Recurrent Neural Networks to Predict the Outcome of Subsequent Defibrillation Shocks in Cardiac Arrest

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Introduction: An accurate prediction of defibrillation success may improve treatment of out-of-hospital cardiac arrest (OHCA). The aim of this study was to assess the performance of recurrent neural networks to predict shock outcomes based on previous shock information.

Materials and methods: The study dataset comprised ECG recordings from 957 OHCA episodes treated between 2008 and 2010 by the Italian emergency services. Cases with several defibrillation attempts were considered. The dataset comprised 3159 shocks, including 2202 subsequent shocks (target of the study). Shocks were labeled as successful or unsuccessful by expert clinicians. Patient data were modeled as a time sequence, each time-step representing a shock, and fed to a gated recurrent unit neural network. Each shock was characterized by a state-of-the-art defibrillation outcome predictor (computed over a 2s ECG segment prior to shock delivery) and the outcome of the previous shock (binary). Seven predictors from different domains (amplitude, slope, frequency, entropy) were analyzed. The network was train/tested using patient-wise 10-fold cross-validation. The process was repeated 10 times to statistically characterize the results. Balanced accuracy (BAC) was chosen as target performance metric.

Results: The best predictor was Mean Slope (MS), with a median BAC (inter-quartile range, IQR) of 84.1 (84.0-84.3)%. Adding the outcome of the previous shock improved the median BAC (ΔBAC) by 2.5-4.6 points for any predictor. Recurrent neural networks may improve the prediction of subsequent defibrillation outcomes making use of prior shock information.

Median (IQR) performance metrics per predictor

Predictor	BAC (%)	ΔBAC (%)	Sensitivity (%)	Specificity (%)
MS	84.1 (84.0-84.3)	3.4 (3.3-3.8)	87.0 (86.7-87.5)	81.2 (81.0-81.4)
MSI	84.0 (84.0-84.2)	4.6 (4.4-5.0)	87.2 (86.9-87.4)	81.0 (80.8-81.1)
MdS	83.8 (83.6-83.9)	3.9 (3.8-4.1)	86.4 (86.2-86.6)	81.1 (80.9-81.3)
FuzzEn	83.7 (83.5-83.8)	4.0 (3.8-4.4)	84.8 (84.5-85.0)	82.5 (82.4-82.6)
SampEn	83.7 (83.4-83.9)	4.1 (3.8-4.4)	85.3 (85.0-85.8)	81.8 (81.6-82.1)
PPA	83.3 (83.0-83.4)	4.1 (3.9-4.3)	83.4 (83.2-83.7)	83.1 (82.8-83.2)
AMSA	83.0 (82.8-83.4)	2.5 (2.3-2.6)	84.5 (84.3-85.1)	81.4 (81.0-85.1)