22 NOV

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Campus Saint-Germain-des-Prés, U. Paris Cité

THÈSES ET HDR

# Alice NICOLAI : Interpretable representations of human biosignals for individual longitudinal follow-up

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AJOUTER AU CALENDRIER

## Abstract

Individual longitudinal follow-up, which aims at following the evolution of an individual state in time, is at the heart of numerous public health issues, particularly in the field of medical prevention. The increasing availability of non-invasive sensors that record various biosignals (e.g., blood glucose, heart rate, eye movements), has encouraged the quantification of human physiology, sensorimotricity, or behavior with the purpose of deriving markers for individual follow-up. This objective raises however several challenges related to signal modelling. Indeed, this particular type of data is complex to interpret, and, a fortiori, to compare across time.

This thesis studies the issue of extracting interpretable representations from biosignals through the problematic of punctual follow-up of balance control in medical consultation, which has crucial implications for the prevention of falls and frailty in older adults. We focus in particular on the use of force platforms, which are commonly used to record posturography measures, and can be easily deployed in the clinical setting thanks to the development of low cost platforms such as the Wii Balance Board.

For this particular application, we investigate the pros and cons of using feature extraction methods or alternatively searching for a generative model of the trajectories. Our contributions include first the review and study of a wide range of state-of-the-art variables that are used to assess fall risk in older adults, derived from the center of pressure (CoP) trajectory. This signal is commonly analyzed in the clinical literature to infer information about balance control. Secondly, we develop a new generative model, « Total Recall », based on a previous stochastic model of the CoP, which has shown to reproduce several characteristics of the trajectories but does not integrate the dynamic between the CoP and the center of mass (CoM) — a dynamic which is considered to be central in postural control. We also review and compare the main methods of estimation of the CoM in quiet standing and conclude that it is possible to obtain an accurate estimation using the Wii Balance Board. The results show the potential relevance of the Total Recall model for the longitudinal follow-up of postural control in a clinical setting. Overall, we highlight the benefit of using generative models, while pointing out the complementarity of feature and generative approachs.

Furthermore, this thesis is interested in introducing representations learned on labeled data and tailored for a particular objective of follow-up. We propose new classification algorithms that take advantage of a priori knowledge to improve performances while maintaining complete interpretability. Our approach relies on bagging-based algorithms that are intrinsically interpretable, and a model-space regularization based on medical heuristics. The method is applied to the quantification of fall risk and frailty in older adults.

This dissertation argues for the importance of researching interpretable methods, designed for specific applications, and incorporating a-priori based on expert knowledge. This approach shows positive results for the integration of the selected biosignals and statistical learning methods in the longitudinal follow-up of postural control. The results encourage the continuation of this work, the further development of the methods, especially in the context of other types of follow-up such as continuous monitoring, and the extension to the study of new biosignals.