

On Dealing with Uncertainties from Kriging
Models in Offline Data-driven Evolutionary
Multiobjective Optimization (Supplementary
Material)

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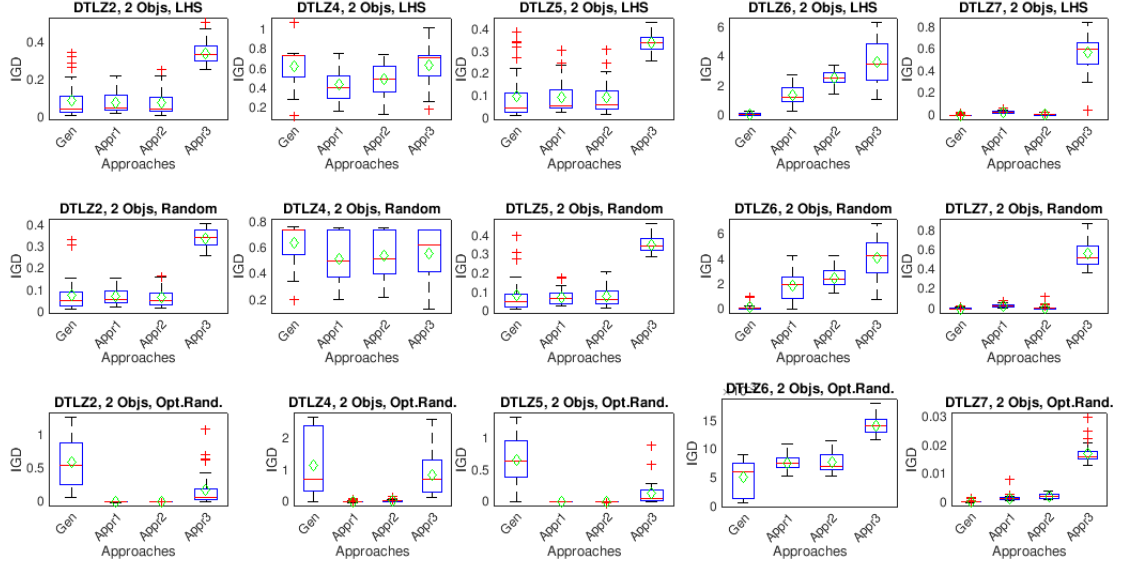


Figure 1: Box plot of IGD for 31 runs for DTLZ problems for 2 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

