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Efficient Fetal Health Prediction using Machine Learning

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Abstract: *The growth of technology in our day-to-day enterprise with advanced machines are outstanding through machinelearning involving both machine learning and deep learning all over the world. Fetal monitoring during pregnancy time is the most important to save the life of the mother as well as the child. In this project, we presenta ML technique that is used to measure the fetal heart rate during the time of pregnancy. The major component used for this detection is Fetal Digital stethoscope sensor which is to be placed on the abdomen of the pregnant and the signals are processed by the micro-controller used and the accurate fetal heart rate. This system is very flexible and low cost helps the patient to monitor the fetal heart rate in home. We will use ML method for our project. In this paper Fetal health is predicted by algorithms namely Decision Tree (DT) as existing and Recurrent NeuralNetwork (RNN) as proposed and compared in terms of accuracy. From our work we can prove that our proposedRNN works better than other existing DT algorithm.*

Keywords: DT: Decision Tree, RNN: Recurrent Neural Network

I. INTRODUCTION

Fetal echocardiography was introduced to assess fetal cardiac function only 15 years ago (the first study was performed in 2004). It has evolved from the description of cardiac anatomical abnormalities toward quantitative assessment of cardiac dimensions, shape, and function and has been demonstrated to be useful in the diagnosis and monitoring of fetuses with a compromised cardiovascular system related to several fetal conditions, such as intrauterine growth restriction (IUGR), twin-to-twin transfusion syndrome, and congenital heart disease. Moreover, some cardiac parameters have already shown to be helpful in predicting prenatal problems and long- term cardiovascular outcomes.

Different ultrasound (US) approaches are currently used to evaluate fetal cardiac function, including conventional2-D imaging, M-mode, blood-pool and tissue Doppler imaging, 2-D speckle tracking, and 4-D spatiotemporal imaging correlation. For any evaluation, an optimal image of the fetal heart is crucial to adequately assess cardiacstructure and function. However, assessing fetal cardiac function is still challenging due to involuntary movements of the fetus, the small size of the heart, the high heart rate, the limited access to the fetus, and the lack of expertise in fetal echocardiography of some sonographers.

After having obtained an optimal image, measurements have to be performed in order to extract relevant cardiac features that relate to remodeling and functional status. Currently, these are mainly carried out manually by the sonographer, either during the investigation or offline using a dedicated workstation. Therefore, the use of new technologies to improve the primary acquired images or help extract and standardize measurements is of great importance for optimal assessment of the fetal heart.

Machine learning (ML) is a computer science discipline focused on teaching a computer to perform tasks, with a specific goal in mind, without explicitly programming the rules on how to perform this task. Mathematically speaking, learning occurs when a computer iteratively improves its performance on the given task (e.g.,classification of a disease or estimation of clinical measurements) with experience or, in other words, when it is exposed to data.

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Usually, ML algorithms are classified into 2 approaches: supervised and unsupervised learning algorithms. Deep learning (DL), a popular algorithm (and often thought of when the term machine learning is used) is just a subset of ML that uses a layered structure of calculations known as artificial neural networks (ANN) on unstructured data. Supervised learning requires explicit ground truth goals (diagnostic labels, outcomes, reference image measurements, etc.) from which the algorithm can optimize its performance during training. Supervised learning algorithms can be further classified into classification and regression. Classification techniques evaluate the given input and come up with a category such as "red" or "blue" or "disease" or "nondisease," while regression techniques result in a continuous output: the value of the predicted quantity (suchas the probability of a diagnosis). Besides DL, the most common classification algorithms include decision trees, support vector machines (SVM), etc., while linear and logistic regressions are typical regression algorithms. On the other hand, unsupervised learning algorithms receive unlabeled examples and aim at discovering main patterns or similarities in the data, which would correspond to different disease manifestations or different phenotypes within a given disease, or different temporal evolution. Consequently, supervised learning is commonly used when the final goal is well known at the time of learning and unsupervised learning is used as an exploratory tool and usually the final goal follows from the analysis of the obtained results. Unsupervised learning algorithms can be further classified into clustering and dimensionality reduction. Typical clustering algorithms include K-means or Gaussian mixture models, while principal component analysis and linear discriminant analysis are classical dimensionality reduction techniques

II. LITERATURE REVIEW

A Simple Algorithm for Fetal Heartrate Estimation Kazuki Tsuji ; Yukihiro Kamiya IEEE 2023.
This paper proposes a simple parameter estimation method applicable to the fetal heartrate estimation. The estimation of the fetal heartrate is not easy since we can observe a composite of the fetal ECG waveform and a maternal ECG waveform. Since these two ECG waveforms overlap on the frequency axis, it is not possible to separate them for the heartrate estimation. The proposed method achieves very high resolution in the separation of multiple highly-correlated signals of which their periods are different. The behavior of the proposed method is investigated through some numerical results.

