Abstract

In order to prevent complications, pulmonary vein isolation, or PVI, is a crucial part of radiofrequency ablation (RFA) therapy for atrial fibrillation. PVI relies on accurately identifying the junction between the pulmonary vein and the left atrium. The precision and dependability of conventional techniques like optical coherence tomography (OCT) and electroanatomic mapping are constrained. Based on near-infrared spectroscopy (NIRS) data, this work offers a unique method for improved pulmonary vein recognition using deep learning, more especially 1D convolutional neural networks (CNNs).

22 swine hearts were used to create the dataset, containing near-infrared spectra with reflectance measurements at 1024 wavelengths between 500 and 1100 nanometers. Three categories have been assigned to the data: normal myocardium (0) , lesions (1) and pulmonary veins (3), RFA lesions, and. Splitting the data by heart and remapping the labels (from label 3 to 2), restructuring the features for CNN input, and standardizing the data with the "StandardScaler" are important phases in the data processing process.

Splitting the data by heart is crucial to ensure there are no overlaps between training, validation, and test sets, which are defined by specific cardiac indices. This method ensures that the heart numbers in the validation and test sets are not included in the training set, thereby maintaining data integrity. Additionally, it is confirmed that there are no overlaps between test and validation indices to prevent any data leakage. The splits are then verified to ensure that the correct heart numbers are present in each set, and label distributions are examined to guarantee balanced representation across the training, validation, and test sets. Labels are remapped to simplify the classification problem, changing label 3 to 2.

Standardization and reshaping of features are performed using the "StandardScaler," ensuring that the data is appropriately prepared for CNN input. This standardization step is essential for normalizing the data, which helps in improving the performance and convergence of the CNN model.

The proposed CNN model demonstrates superior ability to detect pulmonary veins with greater accuracy and specificity compared to existing methods, effectively identifying complex patterns from large datasets. Experimental results validate the efficacy of the CNN-based approach, showing significant improvements in the precision of PVI procedures. By utilizing NIRS data, this model offers a promising tool for real-time intraoperative vein detection, advancing RFA therapy and enhancing patient outcomes in the treatment of atrial fibrillation.

The CNN-based method for pulmonary vein detection using NIRS data represents a substantial advancement over traditional techniques. The model's ability to accurately and specifically identify pulmonary veins in real-time holds great potential for improving the precision of PVI

procedures, thus contributing to better management and outcomes in patients undergoing RFA therapy for atrial fibrillation. The success of this approach underscores the importance of integrating deep learning techniques with advanced imaging modalities to enhance the capabilities and effectiveness of medical interventions