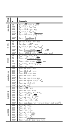
Table 3: Success rate, average solution rank and average run time to find the first solution for stochastic ranking with random restarts. The best results achieved among all algorithms are shown in bold. The results are obtained by training and testing on the same map with the same number of agents n. ∞ indicates that no problem was solved.

Map	n	Success rate (%)						Average solution rank						Avg. run time to the first solution					
		LH	SH	RND	ML-T	ML-P	FML	LH	SH	RND	ML-T	ML-P	FML	LH	SH	RND	ML-T	ML-P	FML
random	175	100	100	100	100	100	100	3.16	**1.88**	2.84	2.40	1.96	2.76	**0.61**	3.64	3.82	1.67	1.41	1.38
	200	88	84	92	**100**	**100**	**100**	2.92	2.36	2.60	2.76	2.24	**2.00**	14.57	21.30	15.79	3.58	**2.91**	3.70
	225	32	16	20	84	**96**	16	2.00	2.20	1.84	1.28	**0.48**	2.08	50.36	52.78	51.32	24.49	**13.39**	52.72
	250	0	4	0	12	**80**	0	0.96	0.88	0.96	0.72	**0.16**	0.96	60.00	58.31	60.00	56.65	**20.77**	60.00
room	75	100	100	100	100	100	100	3.40	2.44	2.36	**2.08**	2.48	2.16	**0.21**	0.29	0.59	0.55	0.38	0.33
	100	80	80	80	96	**100**	92	2.80	2.40	2.92	2.00	**1.80**	2.24	12.56	19.48	20.66	5.00	**1.21**	10.08
	125	24	0	12	76	**92**	12	1.44	2.16	1.92	0.92	**0.56**	1.88	47.74	60.00	55.45	27.70	**8.60**	55.10
	150	0	0	0	8	**76**	**76**	1.60	1.60	1.60	1.48	0.64	**0.32**	60.00	60.00	60.00	57.58	27.41	**16.76**
maze	50	100	100	100	100	100	100	3.52	2.52	**1.52**	2.80	2.20	2.36	0.40	1.63	4.30	1.36	**0.26**	0.74
	70	88	76	72	96	**100**	**100**	3.00	2.40	2.36	**1.96**	2.68	2.04	7.37	20.49	21.75	5.78	**0.45**	7.03
	90	64	20	20	84	**100**	40	1.64	2.64	2.76	1.40	**0.80**	2.24	24.92	49.35	52.59	17.64	**0.57**	39.37
	110	40	0	0	40	**100**	28	1.36	2.08	2.08	1.40	**0.40**	1.36	36.04	60.00	60.00	43.63	**1.86**	50.97
	130	8	0	0	16	**84**	0	1.00	1.08	1.08	0.84	**0.08**	1.08	55.22	60.00	60.00	53.89	**15.81**	60.00
warehouse	350	**96**	**96**	92	**96**	**96**	**96**	3.28	**2.12**	2.36	2.24	2.20	2.20	9.39	14.76	11.23	**8.69**	11.25	14.56
	400	80	**88**	84	80	84	84	3.20	2.04	2.48	2.28	2.04	**1.84**	19.38	**16.41**	23.30	23.04	19.92	22.93
	450	64	64	68	60	**84**	68	2.40	2.08	2.12	2.44	**1.56**	1.96	31.90	35.31	32.71	37.21	**30.30**	31.70
	500	36	20	32	**56**	20	28	1.36	1.60	**0.88**	0.92	1.24	1.08	44.60	55.25	46.89	**42.88**	53.22	49.29
	550	16	12	8	**24**	16	12	0.52	0.60	0.76	**0.48**	0.60	0.64	55.96	57.82	58.56	**52.44**	56.65	56.98
lak303d	500	**100**	**100**	**100**	**100**	96	**100**	4.48	2.08	2.48	**1.72**	2.24	2.00	**5.25**	11.56	22.66	9.41	34.79	8.91
	600	100	100	100	100	100	100	4.64	2.56	1.88	2.40	**1.12**	2.40	**7.49**	40.40	36.11	32.90	99.87	21.10
	700	96	**100**	**100**	96	**100**	**100**	4.32	**1.48**	1.76	2.04	2.40	3.00	41.98	**38.08**	73.10	101.03	72.38	68.01
	800	96	96	92	96	**100**	92	4.12	2.68	2.08	2.24	**1.56**	2.04	**60.65**	148.05	158.82	117.32	126.01	124.54
	900	**92**	**92**	84	84	80	76	2.88	**1.80**	2.00	2.44	1.88	2.64	**130.59**	232.18	249.02	260.38	276.37	255.47
ost003d	500	**100**	96	**100**	96	92	**100**	4.44	2.52	1.84	2.40	**1.16**	2.48	**2.40**	39.21	20.80	31.62	60.03	10.79
	600	**100**	**100**	96	**100**	96	**100**	4.08	2.44	2.28	1.80	**1.36**	3.00	**4.46**	16.58	37.82	18.79	62.19	13.55
	700	**100**	96	96	**100**	96	96	4.32	1.96	2.40	2.00	**1.40**	2.64	**13.79**	47.78	46.36	44.20	83.66	47.17
	800	**100**	96	96	96	96	96	3.56	1.92	2.60	2.72	**1.44**	2.36	**32.53**	95.01	82.01	80.12	110.79	72.39
	900	**100**	92	96	96	92	92	3.68	2.32	2.16	2.08	**2.04**	2.32	**72.49**	164.68	153.91	160.27	172.58	169.36

