Topological nonlinear analysis proposed for neurodegenerative diseases

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Neurodegenerative diseases like amyotrophic lateral sclerosis (ALS), Huntington's disease (HD) and Parkinson's disease (PD), are common progressive nervous system disorders that show intricate clinical patterns.

Using gait fluctuations to evaluate the disease state is an essential technique for clinical trials and healthcare monitoring of neurodegenerative patients.

The research team led by Prof. FAN Jianping and Prof. WANG Lei from the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences proposed a topological analysis framework to characterize the dynamics of the gait fluctuations in different neurodegenerative diseases, which provided a robust qualitative descriptor for the neurodegenerative disease.

The proposed topological motion analysis framework was designed for the gait fluctuation time series analysis. The gait fluctuation time series were embedded into phase spaces using the nonlinear dynamics analysis technique, with which the corresponding point clouds were achieved.

The point clouds were used to perform persistence homology building, i.e., topological signature extraction. The topological signatures of barcodes, persistence diagrams, and persistence landscapes were extracted to classify different gait fluctuation types.

Furthermore, in a comprehensive comparison study on multiple gait fluctuations, including stride-interval, stance-interval and swing-interval-based ones, the proposed method was performed on the dataset of the healthy control group and ALS, HD and PD groups, respectively. The results showed that it is promising in state recognition and neurodegenerative disease classification.

The study demonstrated for the first time that the topological descriptors in different gait fluctuation time series provided a novel insight for human gait modeling and gave evidence for the potential clinical use in biomedical signal analysis.

The study is published in *IEEE Access*.

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