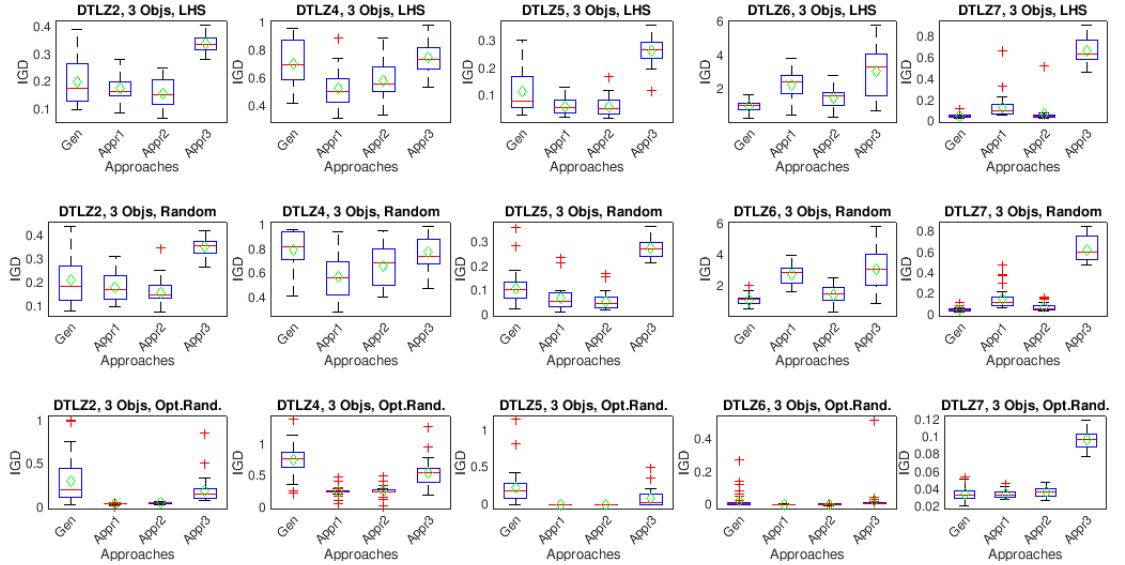


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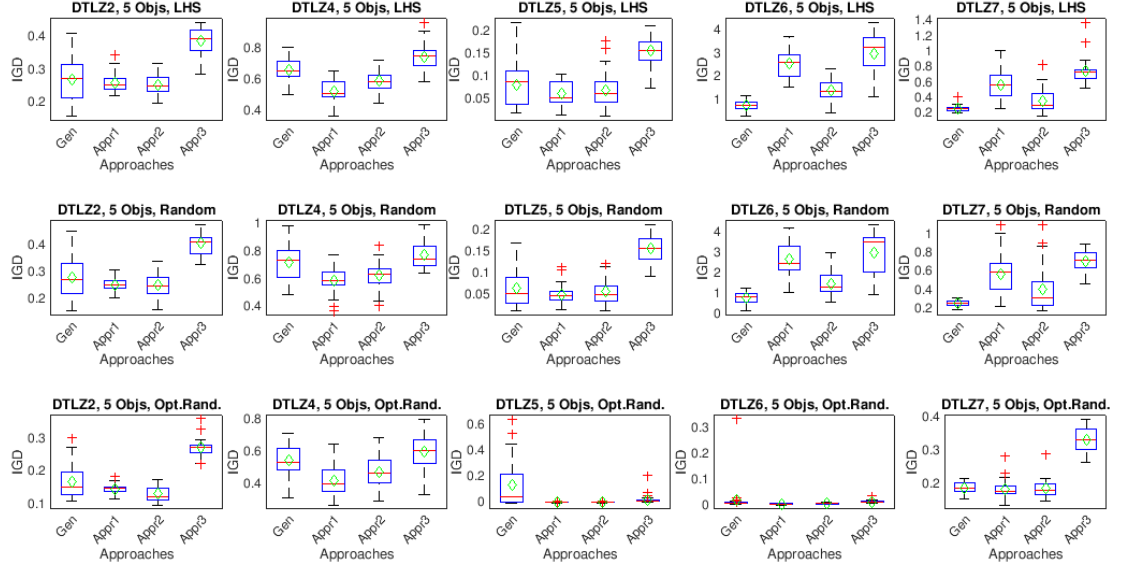


Figure 3: Box plot of IGD for 31 runs for DTLZ problems for 5 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

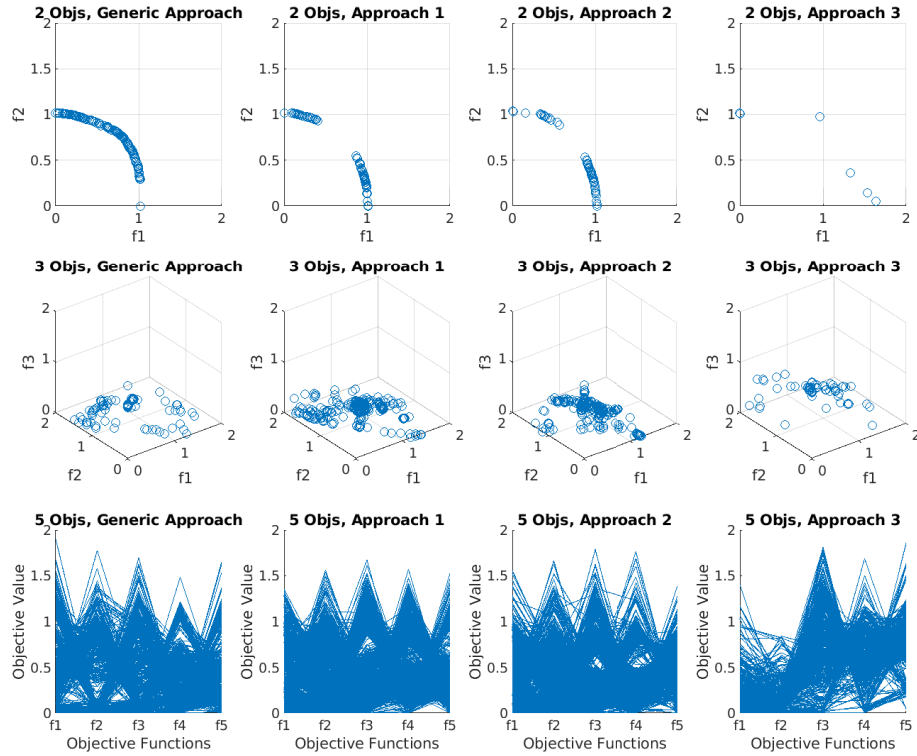


Figure 4: Final solutions obtained of the run with the median IGD value using different approaches for uniform random sampling for DTLZ2 Problem.

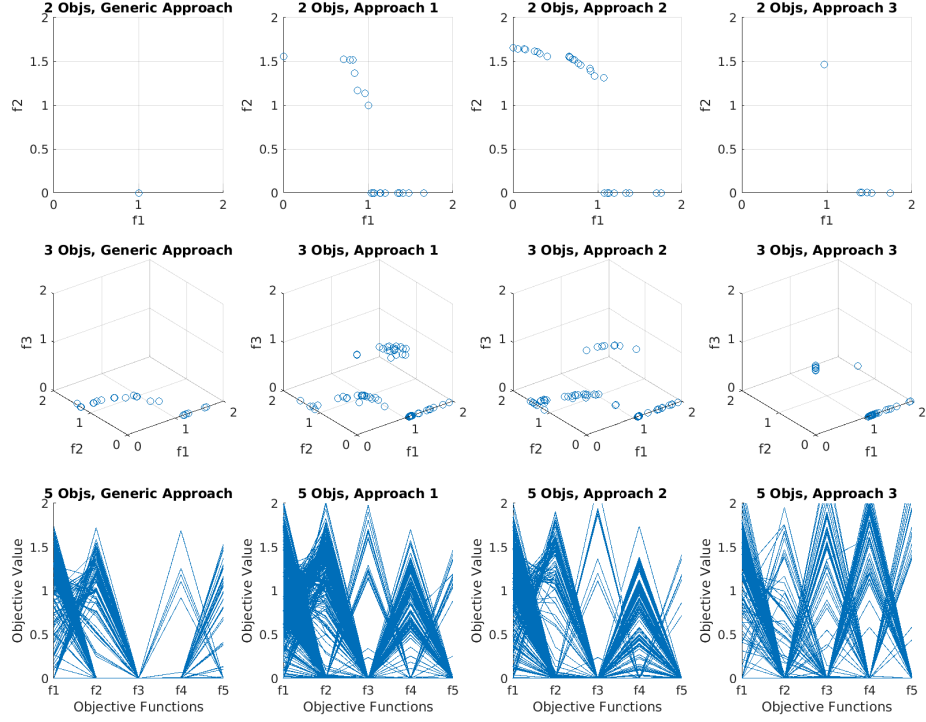


Figure 5: Final solutions obtained of the run with the median IGD value using different approaches for LHS sampling for DTLZ4 Problem.

