A Deep Instance Generative Framework for MILP Solvers Under Limited Data Availability

Zijie Geng[1], Xijun Li[1,2], Jie Wang[1,3]*, Xiao Li[1], Yongdong Zhang[1], Feng Wu[1]

[1] University of Science and Technology of China
[2] Noah's Ark Lab, Huawei
[3] Hefei Comprehensive National Science Center

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Presenter: Zijie Geng, M.S. Student,
MIRA Lab,
University of Science and Technology of China

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Paper: https://arxiv.org/pdf/2310.02807.pdf
Project: https://miralab-ustc.github.io/L2O-G2MILP/
Code: https://github.com/MIRALab-USTC/L2O-G2MILP

Background

Mixed-Integer Linear Programming (MILP)

Real-World Problems

Production Planning

Chip Design

Path Planning

Facility Location

MILP Instances

$$\begin{aligned} &\mathbf{argmin}_{\boldsymbol{x}} \ \boldsymbol{c}^{\top}\boldsymbol{x} \\ &\text{subject to } \boldsymbol{A}\boldsymbol{x} \leq \boldsymbol{b} \\ &\qquad \boldsymbol{l} \leq \boldsymbol{x} \leq \boldsymbol{u} \\ &\qquad \boldsymbol{x} \in \mathbb{Z} \times \mathbb{R}^{\boldsymbol{n}-\boldsymbol{p}} \end{aligned}$$

MILP Solvers

GUROBI OPTIMIZATION

SCIP

OptVerse

MILPs can formulate various real-world optimization problems.

Challenge

Limited Availability of MILP Instances

Data Demand

- **Hyperparameter Configuration**
- **ML Model Training**
- **Solvers Evaluation**
- **Identifying Corner Cases**

Limited Availability of Real-world Instances

Labor-Intensive Data Collection

We will train an AI solver. Please collect some MILP instances from the business scenarios for training.

This kind of data **is very scarce**. Our company has only **a few hundred data instances** over the past few years.

That seems not enough.

Proprietary Issues

We require your solver to solve a specific class of MILP problems.

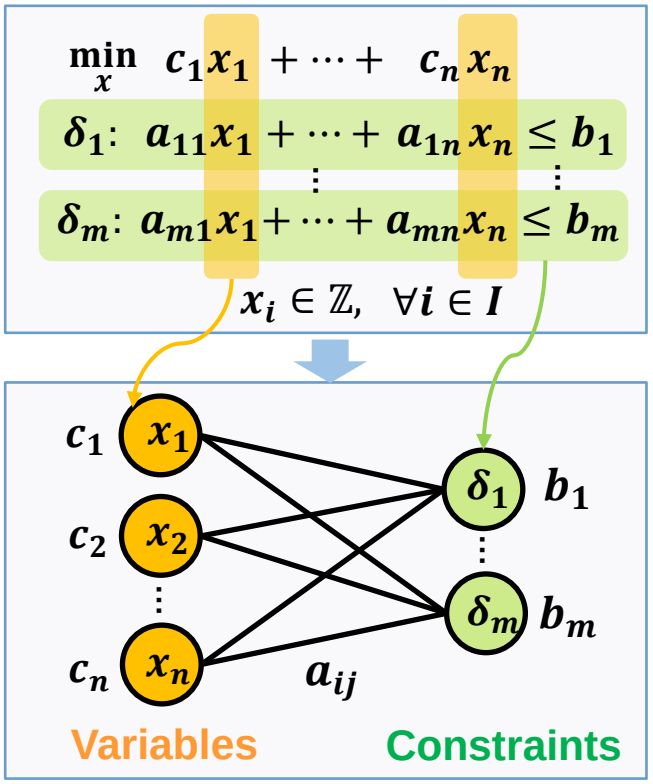
No problem. Kindly provide us with some data for training.

Due to our company's **requirements for confidentiality**, I can only provide **a limited amount of data**.

