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Source Identification Model Based on Label Propagation and Graph Ordinary Differential Equations

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Abstract : Identifying the sources of information dissemination is a pivotal task in the study of collective behaviors in networks, enabling us to discern and intercept the critical pathways through which information propagates from its origins. This allows for the control of the information's dissemination impact in its early stages. Numerous methods for source detection rely on pre-existing, underlying propagation models as prior knowledge. Current models that eschew prior knowledge attempt to harness label propagation algorithms to model the statistical characteristics of propagation states or employ Graph Neural Networks (GNNs) for deep reverse modeling of the diffusion process. These approaches are either deficient in modeling the propagation patterns of information or are constrained by the over-smoothing problem inherent in GNNs, which limits the stacking of sufficient model depth to excavate global propagation patterns. Consequently, we introduce the ODESI model. Initially, the model employs a label propagation algorithm to delineate the distribution density of infected states within a graph structure and extends the representation of infected states from integers to state vectors, which serve as the initial states of nodes. Subsequently, the model constructs a deep architecture based on GNNs-coupled Ordinary Differential Equations (ODEs) to model the global propagation patterns of continuous propagation processes. Addressing the challenges associated with solving ODEs on graphs, we approximate the analytical solutions to reduce computational costs. Finally, we conduct simulation experiments on two real-world social network datasets, and the results affirm the efficacy of our proposed ODESI model in source identification tasks.

Keywords : source identification, ordinary differential equations, label propagation, complex networks
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