Automated Detection of Ventricular Heartbeats from Electrocardiogram (ECG) acquired during Magnetic Resonance Imaging.

Aim: ECG signals are distorted in Magnetic Resonance Imaging (MRI) by the electromagnetic environment. Automated analysis of ECG is therefore highly difficult. The detection of pathological heartbeats is currently limited to excluding heartbeats with outstanding RR intervals. This study aimed at implementing a machine-learning (ML) based heartbeat classifier, based on hand-crafted features, for the automatic detection of ventricular heartbeats during MRI examinations.

Method: A model was trained and assessed on the MIT-BIH Arrythmia Database, using the AAMI recommendations for class labelling and division in two equal subsets DS1 and DS2. ECG signals were first reduced to a single lead using principal component analysis. Features were extracted for each heartbeat: (i) QRS morphological features based on Hermite function decomposition and higher order statistics, (ii) temporal features based on the local RR interval time-series around the heartbeat. A random forest classifier was trained to detect ventricular ectopic beats (V') using these features on DS1. The model was then tested on an in-house database of ECG acquired inside a 1.5T MRI scanner during standard clinical examination.

Results: The classifier achieved a F1 score 0.80 on MIT-BIH (DS2). Analysis of the subset of selected features showed morphological features (Hermite function decomposition) were important for the detection of ventricular beats on ECGs outside MRI. On the ECGs obtained in MRI, the classifier achieved F1 score of 0.47.

Conclusion: A heartbeat classifier was developed on the MIT focusing on QRS morphological features only (as they are less likely to be distorted by the MRI environment). Performance on MIT-BIH was acceptable although slightly lower than state-of-the-art approaches, but dropped significantly on MRI data. This highlights the need for further developments by included MRI-related artifact reduction, while also retraining on MRI acquired datasets.

Class	**V'**		
	Se	PPV	F1
Llamedo [1]	0.89	0.87	0.88
Teijeiro [2]	**0.95**	**0.97**	**0.96**
This work (MIT-BIH Arrythmia Database)	0.91	0.71	0.80
This work (MRI Database)	0.49	0.45	0.47