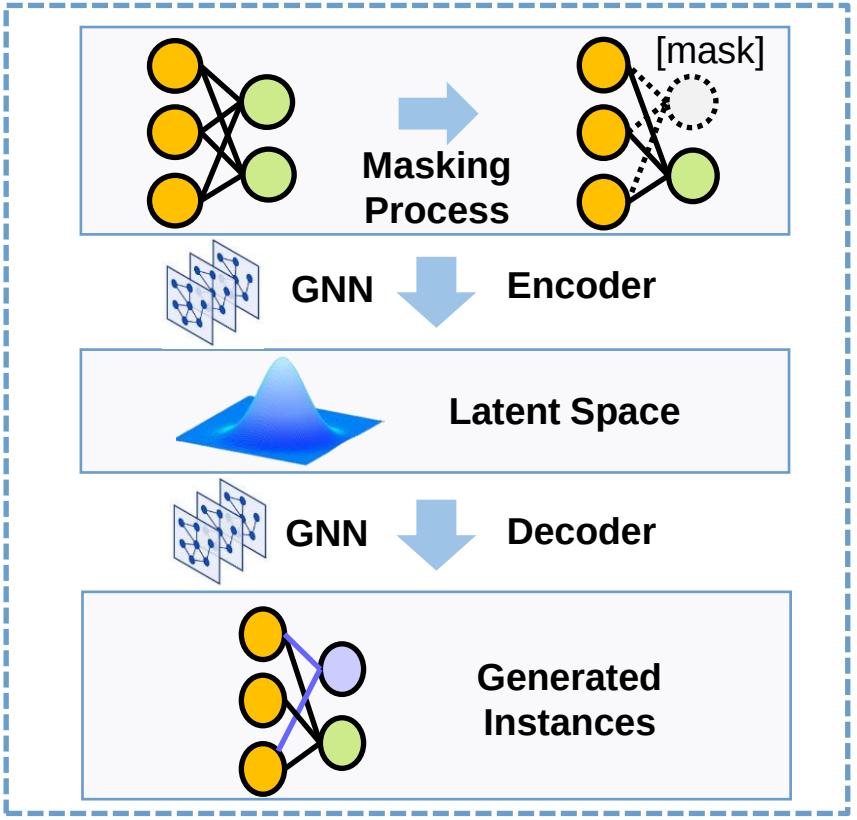
Methodology

G2MILP: The First Deep MILP Generator

Bipartite Graph Representation



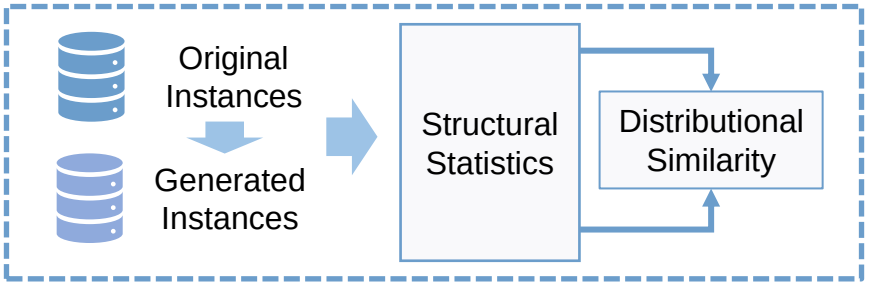
Masked Variational Auto-Encoder (VAE)



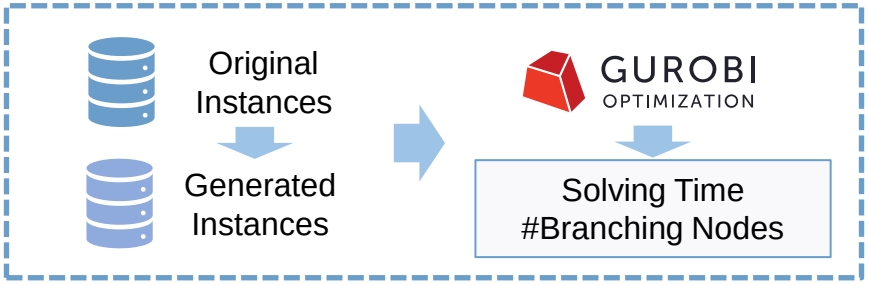
Experiments

Benchmarks to Evaluate the Generated Instances

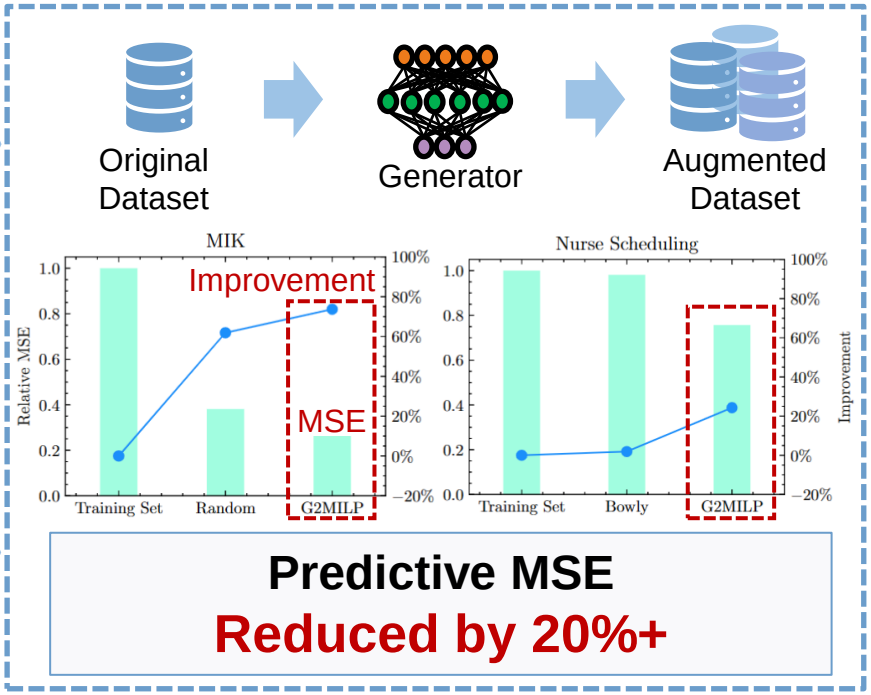
I. Structural Similarity



II. Computational Hardness



III. Downstream Task



G2MILP can generate MILP instances that closely resemble real-world datasets. These instances can facilitate downstream tasks, leading to a performance improvement by MORE THAN 20%.

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