A Hidden Markov Model Approach for Ventricular Fibrillation Detection

Borja Altamira, Erik Alonso, Unai Irusta, Elisabete Aramendi, Mohamud Daya

University of the Basque Country (UPV/EHU)
Bilbao, Spain

Introduction: Early detection of ventricular fibrillation (VF) allows for prompt defibrillation, which is determinant for the survival of out-of-hospital cardiac arrest (OHCA) patients treated with automated external defibrillators (AEDs). Most VF detection methods are developed/validated using public databases that contain ECGs from Holter devices, which may be very different from ECGs recorded by AEDs during OHCA. The aim of this study was to develop a method for VF detection using ECGs obtained from OHCA patients.

Materials and methods: The dataset contained 596 10-s ECG segments, 144 shockable and 452 non-shockable, from 169 OHCA patients treated by Tualatin Valley Fire & Rescue in Portland (OR, USA). The dataset was split patient-wise into training (60%) and test (40%) sets. Each ECG segment was band-pass filtered (1-30 Hz), waveform features were computed and fed as observations to a Hidden Markov Model (HMM) that assigned each observation to one of the two hidden states, shockable or non-shockable. The number of possible observations was reduced using k-means clustering. The optimization of the method consisted of the feature selection (a maximum of 5 features were selected from a bench of 7) and optimization of the number of clusters (k) through a forward greedy wrapping approach using patient-wise 10-fold cross validation in the training set. The performance of the method was computed in terms of sensitivity (SE) and specificity (SP) using the test set. This procedure was repeated 500 times to estimate the distributions of the performance metrics.

Results: The method used always the best five-feature subset, a median (IQR) of 70 (50-90) clusters, and showed a mean (SD) SE and SP of 94,4% (3.8) and 97.8% (1.2), respectively. The method is compliant with the American Heart Association requirements (SE>90% and SP>95%).

Conclusion: A HMM accurately detects VF during OHCA using a reduced number of ECG features.