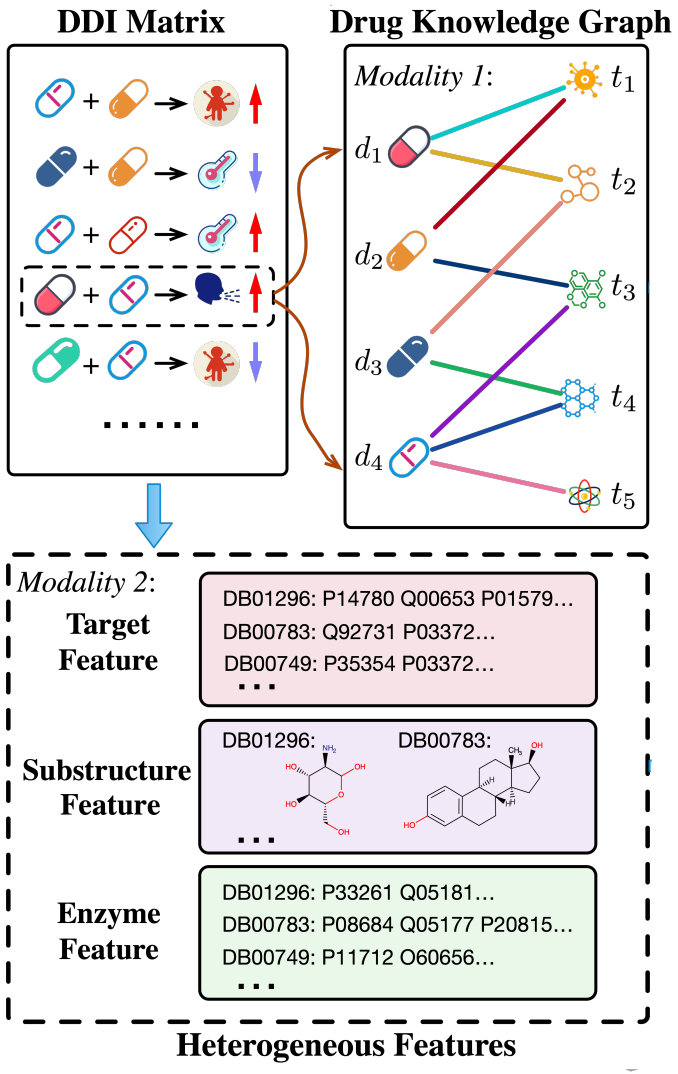
MDNN: A Multimodal Deep Neural Network for Predicting Drug-Drug Interaction Events

Tengfei Lyu[1], Jianliang Gao[1], Ling Tian[1], Zhao Li[2], Peng Zhang[3], and Ji Zhang[4]

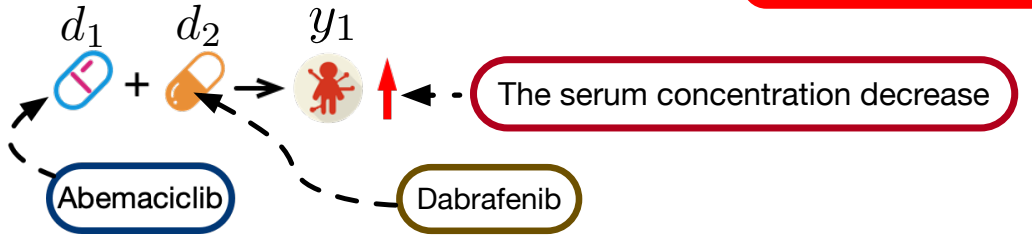
[1]Central South University, [2]Alibaba Group, [3]Gaungzhou University, [4]Zhejiang Lab

Problem Formulation



DDI Matrix: $\mathcal{Y} \in (0, y_{ij})^{N_d \times N_d}$

$$\hat{y}_{ij} = \Gamma(d_i, d_j | \Theta, \mathcal{Y}, \mathcal{G}, \mathcal{X}_d)$$



37264 DDI

572 drugs

65 DDI events

Drug Knowledge Graph: $\mathcal{G} = (\mathcal{D}, \mathcal{R}, \mathcal{T})$

$\mathcal{D}$: Drug $\quad$ $\mathcal{R}$: Relation $\quad$ $\mathcal{T}$: Tail Entity

< DB05812 $\quad$ toxic substance binding $\quad$ P02768 (carrier) >

DKG triples

...