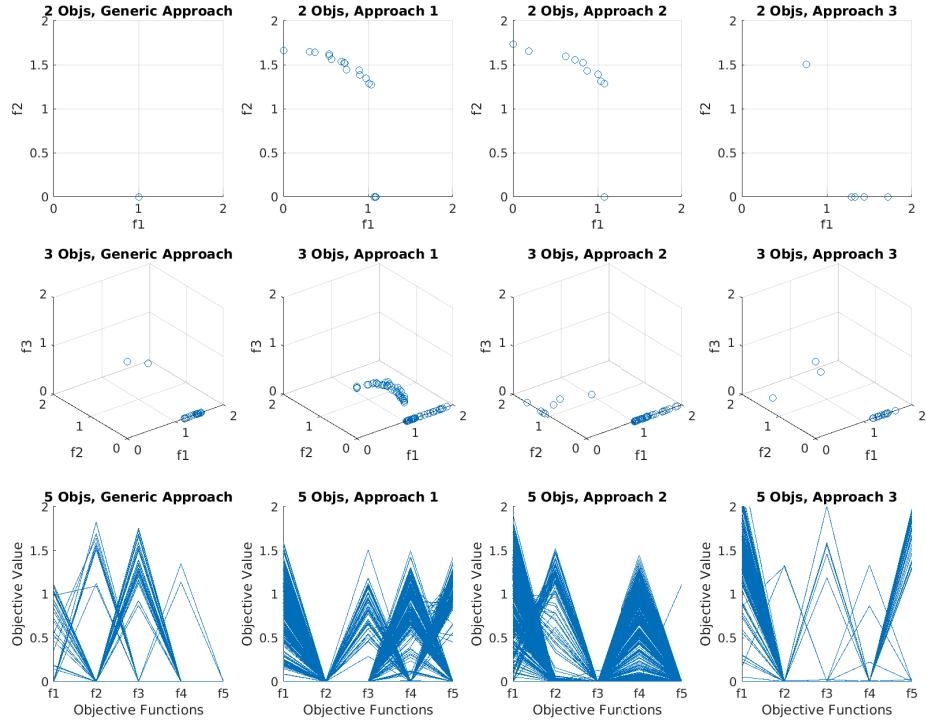


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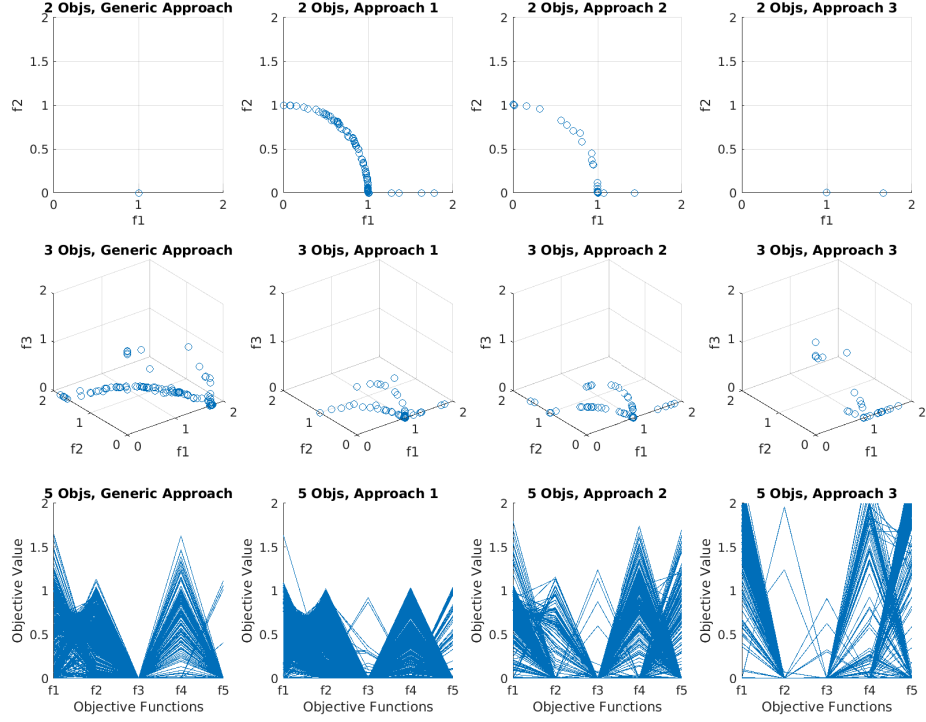


