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sCL-ST: Supervised Contrastive Learning With Semantic Transformations for Multiple Lead ECG Arrhythmia Classification

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Abstract

The automatic classification of electrocardiogram (ECG) signals has played an important role in cardiovascular diseases diagnosis and prediction. With recent advancements in deep neural networks (DNNs), particularly Convolutional Neural Networks (CNNs), learning deep features automatically from the original data is becoming an effective and widespread approach in a variety of intelligent tasks including biomedical and health informatics. However, most of the existing approaches are trained on either 1D CNNs or 2D CNNs, and they suffer from the limitations of random phenomena (i.e. random initial weights). Furthermore, the ability to train such DNNs in a supervised manner in healthcare is often limited due to the scarcity of labeled training data. To address the problems of weight initialization and limited annotated data, in this work, we leverage recent self-supervised learning technique, namely, contrastive learning, and present supervised contrastive learning (sCL). Different from existing self-supervised contrastive learning approaches, which often generate false negatives because of random selection of negative anchors, our contrastive learning makes use of labeled data to pull the same class closer together and push different classes far apart to avoid potential false negatives. Furthermore, unlike other kinds of signals (e.g. speech, image, video), ECG signal is sensitive to changes, and inappropriate transformation could directly affect diagnosis results. To deal with this issue, we present two semantic transformations, i.e. semantic split-join and semantic weighted peaks noise smoothing. The proposed deep neural network sCL-ST with supervised contrastive learning and semantic transformations is trained as an end-to-end framework for the multi-label classification of 12-lead ECGs. Our sCL-ST network contains two sub-networks i.e. pre-text task and down-stream task. Our experimental results have been evaluated on 12-lead PhysioNet 2020 dataset and shown that our proposed network outperforms the state-of-the-art existing approaches.

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