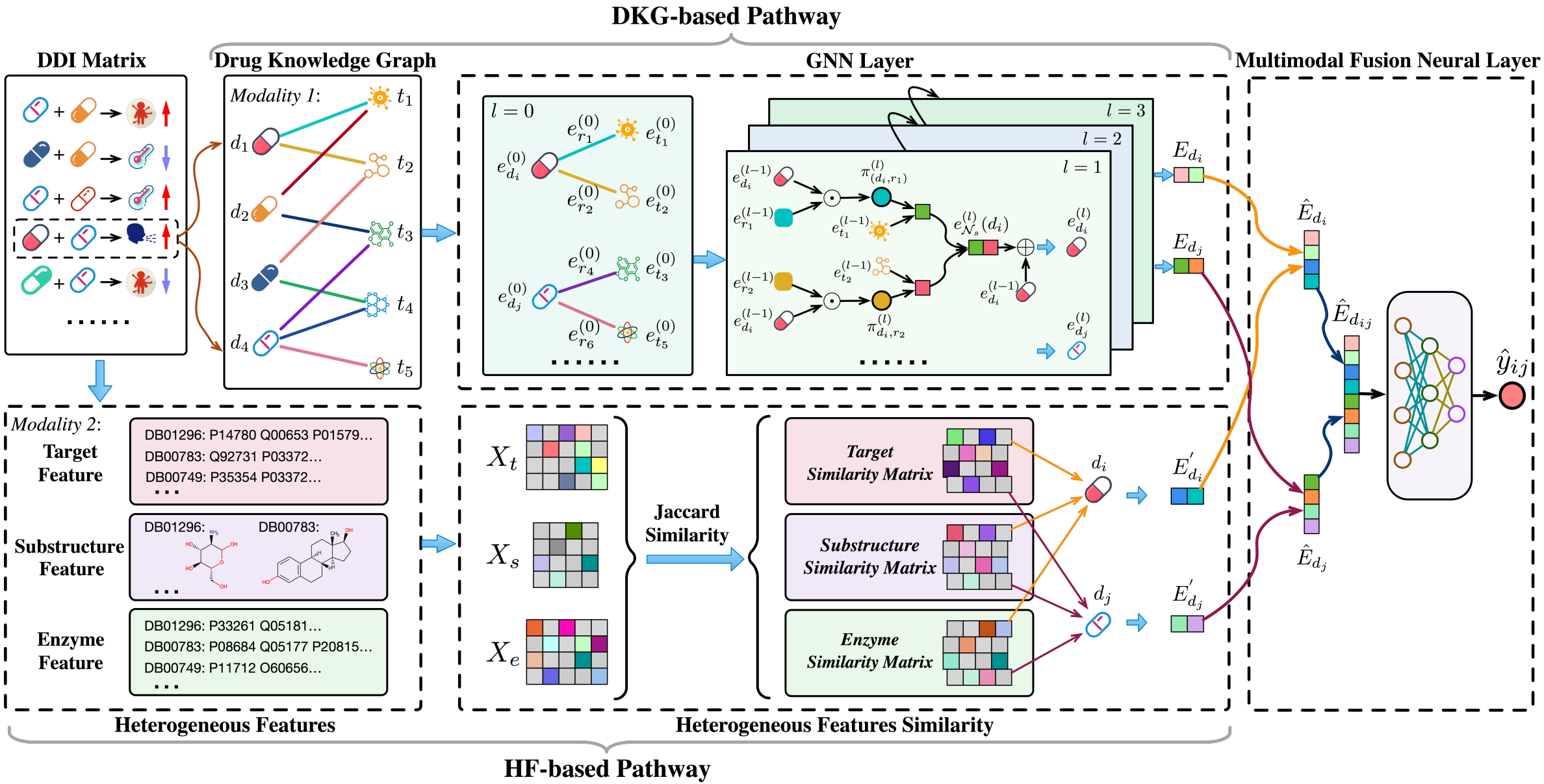
Heterogeneous Features: $\mathcal{X}_d = \{X_t, X_s, X_e\} \in \mathbb{R}^{N_d \times (N_t + N_s + N_e)}$

