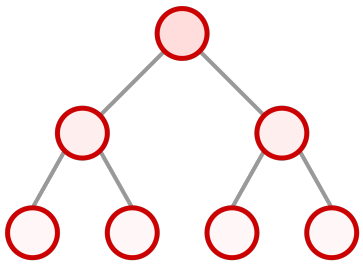
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Distributed Computing

Prof. R. Wattenhofer

Label-Free Compositional Generalization



Compositionality, a core feature of human cognition, can be defined as the ability to understand and generate novel combinations of known concepts in systematic ways. For instance, after seeing the examples {🍍, 🍏}, your brain can easily factorize the concepts of "shape" and "color" and recombine them to produce unseen combinations of the known concepts (e.g., 🍍). Unfortunately, current state-of-the-art neural networks often struggle to model this kind of bias in their internal representations, which translates to significant gaps in compositional generalization and reasoning when deployed in dynamic and frequently changing real-world distributions. Hence, an increasingly wide range of works started investigating how to evaluate and improve compositional generalization in artificial intelligence systems [1, 2]. A major limitation of these frameworks, however, is their dependence on curated and labeled data, which significantly restricts their applicability to natural, real-world scenarios where labels for the specific concepts are often missing or incomplete.

In this project, the key objective would be extending existing approaches that evaluate compositional generalization to natural, unlabeled vision datasets and perform an evaluation of current SOTA models, such as Vision Transformers, with it. Optionally, the insights from the evaluation could also inform the design of new architectural or training techniques that improve compositionality in these models.

Requirements: Strong motivation, ability to work independently, and interest in conducting exciting theoretical and/or empirical research. Solid background in mathematics and deep learning. Good programming skills in Python (and ideally with libraries such as Pytorch). Expertise in Computer Vision and/or LLMs is an advantage.

Interested? Please contact us!

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References

[1] Giacomo Camposampiero, Pietro Barbiero, Hersche Michael, Roger Wattenhofer, and Abbas Rahimi. Scalable evaluation and neural models for compositional generalization. In *Thirty-ninth Conference on Neural Information Processing Systems*, 2025.

[2] Jonathan Thomm, Giacomo Camposampiero, Aleksandar Terzic, Hersche Michael, Bernhard Schölkopf, and Abbas Rahimi. Limits of transformer language models on algorithmic learning. In *Thirty-eight Conference on Neural Information Processing Systems*, 2024.