① Multi-Modal Representation

Problem Semantics

Task Description: "..."
Var: {"type" "desc."…}
Con: {"type" "expr."…}
Edge: {…}

Abstract Model

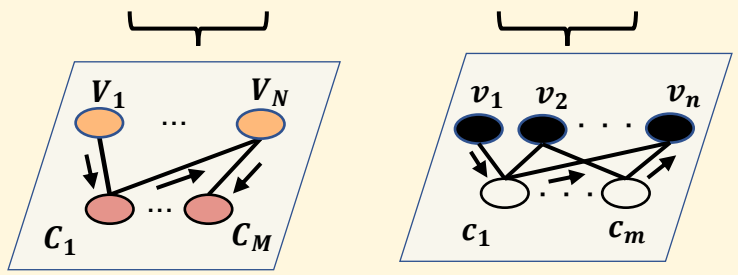
$\min \boldsymbol{c}^T\boldsymbol{x}$
$s.t.\ \boldsymbol{Ax} \le \boldsymbol{b}$
$\boldsymbol{l} \le \boldsymbol{x} \le \boldsymbol{u}$
$\boldsymbol{x} \in \mathbb{Z}^p \times \mathbb{R}^{n-p}$

Instantiation

Instance $\boldsymbol{I_k}$
$= < \boldsymbol{c_k}, \boldsymbol{A_k}, \boldsymbol{b_k}$
$\boldsymbol{l_k}, \boldsymbol{u_k} >$

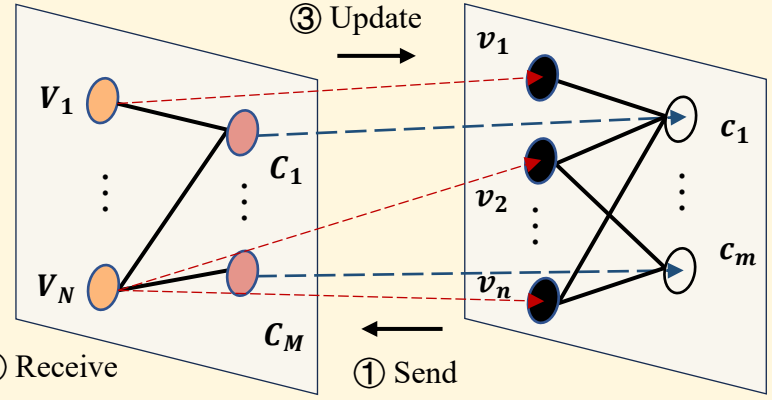
Pre-trained LM | Graph Construction | Instantiate

Intra-layer Message -Passing



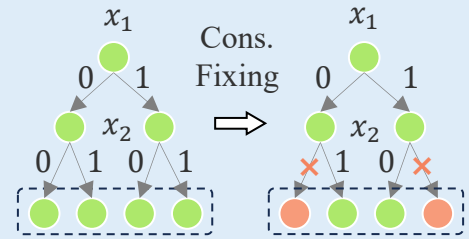
Higher (Abstract-level) GNN | Lower (Instance-level) GNN

Inter-layer Message Passing



② Tight Constraints Priority Module for Training Labels

Constraint Type C_i: $x_1 + x_2 \le 1$

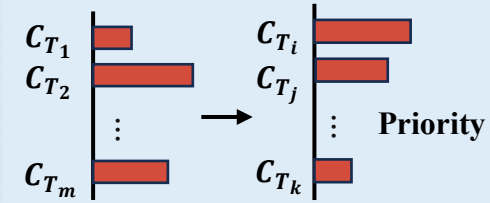


Fixing C_i:
$x_1 + x_2 \le 1 \Rightarrow x_1 + x_2 = 1$
$\rho = |S_{\hat{C}_i}|/|S_{C_i}| = 1/2$

Information Gain of C_i:
$\Delta H_{c_i} = -\log \rho$

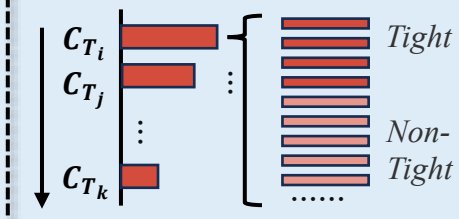
Fixed Constraint Strength ρ

Type	*Strength* ρ
Set Packing	$n/(n+1)$
Set Covering	$n/(2^n-1)$
Bin Packing	$O(1/A\sqrt{n})$
...	...
Knapsack	$O(1/A\sqrt{n})$



Ranking Types by ρ

Critical Tight Constraints (CTC)
Identification by Type Priority



Select $Top - k_c$ within prioritized types

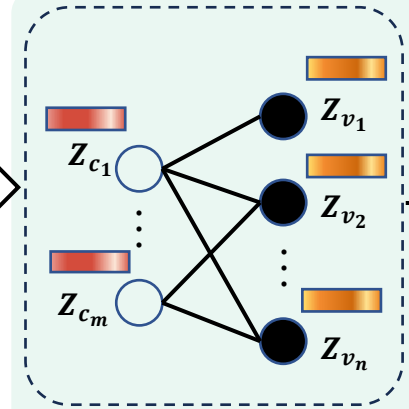
JUDGE Module

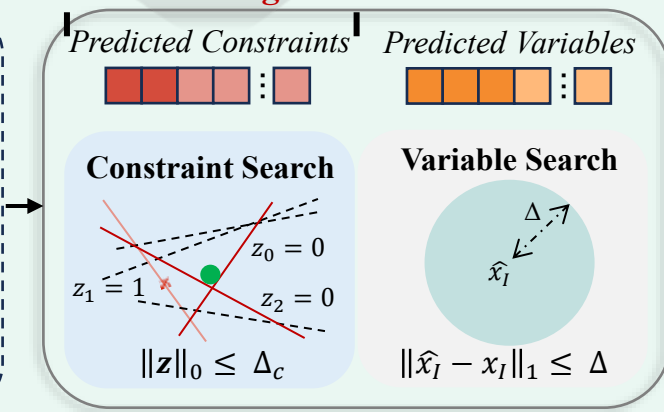
CTC Set

[0,1,1,0,0,1,0,1,…,1]

CTC Set Identification

Detailed in Training





$\min \boldsymbol{c}^T\boldsymbol{x}$
$s.t.\ \boldsymbol{Ax} \le \boldsymbol{b}$
$\boldsymbol{A'x} = \boldsymbol{b'}, \boldsymbol{A'} \subseteq \boldsymbol{A}, \boldsymbol{b'} \subseteq \boldsymbol{b}$
$\boldsymbol{x_p} = \boldsymbol{x_p^{pred}}, \boldsymbol{x_p} \in \boldsymbol{\mathcal{X}_0} \cup \boldsymbol{\mathcal{X}_1}$
$\boldsymbol{l} \le \boldsymbol{x} \le \boldsymbol{u}$
$\boldsymbol{x} \in \mathbb{Z}^p \times \mathbb{R}^{n-p}$

Reduced-model solving

Solver SCIP

③ Model Reduction and Solving