Graph Neural Network for Combinatorial Optimization Problem

Job-Shop Scheduling Problem (JSSP) is a type of scheduling problem that aims to determine the optimal sequential assignments of machines to multiple jobs consisting of a series of operations while preserving the problem constraints (processing precedence and machine-sharing). For a given JSSP, we are interested in finding an optimal schedule for a number of jobs with varying processing times to be executed in parallel on a number of machines. The optimal makespan is the minimum time elapsed for executing all operations in all jobs.

JSSP is one of the most difficult Constraint Optimization Problems (COPs). It is NP-hard, and many of its variations have been proven to be NP-complete. However, once the value of the optimal makespan is known, the search space of the optimal schedule becomes significantly smaller by adding the extra constraint that the makespan of the schedule equals the optimal makespan.

Previously, we built a machine learning model with Convolutional Neural Networks (CNNs) to predict the optimal makespan of a JSSP and use it to speed up the process of finding the optimal makespan. In this master thesis, we would like to explore if Graph Neural Networks (GNNs) would be able to make better-vectorized representations (compared to representations made by CNN) of a JSSP problem, leading to more accurate prediction of makespan. Furthermore, we will also investigate the generalization of the prediction pipeline to other types of COPs, e.g., traveling salesman problem, etc.

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Technical Requirements:

- Familiarity with deep neural networks
- Proficiency in using PyTorch or TensorFlow
- Combinatorial optimization knowledge is beneficial but not mandatory

References:

- Garey, Michael R., David S. Johnson, and Ravi Sethi. "**The complexity of flowshop and jobshop scheduling.**" Mathematics of operations research 1.2 (1976): 117-129.
- Park, Junyoung, et al. **"Learning to schedule job-shop problems: representation and policy learning using graph neural network and reinforcement learning."** International Journal of Production Research 59.11 (2021): 3360-3377.
- Song, Wen, et al. **"Flexible job shop scheduling via graph neural network and deep reinforcement learning."** IEEE Transactions on Industrial Informatics (2022).
- Wang, Tianze, Amir H. Payberah, and Vladimir Vlassov. **"CONVJSSP: Convolutional Learning for Job-Shop Scheduling Problems."** 2020 19th IEEE International Conference on Machine Learning and Applications (ICMLA). IEEE, 2020.