Internship proposal

Evaluation of Multiscale Permutation Entropy Tools for Physiological Signals
(Last year Master / Engineer degree level)

Laboratory: PRISME - Signal Processing team
Period: 01/03/19 until 19/07/19
Location: 12 rue de Blois Orléans, France
Allowance: about 500€/month

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Job Overview:

Entropy measurements are a powerful tool to measure the amount of information contained in a digital signal. This is particularly interesting in the context of physiology, where different entropy levels are associated with aging and motor illnesses, such as Parkinson's disease [1]. However, for the entropy-based techniques, background noise in the signal represents a problem, where the high Entropy result may come from randomness, and not from real information content.

To address this problem, Multiscale Entropy techniques have been proposed [2], where the original signal is processed at different "time scales", and thus helps separate information from noise. Here, the multiscale processing method plays a key role in the behavior and variability of the Entropy results.

In particular, Multiscale Permutation Entropy (MPE) [3,4] have been recently used for medical purposes [5]. Permutation Entropy works with the information contained in "ordinal patterns", which compares the relationships between adjacent data points in a signal. PE has the advantages of being easy to compute and being particularly robust to noise. Although successfully implemented in real physiological data, the statistical properties of PE (and its variants) have been superficially explored. This makes the final interpretation of the results difficult, at best.

To better understand the statistics behind the MPE, the candidate will explore different processing methods on simulated signals (with known Entropy results). He/She will compare well established processing methods, as well as new processing techniques to better estimate the true information content.

The candidate will implement these processing algorithms, test their performance, and build a Summary Report on the results obtained. This will help theoretically understand the MPE properties, and thus, achieve a better understanding on Entropy methods for medical diagnosis.

Responsibilities and Duties:

- Study and get familiar with Permutation Entropy, Multiscale Permutation Entropy, and pre-processing methods.
- Program each MPE algorithm using Matlab (or other suitable language).
- Implement the above algorithms on simulated signals.
- Generate graphs of the MPE estimated values and error estimations for each method.
- Write a report on the results.

Qualifications:

- Degrees. Master Student in Signal Processing, Computer Science, Statistics, or other related field.
- Experience. Previous work with programming languages such as Matlab (C++, Python, or similar languages are also an option). Acquaintance with statistical methods is a plus.
- Specific skills. Mathematics, Statistics, Programming. English language (most literature available in this topic is in English).
- Personal characteristics. Self-learning, Responsibility, Discipline, Teamwork-oriented.

References

[1] Y. Wu *et al.*, "Measuring signal fluctuations in gait rhythm time series of patients with Parkinson's disease using entropy parameters," *Biomed. Signal Process. Control*, vol. 31, no. Supplement C, pp. 265–271, Jan. 2017.

[2] M. Costa, A. L. Goldberger, and C.-K. Peng, "Multiscale Entropy Analysis of Complex Physiologic Time Series," *Phys. Rev. Lett.*, vol. 89, no. 6, p. 068102, Jul. 2002.

[3] C. Bandt and B. Pompe, "Permutation Entropy: A Natural Complexity Measure for Time Series," *Phys. Rev. Lett.*, vol. 88, no. 17, p. 174102, Apr. 2002.

[4] W. Aziz and M. Arif, "Multiscale Permutation Entropy of Physiological Time Series," in *2005 Pakistan Section Multitopic Conference*, 2005, pp. 1–6.

[5] H. Azami and J. Escudero, "Improved multiscale permutation entropy for biomedical signal analysis: Interpretation and application to electroencephalogram recordings - ScienceDirect," 2015. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S174680941500138X. [Accessed: 29-Sep-2017].