

A Data-Distribution and Successive Spline Points based discretization approach for evolving gene regulatory networks from scRNA-Seq time-series data using Cartesian Genetic Programming

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Supplementary Material

This supplementary material presents additional details and extra tabular results when solving the proposed benchmark problems for assessing the performance of the proposal.

1 Curated Problems

Tables 1 and 2 present the tabular results when solving the curated problems considering the AUPRC and AUROC of the median values. The values are presented considering the worst, first quantile (Q1), mean, median, third quantile (Q3), best, and standard deviation (STD) values.

Table 1: Values of AUPRC for the median case. The best results are in boldface.

	Prob.	Alg.	Worst	Q1	Mean	Median	Q3	Best	Std.
0% dropout	GSD	CGP	0.2038	0.2153	0.2304	0.2293	0.2459	0.2584	0.0179
		CGP-DSSPD	0.2157	0.2351	0.2502	0.2548	0.2584	0.2763	0.0190
	HSC	CGP	0.2003	0.2212	0.2550	0.2528	0.2840	0.3253	0.0380
		CGP-DSSPD	0.1956	0.2122	0.2309	0.2303	0.2486	0.2678	0.0235
	mCAD	CGP	0.5297	0.5692	0.5863	0.5913	0.6032	0.6287	0.0281
		CGP-DSSPD	0.5948	0.6440	0.7055	0.7186	0.7341	0.8460	0.0731
	VSC	CGP	0.2284	0.2630	0.2739	0.2724	0.2929	0.3124	0.0242
		CGP-DSSPD	0.2261	0.2579	0.2751	0.2665	0.2884	0.3552	0.0328
50% dropout	GSD	CGP	0.1908	0.2088	0.2255	0.2276	0.2425	0.2573	0.0202
		CGP-DSSPD	0.2151	0.2292	0.2536	0.2519	0.2673	0.3140	0.0309
	HSC	CGP	0.2047	0.2579	0.2688	0.2747	0.2929	0.3063	0.0316
		CGP-DSSPD	0.2129	0.2152	0.2341	0.2237	0.2439	0.2777	0.0230
	mCAD	CGP	0.5385	0.5947	0.6119	0.6201	0.6331	0.6535	0.0327
		CGP-DSSPD	0.5945	0.6426	0.6528	0.6516	0.6633	0.7116	0.0292
	VSC	CGP	0.2494	0.2698	0.2925	0.2819	0.3064	0.3709	0.0372
		CGP-DSSPD	0.2147	0.2502	0.2706	0.2637	0.2789	0.3468	0.0356
70% dropout	GSD	CGP	0.1931	0.2061	0.2180	0.2177	0.2239	0.2515	0.0172
		CGP-DSSPD	0.1851	0.2298	0.2398	0.2389	0.2573	0.2766	0.0242
	HSC	CGP	0.2230	0.2390	0.2604	0.2441	0.2735	0.3246	0.0339
		CGP-DSSPD	0.1951	0.2197	0.2428	0.2499	0.2633	0.2874	0.0287
	mCAD	CGP	0.5386	0.6011	0.6539	0.6446	0.7004	0.7946	0.0796
		CGP-DSSPD	0.5614	0.6146	0.6660	0.6635	0.7239	0.7475	0.0634
	VSC	CGP	0.2463	0.2526	0.2817	0.2832	0.3041	0.3286	0.0286
		CGP-DSSPD	0.2315	0.2518	0.2931	0.2859	0.3157	0.4109	0.0502

Table 2: Values of AUROC for the median case. The best results are in boldface.

