Functional data analysis
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Applications to Neurology

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Description. Most of brain phenomena can be viewed as stochastic processes indexed by the time parameter t. The evolution of sensor technologies now allows to observe sections of such processes at low cost and limited intrusiveness. Sensor networks produce data flows under the form of multivariate time series or functions $(X_1(t), \ldots, X_d(t))$ which capture a low-level description of systems behavior with possibly a large value for the dimension d (number of sensors). The assumption is made that by observing the values on sensors, one can predict the general state of the system described by a one-dimensional time series $Y(t)$. The application of interest for this internship comes from medicine where the output is the reaction of a neurological patient to dopamine based on measurements of his muscular and neurosensorioal activity. An example from a practical viewpoint is to automatically detect the posture of the patient or the type of exercise he is completing based on low-level signals. We propose to explore such problems from the angle of nonlinear function approximation (splines, recursive partitioning, ...) and also with statistical signal processing techniques to detect breakpoints and changes in the signals.

Mathematical techniques.

- Analysis - Signal processing, Function approximation.
- Statistis and Machine Learning - Time series modeling, High dimensional statistics, Machine learning algorithms.
- Data analysis - Neurology, ...

Benefits. The students will gain an in-depth knowledge of the advanced machine learning techniques and time series modeling, and they will also have the opportuniy to familiarize themselves with programming in *R*, *Matlab* and/or *Python*. Since they will address real problems, they will be introduced to neurology. In case of success, the work shall lead to an online publication in the format of IPOL <http://www.ipol.im>.

References.

Hastie, T. , Tibshirani, R. & Friedman J.I. (2001). The elements of statistical learning: data mining, inference, and prediction. *Springer*.
Mallat, S., Papanicolaou, G., Zhang, Z. (1998). *Adaptive Covariance Estimation of Locally Stationary Processes*. Annals of Statistics, 26(1):1-47.
Oudre, L., Jakubowicz, J., Bianchi, P., Simon, C. (2012). *Classification of periodic activities using the Wasserstein distance.* IEEE Transactions on Biomedical Engineering, 59(6):1610-1619.
Ramsay, J.O., Silverman, B.W. (2005). Functional data analysis. *Springer*.