Deep learning model may predict preterm births as early as 31 weeks

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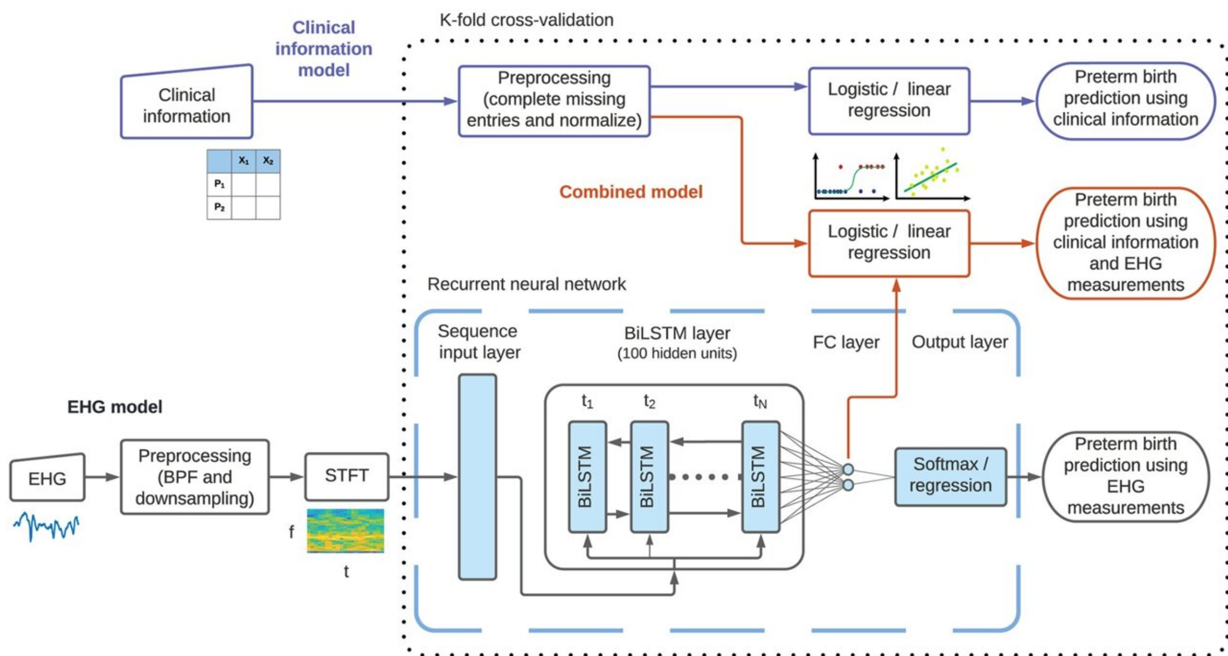

Block diagram of the three classification and regression models developed in this work. The details of these models are provided in Methods. The clinical information model is illustrated in the upper part of the diagram, using shapes with blue outlines. This model uses clinical information, in tabular format, to predict preterm births by using logistic or linear regression, represented as a block with a blue outline and schematic illustrations below it. Preprocessing the clinical information consists of completing missing entries and normalizing the predictors, as described in Methods. The EHG model is illustrated in the lower part of the diagram, using shapes with black outlines. This model uses EHG measurements, represented by an input block with a schematic illustration below it, that are first preprocessed. This preprocessing step includes bandpass filtering (BPF) and downsampling. The preprocessed measurements are used to compute

STFTs, illustrated by a block and a schematic representation, that are used as input to the RNN. This network is composed of an input layer, a BiLSTM layer, a fully connected (FC) layer, and an output layer, which are illustrated using light blue shapes with black outlines and enclosed within a dashed light blue outline. The combined model uses clinical information and EHG measurements to predict preterm births and is illustrated in the middle part of the diagram using shapes with red outlines. The dotted black outline represents the cross-validation technique employed, indicating that the operations within are applied separately for each data partition, whereas the operations outside are applied to all the data, independent of the data partition. Credit: *PLOS ONE* (2023). DOI: 10.1371/journal.pone.0285219

Preterm birth, which occurs when a baby is born before 37 weeks of gestation, affects nearly 10% of pregnancies worldwide, and rates are on the rise. Researchers in the McKelvey School of Engineering at Washington University in St. Louis are developing better ways to predict preterm birth by analyzing electrical activity during pregnancy.

Arye Nehorai, the Eugene & Martha Lohman Professor of Electrical Engineering in the Preston M. Green Department of Electrical & Systems Engineering, and Uri Goldsztejn, who earned a master's and a doctorate in biomedical engineering from Washington University in 2020 and 2022, respectively, developed a model using deep learning to predict preterm births as early as 31 weeks of pregnancy. Results of the research were published May 11 in *PLoS One*.

"Our method predicts preterm births using electrohysterogram measurements and clinical information acquired around the 31st week of gestation with a performance comparable to the clinical standards used to detect imminent labor in women with symptoms of preterm labor," Nehorai said.

To design their method, Nehorai and Goldsztejn used measurements from electrohysterograms (EHG), a noninvasive technique that detects uterine electrical activity through electrodes placed on the abdomen, as well as clinical information from two public databases, such as age, gestational age, weight, and bleeding in the first or second trimester.

They trained a deep learning model on data from 30-minute EHGs performed on a total of 159 pregnant women who were at least 26 weeks' gestation. Some recordings were obtained during regular check-ups while others were recorded from mothers who were hospitalized with symptoms of preterm labor. Of all the women, nearly 19% delivered preterm.

"We predicted the pregnancies' outcomes from EHG recordings using a deep neural network, because neural networks automatically learn the most informative features from the data," Goldsztejn said. "The deep learning algorithm achieved a better performance than other methods and provided a good way to combine EHG data with clinical information."

The team trained its deep recurrent neural network with data samples that indicated their respective pregnancy outcome to learn features from the data that predicted those outcomes.

The work—the first method to predict preterm births as early as 31 weeks using the EHG measurements that achieves a clinically useful accuracy—builds on previous work from Nehorai's lab and published in *PLoS One*. In the earlier study, Nehorai and his collaborators developed a method to estimate electrical current in the uterus during contractions using magnetomyography, a noninvasive technique that maps muscle activity by recording the abdominal magnetic fields that electrical currents in muscles produce.

It also builds on new research by Nehorai and Goldsztejn recently published in Biomedical Signal Processing and Control that details a statistical signal processing method to separate uterine electrical activity from baseline electrical activity, such as from the woman's heart, in multidimensional EHG measurements to identify uterine contractions more precisely

In their research, Nehorai and Goldsztejn found that various components of the EHG measurements contributed to their model's predictions. Higher frequency components of the EHG measurements were more predictive of preterm births. They also found that their model was effective in prediction with shorter EHG recordings, which could make the model easier to use, more cost-effective in a clinical setting and possibly usable in a home setting.

"Preterm birth is an abnormal physiological condition, not just a pregnancy that happened to end early," Nehorai said. "Therefore, we can expect that physiological measurements, such as EHG recordings, may show a stronger dichotomy between pregnancies that end with either preterm or term deliveries than is shown in continuous characteristics correlated with gestational age at delivery."

Going forward, Nehorai and Goldsztejn plan to develop a device to record EHG measurements and to collect data from a larger cohort of pregnant women to improve their method and validate results.

More information: Uri Goldsztejn et al, Predicting preterm births from electrohysterogram recordings via deep learning, *PLOS ONE* (2023). DOI: 10.1371/journal.pone.0285219

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