	Prob.	Alg.	Worst	Q1	Mean	Median	Q3	Best	Std.
0% dropout	GSD	CGP	0.4807	0.4971	0.5118	0.5173	0.5242	0.5472	0.0193
		CGP-DSSPD	0.4780	0.5009	0.5185	0.5267	0.5367	0.5450	0.0220
	HSC	CGP	0.4235	0.4823	0.5265	0.5272	0.5759	0.6193	0.0589
		CGP-DSSPD	0.4146	0.4647	0.4943	0.4918	0.5378	0.5524	0.0441
	mCAD	CGP	0.2857	0.3338	0.3764	0.3846	0.4052	0.4670	0.0552
		CGP-DSSPD	0.4505	0.4890	0.5473	0.5632	0.5783	0.6758	0.0639
	VSC	CGP	0.4041	0.4923	0.5038	0.5020	0.5419	0.5675	0.0472
		CGP-DSSPD	0.4602	0.4872	0.5095	0.5016	0.5205	0.6033	0.0379
50% dropout	GSD	CGP	0.4520	0.4861	0.5069	0.5086	0.5393	0.5450	0.0323
		CGP-DSSPD	0.4737	0.5078	0.5223	0.5267	0.5409	0.5560	0.0232
	HSC	CGP	0.4290	0.5425	0.549	0.5583	0.5837	0.6154	0.0519
		CGP-DSSPD	0.4556	0.4812	0.4935	0.4874	0.5088	0.5396	0.0242
	mCAD	CGP	0.3242	0.3901	0.4346	0.4505	0.4821	0.4890	0.0559
		CGP-DSSPD	0.3956	0.4505	0.4681	0.4698	0.4725	0.5604	0.0390
	VSC	CGP	0.4650	0.5030	0.5320	0.5297	0.5472	0.6480	0.0511
		CGP-DSSPD	0.4114	0.4618	0.4833	0.4911	0.5055	0.5374	0.0373
70% dropout	GSD	CGP	0.4380	0.4727	0.4910	0.4924	0.4984	0.5459	0.0296
		CGP-DSSPD	0.4370	0.5055	0.5127	0.5212	0.5258	0.5511	0.0305
	HSC	CGP	0.4792	0.4944	0.5288	0.4990	0.5615	0.6364	0.0494
		CGP-DSSPD	0.4336	0.4727	0.5054	0.4927	0.5406	0.5820	0.0459
	mCAD	CGP	0.2857	0.4272	0.4890	0.4780	0.5659	0.7363	0.1303
		CGP-DSSPD	0.4341	0.4560	0.5137	0.5247	0.5673	0.5934	0.0582
	VSC	CGP	0.4447	0.4671	0.5090	0.5195	0.5358	0.5813	0.0448
		CGP-DSSPD	0.4398	0.4998	0.5250	0.5415	0.5488	0.5813	0.0418

2 Parameter Sensitivity Analysis

Table 3 presents the tabular results of the parameter sensitivity analysis considering the median values. The first column is the area under (AU) the precision-recall curve (PRC) and the receiver operating characteristic curve (ROC), respectively. Negative values indicate that the parameter generated worse results than the reference (0.02).

Table 3: Parameter sensitivity analysis for the median case. The values are the relative difference between several values for μ_{var} . The reference is $\mu_{var} = 0.02$.

AU	μ_{var}	GSD	0% dropout			GSD	50% dropout			GSD	70% dropout		
			HSC	mCAD	VSC		HSC	mCAD	VSC		HSC	mCAD	VSC
PRC	0.005	2.59%	1.48%	0.31%	-3.83%	2.58%	23.47%	6.48%	-2.43%	1.05%	9.24%	6.63%	-7.14%
	0.01	-1.45%	0.22%	2.16%	-2.63%	1.15%	8.85%	3.62%	5.50%	0.88%	4.16%	6.30%	-14.24%
	0.05	-3.73%	-3.13%	0.31%	15.95%	-1.51%	7.47%	7.00%	17.18%	-0.59%	-5.04%	-4.46%	-8.08%
ROC	0.005	0.66%	-0.14%	-0.50%	-4.70%	0.74%	9.44%	18.11%	0.41%	-0.61%	8.83%	4.73%	-10.06%
	0.01	-0.85%	1.61%	0.48%	-4.86%	1.12%	5.40%	16.37%	0.16%	-0.56%	10.96%	4.73%	-14.35%
	0.05	0.25%	-1.10%	-0.50%	-1.30%	-1.77%	5.50%	17.54%	0.81%	-0.36%	-1.44%	-0.51%	-8.57%