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学際・業際領域

Time Series Classification Using Recurrence Triangle Analysis

TECHNOLOGY SHOWCASE

SATテクノロジー・ショーケース2026

■ Introduction

Understanding and classifying complex time series data is an essential challenge in nonlinear dynamics, neuroscience, and biomedical signal analysis. Many natural and physiological systems exhibit nonlinear, nonstationary, and chaotic behavior, making traditional time-or frequency-domain methods insufficient. To address this, our research explores a geometry-based framework known as the Recurrence Triangle (RT) Analysis, which extends recurrence plot theory to reveal subtle, short-term recurrence patterns in dynamical systems.

RT analysis provides a compact yet highly informative representation of local dynamics by detecting triangular motifs, which are micro-geometric units that capture the fine-scale structure of state transitions. These patterns can serve as discriminative fingerprints of different system behaviors or pathological conditions.

■ Activities

Our ongoing research aims to develop and apply RT-based methods for the classification and characterization of nonlinear time series.

1. We verified the method using toy models such as the Rossler system, Lorenz system, Henon map, and Logistic map, which demonstrate transitions between periodic, mildly chaotic, and chaotic regimes. The RT distributions clearly differentiated these regimes, confirming the method's sensitivity to dynamical complexity.

2. Next, we applied the RT-based framework to clinical data from Parkinson's disease and Healthy controls. The RT features effectively distinguished the two groups with high accuracy.

3. The study also investigated the robustness of RT features under noise, simulating real-world conditions. Results show that increasing the triangle size enhances classification stability and accuracy.

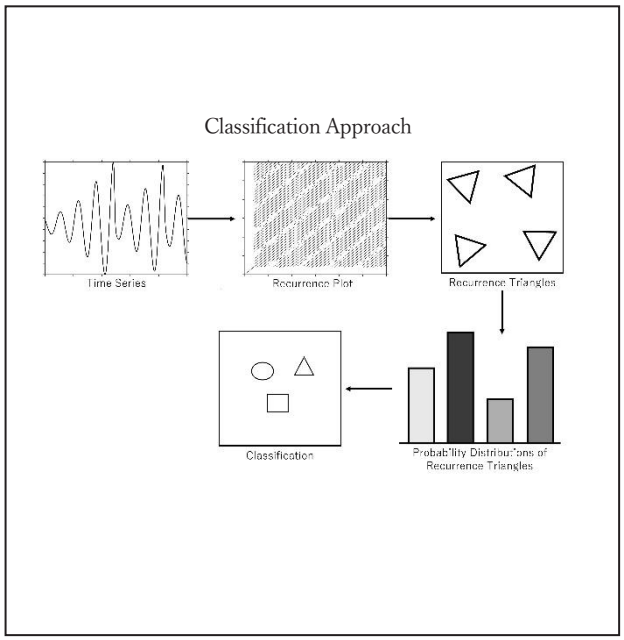
4. Beyond supervised frameworks, we are developing a model for unsupervised classification of time series data using RT-based features. By representing recurrence triangle patterns as probabilistic distributions, the model can automatically cluster data into distinct dynamical categories without labeled samples. This approach broadens the applicability of RT analysis to exploratory studies and data-driven discovery.

Thus, our ongoing work includes combining RT analysis with machine learning to enhance diagnostic prediction and extending it to real-world complex systems such as neurophysiological signal interpretation.

■Related information, etc. (patent-related, facilities)

This research is being conducted at the Mathematical Neuroscience Research Group, Human Information Interaction Research Institute, National Institute of Advanced Industrial Science and Technology, under the supervision of Dr. Masanori Shiro.

No patient applications have been filed at this stage.



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■キーワード： (1) Recurrence Plot
(2) Time series classification
(3) Machine learning

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