On Time-frequency Techniques in Biomedical Signal Analysis

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I am particularly honored and glad to have the opportunity to introduce the comprehensive paper by Wacker and Witte [1] on "Time-frequency Techniques in Biomedical Signal Analysis: A Tutorial Review of Similarities and Differences", as well as the much relevant and deepened contributions by eight qualified discussants.

No doubt that Time-Frequency Analysis is a central topic in the evaluation of signal characteristics which are variable in time and in frequency and biomedical signals are very good examples in which these "variabilities" are present, constitute a major informative source of the signals themselves and, finally, are very strictly connected to diagnostic implications. That is the reason why we have in literature since from the ’80s some earlier applications of T-F algorithms in the area of biomedical signal processing (Choi-Williams et al., 1987 [2]), just in the same time of the first seminal papers by Boashash, 1988 [3] and Cohen, 1989 [4].

The paper by Wacker and Witte has the significant merit of dealing with this topic starting from the unified concept of analytic signal and therefore the Short-Time Fourier transform (STFT), the Gabor transform (GT), the S-transform (ST), the continuous Morlet wavelet transform (CMWT) and the Hilbert transform (HT) are introduced as linear operators of the signal, while the Wigner-Ville distribution (WVD) is employed as example of the “quadratic transforms” class. The combination of WVD and GT with the matching pursuit (MP) decomposition and that of the HT with the empirical mode decomposition (EMD) are instead conceived as belonging to the class of signal-adaptive approaches. In this way, a comprehensive description of these tools is suggested which is elegant from a methodological point of view and also presents a unified approach which could indeed be proactive for a variety of applications in the biomedical context.

The Discussants have elicited important issues which basically confirm and complement the arguments expressed in the paper. I shall briefly point out some general aspects which I think are worth to be further remarked.

The traditional approaches of signal processing in time domain OR in frequency domain have been integrated and enriched by the time AND frequency domain [or time-frequency domain], originally carried out in T-F bidimensional plane. The objective is to optimize T-F resolution for a given implementation presented under the form of T-F atoms with constant T-F resolution or under multiresolution form [5]. In the quadratic case, the objective is instead to minimize the cross-term effects [6].

The solution of this global problem does not seem univocal: the Authors objectively remark that MP presents some attractive properties of optimization of T-F resolution and cross-term reduction; on the other hand, the atom-based structure in ”greedy” form could present a bias which could be reduced via stochastic dictionary, with successive averaging operation.

Further, in more recent years [7, 8], EMD has undoubtedly found many applications in biomedical signal processing. Its decomposition into Intrinsic Mode Functions (IMF’s) is generally processed via HT, by obtaining what is generally called Hil-


References