Feature Extraction from Uterus Signal and Image for Diagnosing Pregnancy Complications

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Abstract - Preeclampsia is a disorder that arises during pregnancy which results in maternal death during delivery, fetal death in the womb and growth retention in infants based on the degree of severity and duration of onset. The markers for identification are found to be Strength of uterine muscles, Decreased velocity & volume of Uterine Artery, Poor placentation, Deficient in Remodeling of Spiral artery. The proposed work emphasis on extraction of features of EHG signal and Ultrasound Image of normal and suspected preeclampsia patients at second trimester to identify the condition at the earliest. The ability of the Uterine Muscle can be identified by recording of electrical activity of the uterus, by a device called Electrohysterograph that uses surface bipolar electrodes placed at various points in the lower abdominal region of pregnant women that can indicate the possibility of Preterm labor. The anatomy of Uterus, an indicator of weaker cervix and anatomy of kidney can be analyzed by Abdominal Ultrasound Imaging. Based on the combined analysis of images and signal along with the support of biochemical tests it is possible to identify the disease at the start of second trimester.

Keywords – Electrohysterograph, Abdominal Ultrasound Imaging, Second Trimester.

1. Introduction
Preeclampsia is characterized by high blood pressure, seizure, swelling, kidney dysfunction, shortness of breath in pregnant women [1]. The disorder will unfortunately show symptoms only during third trimester but during the course of detection it might have brought significant destruction to foetal growth [2]. Reason for disease is not known yet. This disorder is considered to be more fatal during pregnancy. Prediction is found to be via blood test which doesn’t ensure early prediction in most cases.

Proposed Markers for the prediction
- Strength of uterine muscle.
- Poor Placentation.
- Placental abruption.
- Cervical incompetency.

Strength of uterine muscle
Myometrium of uterus is responsible for inducing uterine contractions [3]. The use of EHG can help in recording uterine electrical activity to analyse the strength of the muscle to carry the foetal for the entire trimester.EHG analysis raw signals from the myometrial muscle using bipolar electrodes placing them in the abdominal surface [4]. The electrodes are placed at 2.5 cm to 7cm apart in horizontal or vertical directions such that it covers the entire abdominal region [5].

Poor Placentation -Placenta Previa
Placenta previa is a condition that arises due to low lying or poor placentation [6]. Women with poor placentation are highly susceptible to preeclampsia and may have premature delivery. They are susceptible to hemorrhage during delivery [7].

Placental Abruption
This is a premature departure of the placenta. Despite being an important obstetrical condition, placental abruption lacks a diagnostic procedure [8]. It can be defined as the complete or partial separation of the normally located placenta from its uterine site before the delivery of the fetus [9]. Abruption of placenta is confirmed after placental delivery by evaluation of the retro placental clots or a depression in the maternal surface of placenta [10]. This condition is clearly linked with preterm labor.

Cervical Incompetency
The cervix, mouth uterus, is closed during pregnancy to hold the baby intact [11]. Cervix should open during the time of delivery only. For women with preeclampsia the cervix begins to dilate well in advance leading to premature growth [12].

Abnormal Uterus Shape
Abnormalities in uterus can be identified as,
- appearance as false uterus
• septum in the uterus
• an irregularly shaped uterus mass or cyst in uterus

2. Block Diagram of proposed system

![Block Diagram of proposed system]

Figure 1 shows the Block Diagram of proposed system.

Data Collection
EHG signals are collected from TPEHG database. The TPEHG records were collected from a general population of pregnant patients at the Department of Obstetrics and Gynecology Medical Centre in Ljumljana. Records saved are less taken at less than 26 weeks [13].

The ultrasound images of cervix, uterus, and placenta which are found to be the effective markers for premature labor. All the collected images are taken at the second trimester stage of pregnant patient.

Pre-processing of EHG signals
Band pass filters with pass band frequencies Fc1 and Fc2 set as 0.34 and 1 respectively.

Pre-processing of Images
The images cannot be used directly for analysis. 1. Input image can have different resolution which leads to the increased complexity in processing 2. Poor resolution of anatomical features in raw image. the first drawback is removed, input images are resized to a resolution of 256*256. The second drawback can be minimized by adopting suitable enhancement technique according to the anatomical features extracted.

