

# Ectopic Beats Cancellation for Improved Atrial Activity Extraction from Holter Recordings of Atrial Fibrillation

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Ectopic beats are a frequent and challenging problem in atrial fibrillation (AF) long time monitoring that still is unsolved. Moreover, they provoke important ventricular residua in the atrial activity (AA) signal when methods based on average QRST cancellation are used for its extraction from the ECG. In this work, a new method for ectopic removal in a template-based cancellation technique is proposed.

The first step consists in distinguishing between normal and ectopic beats through a forward/backward level windowing strategy. Next, for each ectopic under cancellation, the most similar 15 ectopic beats are clustered by using an adaptive correlation index, which provides a robust and efficient measure of morphological similarity among signals than Pearson correlation. Next, the eigenvector matrix of the selected beats is obtained by singular value decomposition (SVD). Finally, the highest variance eigenvector (HVE) is considered as the ventricular template for the ectopic beat cancellation.

In order to evaluate the proposed methods performance, an index called reduction ectopic rate (RER) was defined. Concretely, this index was obtained by computing the root mean square value of the ratio between each ectopic in the original ECG and its residue in the AA signal after ectopic cancellation. Through this metric, the proposed technique was compared with a previously published average QRST cancellation technique, in which ventricular template was also generated by applying SVD to normal beats. Twenty 5 hour-length segments extracted from Holter ECG recordings of 20 different AF patients, with a high percentage of ectopic beats, were used for the comparison. Results for the proposed ectopic cancellation provided maximum RER values of 5.76 and minimum of 1.67 being, in average, of  $3.57 \pm 0.25$ . In contrast, when ectopic beats were considered as normal beats, maximum RER was 1.49 and minimum 0.88, being in average  $1.11 \pm 0.25$ . As a consequence, the proposed ventricular ectopic cancellation method is able to improve notably the AA extraction from Holter ECG recordings by reducing notably the residua provoked by the presence of ectopic beats.