

FairGE: Fairness-Aware Graph Encoding in Incomplete Social Networks

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Abstract

Graph Transformers (GTs) are increasingly applied to social network analysis, yet their deployment is often constrained by fairness concerns. This issue is particularly critical in social networks, where sensitive attributes are frequently absent due to privacy and ethical restrictions. Existing solutions commonly generate incomplete attributes, which may introduce additional biases and compromise user privacy. To address this challenge, FairGE (Fair Graph Encoding) is introduced as a fairness-aware framework for GTs in incomplete social networks. Instead of generating sensitive attributes, FairGE encodes fairness directly through spectral graph theory. By leveraging the principal eigenvector to represent structural information and padding incomplete sensitive attributes with zeros to maintain independence, FairGE ensures fairness without data reconstruction. Theoretical analysis demonstrates that the method suppresses the influence of non-principal spectral components, thereby enhancing fairness. Extensive experiments on seven real-world social network datasets confirm that FairGE achieves at least a 16% improvement in both statistical parity and equality of opportunity compared with state-of-the-art baselines. The source code is shown in <https://anonymous.4open.science/r/FairGE-609E>.

CCS Concepts

• Information systems → Social networks; Data mining.

Keywords

Social Networks, Graph Learning, Graph Transformers, Fairness, Incomplete Data

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Comparison Result

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Table 1: Comparison on utility (ACC) and fairness (Δ_{SP} and Δ_{EO}) in percentage (%) with Facebook and Income. \uparrow denotes the larger, the better; \downarrow denotes the opposite. The best results are red and bold-faced. The runner-ups are blue and underlined. OOM denotes out-of-memory.