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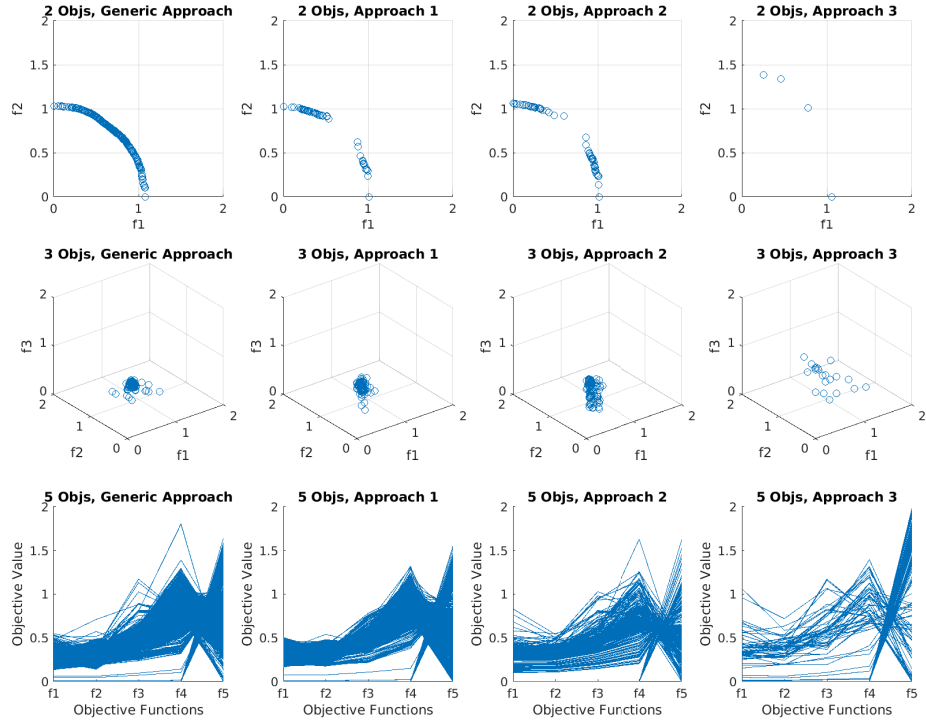


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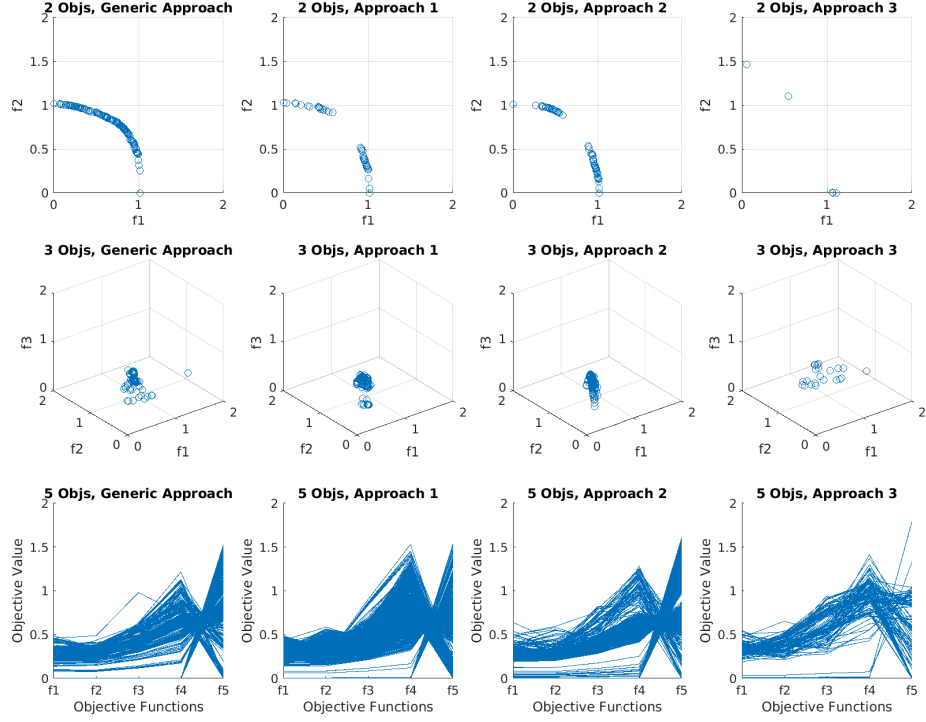


Figure 9: Final solutions obtained of the run with the median IGD value using different approaches for uniform random sampling for DTLZ5 Problem.

