Self-supervised Heterogeneous Graph Neural Network with Co-contrastive Learning

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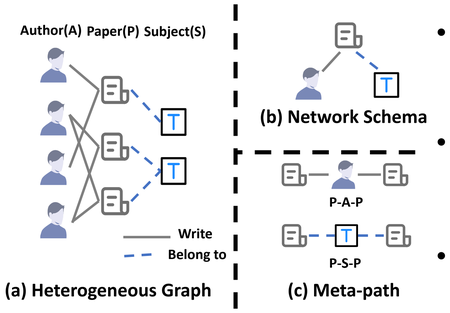
Motivation



- **C1: How to design a heterogeneous contrastive mechanism?**
  → cross view, view-invariant factors
- **C2: How to select proper views in a HG?**
  Local: network schema
  High-order: meta-path
- **C3: How to set a difficult contrastive task?**
  too similar views → too weak signals
  information diversity & harder negative samples

Experiments

- **Node Classification**

Datasets	Metric	Split	GraphSAGE	GAE	Mp2vec	HERec	HetGNN	HAN	DGI	DMGI	HeCo
ACM	Ma-F1	20	47.13±4.7	62.72±3.1	51.91±0.9	55.13±1.5	72.11±0.9	85.66±2.1	79.27±3.8	87.86±0.2	**88.56±0.8**
		40	55.96±6.8	61.61±3.2	62.41±0.6	61.21±0.8	72.02±0.4	87.47±1.1	80.23±3.3	86.23±0.8	**87.61±0.5**
		60	56.59±5.7	61.67±2.9	61.13±0.4	64.35±0.8	74.33±0.6	88.41±1.1	80.03±3.3	87.97±0.4	**89.04±0.5**
	Mi-F1	20	49.72±5.5	68.02±1.9	53.13±0.9	57.47±1.5	71.89±1.1	85.11±2.2	79.63±3.5	87.60±0.8	**88.13±0.8**
		40	60.98±3.5	66.38±1.9	64.43±0.6	62.62±0.9	74.46±0.8	87.21±1.2	80.41±3.0	86.02±0.9	**87.45±0.5**
		60	60.72±4.3	65.71±2.2	62.72±0.3	65.15±0.9	76.08±0.7	88.10±1.2	80.15±3.2	87.82±0.5	**88.71±0.5**
	AUC	20	65.88±3.7	79.50±2.4	71.66±0.7	75.44±1.3	84.36±1.0	93.47±1.5	91.47±2.3	**96.72±0.3**	96.49±0.3
		40	71.06±5.2	79.14±2.5	80.48±0.4	79.84±0.5	85.01±0.6	94.84±0.9	91.52±2.3	96.35±0.3	**96.40±0.4**
		60	70.45±6.2	77.90±2.8	79.33±0.4	81.64±0.7	87.64±0.7	94.68±1.4	91.41±1.9	**96.79±0.2**	96.55±0.3
DBLP	Ma-F1	20	71.97±8.4	90.90±0.1	88.98±0.2	89.57±0.4	89.51±1.1	89.31±0.9	87.93±2.4	89.94±0.4	**91.28±0.2**
		40	73.69±8.4	89.60±0.3	88.68±0.2	89.73±0.4	88.61±0.8	88.87±1.0	88.62±0.6	89.25±0.4	**90.34±0.3**
		60	73.86±8.1	90.08±0.2	90.25±0.1	90.18±0.3	89.56±0.5	89.20±0.8	89.19±0.9	89.46±0.6	**90.64±0.3**
	Mi-F1	20	71.44±8.7	91.55±0.1	89.67±0.1	90.24±0.4	90.11±1.0	90.16±0.9	88.72±2.6	90.78±0.3	**91.97±0.2**
		40	73.61±8.6	90.00±0.3	89.14±0.2	90.15±0.4	89.03±0.7	89.47±0.9	89.22±0.5	89.92±0.4	**90.76±0.3**
		60	74.05±8.3	90.95±0.2	91.17±0.1	91.01±0.3	90.43±0.6	90.34±0.8	90.35±0.8	90.66±0.5	**91.59±0.2**
	AUC	20	90.59±4.3	98.15±0.1	97.69±0.0	98.21±0.2	97.96±0.4	98.07±0.6	96.99±1.4	97.75±0.3	**98.32±0.1**
		40	91.42±4.0	97.85±0.1	97.08±0.0	97.93±0.1	97.70±0.3	97.48±0.6	97.12±0.4	97.23±0.2	**98.06±0.1**
		60	91.73±3.8	98.37±0.1	98.00±0.0	98.49±0.1	97.97±0.2	97.96±0.5	97.76±0.5	97.72±0.4	**98.59±0.1**
