Synchronization of Conventional Electrocardiogram Recordings for Accurate VCG Reconstruction

Elisa Ramírez*, Samuel Riupérez-Campillo, Francisco Castells, Rubén Casado-Arroyo, José Millet

ITACA Institute, Universitat Politècnica de València, Valencia, Spain

Background: In classic electrocardiogram (ECG) recordings, all twelve leads are not acquired simultaneously, but are obtained in intervals of 2.5 seconds, and one lead (usually lead II) is recorded continuously. This poses a problem when reconstructing the vectorcardiogram (VCG) because the beats of each lead belong to different time instants.

Objective/Hypothesis: The objective of this study is to propose a methodology for correctly synchronizing the recording beats to reconstruct the VCG, and to evaluate the proposed method using the complete ECG and VCG signals at the phantom level.

Methodology: For this purpose, 21799 recordings of twelve 10-second leads from normal patients and pathological ones from an open dataset in Physionet were used. A phantom was constructed to simulate the traditional recording layout. Signals were filtered, keeping only recordings in which there was at least one complete heartbeat in all the phantom leads and discarding those with lack of regularity in the beats during the 10 seconds. The displacement of each beat with respect to the first was calculated using the maximum cross correlation. The cut-off indices and their respective offsets were then applied to all other leads, subsequently averaging to finally reconstruct the VCG.

Results: The results demonstrate precise synchronization, as evidenced by Pearson correlation values of 0.9959±0.0034, an MAE of 0.0077±0.0024 mV, and an RMSE of 0.0119±0.0038 mV in the VCG reconstruction.

Conclusion: The proposed methodology successfully synchronizes the recording beats to reconstruct the VCG, which is important for accurate diagnosis and treatment of cardiovascular diseases. The method can be applied to classic ECG recordings taken on paper to obtain VCGs and can be useful for researchers and clinicians working in the field of cardiology.