Features Extracted in EHG Signal for classification
The features considered are Mean, zero crossing, variance, absolute standard deviation, square integral, peak frequency, log detector, amplitude change, absolute standard deviation value, integrated EH is shown in Figure 2.

Feature Extraction in Images
Textural and anatomical features are considered. The features extracted from the image should provide the characteristics of the input type to the classifier by including the properties description of the image into a feature space of specific dimension (n) [14]. The various features such as average mixel value mean, standard deviation, skewness, kurtosis, energy and entropy based on the first order histogram are computed.

3. FNN for Classification
The number of neurons in the input layer is one for the FNN classifier. The output layer is determined by the number of classes desired., The output is either suspected for preeclampsia or no; the output layer consists of one neuron [15]. Here we have used three hidden layers with 60, 6 and 1 neurons in the respective layers. 110 datasets are used for training and testing process. The tangent sigmoid (transig) function is used as the neural activation function is shown in Figure 3. The proposed network is trained with 60 signal cases and 20 images in each category (uterus, cervix, and placenta). MATLAB software package version 13 is used. Learning rate is set to 0.04, the output of the network is 1 for preterm and 0 for term [16]. The training algorithm used for this network is BPA. The performance goal is met at 700 epochs after a training time of 9 sec.

4. Results of Feature Extraction
This section shows the extracted features of EHG signals and ultrasound images as shown in Tables 1-5 and Figures 4-6.
### Table 1: Observation of Placental images P1 to P8 represents placental image.

| Image Name | ag     | ahg    | egy    | megy   | Etp    | metp   | sd     | msd    | sk     | bag    | diff% | ctr    |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|
| P1         | 93.6238| 2.41E+04| 256    | 256    | 2.66E-04| 0.3806 | 11.458 | 0.0425 | 4.12E+12| 0.074  | 93.5498| 0.9984 |
| P2         | 101.2831| 2.60E+04| 256    | 256    | 0      | 0.5675 | 15.4857| 0.0724 | -Inf   | 0.1337 | 101.1494| 0.9974 |
| P3         | 69.7502| 1.79E+04| 256    | 0      | 0      | 0.1602 | 10.16  | 0.0951 | Inf    | 0.0234 | 69.7267| 0.9993 |
| P4         | 76.4461| 1.96E+04| 256    | 21     | 0      | 0.0025 | 0.3954 | 9.1349 | 0.0836 | 3.76E+09| 0.0781 | 76.368| 0.998 |
| P5         | 40.9706| 1.05E+04| 256    | 1      | 0.6697 | 0.0506 | 9.1543 | 0.0644 | 7.50E+06| 0.0057 | 40.9649| 0.9997 |
| P6         | 38.8908| 1.00E+04| 256    | 19     | 5.02E-04| 0.4173 | 4.5773 | 0.1445 | -      | -      | 38.8065| 0.9957 |
| P7         | 57.5338| 1.48E+04| 256    | 0      | 0      | 0.073  | 12.8932| 0.0772 | Inf    | 0.0088 | 57.525| 0.9997 |
| P8         | 80.1051| 2.06E+04| 256    | 0      | 0.1551 | 0.1587 | 8.4724 | 0.0918 | 4.84E+08| 0.0231 | 80.0819| 0.9994 |

### Table 2: Observation of Cervix images C1 to C8 represents cervix images

| Image Name | Ag     | ahg    | egy    | megy   | Etp    | metp   | sd     | msd    | sk     | bag    | diff% | ctr    |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|
| C1         | 30.6533| 7.88E+03| 256    | 0      | 0.9997 | 0.032  | 21.9818| 0.0487 | -6.55E+06| 0.0033 | 30.6499| 0.9998 |
| C2         | 28.2074| 7.25E+03| 256    | 0      | 0.782  | 0.1531 | 12.0002| 0.1039 | -6.03E+06| 0.0221 | 28.1853| 0.9984 |
| C3         | 31.4839| 8.09E+03| 256    | 0      | 0.992  | 0.052  | 13.5276| 0.0617 | -2.13E+06| 0.0059 | 31.4781| 0.9996 |
| C4         | 63.7501| 1.64E+04| 256    | 0      | 0.0018 | 0.1032 | 11.5953| 0.0716 | -1.08E+10| 0.0135 | 63.7366| 0.9996 |
| C5         | 67.6679| 1.74E+04| 256    | 6      | 0.6968 | 0.2092 | 11.6517| 0.0902 | 3.33E+07 | 0.033 | 67.6349| 0.999 |
| C6         | 48.9542| 1.26E+04| 256    | 0      | 0.0216 | 0.0591 | 13.3153| 0.068  | -1.20E+09| 0.0069 | 48.9473| 0.9997 |
| C7         | 51.3678| 1.32E+04| 256    | 39     | 0.0033 | 0.135  | 13.1336| 0.0648 | 9.61E+10| 0.0189 | 51.349| 0.9993 |
| C8         | 57.3338| 1.4735  | 256    | 0      | 0.966  | 0.2595 | 28.3179| 0.1544 | -4.73E+07| 0.0438 | 57.2899| 0.9985 |