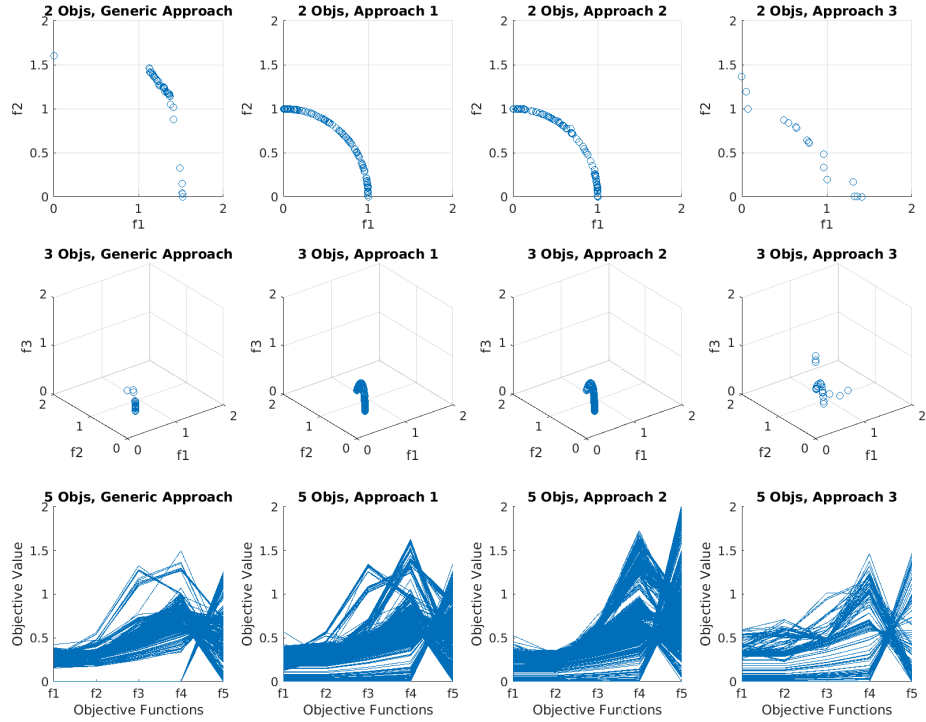


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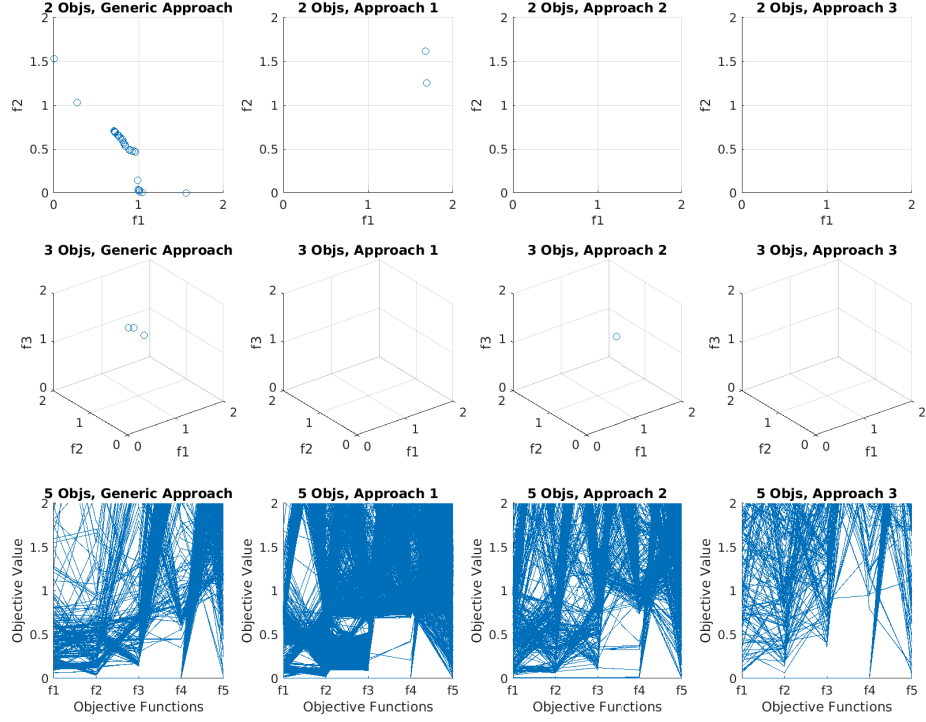


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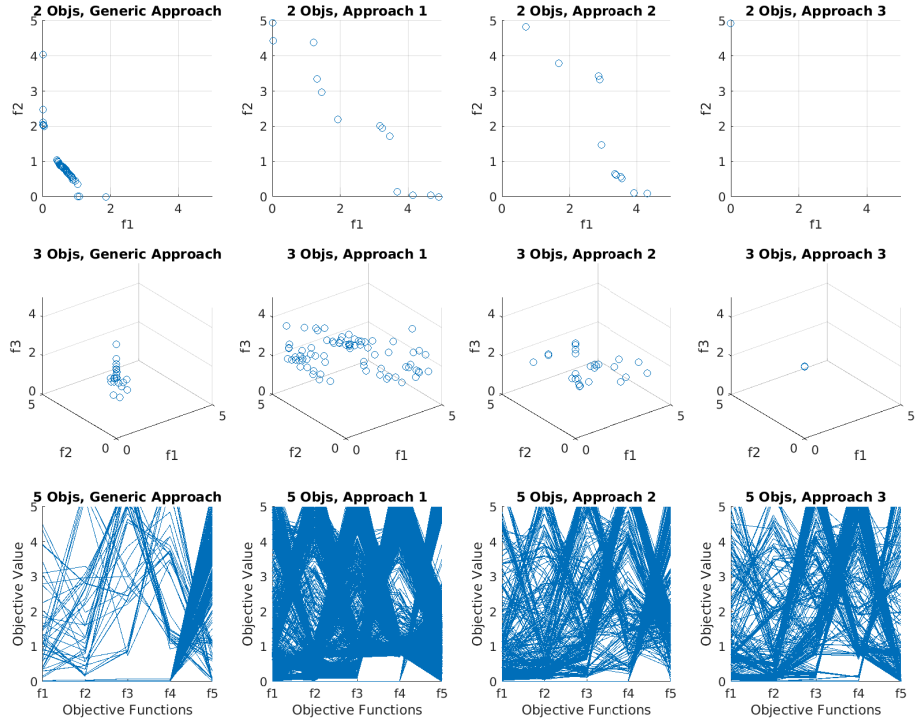


Figure 12: Final solutions obtained of the run with the median IGD value using different approaches for uniform random sampling for DTLZ6 Problem.