Table 4: Formulae synthesized for each number of agents of each map. All formulae are manually simplified and the numeric constants are rounded. When PP with a formula outperforms all other PP methods in both success rate and average solution rank for a given map and a number of agents we mark the line with an asterisk.



→(dd,uu,du,ud),→(dd,uu,du,ud),s(dd,uu,du,ud),↑(uu,ud),→(uu,ud), s(uu,ud),↑(uu),↑(uu),←(ud),↑(ud),↑(ud),→(ud),←(dd,du) ,↑(dd,du) , ↑(dd,du) ,↑(dd,du),s(dd,du),→(dd),→(dd), ↓(du),→(du),→(du),↑(du)

Figure 1: Success rate and average solution rank of f_6 on the three small maps and the medium sized map compared to existing PP algorithms.

istic ranking to demonstrate an example of the formula's portability. Instead of computing the agents' priority scores using the formulae synthesized specifically for that number of agents and that map, we use f_6 on all the maps and with all numbers of agents. As per Figure **??** the formula f_6 has the highest success rate and the best average solution rank for most numbers of agents on `random-32-32-20` and `room-32-32-4`. It performs worse on `maze-32-32-2` and `warehouse-10-20-10-2-1`. This shows that the synthesized formulae can outperform existing PP algorithms even on maps not seen during synthesis.

6 Future Work

While performing well, our priority functions were synthesized for the map and the number of agents. Future work will synthesize priority functions with training data from different maps and/or numbers of agents. The effectiveness of our approach may also be increased by considering additional building blocks for the arithmetic formulae. In particular, these building blocks can include previously synthesized formulae (**?**), leading to iterative expansion of the space of formulae. Finally, future work may aim to scale our approach to larger training sets by using other synthesis methods (**????**).

7 Conclusions

We adopted the approach by **?** to learn priority functions to solve multi-agent pathfinding problems with prioritized planning. The priority functions are expressed as arithmetic formulae and synthesized via a genetic search. They are short and human-readable and often outperform the state-of-the-art machine-learning approach in terms of success rate, run time and solution quality without requiring more training data.

We also showed that our synthesized formula can outperform existing PP algorithms in both success rate and average solution rank even on maps and problems not seen during synthesis and can provide insight in its functions.

Acknowledgments

We appreciate support from Compute Canada and financial support from NSERC.

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