A Novel Algorithm for Full-Automatic Multipurpose ECG Delineation

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Aims: Obtaining high accurate wave segmentation or delineation on ECG signals is extremely essential not only for cardiac interpretation and diagnostics, but also for many cardiovascular applications and cardiac safety. In this works, a new high accurate and efficient method of detection and delineation of QRS complexes, P waves and T waves in single-channel and multi-channel ECG signals including the standard 12-lead ECG is presented.
Methods: The advanced delineation algorithm illustrated in this paper is based on using time and time-frequency methodologies to detect the main fiducial points, segments and intervals in each ECG cycle, namely P onset, P offset, QRS onset, QRS offset and T offset, P wave duration, PQ interval, QRS complex duration and QT interval. Furthermore, the algorithm is able to analyze the morphology of each wave and complex within ECG beat and also to derive large number of corresponding measurements. The delineation performance of the proposed algorithm is validated according to the standard IEC 60601-2-25:2011 using CTS Databank (Conformance Testing Service for Electrocardiography) and a well-defined subset of biological ECG recordings from CSE databank (Common Standard for qualitative Electrocardiography).
Results: The means and the standard deviations (in milliseconds) between the measurements provided by the automatic algorithm and the reference values in CTS and CSE databases are shown in the following tables.

Differences CTS and results:

Measurement	P Duration	PQ Interval	QRS duration	QT Interval
Mean	4.4211	1.5789	0.3158	1.3684
STD	7.381	3.0243	2.6045	3.4675

Differences CSE and results:

Measurement	P Duration	PQ Interval	QRS duration	QT Interval
Mean	-1.56	2.2700	-5.04	0.16
STD	11.3665	7.9058	5.5157	11.3562

Conclusion: The delineation results illustrate a high degree of agreement with the reference annotations done in CTS and CSE and fit perfectly within the tolerance range given by the standard 60601-2-25:2011 making the algorithm in compliance with regulations.