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Guest Editorial

Advances in modeling and characterization of atrial arrhythmias

It is a great pleasure for us to introduce this special issue on *Advances in Modeling and Characterization of Atrial Arrhythmias*. Atrial arrhythmias (AA) represent a common health problem in adults and may appear as a consequence of cardiac interventions as well as without any associated cardiac disease. In this respect, atrial fibrillation (AF) is the most common sustained cardiac arrhythmia and accounts for one third of the hospitalizations caused by cardiac rhythm disturbances. Atrial arrhythmias are associated with increased risk of stroke, heart failure and mortality. The mechanisms leading to the initiation, maintenance and termination of AA have been under intensive investigation in recent years, with an important contribution of signal analysis. Nevertheless much research remains to be done on modeling, signal processing techniques and computational methods in order to optimize AA diagnosis and treatment. Bearing this in mind, we started this research adventure by proposing to *Biomedical Signal Processing and Control* the creation of a special issue. As you can infer from these lines, the Journal responded very positively.

The invitation was broadcasted by the beginning of 2012 and the most active groups researching AA were invited to submit their original contributions. We received 15 high quality submissions, which were peer-reviewed by at least two active experts in current AA research. As a result, seven papers on recent advances in modeling and characterization of atrial arrhythmias, especially in AF, were selected for publication. It is our belief that this issue reflects some of the recent advances and applications of biomedical signal processing to atrial arrhythmias.

The seven papers deal with three open problems in atrial arrhythmias, such as ablation, arrhythmia detection and ventricular response during AF. Specifically, the first three papers apply signal processing algorithms to various aspects of AA ablation. The manuscript by Meo et al. presents a non-invasive method to predict catheter ablation outcome for the treatment of AF. The method is based on weighted principal component analysis applied to the 12-lead ECG, benefiting from the multivariate properties of such recordings. Their results outperform classical single-lead methods. Furthermore, their research could be used to perform a priori selection of patients who will respond positively to therapy, thus avoiding unnecessary procedures.

The work from Buttu et al. introduces new organization indices to quantify the harmonic components of the surface ECG for the purpose of identifying the site of AF termination by stepwise catheter ablation. They assess the contribution to the ECG of right and left atrial appendage activities and propose new organization indices. Good performance is achieved to identify patients whose AF will terminate during left atrial ablation.

El Haddad et al. present a new method for detecting the beginning and the end of bipolar electrograms which offers better accuracy than existing methods. This type of detection is crucial when building maps of local activation times, required, e.g. when ablating atrial tachycardia in real time.

Following the papers on ablation, Lee et al. introduce a new method for automatic detection of atrial flutter and atrial tachycardia using the standard ECG. The method is based on analyzing the atrial activity from TQ intervals through a high resolution time–frequency algorithm, called variable frequency complex demodulation. The method can track the atrial activity time-varying fundamental frequency, thus discriminating recordings with atrial flutter, atrial tachycardia or normal sinus rhythm with high accuracy.

The remaining three papers address the dependence between atrial and ventricular activity in AF from different points of view. Alcaraz and Rieta present a study quantifying real atrial and ventricular activation series from the surface ECG. The work analyzes nonlinear synchronization between these series through cross sample entropy. It shows that for the case of the more organized paroxysmal AF, synchronization between atrial and ventricular series is higher than for the more disorganized persistent AF. Hence, this information could be used to improve current rate control therapies by considering atrial activity organization.

The atrioventricular (AV) node behavior is studied from two scenarios. The paper by Masè et al. introduces the AV synchrogram, a method to quantify AV coupling on beat-by-beat basis from invasive recordings of atrial arrhythmias. The quantification is made by a stroboscopic observation of the ventricular phase at times triggered by the atrial activation. The AV synchrogram can detect different AV nodal response dynamics as a function of arrhythmia type, rate and time course. Thus, the method may be applied to AV node characterization in the clinical setting.

The paper by Corino et al. presents a statistical model of the AV node function during AF which offers more detailed characterization of the AV nodal pathways. The estimation of model parameters is made more robust for the parameters related to refractory period. Furthermore, the improved model is evaluated on both simulated data and real AF recordings, showing that the AV node characteristics can be assessed noninvasively to quantify autonomic stimulation.

The papers in this special issue prove that biomedical signal processing applied to atrial arrhythmias is an effervescent field in constant and rapid development. For the Guest Editors, it has been a long way of about two years since we decided to launch this

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proposal. Now, at this point, we would like to close this editorial by thanking the authors for their impressive effort in preparing the manuscripts, the reviewers for their detailed, rigorous and skillful comments and, finally, the Editor-in-Chief of *Biomedical Signal Processing and Control*, Robert Allen, and the Editorial Office, with special mention to Margaret Howls, for their good disposition and support.

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