Rapid Cardiac Screening Using Deep Learning: A Novel Interpretable AI Model for Cardiovascular Health Assessment

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Heart disease is the #1 global killer. Left ventricular ejection fraction (EF) analysis via echocardiography is crucial for heart failure detection. However, traditional EF calculation is a time-consuming manual process with up to a 30% error rate. In the existing literature, AI models for echocardiogram analysis use end-to-end black box architectures that are difficult to interpret. I developed a novel interpretable algorithm based on cardiac sonographers' workflow to automatically analyze echocardiogram videos and calculate EF for rapid cardiac screening. Using transfer learning, five PyTorch deep learning models were trained, validated, and tested using 10,030 echocardiogram videos with ~~1 million image frames in the EchoNet Dynamic Dataset. I further improved the algorithm by addressing the class imbalance and tuning hyperparameters. The error rate for my best model is ~~8%, comparable to the state-of-the-art models, and significantly outperforms manual analysis by an expert cardiac sonographer (13.9%) and qualitative analysis by physicians (~30%). Model outputs can differentiate heart failure from normal cardiac function with explainable step-by-step diagrams. The optimized MobileNet was further deployed onto a mobile app, Raspberry Pi, laptop, and AWS, allowing physicians to upload echocardiogram videos and obtain EF results within seconds. In collaboration with a handheld ultrasound company, my model has been deployed for clinical testing. Automated echocardiogram analysis can dramatically speed up image analysis, reduce the burden on cardiologists, and democratize cardiac care by enabling non-experts to quickly and accurately assess cardiac functions at the point of care, in rural areas, or in developing countries, where cardiology expertise is limited.

Awards Won:

Second Award of $2,000

Shanghai Association for the Advancement of Science for Youths: Science Seed Award

Association for Computing Machinery: Third Award of $1,500

International Council on Systems Engineering - INCOSE: Certificate of Honorable Mention, a 1-year free student membership to the INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE