Suzumura Laboratory
Large-Scale Graph Foundation Model for Artificial Intelligence

Laboratory Page: https://sites.google.com/view/toyolab/
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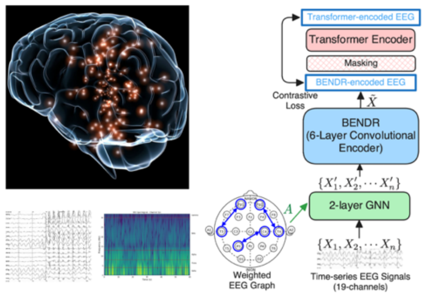
Location: Asano Campus, Information Technology Center
Research Areas: Large-Scale Graph Neural Networks, Artificial Intelligence, Recommender Systems, Neuroscience

At the Suzumura Laboratory, we engage in both foundational research on deep learning for "large-scale graph structures"—a technology of paramount importance as a basis for artificial intelligence—and applied research aimed at solving real-world societal problems. In recent years, with the rapid development of large-scale language models and generative AI, we have been advancing the integration of graph deep learning with these cutting-edge techniques to create "graph foundation models" capable of handling a broader range of data structures and tasks. A graph (or network) is a data structure composed of nodes (vertices) interconnected by edges (links). This representation is remarkably versatile: it can capture social networks on the internet, user purchasing behavior in e-commerce, supply chains that reflect the flow of goods, financial payment networks, road traffic networks, neural networks in neuroscience, protein interaction networks in drug discovery, and even dependency networks within DNA sequence data.

In many cases, such graphs consist of millions to billions of nodes, often enriched with attribute information and spatiotemporal data, underscoring the need for highly efficient and accurate graph deep learning techniques. Graph Neural Networks (GNNs), a prominent example of graph deep learning, have garnered significant attention by learning graph structures through neural network architectures to predict or analyze attributes of nodes, edges, subgraphs, or entire graphs. In practical applications, GNNs have demonstrated success in detecting fraudulent transactions in financial payment data, analyzing supply chain networks, and building product recommendation algorithms for e-commerce platforms, among other achievements.

Our laboratory aims to further advance research in graph deep learning, exploring new territories that include the integration with large-scale language models and generative AI. For example, our research topics encompass: (1) GNN models that can be computed efficiently on extremely large-scale graph structures; (2) technologies for automatically discovering the appropriate granularity of graphs for specific tasks; (3) methods for unifying multiple types of relational data; (4) collaboration with deep reinforcement learning; (5) generating graph structures using adversarial neural networks; (6) designing GNN models that ensure fairness and explainability; and (7) applying transfer learning of GNNs to other problem domains.

In parallel, we consider it essential to maintain a focus on practical applications in AI model research. Through collaborative projects with e-commerce companies and major newspaper publishers, we are developing deep learning models that can accurately and extensively capture user behavior. The insights and technologies derived from these initiatives have led to applications in large-scale recommendation systems and AI chatbots. Furthermore, we are expanding our scope to include the study of human behavior via biological signals such as EEG (electroencephalography). By constructing foundational EEG-based models grounded in large-scale data, we seek wide-ranging applications in fields including Brain–Computer Interfaces (BCI) and mental health. We endeavor to extend this research to foster a more comprehensive understanding of human neural activity while promoting synergy with large-scale language models and other AI technologies. High-performance computing resources, including supercomputers, are indispensable for supporting such diverse research endeavors.



Graph-Enhanced EEG Foundation Model
47th Annual International Conference of the IEEE Engineering in Medicine and Biology Society

At our laboratory, we also devote efforts to the research and development of high-performance computing technologies themselves, ensuring that large-scale data analysis and the training of complex models can be carried out efficiently. A distinctive feature of our laboratory is our commitment to advancing both foundational and applied research from a global perspective, aiming for social implementation of our findings through collaborations with academic institutions and industry partners worldwide. By integrating graph deep learning with large-scale language models and generative AI, we strive to unlock new possibilities in artificial intelligence while fostering interdisciplinary research that both addresses societal challenges and furthers our understanding of human behavior. We warmly invite anyone interested in our work to contact us for further information.