Missing Rate	Facebook(0.1)			Facebook(0.2)			Facebook(0.3)		
Metrics	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow
GCN	80.15 \pm 1.02	5.52 \pm 1.23	8.28 \pm 0.54	77.10 \pm 1.67	8.77 \pm 0.85	5.34 \pm 0.97	77.48 \pm 2.07	8.21 \pm 1.22	4.65 \pm 0.89
SGFormer	90.46\pm1.97	4.51 \pm 0.40	2.93 \pm 0.40	87.02\pm1.83	17.73 \pm 1.04	9.67 \pm 1.41	84.35 \pm 0.92	12.57 \pm 0.79	3.89 \pm 0.17
CoBFormer	80.53 \pm 0.96	3.48 \pm 0.35	4.24 \pm 0.73	84.35 \pm 1.88	3.26 \pm 1.02	1.99 \pm 0.32	86.26\pm1.75	10.70 \pm 1.06	10.79 \pm 0.73
Polynormer	86.26 \pm 1.47	6.21 \pm 0.48	3.63 \pm 0.26	86.64 \pm 1.79	11.38 \pm 1.05	5.01 \pm 0.62	84.35 \pm 1.63	7.32 \pm 0.61	3.63 \pm 0.28
FMP	83.21 \pm 1.45	3.50 \pm 0.36	3.70 \pm 0.23	82.82 \pm 1.78	1.92\pm0.25	1.21 \pm 0.22	82.06 \pm 1.64	6.88 \pm 0.78	3.03 \pm 0.19
FairSIN	81.30 \pm 0.50	2.40 \pm 0.40	1.38\pm0.43	82.44 \pm 1.03	2.71 \pm 1.12	1.12 \pm 1.82	81.68 \pm 0.84	5.58 \pm 0.23	4.83 \pm 0.23
FairGT	88.17 \pm 1.67	2.02\pm0.24	1.90 \pm 0.14	88.93\pm1.36	2.56 \pm 0.16	0.69\pm0.03	85.88 \pm 1.92	1.55\pm0.21	0.69\pm0.08
FairGNN	80.53 \pm 0.75	2.40 \pm 1.45	2.07 \pm 0.32	79.77 \pm 1.08	2.35 \pm 0.41	1.64 \pm 0.45	71.37 \pm 1.56	3.04 \pm 0.16	4.42 \pm 0.24
FairAC	78.37 \pm 1.21	2.87 \pm 1.65	2.13 \pm 0.89	78.88 \pm 1.73	2.90 \pm 0.58	1.32 \pm 0.89	79.01 \pm 1.34	2.07 \pm 0.59	1.35 \pm 0.73
FairGE	88.17\pm1.63	0.89\pm0.04	1.12\pm0.15	86.64 \pm 1.69	0.89\pm0.17	0.17\pm0.08	85.50\pm0.99	1.35\pm0.18	0.95\pm0.29
Missing Rate	Facebook(0.4)			Facebook(0.5)			Facebook(0.6)		
Metrics	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow
GCN	78.24 \pm 1.57	7.12 \pm 0.95	5.86 \pm 0.39	78.63 \pm 1.89	9.37 \pm 0.63	7.93 \pm 0.84	78.24 \pm 1.67	8.26 \pm 0.82	6.55 \pm 0.68
SGFormer	84.35 \pm 1.63	4.45 \pm 0.67	4.05 \pm 0.62	86.26\pm1.73	5.40 \pm 0.73	3.28 \pm 0.74	82.06 \pm 1.93	3.59 \pm 0.53	3.62 \pm 0.68
CoBFormer	84.35 \pm 1.38	3.11 \pm 0.48	5.87 \pm 0.28	84.35 \pm 1.72	5.48 \pm 1.03	1.55 \pm 0.72	83.97\pm1.55	7.19 \pm 0.62	3.86 \pm 0.47
Polynormer	80.53 \pm 1.49	6.18 \pm 0.36	6.48 \pm 0.72	83.59 \pm 1.68	4.35 \pm 1.63	4.06 \pm 0.32	83.59 \pm 0.88	7.65 \pm 0.59	3.28 \pm 0.17
FMP	82.44 \pm 1.81	3.45 \pm 0.61	2.32 \pm 0.28	85.11\pm1.85	2.02 \pm 0.34	3.19 \pm 0.76	78.63 \pm 1.54	4.59 \pm 1.03	6.57 \pm 0.68
FairSIN	82.06 \pm 1.48	3.33 \pm 0.27	2.07\pm0.27	80.53 \pm 1.85	3.80 \pm 0.63	1.38\pm0.26	80.15 \pm 1.92	3.36 \pm 0.57	2.76 \pm 0.41
FairGT	84.73\pm1.47	7.19 \pm 1.05	2.16 \pm 0.62	84.35 \pm 1.72	1.55\pm0.93	2.07 \pm 0.62	84.35\pm1.63	3.65 \pm 0.83	2.07 \pm 1.17
FairGNN	72.90 \pm 1.93	2.75\pm0.45	2.83 \pm 0.17	73.28 \pm 1.94	3.01 \pm 1.01	2.52 \pm 0.21	78.24 \pm 1.73	2.23\pm0.27	1.37\pm0.52
FairAC	80.41 \pm 1.56	3.72 \pm 0.95	2.24 \pm 0.86	79.26 \pm 1.09	2.38 \pm 0.22	1.91 \pm 0.53	79.13 \pm 1.16	2.25 \pm 0.19	2.27 \pm 0.84
FairGE	84.73\pm1.97	0.75\pm0.19	1.38\pm0.89	83.59 \pm 1.73	0.73\pm0.49	0.95\pm0.38	83.59 \pm 1.83	1.27\pm0.68	0.17\pm0.04
Missing Rate	Income(0.1)			Income(0.2)			Income(0.3)		