Targets

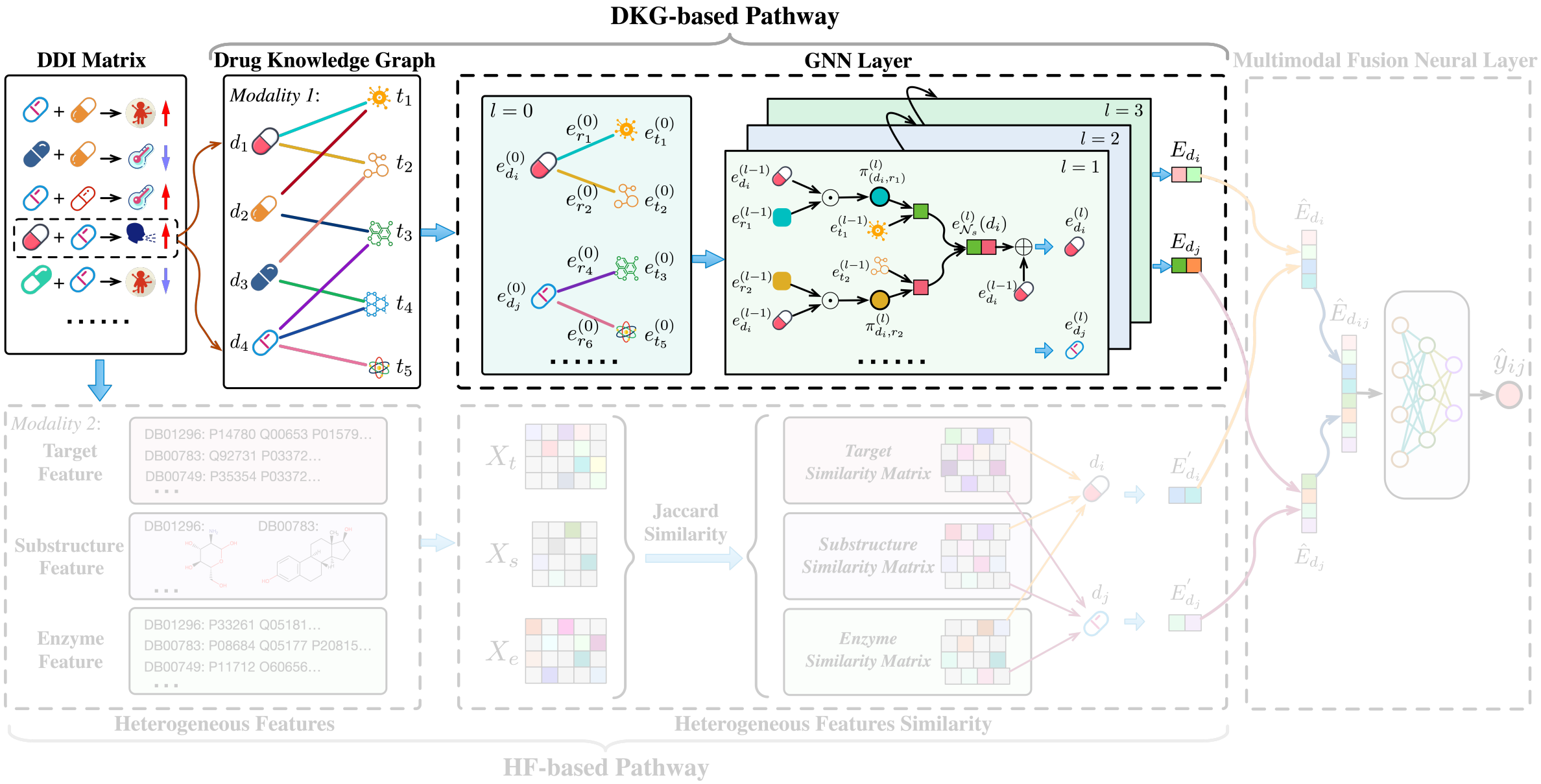
Substructure

Enzyme

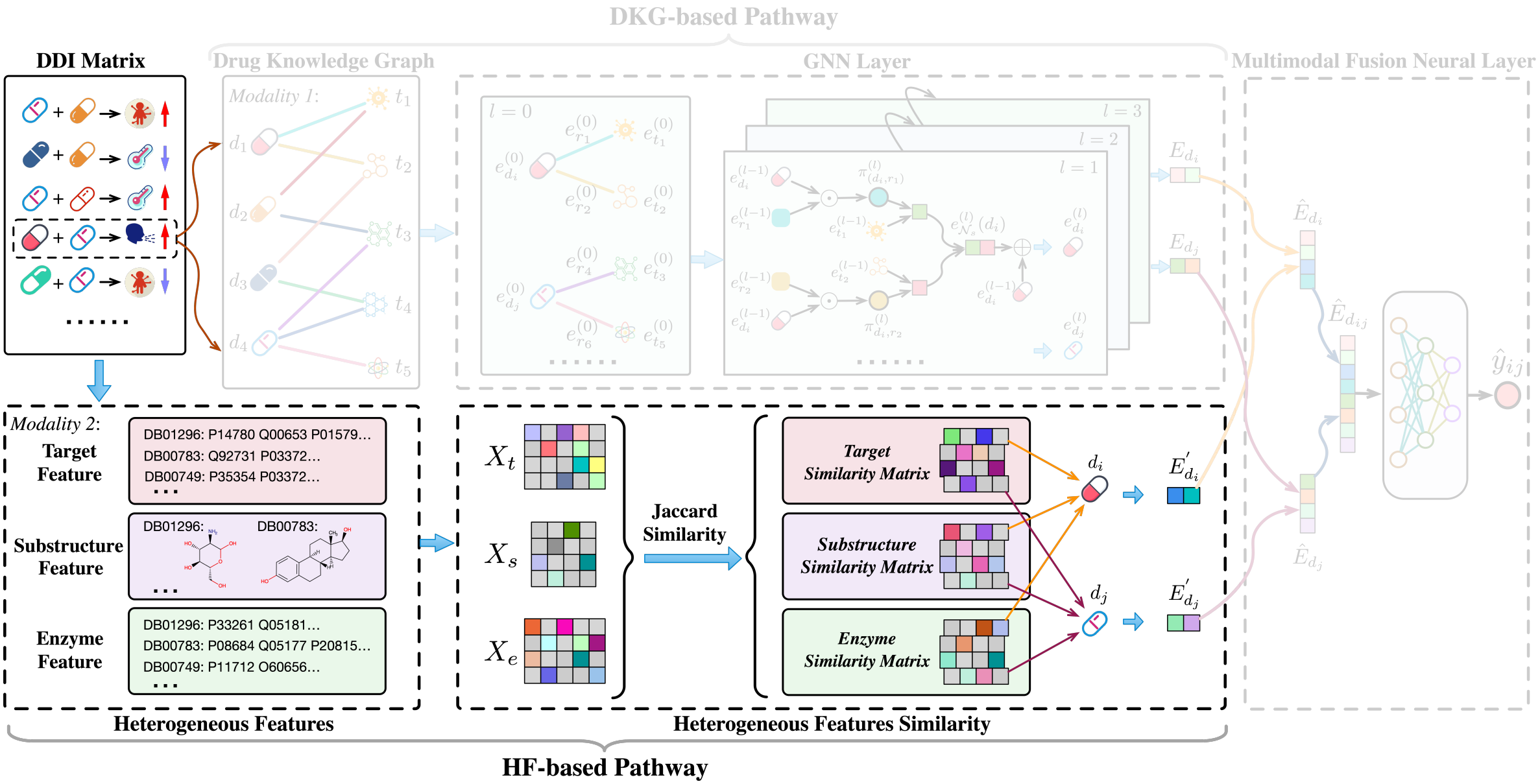
