Attractor-based kinematic gait analysis

methodological & clinical considerations

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Abstract

The attractor method and some of its applications are presented. We start with the original research question “How to diagnose fatigue (fatigability) in MS patients reliably”. So far a decisive method to discriminate between non-fatiguing and marginal fatiguing patients was not available. Traditional kinematic methods looking at step length, width, height, time, cadence, speed etc. and non-linear methods considering the Lyapunov exponent are able to describe groups of fatiguing populations but unable to diagnose fatigue of single individuals reliably. Therefore, this novel method based on attractor attributes was developed (Vieten, Sehle, & Jensen, 2013). The core idea behind the method is the description of a cyclic movement as a state vector described in terms of a limit cycle attractor and the variation of a well-defined magnitude around it.

For the experimental setup of the gait analysis we use two three-axial sensors mounted on each foot to acquire acceleration data of subjects walking at a constant speed on a treadmill. Those data constitute a subset of the state vector describing walking, rich in information content and sensitive enough to quantify subtle changes in the movement pattern and in the variability. The low frequency information of the sensor data is used to calculate the attractor and the variation of the state vector around it. We established three parameters: δM the speed normalized mean distance between two attractors - a measure of movement pattern differences; δD the measure of variation changes between two measurements; $\delta F = \delta M \cdot \delta D$ the “Fatigue index Kliniken Schmieder (FKS)”, a measure describing fatigability. The accuracy of the method is shown and its ability to quantify subtle differences demonstrated. The presentation ends with some applications (Sehle, Vieten, Mundermann, & Dettmers, 2014; Sehle, Vieten, Sailer, Mundermann, & Dettmers, 2014).

Sehle, A., Vieten, M., Mundermann, A., & Dettmers, C. (2014). Difference in Motor Fatigue between Patients with Stroke and Patients with Multiple Sclerosis: A Pilot Study. *Front Neurol, 5*, 279. doi: 10.3389/fneur.2014.00279

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Vieten, M. M., Sehle, A., & Jensen, R. L. (2013). A novel approach to quantify time series differences of gait data using attractor attributes. *PLoS One, 8*(8), e71824. doi: 10.1371/journal.pone.0071824