

Deep Learning Approach for Identification of Cardiac Abnormalities from a Variable Number of Leads

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Objective. The objective of this study is to explore new imaging techniques with the use of Deep Learning method for the identification of cardiac abnormalities present in ECG recordings with 2, 3, 6 and 12-lead in the framework of the PhysioNet Challenge 2021.

Materials. The training set is a public database of 43101 twelve-lead ECG recordings lasting from 6 seconds to 60 seconds. Each ECG recording has one or more diagnostic labels. The six-lead, three-lead, and two-lead are reduced-lead version of the original twelve-lead data.

Method. The Deep Learning method considers images that are built from raw ECG signals. Two techniques have been tested. In the first case, ECG data are processed by the classical continuous wavelet transform (CWT) analysis obtaining a time-frequency domain representation, with the generation of specific images. The second technique considers innovative 3D images of the entire ECG signal, observing the regional constraints of the leads, obtaining time-spatial images. In both cases, these images are then used for training Convolutional Neural Networks (CNN) for ECG diagnostic classification. The pre-trained CNN GoogleNet network for image classification has been used. Class imbalance is addressed with random over sampling (ROS) algorithm and it has been applied and tested in the first phase.

Results. From the complete training set, two reduced random subsets (8320 and 16002 records) have been defined minimizing class imbalance. Unofficial results of the classification accuracy on an independent ECG testing set are reported in the Table. The results produce two interesting considerations. The 2-lead scores are surprisingly similar compared to those obtained with 3, 6 or 12-lead. This aspect is related to the pattern recognition capacity and the characteristics of cardiac abnormalities. The ROS technique for class imbalance does not produce any significant improvement of the scores (C-D), and alternative or modified algorithms will be tested in the second phase.

Results of the unofficial phase of the Challenge

Method	Training set	CPU (m)	Challenge metric score			
			12-lead	6-lead	3-lead	2-lead
A. CWT + ROS	8320	660	0.354	0.329	0.346	0.363
B. 3D + ROS	8320	330	0.363	0.364	0.358	0.354
C. 3D + ROS	16002	847	0.391	0.388	0.388	0.378
D. 3D	16002	640	0.396	0.397	0.388	0.384