DL-LVEF: Deep-Learning Measurement of the Left Ventricular Ejection Fraction from Echocardiographic Images

Agnese Sbrollini, MHD Jafar Mortada, Selene Tomassini, Haidar Anbar, Micaela Morettini, Laura Burattini

Department of Information Engineering, Università Politecnica delle Marche, Ancona, Italy

Left ventricular ejection fraction (LVEF) is a commonly used index of cardiac functionality. Thus, accuracy in its measurement is fundamental. LVEF measure is usually manually performed by clinicians from echocardiographic images. Use of automatic algorithms could make LVEF measurement more objective. Thus, the aim of the present work is to present DL-LVEF, a new automatic algorithm for LVEF measurement. DL-LVEF was implemented in Google Colab Pro and includes two computational phases, which are: 1) deep-learning identification and segmentation of the left ventricular endocardium, performed by combining the YOLOv7 algorithm with a U-Net; and 2) LVEF computation, based on the Simpson's rule. DL-LVEF was set up and tested on the CAMUS database, which includes 1800 echocardiographic images acquired from 450 patients with annotated LVEF values and manual segmentation of the left ventricular endocardium. The database was divided into training dataset (70%) and testing dataset (30%); 14% of the training dataset was used as validation dataset for defining the early stopping point. In both training and testing datasets (Table), measured LVEF values (mLVEF, %) and annotated LVEF values (aLVEF, %) were found to be statistically highly correlated ($\rho \geq 0.89$); moreover, median mLVEF value was not statistically different from median aLVEF value. Eventually, mean absolute error (MAE, %) was $\leq 5\%$. Thus, DL-LVEF provided objective and accurate LVEF measurement. Future DL-LVEF evolutions will provide segmentation of other cardiac anatomical structures and, thus, will allow measurement of other clinically relevant cardiac indexes.

Table: mLVEF, aLVED and MEA distributions (median [25th;75th] percentiles) and ρ values. * and § indicate a P< 0.05 when comparing mLVEF vs aLVEF and when performing correlation analysis, respectively.

Dataset	# subjects	aLVEF (%)	mLVEF (%)	MAE (%)	ρ
Training	315	52.6 [44.3;60.6]	52.6 [43.8;60.8]	4 [2;7]	0.96§
Testing	135	54.6 [44.9;60.2]	53.9 [44.2;61.1]	5 [3;11]	0.89§