Metrics	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow
GCN	72.94 \pm 0.78	8.72 \pm 0.45	4.99 \pm 0.67	72.75 \pm 1.23	6.77 \pm 0.23	6.13 \pm 0.56	71.65 \pm 1.05	10.51 \pm 0.34	7.91 \pm 0.76
SGFormer	76.69 \pm 0.99	8.14 \pm 0.12	6.57 \pm 0.34	77.60 \pm 0.87	7.87 \pm 0.67	6.57 \pm 0.23	78.29 \pm 1.34	7.87 \pm 0.12	6.57 \pm 0.56
CoBFormer	79.13\pm0.67	4.72 \pm 0.78	3.62 \pm 1.00	78.35 \pm 1.45	4.17 \pm 0.56	3.83 \pm 0.78	78.18 \pm 1.12	4.64 \pm 0.45	4.93 \pm 0.89
Polynormer	77.84 \pm 1.23	1.02 \pm 0.34	1.21 \pm 0.67	77.71 \pm 1.02	0.95 \pm 0.87	1.45 \pm 0.67	77.91 \pm 1.23	0.71 \pm 0.78	1.23 \pm 0.90
FMP	78.34 \pm 0.87	2.37 \pm 0.45	2.39 \pm 0.91	78.34 \pm 1.34	1.76 \pm 0.78	2.09 \pm 0.56	77.62 \pm 1.12	2.33 \pm 0.67	1.79 \pm 0.78
FairSIN	78.16 \pm 1.12	0.46\pm0.26	1.68 \pm 0.78	78.32 \pm 1.45	0.65\pm0.34	1.53 \pm 0.67	78.17 \pm 1.01	0.65\pm0.87	1.16 \pm 0.91
FairGT	78.87\pm1.01	1.59 \pm 0.67	1.69 \pm 0.87	78.83\pm1.34	1.62 \pm 0.45	1.93 \pm 0.78	78.32\pm1.23	1.66 \pm 0.9	2.32 \pm 0.78
FairGNN	78.69 \pm 1.34	2.78 \pm 0.45	0.98\pm0.67	78.65\pm1.02	2.87 \pm 0.87	0.79 \pm 0.56	78.29 \pm 1.45	2.61 \pm 0.78	0.80\pm0.72
FairAC	77.01 \pm 0.91	1.44 \pm 0.56	1.70 \pm 0.78	78.28 \pm 1.23	0.77 \pm 0.45	0.75\pm0.67	75.20 \pm 1.34	1.95 \pm 0.87	4.41 \pm 0.89
FairGE	78.36 \pm 1.23	0.09\pm0.06	0.75\pm0.67	78.33 \pm 1.12	0.58\pm0.38	0.65\pm0.56	78.36\pm1.01	0.29\pm0.21	1.06\pm0.78
Missing Rate	Income(0.4)			Income(0.5)			Income(0.6)		
Metrics	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow	ACC(%) \uparrow	Δ_{SP} (%) \downarrow	Δ_{EO} (%) \downarrow
GCN	71.22 \pm 0.87	7.49 \pm 0.23	7.78 \pm 0.45	70.10 \pm 1.12	6.41 \pm 0.67	8.69 \pm 0.34	69.11 \pm 0.98	8.18 \pm 0.12	9.65 \pm 0.56
SGFormer	78.75\pm1.23	4.59 \pm 0.45	4.21 \pm 0.78	77.81 \pm 0.92	3.02 \pm 0.56	3.90 \pm 0.23	78.07 \pm 1.34	4.68 \pm 0.45	3.90 \pm 0.67
CoBFormer	78.47 \pm 0.67	4.34 \pm 0.78	4.23 \pm 0.62	78.17 \pm 1.45	3.89 \pm 0.34	2.60 \pm 0.67	77.96 \pm 1.12	3.05 \pm 0.56	2.24 \pm 0.89
Polynormer	78.00 \pm 1.12	0.54\pm0.34	1.05 \pm 0.67	78.07 \pm 1.23	0.91 \pm 0.78	0.72\pm0.56	78.10 \pm 1.02	0.93 \pm 0.67	0.69\pm0.25
FMP	77.30 \pm 0.98	1.24 \pm 0.45	2.16 \pm 0.78	77.76 \pm 1.34	1.94 \pm 0.56	2.54 \pm 0.23	77.09 \pm 1.23	1.94 \pm 0.45	2.54 \pm 0.78
FairSIN	78.16 \pm 1.08	0.64 \pm 0.56	0.85 \pm 0.57	78.02 \pm 1.45	0.69\pm0.34	1.81 \pm 0.67	77.42 \pm 1.12	0.65 \pm 0.78	2.17 \pm 0.16
FairGT	78.37 \pm 1.23	1.54 \pm 0.34	2.34 \pm 0.67	78.42\pm1.06	1.59 \pm 0.45	3.29 \pm 0.78	78.61\pm1.34	1.31 \pm 0.87	2.70 \pm 0.95
FairGNN	78.82\pm1.34	2.64 \pm 0.45	0.79\pm0.78	78.59\pm1.23	1.61 \pm 0.56	1.94 \pm 0.23	78.72\pm1.45	0.63 \pm 0.67	1.94 \pm 0.65
FairAC	78.18 \pm 0.91	0.75 \pm 0.56	1.06 \pm 0.78	78.36 \pm 1.12	0.69\pm0.45	1.00 \pm 0.67	76.58 \pm 1.34	0.57\pm0.17	0.75 \pm 0.12
FairGE	78.12 \pm 1.12	0.47\pm0.34	0.30\pm0.27	78.31 \pm 1.01	0.54\pm0.38	0.50\pm0.46	78.44 \pm 1.23	0.53\pm0.37	0.30\pm0.18

Table 2: Comparison results in Bail and Credit.