Framework of MDNN



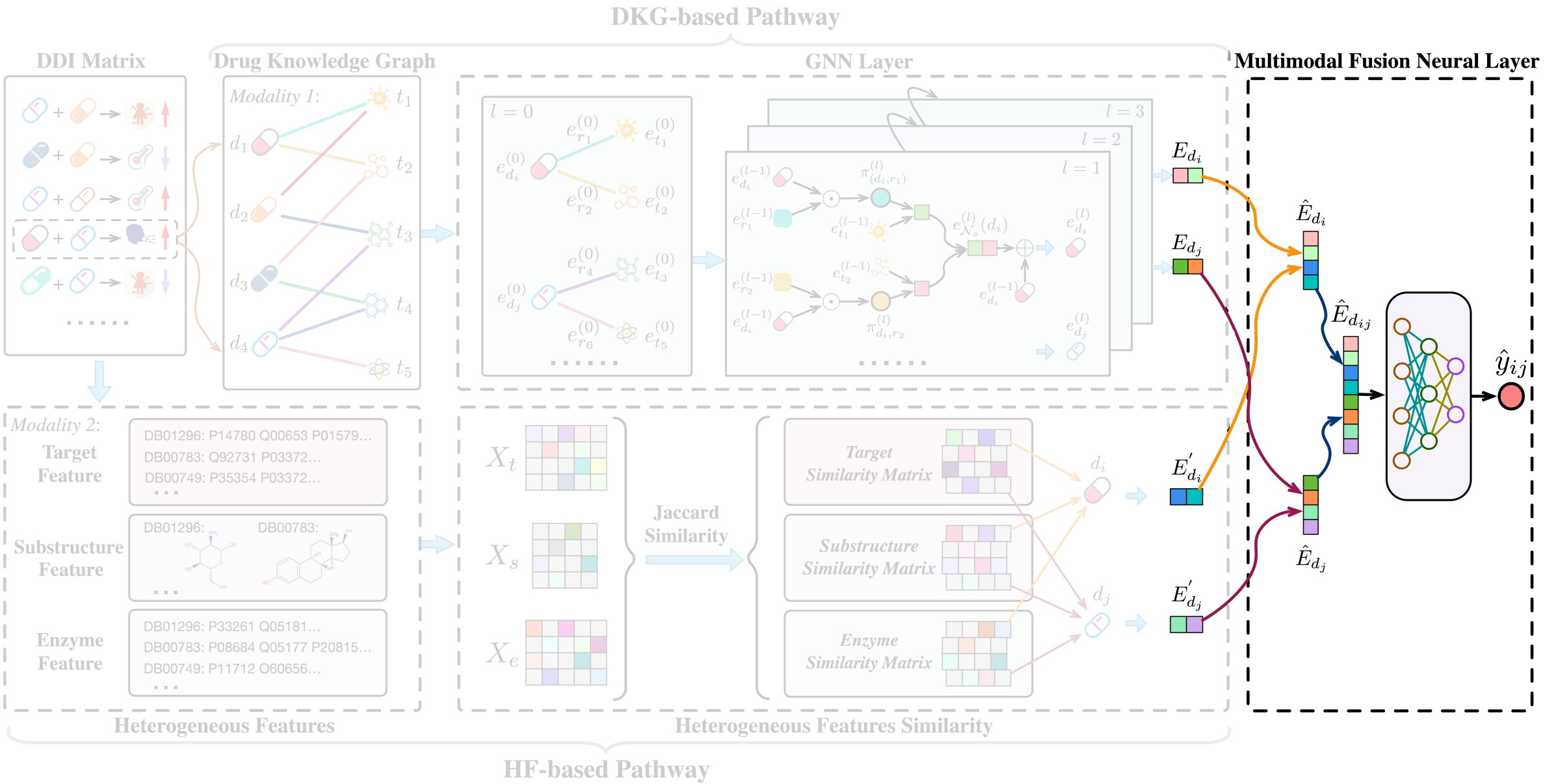
Framework of MDNN



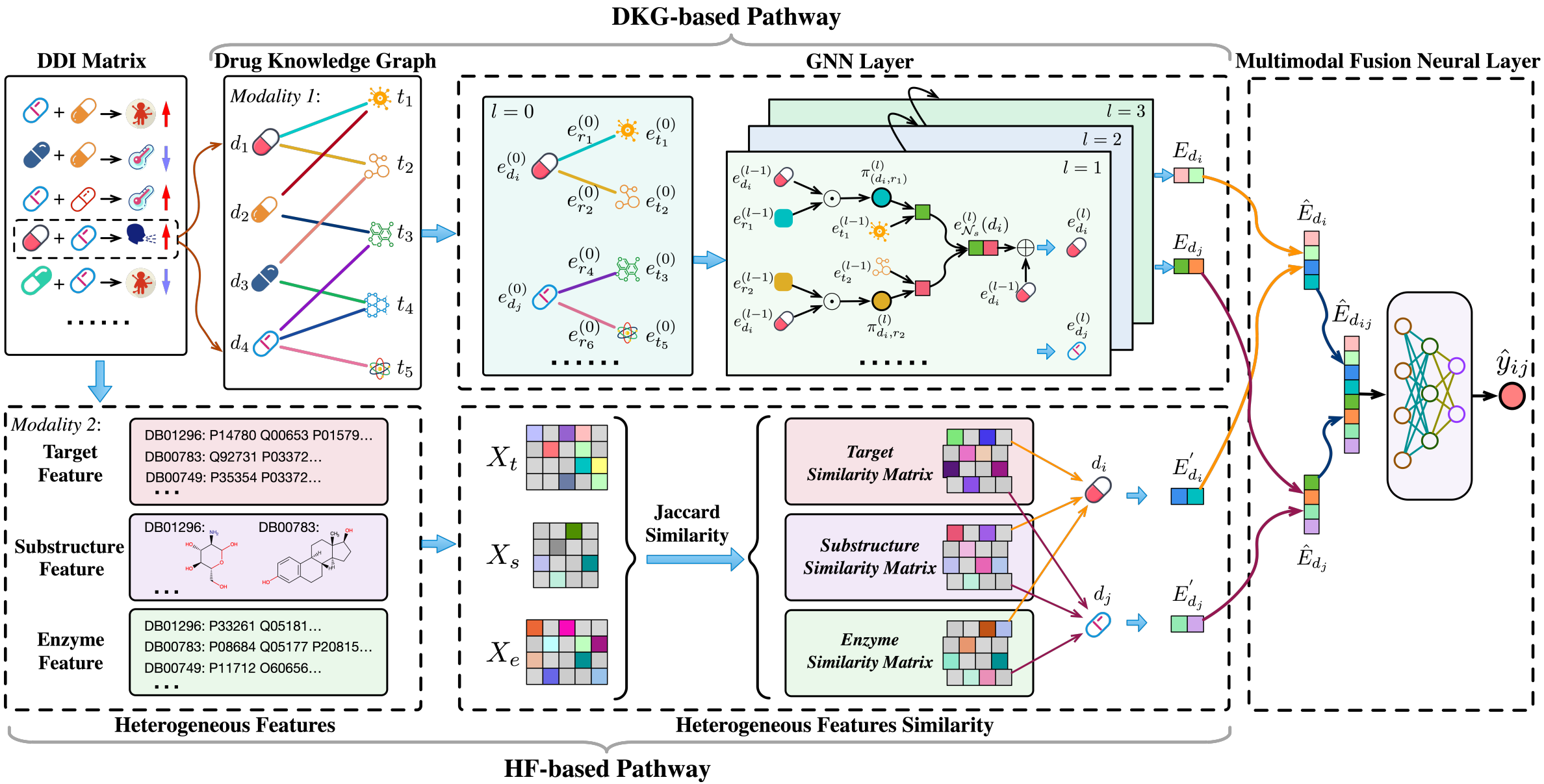
The HF-based Pathway



Multimodal Neural Fusion Layer



Framework of MDNN



Experiments & Results

➢ Performance Comparison

- We compare our results with DDIMDL[1], DeepDDI[2], DNN, RF, KNN and LR.

