem. The birth of a preterm infant results in significant health consequences. EHG signals can be used to predict preterm birth. Different features are calculated from the EHG signal, among them MAD and variance give a higher accuracy. It shows that accuracy increases when number of feature increases. Linear and SVM classifier accuracy is higher for MAD and variance, 58.34% and 66.67% respectively. From this analysis we can say that binary SVM classifier give better performance with these features.

REFERENCES
5. EHG database has been downloaded from: http://www.physionet.org/cgi-bin/atm/ATM.