Fetal heart rate monitoring system with mobile internet Wendi Yang ; Kai Yang ; Hanjun Jiang ; Zhihua Wang ; Qingliang Lin ; Wen Jia IEEE 2023.
The fetal heart rate is vital for monitoring fetal well-being. Fetal heart rate monitoring based on acoustic techniques is passive and noninvasive. In this work, a fetal heart rate monitoring system based on phonocardiographic method is proposed. A portable low-power stethoscope is customized which meets the need for sensitivity in the monitoring. A noise cancellation method and adaptive matching method are applied to extract the fetal heart rate effectively. Clinical trials are carried out on pregnant women, and the comparison of fetal heart rates given by the proposed system with those given by the Doppler monitor is given to show the accuracy.

Heart Rate Detection in Low Amplitude Non-Invasive Fetal ECG Recordings Chris Peters ; Rik Vullings ; Jan Bergmans ; Guid Oei ; Pieter Wijn IEEE 2023.
Multi-electrode electrical measurements on the maternal abdomen may provide a valuable alternative to standardfetal monitoring. Removal of the maternal ECG from these recordings by means of subtracting a weighted linear combination of segments from preceding maternal ECG complexes, results in fetal ECG traces from which the fetal heart rate can be determined. Unfortunately, these traces often contain too much noise to determine the heartrate by R-peak detection. To overcome this limitation, an algorithm has been developed that calculates the heart
rate based on cross-correlation. To validate the algorithm, noise was added to a fetal scalp ECG recording to simulate low amplitude abdominal recordings. Heart rates calculated by the algorithm were compared to the heartrates from the original scalp ECG. For simulated signals with a signal to noise ratio of 2, the coefficient of correlation was 0.99 ($p<0.001$). By using the developed algorithm for calculating the fetal heart rate, multi- electrode electrical

measurements on the maternal abdomen now can be used for fetal monitoring in relatively early stages of pregnancy or other situations where ECG amplitudes are low or noise levels are high

Examination and Optimization of the Fetal Heart Rate Monitor : Evaluation of the effect influencing the measuring system of the Fetal Heart Rate Monitor Jakub Kolarik ; Lukas Soustek ; Radek Martinek IEEE 2023.
Long-term monitoring of the fetal heart rate (fHR) is important to control the fetal well-being. One of the promising methods for fetal monitoring is fetal phonocardiography which is based on recording fetal heart sounds. This paper presents a compact low-cost device for multi lead fHR measurement. The device introduced allows monitoring of fHR non-invasively and with no side effects for the mother or the foetus. In this case, the device presented is used to measure HR of the adult to compare the performance of various stethoscope heads. In addition to this measurement, the LabVIEW application for signal processing and analysis was improved.

Comparison of Doppler ultrasound and direct electrocardiography acquisition techniques for quantification of fetal heart rate variability J. Jezewski ; J. Wrobel ; K. Horoba IEEE 2023.
A method for comparison of two acquisition techniques that are applied in clinical practice to provide information on fetal condition is presented. The aim of this work was to evaluate the commonly used Doppler ultrasound technique for monitoring of mechanical activity of fetal heart. Accuracy of beat-to-beat interval determination together with its influence on indices describing the fetal heart rate (FHR) variability calculated automatically using computer-aided fetal monitoring system were examined. We considered the direct fetal electrocardiography as a reference technique because it ensures the highest possible accuracy of heart interval measurement, and additionally all the definitions of popular time domain parameters quantifying FHR variability formerly have been created using the fetal electrocardiogram. We evaluated the reliability of various so called short-term and long-term variability indices, when they are calculated automatically using the signal obtained via the Doppler US from a fetal monitor. The results proved that evaluation of the acquisition technique influence on fetal well-being assessment cannot be accomplished basing on direct measurements of heartbeats only. The more relevant is the estimation of accuracy of the variability indices, since analysis of their changes can significantly increase predictability of fetal distress