Missing Rate Metrics	Bail(0.1)			Bail(0.2)			Bail(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	90.23 \pm 1.02	6.33 \pm 0.45	4.05 \pm 0.78	90.42 \pm 0.67	6.53 \pm 0.34	4.47 \pm 0.21	90.60 \pm 0.99	6.63 \pm 0.53	4.41 \pm 0.12
SGFormer	92.76 \pm 0.89	8.24 \pm 0.12	5.97 \pm 1.45	92.47 \pm 0.32	7.97 \pm 0.67	5.68 \pm 0.45	92.48 \pm 0.23	7.73 \pm 0.76	5.35 \pm 0.21
CoBFormer	96.22\pm0.56	6.87 \pm 0.78	2.96 \pm 1.23	95.50\pm0.56	6.75 \pm 0.45	2.66 \pm 0.67	94.97\pm0.34	6.78 \pm 0.87	2.47 \pm 0.45
Polynormer	93.97 \pm 1.23	<u>3.94\pm0.34</u>	2.13 \pm 0.98	94.10 \pm 0.67	4.86 \pm 0.56	2.14 \pm 0.23	<u>94.23\pm0.12</u>	5.12 \pm 0.45	<u>1.99\pm0.67</u>
FMP	90.75 \pm 0.99	7.85 \pm 0.23	7.64 \pm 1.45	90.66 \pm 0.87	7.73 \pm 0.34	7.38 \pm 0.67	90.65 \pm 0.56	7.62 \pm 0.78	7.10 \pm 0.21
FairSIN	85.90 \pm 1.02	5.21 \pm 0.45	3.47 \pm 0.78	86.31 \pm 0.67	5.41 \pm 0.34	3.57 \pm 0.21	86.11 \pm 0.99	5.98 \pm 0.53	4.68 \pm 0.12
FairGT	92.63 \pm 0.89	4.05 \pm 0.12	1.88\pm1.45	92.58 \pm 0.32	<u>2.95\pm0.67</u>	<u>1.90\pm0.45</u>	91.52 \pm 0.23	<u>3.09\pm0.76</u>	2.24 \pm 0.21
FairGNN	92.31 \pm 0.56	6.98 \pm 0.78	3.62 \pm 1.23	92.25 \pm 0.56	6.87 \pm 0.45	3.47 \pm 0.67	82.23 \pm 0.34	6.87 \pm 0.87	3.53 \pm 0.45
FairAC	88.77 \pm 1.23	7.62 \pm 0.34	4.54 \pm 0.98	89.38 \pm 0.67	8.40 \pm 0.56	4.55 \pm 0.23	89.83 \pm 0.12	7.37 \pm 0.45	4.30 \pm 0.67
FairGE	<u>94.90\pm0.99</u>	2.22\pm0.23	<u>1.97\pm1.45</u>	<u>94.12\pm0.87</u>	2.61\pm0.34	1.69\pm0.67	94.11 \pm 0.56	2.99\pm0.78	1.77\pm0.21
Missing Rate Metrics	Bail(0.4)			Bail(0.5)			Bail(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	90.74 \pm 0.67	7.12 \pm 0.14	4.73 \pm 0.82	90.75 \pm 0.95	7.17 \pm 0.43	4.77 \pm 0.31	90.76 \pm 1.12	7.21 \pm 0.69	4.90 \pm 0.24
SGFormer	92.88 \pm 1.45	7.35 \pm 0.29	4.86 \pm 0.56	92.95 \pm 0.78	7.28 \pm 0.51	5.09 \pm 0.19	<u>92.74\pm0.87</u>	7.31 \pm 0.32	5.01 \pm 0.15
CoBFormer	<u>93.95\pm0.89</u>	5.95 \pm 0.37	2.13 \pm 1.02	<u>93.66\pm0.61</u>	5.94 \pm 0.47	1.82 \pm 0.25	92.59 \pm 0.94	5.32 \pm 0.58	<u>1.38\pm0.22</u>
Polynormer	94.63\pm1.28	5.50 \pm 0.12	<u>1.57\pm0.93</u>	94.11\pm0.54	5.49 \pm 0.39	<u>1.76\pm0.27</u>	93.70\pm1.01	5.08 \pm 0.42	1.50 \pm 0.18
FMP	90.54 \pm 0.92	7.54 \pm 0.41	<u>6.78\pm1.37</u>	90.43 \pm 0.83	7.59 \pm 0.52	<u>6.67\pm0.33</u>	90.33 \pm 0.76	7.55 \pm 0.64	6.42 \pm 0.29
FairSIN	86.36 \pm 1.11	6.29 \pm 0.23	4.89 \pm 0.74	85.53 \pm 0.69	6.42 \pm 0.45	4.78 \pm 0.21	82.86 \pm 1.23	6.70 \pm 0.57	4.96 \pm 0.31
FairGT	90.89 \pm 1.34	<u>2.46\pm0.32</u>	2.17 \pm 0.68	90.89 \pm 0.72	<u>3.45\pm0.48</u>	2.30 \pm 0.24	91.25 \pm 1.19	<u>3.82\pm0.46</u>	2.03 \pm 0.27
FairGNN	91.38 \pm 0.76	6.89 \pm 0.18	3.83 \pm 1.15	91.12 \pm 0.64	<u>7.02\pm0.59</u>	3.95 \pm 0.36	91.20 \pm 0.92	6.95 \pm 0.71	3.85 \pm 0.33
FairAC	89.79 \pm 1.03	7.08 \pm 0.26	4.63 \pm 0.87	89.26 \pm 0.76	7.03 \pm 0.44	4.15 \pm 0.22	90.17 \pm 1.08	6.70 \pm 0.54	4.45 \pm 0.28
FairGE	93.41 \pm 0.97	1.69\pm0.42	1.01\pm0.51	93.45 \pm 0.67	1.88\pm0.53	1.67\pm0.34	92.15 \pm 1.35	2.66\pm0.62	1.18\pm0.39
