

Table 2. A comparison of the fault localization techniques. For each system, we show the technique with the best MFR in bold (the lower the better). DepGraph w/o Code Change shows the result after adopting Dependency-Enhanced Coverage Graph, and DepGraph shows the result of incorporating both Dependency-Enhanced Coverage Graph and Code Change Information. The number in the parentheses shows the percentage improvement over Grace [29]. The best result is marked in bold. Due to space constraints, the Tarantula results are not presented in the table but are available in our GitHub repository for reference [4].

System (# faults)	Techniques	Top-1	Top-3	Top-5	Top-10	MFR	MAR
Cli (39)	Ochiai	3	5	10	18	15.711	18.272
	DeepFL	11	21	24	28	8.991	10.681
	GNN	14	24	26	30	7.861	9.903
	DepGraph w/o Code Change	15 (7%)	22 (-8%)	26 (0%)	31 (3%)	5.973 (24%)	7.118 (28%)
	DepGraph	17 (21%)	24 (0%)	27 (4%)	34 (10%)	5.105 (30%)	6.223 (32%)
Closure (174)	Ochiai	20	39	70	72	98.652	110.348
	DeepFL	46	61	92	99	29.388	35.333
	GNN	51	78	102	121	12.854	14.814
	DepGraph w/o Code Change	58 (14%)	97 (24%)	123 (21%)	148 (22%)	4.844 (62%)	7.911 (47%)
	DepGraph	60 (18%)	99 (27%)	126 (24%)	148 (22%)	4.512 (65%)	7.306 (51%)
Codec (18)	Ochiai	3	12	17	17	2.701	3.461
	DeepFL	5	10	12	16	2.742	4.803
	GNN	6	11	13	17	2.536	4.015
	DepGraph w/o Code Change	7 (17%)	12 (9%)	14 (8%)	16 (-6%)	2.412 (5%)	3.265 (19%)
	DepGraph	7 (17%)	10 (-9%)	14 (8%)	16 (-6%)	3.111 (-23%)	4.327 (-8%)
Collections (4)	Ochiai	1	1	2	2	3.871	3.431
	DeepFL	1	1	2	2	1.512	1.519
	GNN	1	1	2	2	1.511	1.511
	DepGraph w/o Code Change	1 (0%)	1 (0%)	2 (0%)	2 (0%)	1.511 (0%)	1.511 (0%)
	DepGraph	1 (0%)	2 (100%)	2 (0%)	2 (0%)	1.445 (4%)	1.445 (4%)
Compress (47)	Ochiai	5	12	17	29	20.106	23.275
	DeepFL	22	27	31	38	9.573	12.955
	GNN	23	29	34	42	5.383	6.987
	DepGraph w/o Code Change	24 (4%)	32 (10%)	36 (6%)	42 (0%)	4.384 (19%)	5.209 (25%)
	DepGraph	25 (9%)	33 (14%)	36 (6%)	45 (7%)	3.361 (38%)	4.245 (39%)
Csv (16)	Ochiai	3	8	10	12	5.625	5.782
	DeepFL	7	8	9	11	5.623	5.971
	GNN	6	8	10	12	5.438	5.938
	DepGraph w/o Code Change	8 (33%)	9 (13%)	10 (0%)	13 (8%)	5.362 (1%)	5.581 (6%)
	DepGraph	8 (33%)	9 (13%)	12 (20%)	13 (8%)	4.813 (12%)	5.001 (16%)
Gson (18)	Ochiai	4	9	9	12	9.177	10.183
	DeepFL	8	11	12	12	8.873	9.324
	GNN	11	13	14	15	6.471	6.755
	DepGraph w/o Code Change	12 (9%)	14 (8%)	15 (7%)	15 (0%)	2.177 (66%)	2.471 (63%)
	DepGraph	14 (27%)	15 (15%)	16 (14%)	16 (7%)	1.353 (79%)	1.765 (74%)
JacksonCore (26)	Ochiai	6	11	13	14	9.789	16.754
	DeepFL	5	5	9	10	8.671	9.711
	GNN	9	13	14	15	6.471	6.755
	DepGraph w/o Code Change	9 (0%)	14 (8%)	15 (7%)	17 (13%)	3.474 (29%)	4.509 (28%)
	DepGraph	12 (33%)	15 (15%)	15 (7%)	16 (7%)	3.052 (38%)	4.015 (36%)
JacksonXml (6)	Ochiai	0	0	0	0	59.2	59.2
	DeepFL	3	3	4	5	3.513	4.245
	GNN	3	3	4	5	2.401	2.401
	DepGraph w/o Code Change	4 (33%)	5 (67%)	5 (25%)	5 (0%)	0.411 (83%)	0.411 (83%)
	DepGraph	4 (33%)	5 (67%)	5 (25%)	5 (0%)	0.409 (83%)	0.409 (83%)
Jsoup (93)	Ochiai	15	40	48	57	14.944	20.209
	DeepFL	33	39	46	49	10.23	11.444
	GNN	40	64	72	77	8.223	9.669
	DepGraph w/o Code Change	50 (25%)	70 (9%)	77 (7%)	82 (6%)	4.022 (51%)	6.815 (30%)
	DepGraph	53 (33%)	73 (14%)	78 (8%)	83 (8%)	3.023 (63%)	4.6174 (52%)
Lang (64)	Ochiai	25	45	51	59	4.68	5.15
	DeepFL	42	53	55	57	2.833	3.08
	GNN	43	53	57	58	2.113	2.462
	DepGraph w/o Code Change	45 (5%)	55 (4%)	58 (2%)	61 (5%)	1.564 (26%)	1.902 (23%)
	DepGraph	48 (12%)	55 (4%)	60 (5%)	61 (5%)	1.153 (45%)	1.481 (40%)
Math (106)	Ochiai	23	52	62	82	9.73	11.72
	DeepFL	52	81	90	95	3.95	4.911
	GNN	64	79	92	97	2.355	3.082
	DepGraph w/o Code Change	67 (5%)	90 (14%)	96 (4%)	100 (3%)	1.185 (50%)	1.528 (50%)
	DepGraph	72 (13%)	92 (16%)	97 (5%)	102 (5%)	1.115 (53%)	1.454 (53%)
Mockito (38)	Ochiai	7	14	18	23	20.22	24.77
	DeepFL	10	18	23	26	13.541	17.001
	GNN	16	24	26	29	9.611	13.621
	DepGraph w/o Code Change	20 (25%)	28 (17%)	34 (31%)	34 (17%)	2.361 (75%)	3.307 (76%)
	DepGraph	21 (31%)	29 (21%)	32 (23%)	34 (17%)	2.194 (77%)	2.998 (78%)
Time (26)	Ochiai	6	12	13	16	16.14	18.98
	DeepFL	12	15	18	20	12.722	13.754
	GNN	11	16	20	21	7.842	8.448
	DepGraph w/o Code Change	16 (45%)	19 (19%)	20 (0%)	22 (5%)	3.321 (58%)	4.465 (47%)
	DepGraph	17 (55%)	20 (25%)	21 (5%)	22 (5%)	3.044 (61%)	4.371 (48%)
Total (675)	Ochiai	121	260	340	413	20.753	24.038
	DeepFL	257	353	427	468	8.726	10.338
	GNN	298	416	486	541	5.678	6.851
	DepGraph w/o Code Change	336 (13%)	470 (13%)	534 (10%)	588 (9%)	3.049 (46%)	3.957 (42%)
	DepGraph	359 (20%)	481 (16%)	541 (11%)	597 (10%)	2.562 (55%)	3.272 (52%)