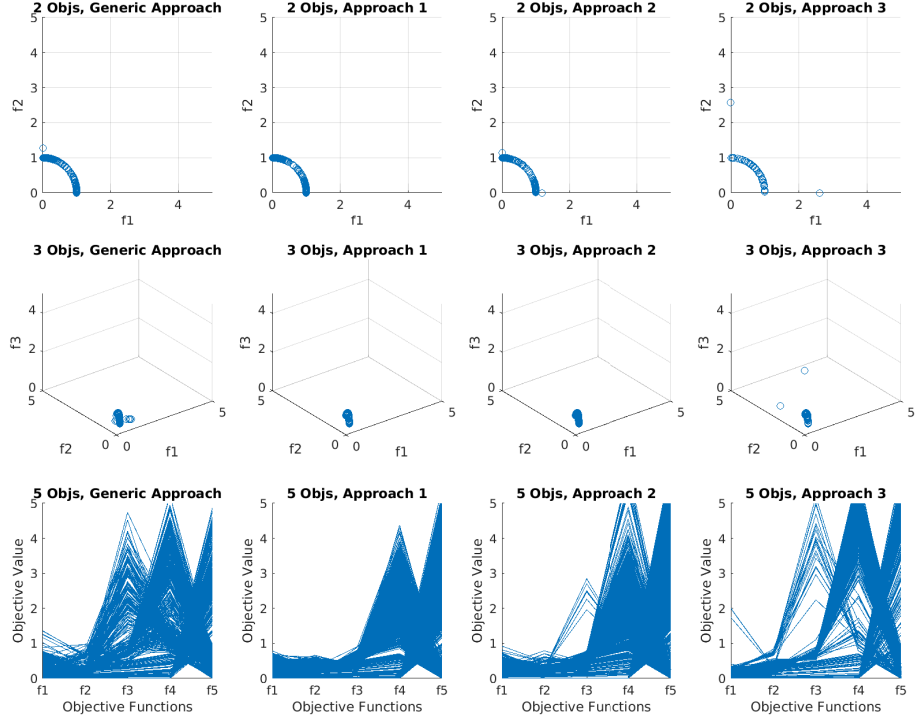


Figure 13: Final solutions obtained of the run with the median IGD value using different approaches for optimal-random sampling for DTLZ6 Problem.

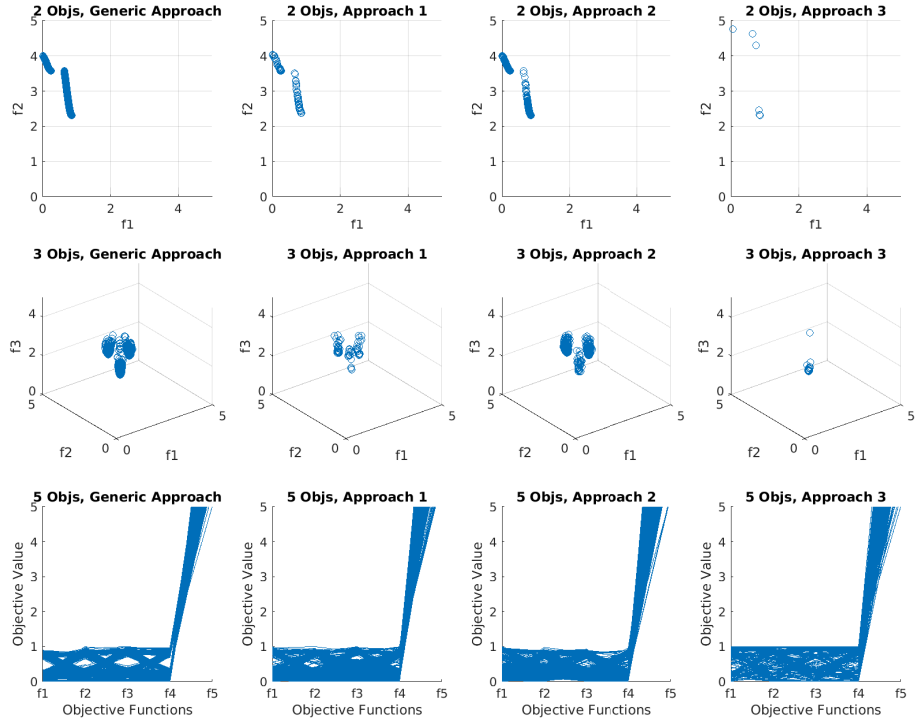


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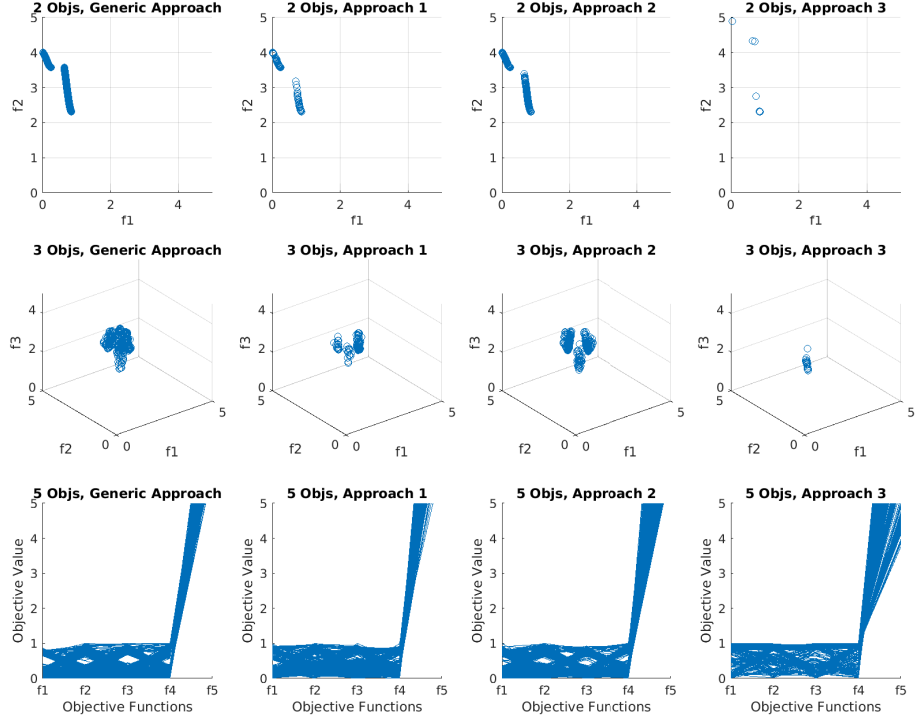


Figure 15: Final solutions obtained of the run with the median IGD value using different approaches for uniform random sampling for DTLZ7 Problem.