### Table 3: Observation of images U1 to U8 represents the uterus image

### Table 4: Observation of normal pregnancy patients EHG Signals
### Table 5: Observation of suspected pre-eclampsia patients EHG Signals

| Signals | IEHG   | MAE    | SSI   | VO     | WL     | LOG    | RMSE   | VAR   | ASD   | MFL    | AA     | PF     |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|-------|--------|--------|--------|
| 546     | 152128.| 760.644| 1.63E+08 | 802.9051 | 228156 | 511.3318 | 902.9051 | -1.6E+08 | -2.6E-09 | 4.292874 | 1142.357 | 1.161063 |
| 567     | 149483.4 | 747.417 | 1.6E+08 | 894.4717 | 208128.4 | 501.7434 | 894.4717 | -1.6E+08 | -2.7E-09 | 4.281816 | 1046.085 | -1.47189 |
| 586     | 161619.9 | 808.0996 | 1.77E+08 | 840.7023 | 240385 | 594.7281 | 940.7023 | -1.8E+08 | -2.2E-09 | 4.329565 | 1216.245 | 2.651872 |
| 614     | 160777.9 | 803.3896 | 1.64E+08 | 804.2184 | 216378 | 623.0601 | 904.2184 | -1.6E+08 | -2.7E-09 | 4.28425 | 1088.299 | -2.50334 |
| 617     | 164798 | 823.9901 | 1.89E+08 | 71.5568 | 244456.1 | 577.9021 | 971.5568 | -1.9E+08 | -2.1E-09 | 4.339434 | 1229.274 | 2.57069 |
| 641     | 175379.4 | 876.8968 | 2.06E+08 | 701.825 | 254508.7 | 649.7222 | 1013.825 | -2.1E+08 | -1.9E-09 | 4.363504 | 1286.006 | 0.501251 |
| 745     | 176572.5 | 882.8626 | 2.24E+08 | 1059.024 | 275217.1 | 626.0801 | 1059.024 | -1.6E+08 | 1.6E-09 | 4.393842 | 1378.702 | 1.570796 |
| 797     | 171788.6 | 858.9428 | 2.07E+08 | 517.855 | 275675.4 | 614.6613 | 1017.855 | -1.5E+08 | 1.7E-09 | 4.381676 | 1387.048 | 1.570796 |
| 877     | 145280.3 | 726.4014 | 1.52E+08 | 871.8792 | 216972.9 | 511.1103 | 871.8792 | -1.5E+08 | -2.6E-09 | 4.289826 | 1091.291 | 1.685525 |
| 914     | 205354.6 | 1026.773 | 2.72E+08 | 766.474 | 302368.4 | 764.0376 | 1166.474 | -2.7E+08 | -1.4E-09 | 4.427981 | 1521.053 | 2.509373 |
| 939     | 161747.9 | 808.7395 | 1.87E+08 | 976.65 | 235789.8 | 573.0436 | 966.5 | -1.9E+08 | -2.1E-09 | 4.340618 | 1193.48 | 1.733747 |
| 1007    | 163841.9 | 819.2093 | 1.83E+08 | 756.8761 | 237210 | 603.4726 | 956.8761 | -1.8E+08 | -2.2E-09 | 4.332046 | 1196.167 | 1.945705 |
5. Conclusion
From the analysis of the ultrasound images feature values Mean Energy and Average pixel value tend to become deviate for suspected preeclampsia patients. Other features in the image are not showing considerable deviations. EHG feature difference between suspected and normal preeclampsia patients show considerable change in variance of EHG signal. There are only few parameters that shows difference between preeclampsia and normal patients hence it is necessary to validate increased number of features in combination with blood test to confirm the result.

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