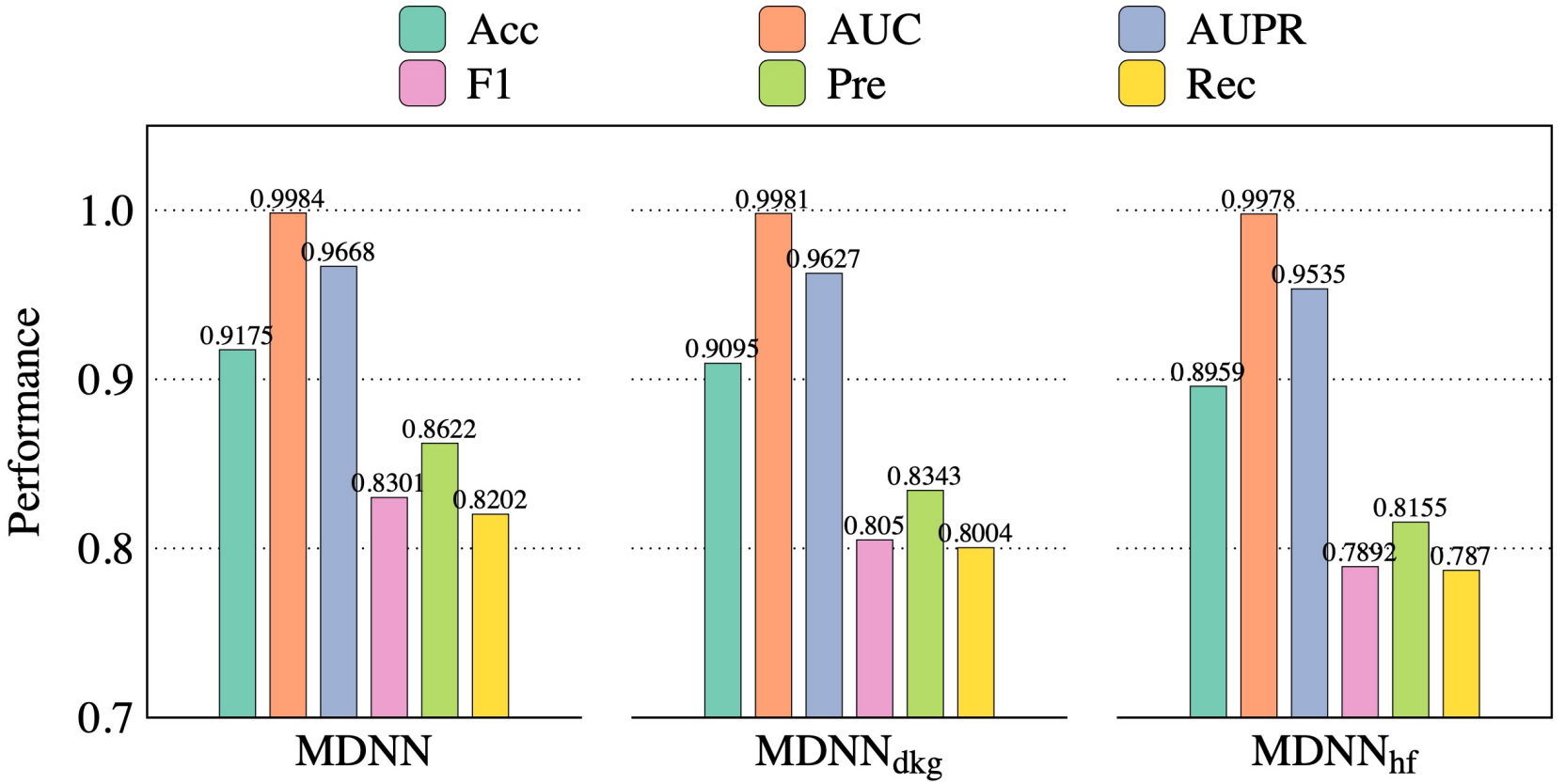
Methods	Acc	AUPR	AUC	F1	Pre	Rec
Logistic Regression	0.7920	0.8400	0.9960	0.5948	0.7437	0.5236
K-Nearest Neighbour	0.7214	0.7716	0.9813	0.4831	0.7174	0.4081
Random Forest	0.7775	0.8349	0.9956	0.5936	0.7893	0.5161
Deep Neural Network	0.8797	0.9134	0.9963	0.7223	0.8047	0.7027
DeepDDI [Ryu *et al.*, 2018]	0.8371	0.8899	0.9961	0.6848	0.7275	0.6611
DDIMDL [Deng *et al.*, 2020]	0.8852	0.9208	0.9976	0.7585	0.8471	0.7182
MDNN	**0.9175**	**0.9668**	**0.9984**	**0.8301**	**0.8622**	**0.8202**

[1] Deng Y, Xu X, Qiu Y, et al. A multimodal deep learning framework for predicting drug–drug interaction events[J]. Bioinformatics, 2020, 36(15): 4316-4322.

[2] Ryu J Y, Kim H U, Lee S Y. Deep learning improves prediction of drug–drug and drug–food interactions[J]. Proceedings of the National Academy of Sciences, 2018, 115(18): E4304-E4311.