A rule-based phonocardiographic method for long-term fetal heart rate monitoring F. Kovacs ; M. Torok; I. Habermajer IEEE 2023.
A real-time method for fetal heart rate (FHR) monitoring based on signal processing of the fetal heart sounds is presented. The acoustic method, which utilizes an adaptive time pattern analysis to select and analyze those heartbeats that can be recorded without artefact, is guided by a number of rules involving an introduced confidence factor on the timing prediction. The algorithm was implemented in a low-power portable electronic instrument to enable long-term fetal surveillance. A large number of clinical tests have shown the very good performance of the phonocardiographic method in comparison with FHR curves simultaneously recorded with ultrasound cardiotocography. Indeed, approximately 90% of the time, the acoustic FHR curve remained inside a /spl plusmn/3 beats/min tolerance limit of the reference ultrasound method. The confidence was typically CF>0.85. The acoustic method exceeded a /spl plusmn/5 beats/min limit relative to the ultrasound method approximately 5% of the time. Finally, no relevant FHR data was measured approximately 5% of the time..
A tree-search method for single-channel fetal QRS complexes detection in fetal heart rate Wei Zhong ; Zhongping Cao ; Wen Ding ; Xuemei Guo ; Guoli Wang IEEE 2023.
Objective: Fetal heart rate (FHR) measurement is essential in monitoring the fetal well-being. This paper introduces a tree-search method for FHR measurement from single-channel abdominal ECG (AECG) recording
Approach: The proposed method is composed of three main stages: a preprocessing stage for signal denoising, a new tree-search methodology for detecting fetal QRS complexes, and a final stage for false positive and false negative correction. Main results: Two databases are used to illustrate the efficiency of the proposed method. The results show that the proposed technique exhibits a satisfactory performance when compared to seven other works. And a higher

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robustness is showed in the proposed method. Significance: The proposed method is capable of extracting the FHR from single-channel AECG recording. This work contributes to facilitating the long-term monitoring for healthcare at home.

An adaptive real-time method for fetal heart rate extraction based on phonocardiography Kai Yang ; HanjunJiang ; Jingjing Dong ; Chun Zhang ; Zhihua Wang IEEE 2023.

The fetal heart rate is a key element to monitor a fetus's health status. Fetal heart monitoring using phonocardiography has been proposed because the commonly used Doppler ultrasonic monitoring has some drawbacks. To extract the fetal heart rate from the feeble phonocardiographic signal mixed with noise and interference, an adaptive real-time method is proposed in this paper. Adaptive heartbeat patterns are used in the method to match the recorded heart sound signal and extract the fetal heart rate effectively. The method has been realized on a low-power DSP in real time and its reliability has been verified preliminarily.

Analysis of the Fetal Heart Rate Variability by Means of the Abdominal Electrocardiogram Monitoring SystemYuliya A. Zhivolupova IEEE 2023.

The question of the vital indicators continuous monitoring cannot be solved separately from the question of creating a system suitable for use in everyday life, without significant discomfort for the patient. Miniaturization, advanced electrode materials and transition to the wireless technology may help to solve several problems related to user convenience but will cause a whole range of new technical and methodological issues. Main approaches to the solution of the fetal electrocardiogram recording problems are discussed in the article. Solution that can beapplied in the system of long-term monitoring in conditions of life activities is proposed