Missing Rate Metrics	Credit(0.1)			Credit(0.2)			Credit(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	75.70 \pm 0.82	4.54 \pm 0.31	4.44 \pm 1.25	75.37 \pm 0.96	5.06 \pm 0.48	5.06 \pm 0.22	75.37 \pm 1.34	5.06 \pm 0.73	5.06 \pm 0.29
SGFormer	72.23 \pm 1.33	8.35 \pm 0.27	7.39 \pm 0.69	72.70 \pm 0.84	4.85 \pm 0.54	3.43 \pm 0.19	73.23 \pm 0.91	3.26 \pm 0.46	3.55 \pm 0.16
CoBFormer	75.67 \pm 0.95	2.44 \pm 0.39	2.22 \pm 1.18	75.39 \pm 0.73	2.11 \pm 0.49	2.11 \pm 0.25	76.01 \pm 1.02	1.59 \pm 0.59	1.78 \pm 0.24
Polynormer	77.24 \pm 1.08	<u>0.20\pm0.13</u>	<u>0.19\pm0.12</u>	76.99 \pm 0.58	0.46 \pm 0.37	0.28 \pm 0.26	76.21 \pm 1.17	<u>0.45\pm0.43</u>	0.26\pm0.19
FMP	75.96 \pm 1.21	1.57 \pm 0.42	1.87 \pm 1.36	76.00 \pm 0.65	1.28 \pm 0.50	1.78 \pm 0.33	76.11 \pm 1.29	1.47 \pm 0.61	1.85 \pm 0.28
FairSIN	<u>77.64\pm1.14</u>	0.53 \pm 0.23	0.57 \pm 0.77	77.72 \pm 0.68	0.56 \pm 0.46	0.49 \pm 0.21	77.50 \pm 1.32	0.52 \pm 0.50	0.54 \pm 0.32
FairGT	77.27 \pm 1.47	1.96 \pm 0.32	1.30 \pm 1.03	77.26 \pm 0.79	2.08 \pm 0.45	1.91 \pm 0.24	77.29 \pm 1.15	1.52 \pm 0.48	1.46 \pm 0.26
FairGNN	75.06 \pm 0.78	1.12 \pm 0.18	1.18 \pm 1.15	74.29 \pm 0.64	1.07 \pm 0.59	0.98 \pm 0.36	75.10 \pm 0.92	1.94 \pm 0.71	1.53 \pm 0.33
FairAC	77.18 \pm 1.03	2.21 \pm 0.26	2.15 \pm 0.87	<u>77.87\pm0.76</u>	0.09\pm0.05	<u>0.15\pm0.12</u>	77.67\pm1.08	2.84 \pm 0.54	2.93 \pm 0.28
FairGE	77.72\pm0.97	0.03\pm0.02	0.12\pm0.10	78.08\pm0.67	<u>0.24\pm0.13</u>	0.07\pm0.04	77.67\pm1.35	0.16\pm0.12	<u>0.30\pm0.09</u>
Missing Rate Metrics	Credit(0.4)			Credit(0.5)			Credit(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	75.85 \pm 1.45	6.03 \pm 0.29	4.04 \pm 1.23	74.85 \pm 0.98	5.03 \pm 0.47	6.04 \pm 0.31	74.85 \pm 1.12	6.06 \pm 0.69	6.04 \pm 0.24
SGFormer	73.40 \pm 0.89	3.89 \pm 0.12	3.85 \pm 0.56	73.34 \pm 0.78	3.98 \pm 0.51	3.58 \pm 0.19	72.37 \pm 0.87	4.89 \pm 0.32	4.85 \pm 0.15
CoBFormer	76.08 \pm 1.02	1.47 \pm 0.34	1.18 \pm 0.78	75.92 \pm 0.67	1.58 \pm 0.45	1.97 \pm 0.21	76.30 \pm 0.99	1.91 \pm 0.53	2.08 \pm 0.12
Polynormer	76.18 \pm 1.23	0.48 \pm 0.34	<u>0.27\pm0.18</u>	76.61 \pm 0.67	0.61 \pm 0.56	<u>0.65\pm0.23</u>	<u>77.62\pm1.01</u>	<u>0.60\pm0.42</u>	<u>0.64\pm0.18</u>
FMP	75.59 \pm 0.99	1.51 \pm 0.23	1.92 \pm 1.45	75.55 \pm 0.87	1.91 \pm 0.34	1.86 \pm 0.67	75.48 \pm 0.56	1.57 \pm 0.78	1.23 \pm 0.21
FairSIN	77.32 \pm 1.11	<u>0.40\pm0.23</u>	0.51 \pm 0.24	<u>77.21\pm0.69</u>	0.69 \pm 0.45	0.70 \pm 0.21	77.33 \pm 1.23	0.92 \pm 0.57	0.88 \pm 0.31
FairGT	77.12 \pm 1.34	2.15 \pm 0.32	1.78 \pm 0.68	77.09 \pm 0.72	1.43 \pm 0.48	1.48 \pm 0.24	76.76 \pm 1.19	2.00 \pm 0.46	1.78 \pm 0.27
FairGNN	75.03 \pm 0.76	1.92 \pm 0.18	1.52 \pm 1.15	76.39 \pm 0.64	1.75 \pm 0.59	1.16 \pm 0.36	75.66 \pm 0.92	1.86 \pm 0.71	1.47 \pm 0.33
FairAC	77.75\pm1.03	0.62 \pm 0.26	0.62 \pm 0.87	77.77\pm0.76	<u>0.59\pm0.44</u>	<u>0.65\pm0.22</u>	77.56 \pm 1.08	0.72 \pm 0.54	0.96 \pm 0.28
FairGE	<u>77.60\pm0.97</u>	0.04\pm0.03	0.15\pm0.09	77.13 \pm 0.67	0.48\pm0.53	0.64\pm0.34	78.20\pm1.35	0.37\pm0.22	0.41\pm0.39

