A Comprehensive Guide to Signal Quality Assessment Across Diverse Abnormal Types in Heart Sounds

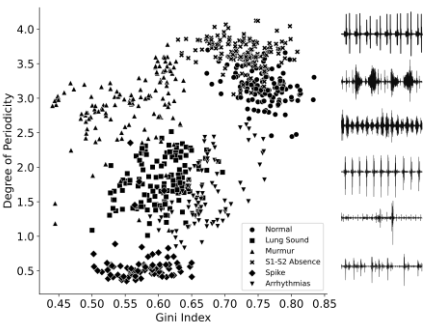
Jae-Man Shin*, Woo-Young Seo, Woo-Jin Kim, Hyun-Seok Kim, Sung-Hoon Kim

Department of Anesthesiology and Pain Medicine, Asan Medical Center, Brain Korea 21 Project, University of Ulsan College of Medicine, Seoul, Republic of Korea

Aims: Abnormal heart sounds comprise both physiological variations and non-physiological artifacts. This study proposes signal quality indicators (SQIs) to classify these abnormal sounds and assesses their performances.

Methods: The heart sound dataset was collected using an esophageal stethoscope during surgery under general anesthesia at Asan Medical Center. By investigating established SQIs, we performed outlier analysis to categorize abnormal heart sounds. Subsequently, abnormal heart sounds were categorized into five types: lung sound interference, heart murmur, absence of S1 or S2, arrhythmias, and spikes. Annotations were performed manually by two engineers and one clinician. Lastly, we conducted inter-group statistical analysis using Tukey's honestly significant difference test was performed, and the discriminative performance of the SQIs was evaluated through re-labeling analysis.

Results: A total of 718 recordings, each 20 seconds in duration, were obtained from 126 subjects. The Gini index and degree of periodicity emerged as the primary indicators for signal quality assessment. Specifically, the Gini index exhibited statistical significance ($P<0.001$) among four groups (normal, lung sound interference, heart murmur, S1-S2 absence). In contrast, the degree of periodicity exhibited statistical significance ($P<0.001$) among four groups (normal, lung sound interference, spike, and arrhythmias). The discriminative performance reached macro precision, recall, and F1-score of 0.86, 0.80, and 0.79, respectively.



Clustered abnormal signals and their corresponding waveform examples

Conclusion: In this study, we identified key SQIs that can effectively distinguish among five distinct types of abnormal heart sounds in a multi-class setting. Our findings offer comprehensive guidance for establishing signal quality assessment frameworks in heart sound monitoring.