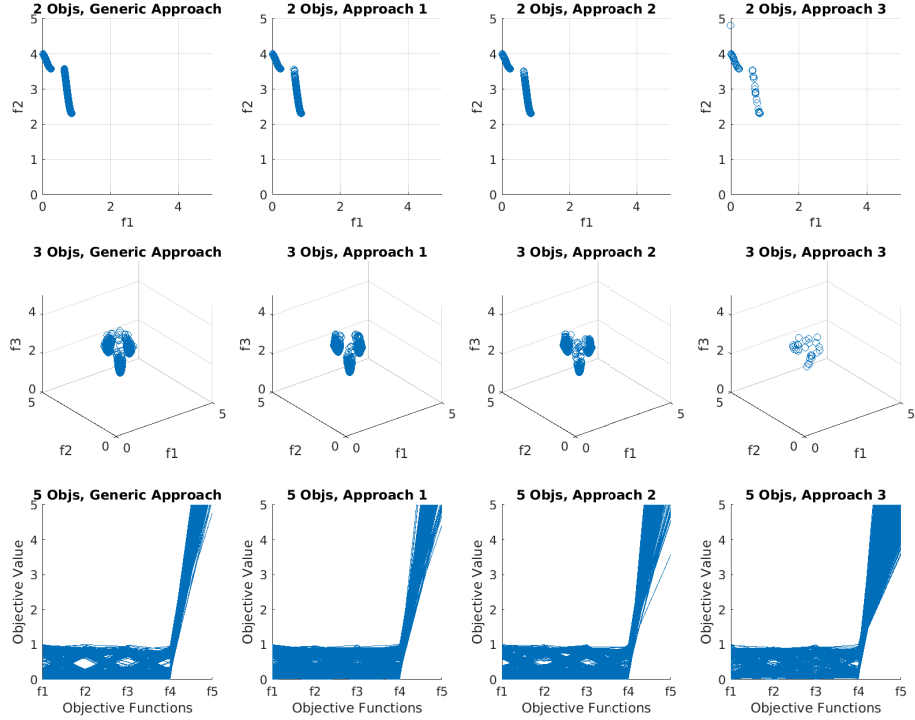


Figure 16: Final solutions obtained of the run with the median IGD value using different approaches for optimal-random sampling for DTLZ7 Problem.

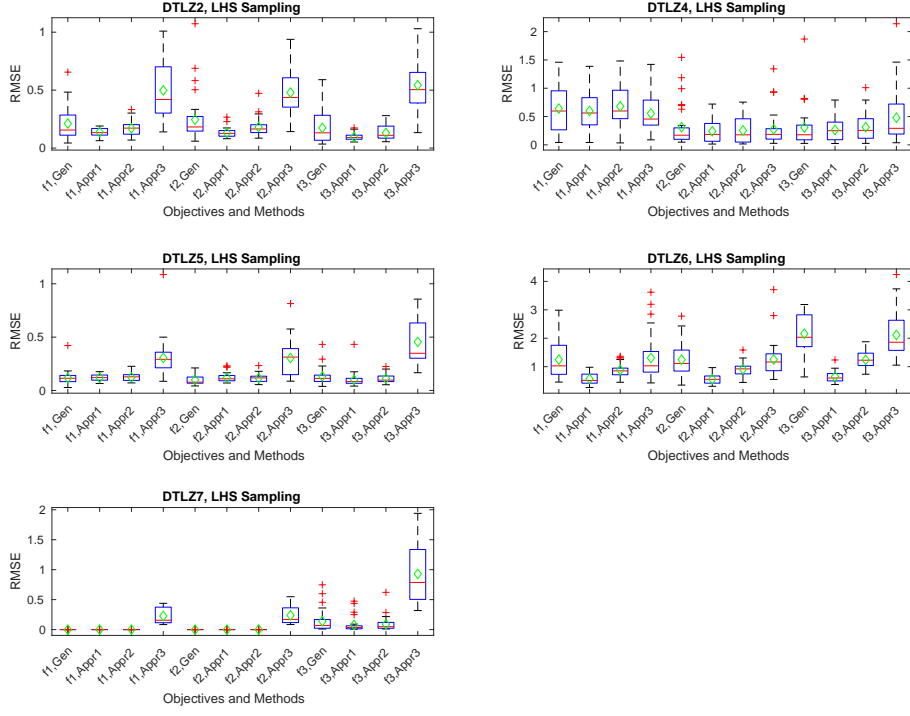


Figure 17: RMSE of the final solutions for three objective problems, LHS sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

