PhD position

Hiring interview: 04-22 of June 2018

Decision notification: late June/early July

PhD Starting Date: October 1st

Title

Joint Segmentation and Clustering using tensor decomposition for human behavioral discovery

Affiliation

LITIS / Normandy University / INSA Rouen (France) http://www.litislab.fr/

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Supervisors

- Gilles Gasso, Full Professor, INSA Rouen / LITIS, France
- Ludovic Seifert, Full Professor, Université de Rouen / CETAPS, France
- Romain Hérault, Assistant Professor, INSA Rouen / LITIS, France

Keywords

Signal segmentation, Signal clustering, Tensor Decomposition, Non Negative Matrix Factorization, Dictionary learning, Human Movement science, Climbing

Skills

Master in either Statistics, Data Science, Machine Learning, or Signal Processing.

Programming skills in Matlab / Python. An experience on Keras / Theano would be appreciated as well as some knowledge about Human Movement science.

Project context

The PhD Student will be part of a multi-disciplinary project (funded by ANR DynaCev) which mixes research in the humanities and computational sciences to understand and explain the role of visual-motor exploratory strategies in learning dynamics for fire-fighters in climbing task. Traditionally, learning is studied by comparing behavior before and after practice, which does not facilitate understanding of transitional phases, where new behaviors can temporarily alternate with previous behaviors, called an 'intermittent regime'. This multi-disciplinary project seeks to model transitions between the three

phases of learning dynamics (initial, intermittent, final) to understand how the frequency of novelty and complexity of learning situations influence the intermittent regime. This modeling in the humanities and computational sciences will be used to design optimal practice environments to train fire-fighters to exploit adaptive behaviors, inviting them to safely explore novel, and functional behaviors.

Description of the PhD work

Recordings of climbers on artificial climbing walls that should reproduce what a fire-fighter can expect in his day to day practice have been made for the project. The data consist in video of the wall, video from the climber helmet (point of gaze) and extracted position of the climber member and hips. In general, learning in sport practice can be divided into three phases: (i) initial stable behavior, (ii) intermittent regime of transient behavior, (iii) final stable behavior. The goal of the PhD Work is to design statistical methods to automatically segment and characterize these phases from climbers recording.

In order to perform a joint signal segmentation and clustering we foresee the use of tensor decomposition techniques along 3 dimensions (climb features, climber, time). Tensor is an extension of matrix in n dimensions. Canonical polyadic or Tucker decomposition (CPD) can be seen as extensions of Singular Value Decomposition (SVD) of 2D matrices to Tensors. From that decomposition, one can find profiles along climb features and climber axes and segmentations along the time axis (Cichocki 2015). To constrain the decomposition achieving coherent time segmentation we envision to explore a Total Variation regularization or group fused lasso such as in (Vert et al, 2010).

Moreover, it will be interesting to qualify the climber trajectory variances and changes in direction to help human movement experts interpret clusters resulting from the previous stage. Weighted Current (Durrleman, 2010; Gori et al., 2017) is a generative model that can synthesis new geometrical shape statistically similar from a geometrical shapes available in a learned database. It computes the manifold where all the seen shapes lies and provided a way to navigate in this manifold to generate unseen but likely shapes. At each point of the latent space, it provides major change directions that follow the manifold tangent. Thus, this tool can also be used to analyze how shapes variates. The idea is to learn a model of the climb path over multiple session of the same climber. Preferred directions on the manifold will indicate where the variance resides in the climb path.

References

Cichocki, A., Mandic, D., De Lathauwer, L., Zhou, G., Zhao, Q., Caiafa, C., & Phan, H. A. (2015). Tensor decompositions for signal processing applications: From two-way to multiway component analysis. IEEE Signal Processing Magazine, 32(2), 145-163.

Durrleman, S. (2010). *Statistical models of currents for measuring the variability of anatomical curves, surfaces and their evolution* (Doctoral dissertation, Université Nice Sophia Antipolis).

Gori, P., Colliot, O., Marrakchi-Kacem, L., Worbe, Y., Poupon, C., Hartmann, A., ... & Durrleman, S. (2017). A Bayesian framework for joint morphometry of surface and curve meshes in multi-object complexes. *Medical image analysis*, *35*, 458-474.

Vert, J. P., & Bleakley, K. (2010). Fast detection of multiple change-points shared by many signals using group LARS. In *Advances in Neural Information Processing Systems* (pp. 2343-2351)