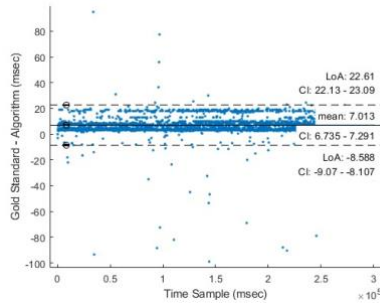


Spectral-Statistical Analysis for Fetal R-Peak and Heart Rate Variability Calculation from Abdominal ECG

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Introduction: Intrauterine fetal death is a leading cause of fetal death globally. Fetal heart rate variability (FHRV) can readily indicate causes of compromise. Recently ECG has emerged as an accurate means of measuring FHRV. Thus, we propose a computationally low-cost algorithm capable of locating R-peaks, and subsequently calculating FHRV developed based on online open-source dataset.



Bland Altman plot comparing gold standard and algorithm calculated FHRV

Methods: An opensource abdominally recorded ECG dataset from physionet.org was acquired with 5-minute recordings from 5 patients. Fetal scalp electrocardiography acted as the gold standard. Spectral analysis of the recorded signal is performed, and a final 15 Hz – 45 Hz IIR bandpass filter is applied, emphasizing fetal ECG while attenuating maternal ECG. We then developed the following 5 step R-Peak detection algorithm below:

Step 1: Averaging of 4 ECG electrodes into a single array of data.

Step 2: Squaring of data to emphasis peaks associated fetal QRS.

Step 3: Reducing dataset to samples greater than the upper tail of the mean plus three times the standard deviation.

Step 4: Threshold for R-peak is mean minus standard deviation of the reduced dataset. If the standard deviation is greater than half the mean, then half the mean is used as the threshold.

Step 5: Final R-peak detection performed based on steps 1-4.

Results: All subjects enrolled for recording demonstrated legitimate performance, with precision, recall, and F_1 scores ranging from 97%–100% in subjects 1–4, with 5 still performing modestly well. For FHRV, subjects 1-4 yielded MAPEs < 3%. Bland Altman plot of FHRV performance is provided above. Subject 5s data demonstrating significant fluctuations in voltages, potentially due to maternal body habitus, or high variations in FHRV itself.