National Institute of Technology Rourkela

Registration Seminar

Seminar Title	: Explainable Multi-Modal Advanced Deep Learning Frameworks for Analyzing Sleep Apnea using Single-lead Electrocardiogram Signals with Limited Annotations
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Abstract	: Sleep Apnea (SA) is a widespread and significant breathing disorder that impacts individuals globally, regardless of age. Recent progress in deep learning offers a promising path toward automated analysis, potentially helping medical professionals identify sleep apnea more quickly. However, deep learning (DL) is changing the game by automatically learning features directly from raw data. In recent years, researchers have introduced numerous DL-based architectures. While these DL-based methods have offered promise, they rely heavily on large amounts of labeled data, which is a major hurdle in the medical field. To address this challenge, we introduce SmartMatch and SPHE-Match. The proposed SmartMatch is inspired by hierarchical structures observed in real-world scenarios, where leader-follower dynamics play a crucial role in decision-making. This approach integrates deep metric learning, employing Adaptive batch hard mining to enhance feature representation, alongside an Adaptive pseudo-labeling strategy to refine label quality, and an Adaptive temporal ensembling to stabilize learning while preserving consistency loss constraints. On the other hand, the proposed SPHE-Match is a prototype-aware hierarchical feature embedding matching approach to correctly classify SA events using a single-lead Electrocardiogram (ECG) signal. Both methods effectively leverage limited annotated datasets without compromising performance, thereby lessening the reliance on extensive manual data labeling.Evaluations on the PhysioNet Apnea-ECG dataset (PA-ECG) demonstrated the strength of the Smart-Match approach, yielding consistent per-segment results:91.99% (±0.08), 91.98% (±0.10), 91.99% (±0.11), and 91.97% (±0.10). Its performance on the MIT-BIH Polysomnographic Database (MIT-BIH PSG) was also robust, with an accuracy of 82.28 (±0.06), precision of 88.07 (±0.07), recall of 82.60 (±0.08), and F1-score of 82.43 (±0.07). Similarly, the SPHE-Match method delivered compelling outcomes. On its primary dataset, it achieved an accuracy of 93.24% (±0.08), specificity of 93.21% (±0.10), recall of 93.21% (±0.10), and an F1-score of 93.18% (±0.09). When applied to the MIT-BIH PSG, it maintained high performance with an accuracy of 84.88% (±0.08), specificity of 90.30% (±0.07), recall of 84.78% (±0.10), and F1-score of 84.73% (±0.08). These findings show how semi-supervised learning can improve SA classification, especially in resource-constrained environments.
Keywords: Collaborative knowledge distillation, Deep Learning, Pseudo Labeling, Semi Supervised Learning, Single-lead Electrocardiogram Signal, Sleep Apnea