Table 3: Comparison results in Pokec-z-R and Pokec-z-G.

Missing Rate Metrics	Pokec-z-R(0.1)			Pokec-z-R(0.2)			Pokec-z-R(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	62.59 \pm 1.74	6.80 \pm 0.82	6.66 \pm 0.48	62.16 \pm 1.93	5.54 \pm 0.59	5.06 \pm 1.02	61.96 \pm 1.47	4.18 \pm 0.59	3.70 \pm 0.85
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	64.11 \pm 1.76	2.29 \pm 0.69	3.80 \pm 0.88	66.95 \pm 1.69	2.74 \pm 0.94	1.49 \pm 0.73	65.51 \pm 1.83	1.20 \pm 1.58	5.18 \pm 0.84
Polynormer	<u>66.64\pm1.85</u>	2.67 \pm 0.33	1.68 \pm 0.68	64.85 \pm 1.93	1.79 \pm 1.37	2.17 \pm 0.96	63.87 \pm 1.83	2.06 \pm 0.49	2.57 \pm 0.74
FMP	63.37 \pm 1.72	1.92 \pm 0.75	2.06 \pm 0.58	62.31 \pm 1.38	2.14 \pm 1.38	2.86 \pm 0.84	62.20 \pm 1.58	1.59 \pm 0.83	2.84 \pm 0.74
FairSIN	62.80 \pm 0.50	1.33 \pm 0.63	<u>0.81\pm0.13</u>	62.08 \pm 1.83	1.65 \pm 0.83	<u>0.95\pm0.68</u>	61.39 \pm 1.93	1.02 \pm 0.46	<u>1.19\pm0.96</u>
FairGT	63.90 \pm 0.15	<u>1.02\pm0.37</u>	1.76 \pm 0.43	62.63 \pm 1.38	1.67 \pm 0.45	2.63 \pm 0.60	62.11 \pm 1.39	<u>0.82\pm0.11</u>	1.86 \pm 0.65
FairGNN	67.73\pm0.07	1.73 \pm 0.72	0.97 \pm 0.39	67.38\pm1.38	<u>1.08\pm0.27</u>	1.95 \pm 0.38	66.48\pm1.55	1.92 \pm 0.35	2.32 \pm 0.49
FairAC	63.12 \pm 1.44	2.52 \pm 1.29	2.69 \pm 0.48	62.35 \pm 1.42	1.42 \pm 0.43	1.72 \pm 1.02	63.34 \pm 0.89	2.76 \pm 0.49	2.70 \pm 0.06
FairGE	65.71 \pm 1.04	0.79\pm0.17	0.77\pm0.24	64.73 \pm 1.82	1.07\pm0.46	0.62\pm0.42	<u>65.74\pm1.28</u>	0.67\pm0.25	0.02\pm0.02
Missing Rate Metrics	Pokec-z-R(0.4)			Pokec-z-R(0.5)			Pokec-z-R(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	60.87 \pm 1.73	4.35 \pm 0.38	5.42 \pm 0.63	60.80 \pm 1.86	3.45 \pm 0.58	5.06 \pm 1.21	59.59 \pm 1.69	1.75 \pm 0.73	3.89 \pm 0.63
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	63.76 \pm 1.59	1.28 \pm 0.42	2.21 \pm 0.31	<u>64.50\pm1.48</u>	1.29 \pm 0.63	<u>1.52\pm0.73</u>	<u>65.86\pm1.48</u>	3.33 \pm 1.86	1.51 \pm 0.58
Polynormer	<u>64.46\pm1.88</u>	2.62 \pm 1.52	3.47 \pm 1.06	61.26 \pm 1.37	3.97 \pm 0.95	2.61 \pm 0.84	60.48 \pm 1.49	4.26 \pm 0.58	3.15 \pm 0.63
FMP	61.15 \pm 1.78	<u>1.25\pm1.24</u>	2.45 \pm 0.47	61.34 \pm 1.36	1.96 \pm 0.73	2.48 \pm 0.58	61.57 \pm 1.97	1.94 \pm 0.64	3.18 \pm 0.57
FairSIN	60.83 \pm 1.72	1.27 \pm 0.26	<u>1.33\pm0.73</u>	60.17 \pm 1.47	<u>0.33\pm0.07</u>	2.50 \pm 0.52	59.46 \pm 1.34	<u>1.05\pm0.12</u>	1.14 \pm 0.74
FairGT	61.72 \pm 1.51	1.44 \pm 0.22	1.36 \pm 0.25	60.83 \pm 1.83	0.72 \pm 0.22	2.17 \pm 0.39	60.99 \pm 2.39	1.43 \pm 0.51	1.33 \pm 0.38
FairGNN	66.13\pm1.64	1.99 \pm 0.25	2.32 \pm 0.78	66.91\pm1.44	1.03 \pm 0.78	1.68 \pm 1.25	66.76\pm1.84	1.42 \pm 0.34	0.74\pm0.26
FairAC	63.72 \pm 1.56	2.39 \pm 0.46	2.40 \pm 1.02	63.94 \pm 1.58	1.26 \pm 0.47	1.53 \pm 0.72	63.52 \pm 1.39	1.80 \pm 0.67	1.94 \pm 0.88
FairGE	64.26 \pm 1.75	1.03\pm0.35	1.28\pm0.68	64.11 \pm 1.28	0.31\pm0.15	1.08\pm0.82	64.19 \pm 1.63	0.11\pm0.04	<u>0.98\pm0.67</u>
Missing Rate Metrics	Pokec-z-G(0.1)			Pokec-z-G(0.2)			Pokec-z-G(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	61.70 \pm 1.62	5.62 \pm 0.49	6.58 \pm 1.34	61.3 \pm 0.87	5.63 \pm 0.54	6.77 \pm 0.22	61.15 \pm 1.41	6.68 \pm 0.76	6.81 \pm 0.25
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.51\pm1.24	1.99 \pm 0.36	<u>1.58\pm0.95</u>	65.46 \pm 0.75	1.24 \pm 0.49	2.24 \pm 0.24	<u>65.27\pm1.18</u>	<u>1.02\pm0.58</u>	1.95 \pm 0.23
Polynormer	65.32 \pm 1.15	<u>1.45\pm0.17</u>	3.83 \pm 0.83	64.99 \pm 0.69	1.63 \pm 0.38	3.23 \pm 0.26	64.92 \pm 1.23	1.76 \pm 0.47	2.77 \pm 0.16
FMP	61.80 \pm 1.37	2.92 \pm 0.45	3.29 \pm 1.42	62.05 \pm 0.84	2.92 \pm 0.52	3.29 \pm 0.33	62.25 \pm 1.31	2.54 \pm 0.64	2.76 \pm 0.29
FairSIN	60.57 \pm 1.10	1.92 \pm 0.22	3.41 \pm 0.79	59.76 \pm 0.68	<u>1.09\pm0.46</u>	3.00 \pm 0.21	60.47 \pm 1.27	1.69 \pm 0.59	2.94 \pm 0.32
FairGT	63.43 \pm 1.48	1.87 \pm 0.34	2.19 \pm 1.10	62.08 \pm 0.79	1.93 \pm 0.48	<u>2.17\pm0.25</u>	61.53 \pm 1.25	1.63 \pm 0.63	<u>1.25\pm0.31</u>
FairGNN	65.46 \pm 0.82	1.65 \pm 0.19	1.70 \pm 1.17	<u>65.75\pm0.64</u>	1.22 \pm 0.59	2.63 \pm 0.36	66.29\pm0.92	1.43 \pm 0.72	2.66 \pm 0.34
FairAC	62.31 \pm 1.05	2.52 \pm 0.27	3.67 \pm 0.88	61.53 \pm 0.76	3.39 \pm 0.44	3.93 \pm 0.22	62.67 \pm 1.09	2.85 \pm 0.55	2.91 \pm 0.29
FairGE	<u>65.47\pm1.01</u>	0.73\pm0.44	0.91\pm0.23	66.84\pm0.67	0.61\pm0.53	0.85\pm0.34	64.77 \pm 1.36	0.28\pm0.18	0.85\pm0.37
Missing Rate Metrics	Pokec-z-G(0.4)			Pokec-z-G(0.5)			Pokec-z-G(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	61.15 \pm 0.58	5.29 \pm 0.12	5.23 \pm 1.43	61.02 \pm 0.76	5.87 \pm 0.49	6.75 \pm 0.21	60.38 \pm 1.32	6.50 \pm 0.65	7.74 \pm 0.27
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.11 \pm 1.35	1.12 \pm 0.29	<u>1.50\pm0.97</u>	<u>65.23\pm0.82</u>	2.01 \pm 0.47	<u>1.05\pm0.25</u>	<u>65.12\pm1.19</u>	2.40 \pm 0.54	<u>0.88\pm0.22</u>
Polynormer	64.71 \pm 1.10	1.80 \pm 0.15	3.09 \pm 0.85	64.40 \pm 0.66	1.09 \pm 0.38	2.77 \pm 0.27	64.36 \pm 1.25	<u>1.11\pm0.46</u>	3.24 \pm 0.19
FMP	62.06 \pm 1.43	2.84 \pm 0.41	2.82 \pm 1.38	61.96 \pm 0.84	2.84 \pm 0.52	2.82 \pm 0.33	61.87 \pm 1.31	1.99 \pm 0.62	3.01 \pm 0.28
FairSIN	58.57 \pm 1.07	<u>0.84\pm0.23</u>	3.47 \pm 0.78	58.30 \pm 0.69	<u>0.53\pm0.45</u>	1.17 \pm 0.21	58.34 \pm 1.23	1.16 \pm 0.58	3.56 \pm 0.32
FairGT	62.49 \pm 1.49	1.73 \pm 0.35	<u>1.50\pm1.04</u>	62.49 \pm 0.79	1.73 \pm 0.48	1.50 \pm 0.24	62.63 \pm 1.16	2.79 \pm 0.49	2.13 \pm 0.26
FairGNN	68.05\pm0.73	1.01 \pm 0.18	2.33 \pm 1.16	67.13\pm0.64	1.40 \pm 0.59	1.69 \pm 0.36	66.87\pm0.93	1.88 \pm 0.72	1.21 \pm 0.34
FairAC	63.02 \pm 1.04	1.93 \pm 0.26	2.57 \pm 0.89	62.76 \pm 0.76	2.75 \pm 0.44	2.92 \pm 0.22	62.82 \pm 1.09	1.64 \pm 0.55	3.05 \pm 0.29
FairGE	<u>65.28\pm0.98</u>	0.54\pm0.42	0.99\pm0.22	64.50 \pm 0.67	0.30\pm0.43	0.88\pm0.34	64.58 \pm 1.35	0.72\pm0.63	0.34\pm0.28