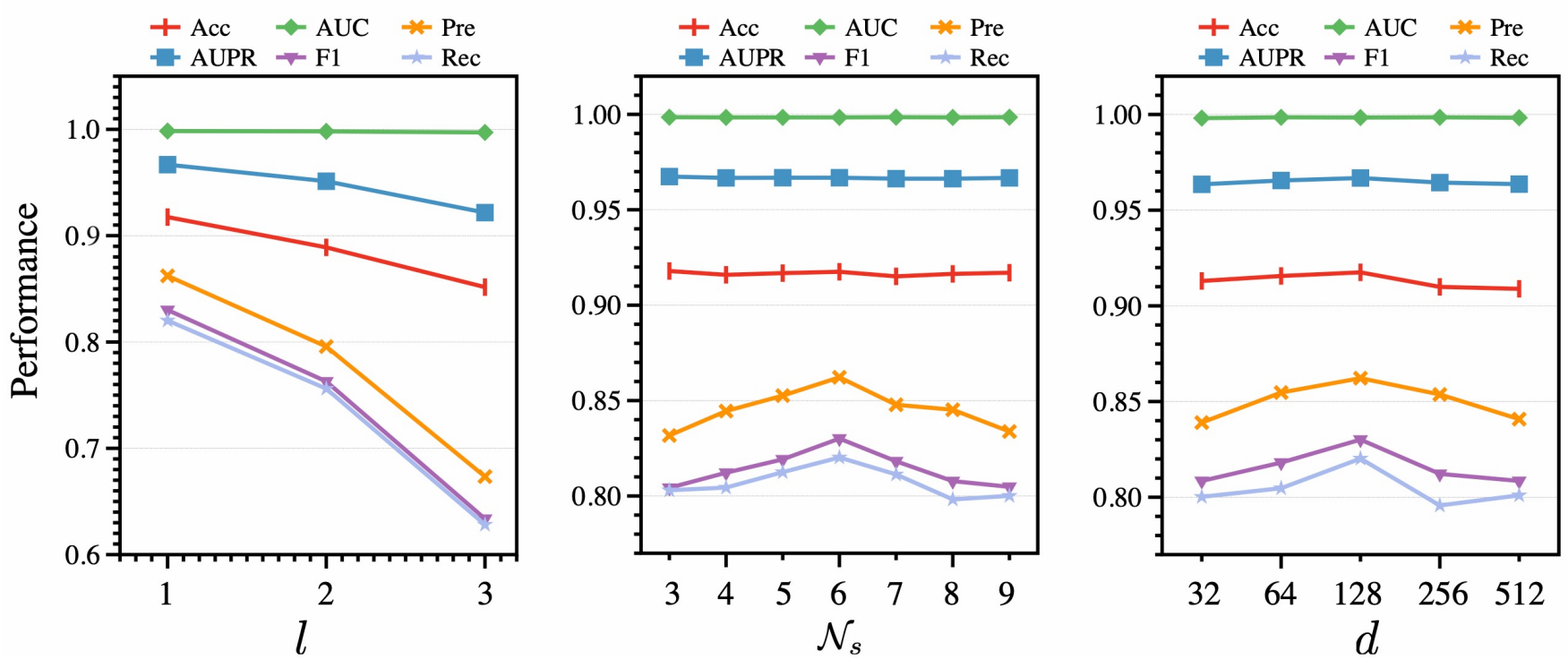
Experiments & Results

- Ablation Test



Experiments & Results

- Parameter Sensitivity Analysis



[3]Datasets are available at https://www.cbioportal.org/

Experiments & Results

- Multi-task Analysis
  - Task A, prediction models are constructed on the DDI between training drugs, and then make predictions for DDI events between training drugs and test drugs.
  - For task B, it make prediction for DDI events between test drugs.

Task	Methods	Acc	AUPR	F1	Rec
Task A	DNN	0.6239	0.6361	0.2997	0.2840
	DeepDDI	0.5774	0.5594	0.3416	0.3890
	DDIMDL	0.6415	0.6558	0.4460	0.4319
	MDNN	**0.6495**	**0.6661**	**0.4471**	**0.4611**
Task B	DNN	0.4087	0.3776	0.1152	0.1093
	DeepDDI	0.3602	0.2781	0.1373	0.1450
	DDIMDL	0.4075	0.3635	0.1590	0.1452
	MDNN	**0.4575**	**0.4215**	**0.1697**	**0.1709**

Thank You

中南大學
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Alibaba Group
阿里巴巴集团

广州大学
GUANGZHOU UNIVERSITY

之江实验室
ZHEJIANG LAB