Trajectory Classification through Topological Data Analysis: A Study on Simulated and Real-World Datasets

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Abstract: This study introduces Topological Data Analysis (TDA) as a novel method for classifying trajectories, incorporating machine learning techniques to enhance the understanding and interpretation of complex spatial movement patterns. By applying TDA, we leverage the power of machine learning to investigate the structures and relationships within trajectory datasets, offering a new angle on classification methodologies. This research examines how TDA techniques, augmented with machine learning algorithms, can be seamlessly integrated into trajectory analysis to capture spatial features that traditional methods might overlook. Our machine learning-enhanced approach is tested on both simulated data trajectories and real-world datasets from vehicles and ships, illustrating TDA's versatility and effectiveness across various transportation modes. The use of simulated trajectories allows for a controlled evaluation of TDA and machine learning techniques together. Findings from this study highlight the significant potential of TDA, combined with machine learning, to transform trajectory analysis by uncovering intricate spatial patterns and relationships that conventional analytics might miss. Through detailed computational experiments and analysis of real-world data, we demonstrate how the integration of machine learning with TDA can enhance our ability to analyze and interpret trajectory data, opening up new possibilities for research and practical applications in numerous fields.