Table 4: Comparison results in Pokec-n-R and Pokec-n-G.

Missing Rate Metrics	Pokec-n-R(0.1)			Pokec-n-R(0.2)			Pokec-n-R(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow
GCN	64.09 \pm 1.32	6.18 \pm 0.46	5.42 \pm 1.19	62.59 \pm 0.85	8.02 \pm 0.52	6.44 \pm 0.27	63.27 \pm 1.24	6.31 \pm 0.70	6.04 \pm 0.19
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.73 \pm 1.17	<u>2.08\pm0.33</u>	2.39 \pm 0.89	63.68 \pm 0.74	3.05 \pm 0.46	3.29 \pm 0.25	64.36 \pm 1.05	3.21 \pm 0.58	4.55 \pm 0.22
Polynormer	66.32\pm1.05	2.64 \pm 0.14	3.06 \pm 0.93	64.09 \pm 0.66	3.40 \pm 0.38	4.70 \pm 0.22	65.73\pm1.17	2.28 \pm 0.43	2.52 \pm 0.17
FMP	64.23 \pm 1.28	5.12 \pm 0.41	5.46 \pm 1.36	62.73 \pm 0.83	2.87 \pm 0.50	1.96 \pm 0.33	62.27 \pm 1.29	2.74 \pm 0.61	<u>1.63\pm0.28</u>
FairSIN	63.27 \pm 1.12	3.32 \pm 0.23	4.21 \pm 0.77	62.08 \pm 0.68	<u>1.43\pm0.45</u>	<u>1.79\pm0.21</u>	61.32 \pm 1.32	<u>2.10\pm0.57</u>	2.16 \pm 0.31
FairGT	63.27 \pm 1.47	2.42 \pm 0.32	2.70 \pm 1.03	61.75 \pm 0.79	2.05 \pm 0.45	3.08 \pm 0.24	61.00 \pm 1.15	2.40 \pm 0.48	3.17 \pm 0.26
FairGNN	66.00 \pm 0.78	3.08 \pm 0.18	1.23\pm1.15	65.95\pm0.64	2.13 \pm 0.59	2.35 \pm 0.36	<u>65.68\pm0.92</u>	2.87 \pm 0.71	2.22 \pm 0.33
FairAC	63.76 \pm 1.03	2.63 \pm 0.26	5.47 \pm 0.87	63.49 \pm 0.76	2.59 \pm 0.44	2.48 \pm 0.22	63.90 \pm 1.08	2.49 \pm 0.54	3.45 \pm 0.28
FairGE	<u>66.18\pm0.97</u>	0.09\pm0.02	<u>1.37\pm1.21</u>	<u>65.82\pm0.67</u>	0.33\pm0.13	0.47\pm0.34	64.95 \pm 1.35	0.75\pm0.62	0.50\pm0.39
Missing Rate Metrics	Pokec-n-R(0.4)			Pokec-n-R(0.5)			Pokec-n-R(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow
GCN	62.82 \pm 1.54	6.84 \pm 0.37	5.87 \pm 1.26	63.05 \pm 0.91	8.52 \pm 0.48	6.98 \pm 0.23	62.23 \pm 1.38	10.82 \pm 0.72	9.70 \pm 0.20
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	<u>65.36\pm1.19</u>	2.72 \pm 0.32	2.85 \pm 0.92	<u>64.05\pm0.73</u>	5.77 \pm 0.46	5.12 \pm 0.25	63.09 \pm 1.05	2.38 \pm 0.59	2.62 \pm 0.22
Polynormer	63.36 \pm 1.07	3.91 \pm 0.16	3.83 \pm 0.84	61.68 \pm 0.67	3.86 \pm 0.39	6.21 \pm 0.26	58.41 \pm 1.17	5.67 \pm 0.44	2.48 \pm 0.17
FMP	61.55 \pm 1.26	2.57 \pm 0.43	2.76 \pm 1.36	60.95 \pm 0.82	2.45 \pm 0.51	1.80 \pm 0.33	60.05 \pm 1.29	2.14 \pm 0.60	3.08 \pm 0.28
FairSIN	61.44 \pm 1.14	2.43 \pm 0.23	2.64 \pm 0.77	60.71 \pm 0.68	<u>1.73\pm0.45</u>	2.46 \pm 0.21	57.05 \pm 1.23	<u>1.00\pm0.57</u>	<u>1.22\pm0.32</u>
FairGT	58.81 \pm 1.39	<u>2.04\pm0.35</u>	2.68 \pm 1.03	58.45 \pm 0.79	2.12 \pm 0.45	<u>1.70\pm0.24</u>	57.45 \pm 1.15	1.74 \pm 0.48	1.74 \pm 0.26
FairGNN	65.50\pm0.76	3.06 \pm 0.18	<u>1.24\pm1.15</u>	65.00\pm0.64	2.60 \pm 0.59	2.12 \pm 0.36	64.55\pm0.92	4.01 \pm 0.71	2.66 \pm 0.33
FairAC	64.32 \pm 1.03	2.46 \pm 0.26	3.57 \pm 0.87	63.77 \pm 0.76	2.68 \pm 0.44	1.99 \pm 0.22	<u>63.21\pm1.08</u>	2.78 \pm 0.54	3.52 \pm 0.28
FairGE	62.59 \pm 0.97	0.20\pm0.12	0.04\pm0.01	63.23 \pm 0.67	1.10\pm0.53	0.24\pm0.14	61.95 \pm 1.35	0.13\pm0.02	0.99\pm0.39
Missing Rate Metrics	Pokec-n-G(0.1)			Pokec-n-G(0.2)			Pokec-n-G(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow
GCN	61.88 \pm 1.2	5.36 \pm 0.38	5.58 \pm 1.45	61.56 \pm 0.92	5.05 \pm 0.51	5.45 \pm 0.26	61.42 \pm 1.37	5.19 \pm 0.74	5.54 \pm 0.29
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.98\pm1.38	1.84 \pm 0.27	5.43 \pm 0.91	65.83\pm0.75	1.89 \pm 0.48	5.52 \pm 0.24	<u>64.86\pm1.18</u>	1.72 \pm 0.58	6.61 \pm 0.23
Polynormer	63.85 \pm 1.12	3.60 \pm 0.19	7.50 \pm 0.84	64.07 \pm 0.67	2.84 \pm 0.39	6.06 \pm 0.26	63.77 \pm 1.24	1.87 \pm 0.47	5.05 \pm 0.17
FMP	63.71 \pm 1.45	<u>1.46\pm0.42</u>	1.95 \pm 1.37	63.72 \pm 0.84	1.53\pm0.53	1.95 \pm 0.33	63.71 \pm 1.31	1.99 \pm 0.64	<u>1.20\pm0.28</u>
FairSIN	62.20 \pm 1.09	2.28 \pm 0.23	2.67 \pm 0.79	63.03 \pm 0.69	<u>1.57\pm0.46</u>	3.97 \pm 0.21	62.3 \pm 1.28	<u>0.69\pm0.59</u>	5.45 \pm 0.32
FairGT	62.58 \pm 1.47	2.28 \pm 0.35	4.03 \pm 1.05	62.24 \pm 0.79	2.94 \pm 0.48	2.83 \pm 0.25	61.45 \pm 1.25	2.03 \pm 0.63	4.18 \pm 0.31
FairGNN	<u>65.66\pm0.81</u>	3.15 \pm 0.19	<u>1.50\pm1.18</u>	<u>65.48\pm0.64</u>	3.30 \pm 0.59	<u>1.50\pm0.36</u>	65.37\pm0.93	3.39 \pm 0.72	1.50 \pm 0.34
FairAC	62.87 \pm 1.05	3.92 \pm 0.27	2.04 \pm 0.90	63.32 \pm 0.76	3.75 \pm 0.44	2.35 \pm 0.22	63.55 \pm 1.10	3.38 \pm 0.55	3.01 \pm 0.29
FairGE	64.68 \pm 0.99	1.03\pm0.44	1.25\pm1.22	64.05 \pm 0.67	<u>1.57\pm0.53</u>	1.34\pm0.34	64.45 \pm 1.36	0.36\pm0.28	1.12\pm0.37
Missing Rate Metrics	Pokec-n-G(0.4)			Pokec-n-G(0.5)			Pokec-n-G(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow	ACC(%) \uparrow	$\Delta_{SP}(\%)$ \downarrow	$\Delta_{EO}(\%)$ \downarrow
GCN	61.42 \pm 1.28	5.31 \pm 0.45	5.93 \pm 1.39	61.76 \pm 0.93	5.89 \pm 0.56	5.99 \pm 0.22	62.38 \pm 1.42	5.83 \pm 0.78	6.48 \pm 0.26
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	<u>64.44\pm1.33</u>	1.99 \pm 0.31	7.04 \pm 0.94	<u>64.58\pm0.72</u>	2.36 \pm 0.47	6.97 \pm 0.25	<u>65.62\pm1.19</u>	2.32 \pm 0.59	6.95 \pm 0.21
Polynormer	63.69 \pm 1.08	<u>1.38\pm0.14</u>	4.50 \pm 0.85	63.20 \pm 0.68	2.48 \pm 0.39	5.51 \pm 0.26	63.25 \pm 1.26	2.64 \pm 0.47	5.34 \pm 0.18
FMP	63.71 \pm 1.42	2.22 \pm 0.41	1.52 \pm 1.37	63.93 \pm 0.84	<u>1.87\pm0.53</u>	1.38\pm0.33	64.73 \pm 1.32	<u>1.67\pm0.64</u>	<u>1.38\pm0.27</u>
FairSIN	61.23 \pm 1.10	2.14 \pm 0.23	5.28 \pm 0.78	60.91 \pm 0.69	<u>1.87\pm0.45</u>	3.62 \pm 0.21	60.73 \pm 1.24	3.67 \pm 0.58	4.32 \pm 0.32
FairGT	63.27 \pm 1.49	3.35 \pm 0.35	<u>0.55\pm0.44</u>	62.80 \pm 0.79	2.34 \pm 0.48	4.00 \pm 0.24	61.11 \pm 1.17	3.56 \pm 0.49	3.51 \pm 0.26
FairGNN	65.37\pm0.75	3.54 \pm 0.19	3.69 \pm 1.16	65.56\pm0.64	3.33 \pm 0.59	3.69 \pm 0.36	65.82\pm0.94	2.55 \pm 0.73	3.69 \pm 0.35
FairAC	63.80 \pm 1.04	2.74 \pm 0.27	3.50 \pm 0.89	63.71 \pm 0.76	4.07 \pm 0.44	3.86 \pm 0.22	63.23 \pm 1.10	4.21 \pm 0.56	3.53 \pm 0.29
FairGE	64.27 \pm 0.98	0.68\pm0.43	0.35\pm0.23	64.09 \pm 0.67	0.65\pm0.54	<u>1.59\pm0.35</u>	64.14 \pm 1.36	1.57\pm0.65	0.73\pm0.38

Table 5: Comparison results in AMiner-S.

