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ScienceDirect
Physica A 387 (2008) 2100–2110
PHYSICA A
www.elsevier.com/locate/physa

Statistical quantifiers of memory for an analysis of human brain and neuro-system diseases

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Received 1 August 2007; received in revised form 13 November 2007
Available online 8 December 2007

Abstract

On the basis of a memory function formalism for correlation functions of time series we investigate statistical memory effects by the use of appropriate spectral and relaxation parameters of measured stochastic data for neuro-system diseases. In particular, we study the dynamics of the walk of a patient who suffers from Parkinson's disease (PD), Huntington's disease (HD), amyotrophic lateral sclerosis (ALS), and compare against the data of healthy people (CO — control group). We employ an analytical method which is able to characterize the stochastic properties of stride-to-stride variations of gait cycle timing. Our results allow us to estimate quantitatively a few human locomotion function abnormalities occurring in the human brain and in the central nervous system (CNS). Particularly, the patient's gait dynamics are characterized by an increased memory behavior together with sizable fluctuations as compared with the locomotion dynamics of healthy patients. Moreover, we complement our findings with peculiar features as detected in phase-space portraits and spectral characteristics for the different data sets (PD, HD, ALS and healthy people). The evaluation of statistical quantifiers of the memory function is shown to provide a useful toolkit which can be put to work to identify various abnormalities of locomotion dynamics. Moreover, it allows one to diagnose qualitatively and quantitatively serious brain and central nervous system diseases.

PACS: 05.45.Tp; 87.19.Xx; 89.75.-k

Keywords: Discrete non-Markov processes; Time series analysis; Memory effects; Nervous system diseases; Human locomotion

1. Introduction: Time series analysis to study human movement

The challenge of identifying statistical memory effects occurring in time series analysis of discrete, temporal data sets of medical disorders continues to attract considerable attention in various cross disciplines. This is so because the ultimate goal is always the construction of suitable statistical quantifiers that carry the potential to indicate and quantify the underlying medical disorder. In this context, the time series analysis presents an important tool, which can be put to work to characterize the complex behavior in medical physics.

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0378-4371/$ - see front matter
doi:10.1016/j.physa.2007.12.003