ErgoVar: A Toolbox for Exposure Variation Analysis

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Abstract
Ergonomists suggest that increasing exposure variation at work may prevent development of work related musculoskeletal disorder in the jobs which are characterized by repetitive pattern of exposure. However, different methodological approaches could be adopted to quantify exposure variation. ErgoVar provides the implementation of relevant computational methods for analysis of exposure variation. It consists of a set of linear and nonlinear processing methods relevant to exposure variation analysis. It is free for downloading and sharing. ErgoVar aim is to facilitate the research focusing on exposure variation.

Introduction
Lack of exposure variation has been suggested to be associated with development of work related musculoskeletal disorder in “repetitive works” [1]. As a remedy, ergonomists have suggested exploiting of redundancy of human motorcontrol to increase the variation in pattern of biomechanical loading [2,3]. Further, a similar concept has attracted attention within the sport science field where the implication of the motor variability in sport activities has been introduced in skill achievement and susceptibility to injuries [4].

What is known as motor variability reflects the observed variability at different levels of movement execution across and within individuals [5]. This variability can be observed in the kinetic and kinematic properties of end-point or joint angles as well as variability of muscular activity of muscles within or outside the same muscular synergy. However, a sophisticated universal index to quantify and interpret motor variability is still absent or may be non-existing because variability has different aspects that cannot be reflected in only one index [5]. While some previous studies have reported cycle-to-cycle standard deviation as an index of variability [2,6], more recent studies have addressed the complexity and stability as different aspects of motor variability [7,8]. Systematically speaking, different approaches of variability quantification methods could be categorized into linear and non-linear methods [9].

Heterogeneity and variety of studies in this field call for an integrated framework to establish a comparable and easy to use base for the studies in this field. ErgoVar is a framework which consists of several functionalities including aforementioned quantification methods and allows the researchers in the field to take benefit of the proposed methods in their own research.

Availability of such application may facilitate the research in this field and renders a comparable base between different studies. To my best knowledge, there is no collective package with this particular focus on exposure variation for the researchers in this field. The current short communication introduces different functionalities of ErgoVar and potential application of this framework.

ErgoVar Environment
ErgoVar is the results of efforts put into analysis of biomechanical exposure variation over several years and now it is developed to be an open-source toolbox in MATLAB that allows quantification of exposure variation using several methods.

ErgoVar is implemented using a graphical user interface and the users of this application do not need to have extensive knowledge on how to use MATLAB.

Functionalities of ErgoVar
ErgoVar consists of linear and non-linear approaches of exposure variation quantifications. In addition to conventional statistical descriptors, e.g., coefficient of variation, exposure variation analysis (EVA) [10], cluster-based exposure variation analysis (C-EVA) [11] can be studied. From the category of non-linear methods, entropy measures and recurrent map analysis (RQA) are also included (see figure 1).

Exposure variation analysis: EVA was first introduced about two decades ago as a general computational framework for exposure variation quantification in ergonomic studies [10] and it has been subsequently used in several other studies in its original or a modified format [12,13]. ErgoVar provides a simple interface for users to modify the layout of EVA according to their own application and obtain the analyzed results.

Cluster-based exposure variation analysis: C-EVA is a very recent modification of EVA to optimize its layout and allow a multivariate setup to include time line of exposure variation from multiple sources [11]. Instead of splitting the exposure level into exposure classes, C-EVA works based on a data clustering algorithm. This is now available in ErgoVar environment.

Entropy measures: Entropy measures quantify what is known as complexity of a signal and thus introduce a new aspect of variability. For the first time, this category of measures was utilized to verify the principal of “loss of complexity” in pathological cases compared with healthy physiological systems [14]. As a computational tool, entropy  

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measures quantify the complexity of the signals such that the higher the entropy values, the more complex the signal.

ErgoVar can compute sample entropy and its permuted version as well as permutation entropy [15-17]. Additionally, it can compute multi-variante multi-scale entropy defined by Ahmed et al (2012) [18]. Users have the possibility to adjust the parameters of the algorithms and the results will be stored for further analysis.

Recurrent map analysis: RQA is comprised of indices which quantify the recurrence pattern of observations and thereby reveal some information about the complexity of underlying systems. RQA has been used in processing of biological signals and in some cases it performed better than some other conventional methods [19,20]. ErgoVar can compute the most frequently used indices from the recurrence maps.

- Recurrent percentage (Rec%), Determinism (Det%), maximum length of a vertical line in the recurrence map (LINMAX), entropy of the map (ENT), trend (TND), Laminarity (LAM%), maximum length of a horizontal line in the recurrence map (LINMAX_LAM) can be computed. The recurrence map is based on reconstructing the embedding space and ErgoVar also presents tools to find proper values for the parameters of embedding space reconstruction [21].

Conclusion

ErgoVar as a package is developing to include any potentially relevant method for exposure variation analysis. The routines of the software have been tested on some synthetic inputs as introduced in the referenced articles and identical outcomes were observed. Thus, the accuracy of implemented methods is, in turn, identical to those reported in the referenced articles and it also faces with all limitations that the referenced papers have previously reported. However, ErgoVar is provided “AS IS” and expressly disclaims all warranties. ErgoVar is distributed under the General Public License (version 3 or later).

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References