III. METHODOLOGY SECTION

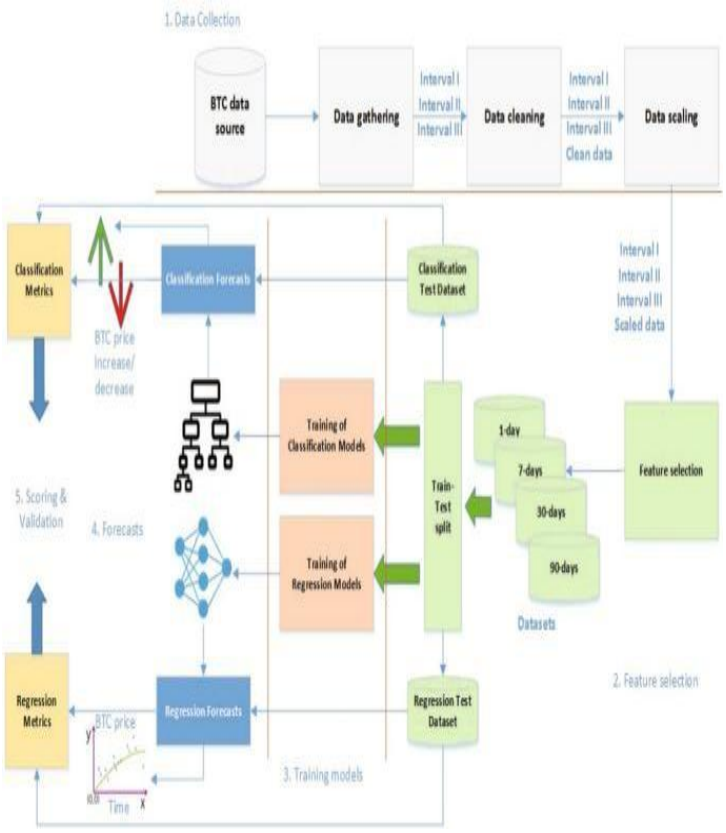

Fig 1 : System Architecture

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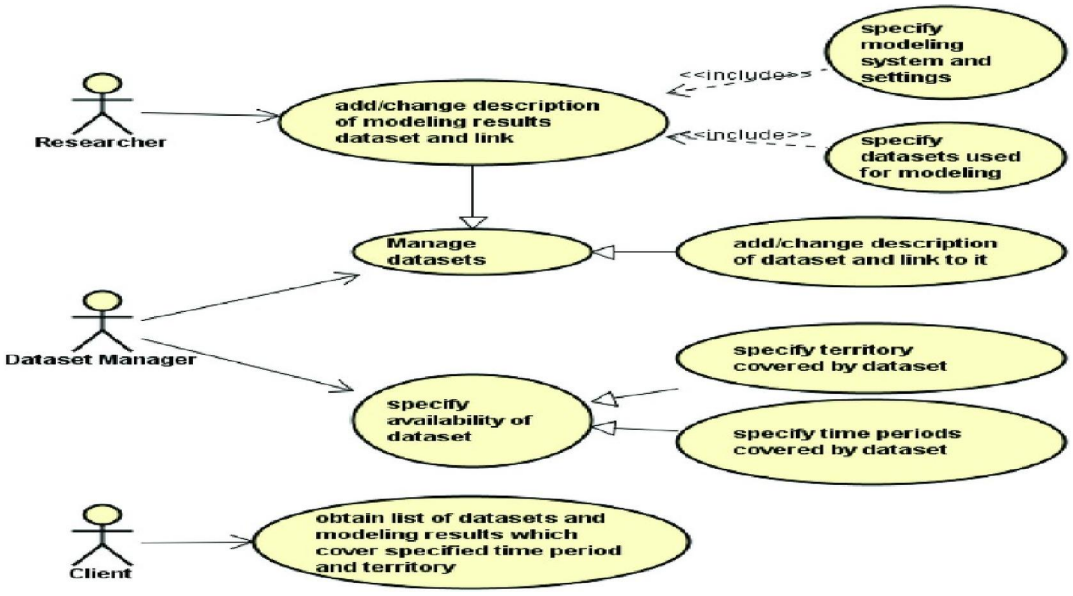

Fig 2 : UML Diagram

IV. CONCLUSION

In this research, we have used machine learning algorithms to predict the fetal health. We have mentioned the stepby step procedure to analyze the dataset and finding the correlation between the parameters. Thus we can select the parameters which are not correlated to each other and are independent in nature. These feature set were then given as an input to two algorithms and a csv file was generated consisting of predicted fetal health. Hence we calculated the performance of each model using different performance metrics and compared them based on thesemetrics. We found that ML accuracy level is good than existing classifiers.

Future Enhancement

For future work, we recommend that working on large dataset would yield a better and real picture about the model. We have undertaken only few Machine Learning algorithms that are actually classifiers but we need to train many other classifiers and understand their predicting behavior for continuous values too. By improving theerror values this research work can be useful for development of applications for various respective hospitals.

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