Effect of Input Parameters on Detrended Fluctuation Analysis of Postural Control Data

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MOTIVATION

HUMAN MOVEMENT VARIABILITY

- Critical for healthy function and present in all physiological movements [1,2]
- Exists on a spectrum with the optimal amount falling between two extremes [1,2]
  - Lack of variability indicating rigidity and limited adaptability
  - Excessive variability indicating instability and random, uncontrolled motion
- Consistent physiological performance relies on flexibility and variability in joint coordination patterns that allow adaptation [3]
- May also reduce injury risk by changing the tissues loaded during a specific task [3,4]
- Typically analyzed using linear analyses that examine amount of variability (i.e. ranges and RMS) [2]

NONLINEAR ANALYSIS

- Evaluate time series data to describe the complexity and structure of variability and quantify subtle changes [2]
- Provide insight into variability that can help predict future movements from current movements to allow interventions to alter coordinative patterns [2]

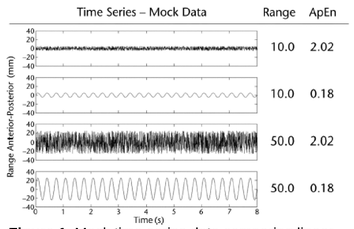

Figure 1. Mock time series data comparing linear and nonlinear analyses measures. (From [2])

DETRENDED FLUCTUATION ANALYSIS (DFA)

- Nonlinear analysis based in fractals used to detect long-range correlations in nonstationary time series data [5]
- Limitation: Results depend heavily on data length, window size, and scaling region used to determine the scaling exponent α, but little guidance exists for their selection [5]
- α is the slope of the line relating log(F(n)) to log(n) and indicates the level of correlation [6]
  - 0<α<0.5: large and small values of time series likely alternate
  - α≈0.5: only short-term correlations exist
  - 0.5<α≤1: long-range correlations exist

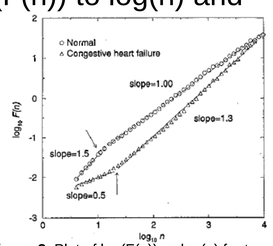

Figure 2. Plot of log(F(n)) vs log(n) for two heart interbeat interval times series. (From [6])

OBJECTIVES

- Examine effects on DFA of center of pressure (CoP) data of changing the following inputs:
  - Data length
  - Window size
  - Scaling region
- Determine best practices for input parameter selection so:
  - Important effects in posturography data are not skewed
  - Results from different studies are consistent
- Use new selection method to determine if differences in CoP variability between controls and individuals with conditions known to affect variability can be better detected

HYPOTHESIS

- Choice of scaling region will most influence results of DFA, as α is the slope of the data present in the scaling region

PROPOSED METHODS

PHASE 1

- Evaluate impact of various input parameters on the value of α obtained from DFA
- Similar work has been done to evaluate the effects of various input parameters on the calculations of approximate and sample entropy [7]
- Data sets
  - Matlab created theoretical time series data with random initial conditions and known α
    - 20 chaotic
    - 20 white noise

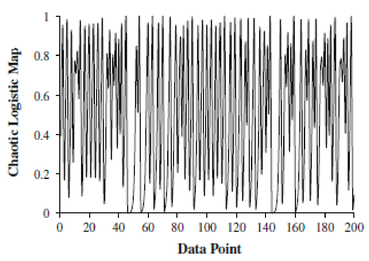

Figure 3. Theoretical chaotic logistic map. (From [7])

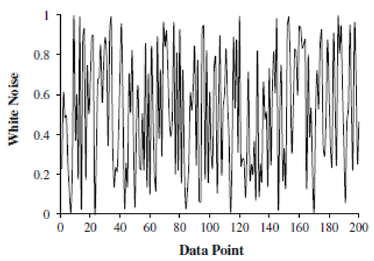

Figure 4. Theoretical random white noise. (From [7])

PROPOSED METHODS CONTINUED...

- Experimental center of pressure (CoP) sway measures from 20 healthy young adults (~18-30 years)

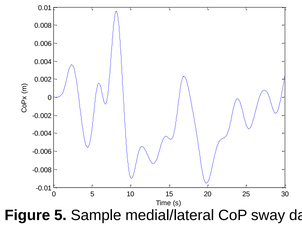

Figure 5. Sample medial/lateral CoP sway data.

- Perform DFA on theoretical and experimental data sets while varying input parameters
  - Literature review to yield common input parameters used in prior studies to use as initial values
- Determine α for all combinations of input parameters and explore the effects of varying parameters using ANOVA
- Statistical significance ($p<0.05$) of any of the main effects or interactions will indicate that α is dependent on the input parameter varied

PHASE 2

- Subjects
  - 20 healthy adults
  - 20 adults with a condition known to affect postural variability (i.e. Parkinson's disease)
- Measure CoP sway
- Perform DFA on both data sets using combinations of common input parameters found from literature review and the selection criteria developed in Phase 1
- Perform paired t-tests to determine whether significant differences exist in CoP sway between the two groups
  - Larger significant differences (lower p-values) indicating the more discriminative method

REFERENCES

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