

On the Measurement of Physiological Similarity Between Independent Components: Time-Structure Versus Frequency-Based Methods

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This work explored two methodologies to quantify physiological similarity between independent components (ICs) extracted from abdominal phonograms by single-channel independent component analysis (SCICA).

ICs were processed to produce (a) one index about time-structure (through rhythmicity calculation) and (b) one index about frequency content. The rhythmicity index (R) was calculated by: (1) envelope generation, (2) autocorrelation, and (3) autospectrum to quantify the frequency of the dominant rhythm (i.e. R). The frequency content index (S) was obtained from the IC power spectral density, where the central frequency of its single-peak spectrum was taken as S .

The criteria to recognise similar rhythmicities were established by considering physiological rates. Thus, since the physiological ICs in the abdominal phonogram correspond to maternal respiratory (MR), maternal cardiovascular (MC), and foetal heart sounds activities (FHS), four ranges of similarity were proposed for R : $R_{MR} = [0.1-0.6]$ Hz, $R_{MC} = [0.83-1.7]$ Hz, $R_{FHS} = (1.7-3.0)$ Hz, and R_N for noise. The criteria for similar frequency content were only based on our empirical observations, which led to ranges of similarity for S as: $S_{MR} = (0-2]$ Hz, $S_{MC} = (2.0-19.0]$ Hz, $S_{FHS} = (19.0-44.5]$ Hz, and $S_N > 44.5$ Hz for noise.

Both methodologies were tested on a dataset of 750 ICs (preclassified as MR, MC, FHS, and noise) by quantifying their sensitivity (Se) and specificity (Sp). The ICs were extracted from 25 abdominal phonograms recorded between 29 and 40 weeks of gestational age.

These methods are fast and easily implemented since they are based on autocorrelation and/or spectral analysis. Particularly, results showed optimal Se - Sp values of 0.75 for the R -based methodology, and 0.93 for the S -based methodology, which means that S is better than R to recognise similar ICs. On the other hand, R is more complete since rhythmicity not only recognises similar ICs, but also identifies their physiological origin, which is a desired quality. Thus, both methodologies are promising for automatic classification purposes. Most importantly, they lead to the possibility of enhancing the classification of physiological ICs extracted by SCICA. Future work will aim for such an enhancement by combining these two approaches to exploit their advantages.