Freebase	Ma-F1	20	45.14±4.5	53.81±0.6	53.96±0.7	55.78±0.5	52.72±1.0	53.16±2.8	54.90±0.7	55.79±0.9	**59.23±0.7**
		40	44.88±4.1	52.44±2.3	57.80±1.1	59.28±0.6	48.57±0.5	59.63±2.3	53.40±1.4	49.88±1.9	**61.19±0.6**
		60	45.16±3.1	50.65±0.4	55.94±0.7	56.50±0.4	52.37±0.8	56.77±1.7	53.81±1.1	52.10±0.7	**60.13±1.3**
	Mi-F1	20	54.83±3.0	55.20±0.7	56.23±0.8	57.92±0.5	56.85±0.9	57.24±3.2	58.16±0.9	58.26±0.9	**61.72±0.6**
		40	57.08±3.2	56.05±2.0	61.01±1.3	62.71±0.7	53.96±1.1	63.74±2.7	57.82±0.8	54.28±1.6	**64.03±0.7**
		60	55.92±3.2	53.85±0.4	58.74±0.8	58.57±0.5	56.84±0.7	61.06±2.0	57.96±0.7	56.69±1.2	**63.61±1.6**
	AUC	20	67.63±5.0	73.03±0.7	71.78±0.7	73.89±0.4	70.84±0.7	73.26±2.1	72.80±0.6	73.19±1.2	**76.22±0.8**
		40	66.42±4.7	74.05±0.9	75.51±0.8	76.08±0.4	69.48±0.2	77.74±1.2	72.97±1.1	70.77±1.6	**78.44±0.5**
		60	66.78±3.5	71.75±0.4	74.78±0.4	74.89±0.4	71.01±0.5	75.69±1.5	73.32±0.9	73.17±1.4	**78.04±0.4**
AMiner	Ma-F1	20	42.46±2.5	60.22±2.0	54.78±0.5	58.32±1.1	50.06±0.9	56.07±3.2	51.61±3.2	59.50±2.1	**71.38±1.1**
		40	45.77±1.5	65.66±1.5	64.77±0.5	64.50±0.7	58.97±0.9	63.85±1.5	54.72±2.6	61.92±2.1	**73.75±0.5**
		60	44.91±2.0	63.74±1.6	60.65±0.3	65.53±0.7	57.34±1.4	62.02±1.2	55.45±2.4	61.15±2.5	**75.80±1.8**
	Mi-F1	20	49.68±3.1	65.78±2.9	60.82±0.4	63.64±1.1	61.49±2.5	68.86±4.6	62.39±3.9	63.93±3.3	**78.81±1.3**
		40	52.10±2.2	71.34±1.8	69.66±0.6	71.57±0.7	68.47±2.2	76.89±1.6	63.87±2.9	63.60±2.5	**80.53±0.7**
		60	51.36±2.2	67.70±1.9	63.92±0.5	69.76±0.8	65.61±2.2	74.73±1.4	63.10±3.0	62.51±2.6	**82.46±1.4**
	AUC	20	70.86±2.5	85.39±1.0	81.22±0.3	83.35±0.5	77.96±1.4	78.92±2.3	75.89±2.2	85.34±0.9	**90.82±0.6**
		40	74.44±1.3	88.29±1.0	88.82±0.2	88.70±0.4	85.14±1.6	80.72±2.1	77.86±2.1	88.02±1.3	**92.11±0.6**
		60	74.16±1.3	86.92±0.8	85.57±0.2	87.74±0.5	84.77±0.9	80.39±1.5	77.21±1.4	86.20±1.7	**92.40±0.7**

- **Model Extension**

Task 1		DMGI	HeCo	HeCo_MU	HeCo_GAN
Ma	20	87.86±0.2	88.56±0.8	88.65±0.8	**89.22±1.1**
	40	86.23±0.8	87.61±0.5	87.78±1.7	**88.61±1.6**
	60	87.97±0.4	89.04±0.5	**89.83±0.5**	89.55±1.3
Mi	20	87.60±0.8	88.13±0.8	88.39±0.9	**88.92±0.9**
	40	86.02±0.9	87.45±0.5	87.66±1.7	**88.48±1.7**
	60	87.82±0.5	88.71±0.5	**89.52±0.5**	89.29±1.4
AUC	20	96.72±0.3	96.49±0.3	96.38±0.5	**96.91±0.3**
	40	96.35±0.3	96.40±0.4	96.54±0.5	**97.13±0.5**
	60	96.79±0.2	96.55±0.3	96.67±0.7	**97.12±0.4**
Task 2		DMGI	HeCo	HeCo_MU	HeCo_GAN
NMI		51.66	56.87	58.17	**59.34**
ARI		46.64	56.94	59.41	**61.48**

