Invited Talk: Designing Graph Neural Networks as Dynamical Systems

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Abstract

Most graph neural networks operate by exchanging information along the edges of a graph. This local mechanism of diffusion is a key reason for their effectiveness, but it also brings a fundamental architectural question: how can information propagate over sufficient distances to capture long-range dependencies without becoming diluted, oversmoothed, or lost?

In this talk, we reconsider the design of graph neural networks from a dynamical systems perspective. Instead of viewing message passing simply as a stack of generic layers, we interpret it as a neural flow in which propagation, conservation, and dissipation can be explicitly shaped. This viewpoint gives rise to principled architectures for both static and temporal graphs, while also providing theoretical tools to characterize when information is maintained and when it decays.

The keynote will highlight ideas with broad relevance for learning systems: how dynamics can guide model design, how stability and conservation can serve as architectural principles, and how theoretical guarantees can support the development of graph models that transmit information more reliably across complex data.

Invited Speaker's Bio

Full Professor of Machine Learning at the Department of Computer Science, University of Pisa, where he leads the Pervasive AI Laboratory. His research focuses on the design of neural learning systems for graph-structured, temporal, and distributed data, with interests spanning graph representation learning, generative models, continual learning, and pervasive AI. He has co-authored over 250 research works on the field. He has coordinated major European research projects, including EIC Pathfinder EMERGE, and serves as Director of AI Research at Aptus.AI. He sits in the AdCom board of the IEEE Computational Intelligence Society, and previously served as Chair of the IEEE CIS Neural Network technical committee, as Senior Editor of the IEEE Transactions on Neural Networks and as Vice-President of the Italian Association for AI.

Declaration on Generative AI

During the preparation of this work, the author used ChatGPT in order to: grammar and spelling check, paraphrase and reword. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

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