Scattering Transform Parameter Selection for Fetal Heart Rate Classification

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Background: Clinical detection of intrapartum hypoxic-ischemic encephalopathy (HIE) from electronic fetal monitoring signals is limited by subjective interpretations with low specificity. Automated classification techniques seek to address this. This study focuses on a fetal heart rate (FHR) signal representation for classification using the scattering transform (ST). This nonlinear time-scale filtering using wavelets has attractive stability, time-invariance, and discriminative properties. The hyperparameter *T, which* controls the ST lowpass-filter width before downsampling, determines the degree of time invariance of the ST coefficients.

Aim: This study investigates the sensitivity of the ST *T* value in a neural-network classifier for the early detection of fetuses at risk of HIE during labour.

Method: Our data consisted of up to 12 hours of FHR signals from 418 healthy and 417 HIE neonates from Kaiser Permanente Northern California hospitals. We applied ST with maximum wavelet scale J=11 to 20-min epochs of FHR before passing them to a 3-layer bidirectional long short-term memory and a dense layer. The coefficients were used to train a model to classify fetuses as either HIE or healthy. Using 10-fold cross validation with 10 repetitions, the model with an average specificity of 0.7 and the highest average sensitivity for each fold was selected. We chose $T = 2^{J-\delta_J}$ varying δ_J from 1 (the usual ST default) to J. At each labour epoch, we used the Kruskal–Wallis' test to determine whether the performance differences for *T* value pairs were significant.

Results: Figure 1 shows the test data AUROC median and the 10th and 90th percentiles over time for *T*=64 and *T*=1024. The black asterisks indicate significant differences between distributions. AUROCs for T=16, 32 and 64 were not distinguishable, but higher *T* generates fewer ST coefficients, so is preferable. For *T*=64 and T=1024 there were significant differences as early as 10 hours before delivery.

Conclusion: This study demonstrates that adjusting the ST *T* values to achieve higher time resolution produced better prediction. In future, we will conduct more hyper-parameter tuning experiments and extend the current analysis to a larger imbalanced dataset.

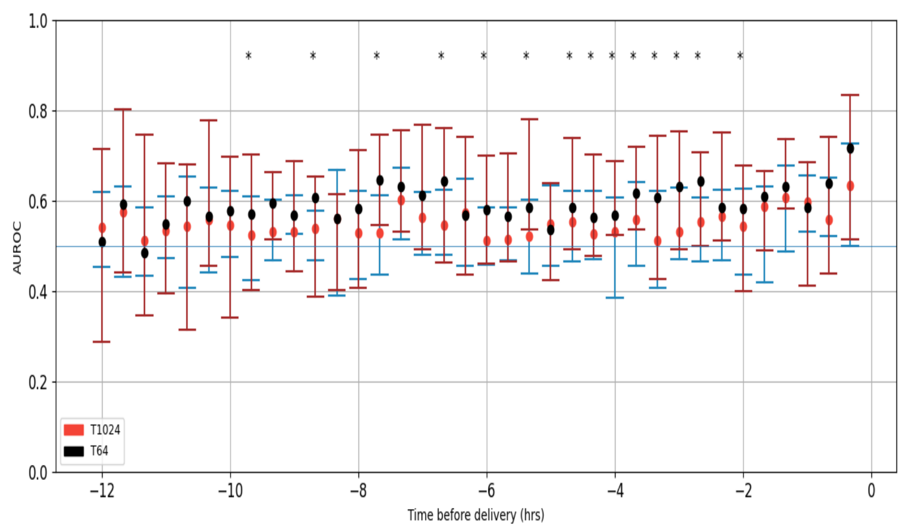

Figure 1: Test median and its corresponding 10th and 90th percentile of the area under the receiver operating characteristic (AUROC) of experiments with the scattering transform coefficient for *T*=64 and *T*=1024 as a function of time before birth. The black asterisk indicates significant differences between the *T*=64 and *T*=1024 distributions according to the Kruskal-Wallis' test while the legend reports the corresponding *T* value.