Contact

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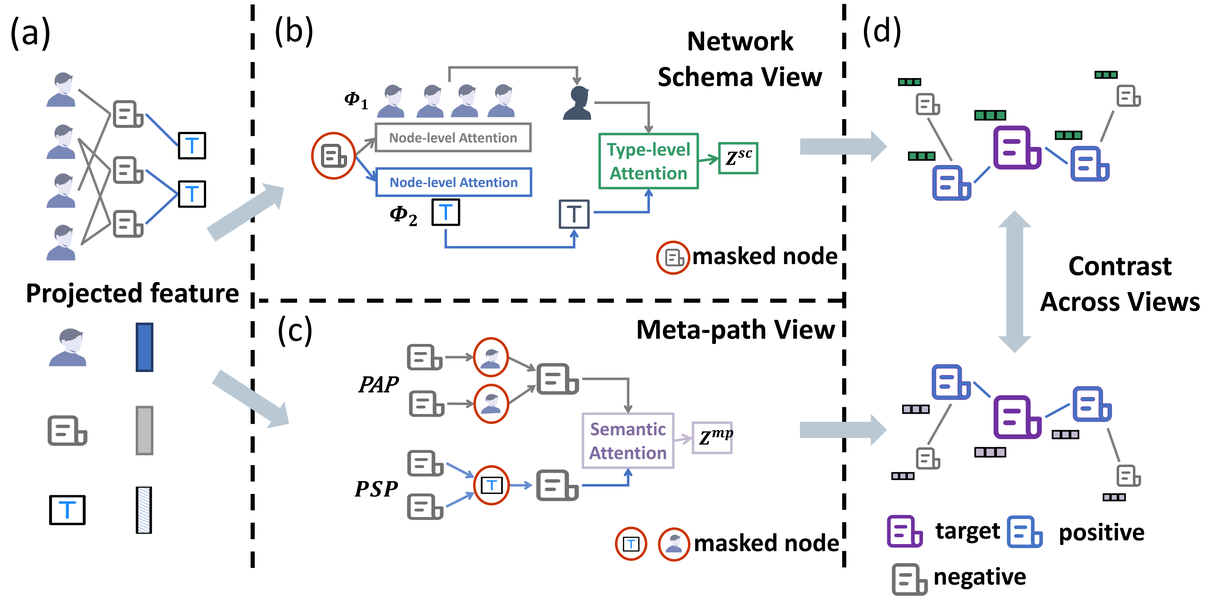
- **Code & Data**: https://github.com/BUPT-GAMMA/HeCo

Method



a) Node Feature Transformation
- Project different type of nodes into common space

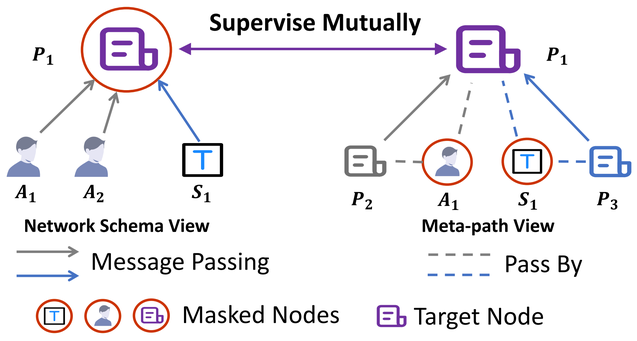
b) Network Schema View Guided Encoder
- Node-level attention
- Type-level attention

c) Meta-path View Guided Encoder
- Meta-path specific GCN
- Semantic-level attention

d) Collaboratively Contrastive Optimization
- If two nodes are connected by many meta-paths, they are positive samples.

- **information diversity:**

➢**View Mask**
- hide different parts of inputs



- **harder negative samples:**

➢**Model Extensions**
- make contrastive more difficult

①**HeCo_GAN**:
utilize a well-trained GAN to generate harder samples

② **HeCo_MU**:
for every node, randomly add k hardest negatives to create new k ones