Missing Rate Metrics	AMiner-S(0.1)			AMiner-S(0.2)			AMiner-S(0.3)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	88.85 \pm 1.09	5.19 \pm 2.63	4.98 \pm 1.34	83.72 \pm 1.96	8.61 \pm 2.09	8.58 \pm 2.12	83.13 \pm 1.32	7.12 \pm 1.16	6.43 \pm 1.09
SGFormer	89.54\pm0.07	4.63 \pm 0.69	4.75 \pm 0.25	88.30 \pm 0.08	4.64 \pm 0.05	5.18 \pm 1.61	<u>87.88\pm0.18</u>	4.33 \pm 0.06	3.31 \pm 0.53
CoBFormer	88.13 \pm 1.26	4.65 \pm 0.94	5.36 \pm 2.65	87.86 \pm 0.28	4.46 \pm 0.78	4.99 \pm 3.60	86.26 \pm 0.40	5.19 \pm 1.09	<u>3.05\pm1.57</u>
Polynormer	<u>89.42\pm0.19</u>	5.16 \pm 0.91	3.98 \pm 1.51	88.68\pm0.34	4.11 \pm 0.21	5.86 \pm 2.70	87.99\pm1.34	4.31 \pm 0.79	4.18 \pm 1.79
FMP	88.33 \pm 0.96	7.10 \pm 2.02	4.33 \pm 1.92	86.46 \pm 1.52	5.81 \pm 1.57	6.03 \pm 1.63	85.84 \pm 1.26	4.44 \pm 1.65	4.24 \pm 0.78
FairSIN	85.74 \pm 1.60	4.85 \pm 3.78	4.88 \pm 1.72	84.25 \pm 0.01	4.52 \pm 1.89	<u>4.68\pm1.24</u>	84.04 \pm 0.16	4.29 \pm 0.24	3.28 \pm 0.22
FairGT	89.05 \pm 1.00	4.51 \pm 0.60	4.05 \pm 0.89	87.25 \pm 1.11	<u>3.54\pm0.23</u>	5.88 \pm 1.90	86.59 \pm 0.42	3.60 \pm 0.63	3.57 \pm 1.95
FairGNN	86.00 \pm 1.05	4.03 \pm 1.63	<u>3.75\pm2.86</u>	87.59 \pm 1.81	4.81 \pm 2.39	5.44 \pm 2.37	86.62 \pm 1.11	4.48 \pm 0.65	4.23 \pm 1.26
FairAC	78.94 \pm 2.04	<u>3.63\pm2.10</u>	6.37 \pm 2.03	79.61 \pm 0.02	3.93 \pm 0.04	6.43 \pm 1.31	80.86 \pm 0.06	<u>3.47\pm1.13</u>	5.88 \pm 1.51
FairGE	89.12 \pm 1.34	3.59\pm0.28	2.97\pm0.37	<u>88.33\pm2.03</u>	3.52\pm1.05	3.52\pm1.06	87.01 \pm 1.01	2.94\pm0.49	1.69\pm0.54

Missing Rate	AMiner-S(0.4)			AMiner-S(0.5)			AMiner-S(0.6)		
	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) \uparrow	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	83.08 \pm 1.87	5.81 \pm 1.27	4.96 \pm 1.77	81.48 \pm 1.36	4.49 \pm 0.90	5.67 \pm 1.08	81.89 \pm 1.71	4.41 \pm 1.01	6.13 \pm 1.46
SGFormer	<u>85.54\pm1.35</u>	4.87 \pm 0.86	4.11 \pm 2.07	<u>84.57\pm0.51</u>	4.24 \pm 0.37	4.00 \pm 1.74	83.47 \pm 1.00	4.90 \pm 0.42	4.06 \pm 0.84
CoBFormer	84.84 \pm 1.29	<u>2.54\pm0.33</u>	4.40 \pm 0.64	83.32 \pm 2.58	<u>2.19\pm0.19</u>	5.46 \pm 2.29	<u>84.18\pm0.30</u>	3.49 \pm 0.14	4.07 \pm 3.97
Polynormer	85.04 \pm 2.48	3.79 \pm 2.01	3.40 \pm 1.49	85.14\pm1.94	3.57 \pm 1.69	4.11 \pm 1.91	83.17 \pm 0.09	3.41 \pm 0.14	4.87 \pm 0.75
FMP	85.42 \pm 1.25	4.76 \pm 0.17	3.90 \pm 0.17	84.23 \pm 1.65	4.47 \pm 1.16	4.76 \pm 0.78	85.50\pm1.32	3.80 \pm 0.62	5.68 \pm 0.69
FairSIN	82.15 \pm 0.07	3.16 \pm 0.04	<u>3.15\pm0.04</u>	80.06 \pm 0.29	2.21 \pm 0.31	<u>2.07\pm0.05</u>	79.91 \pm 0.80	3.63 \pm 2.32	<u>3.69\pm3.46</u>
FairGT	84.26 \pm 1.88	2.66 \pm 1.39	4.65 \pm 2.04	82.12 \pm 0.38	2.60 \pm 0.61	4.23 \pm 1.87	80.24 \pm 0.00	2.94 \pm 0.60	3.92 \pm 0.42
FairGNN	83.58 \pm 0.35	4.84 \pm 1.98	4.63 \pm 2.49	83.36 \pm 1.77	4.75 \pm 1.22	4.64 \pm 2.54	82.58 \pm 1.93	<u>2.59\pm1.28</u>	6.33 \pm 1.18
FairAC	81.44 \pm 0.25	2.81 \pm 0.35	5.92 \pm 1.40	81.44 \pm 1.61	4.18 \pm 1.91	11.09 \pm 2.01	81.93 \pm 0.74	5.23 \pm 2.95	10.14 \pm 2.74
FairGE	85.56\pm0.53	2.26\pm1.89	2.42\pm0.24	83.77 \pm 0.69	2.10\pm0.19	1.74\pm0.01	83.52 \pm 0.35	1.92\pm0.29	2.21\pm0.43