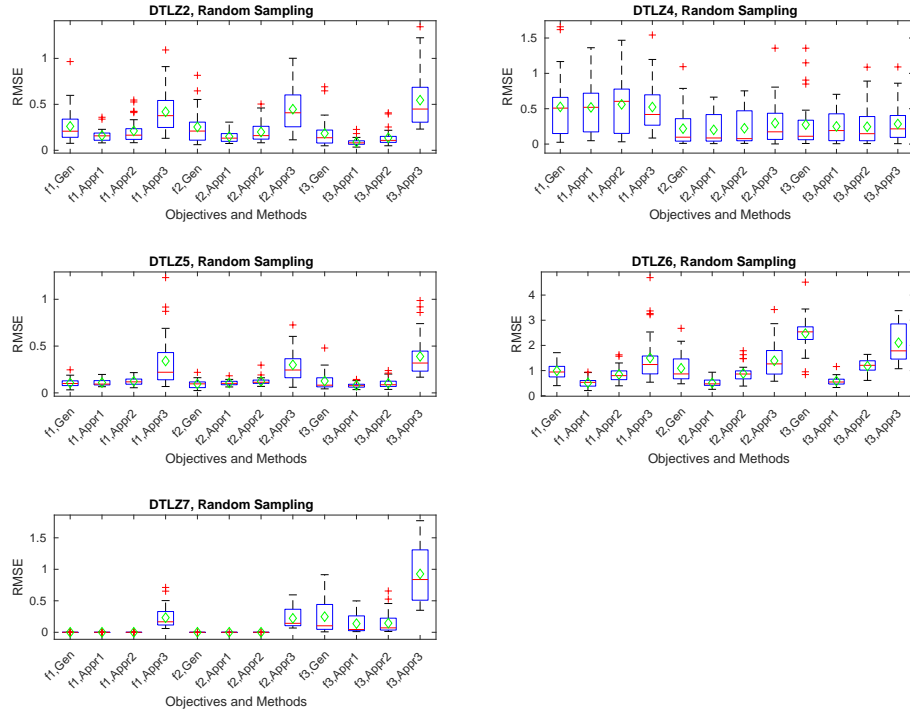


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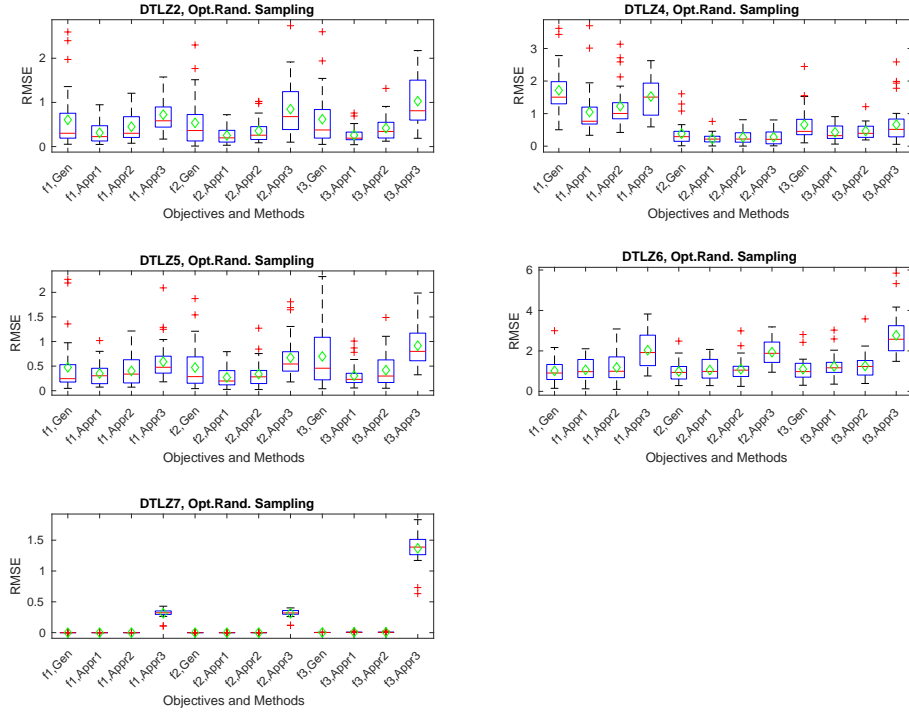


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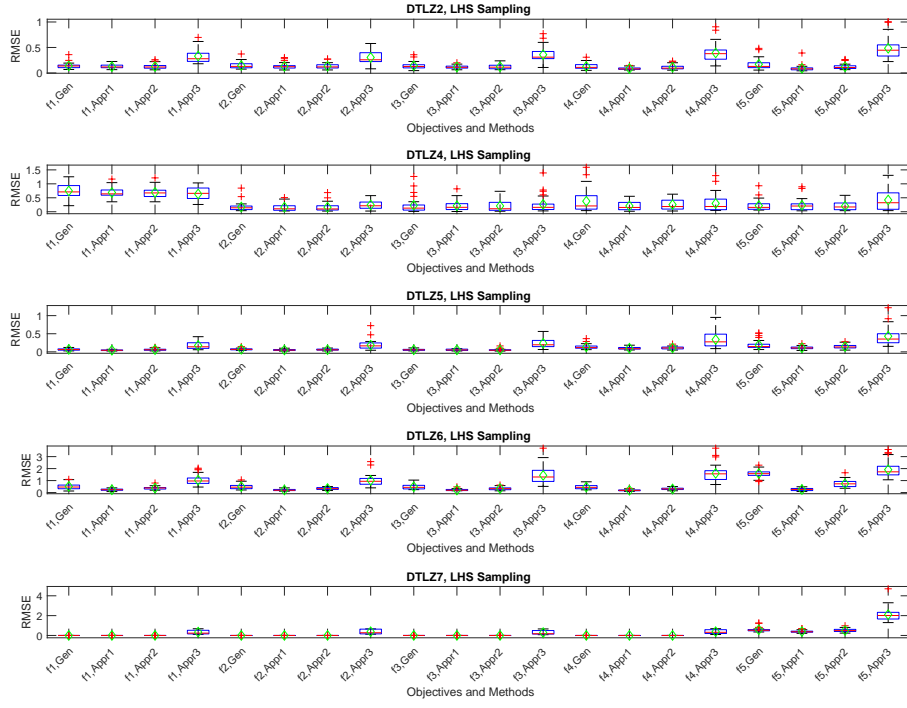


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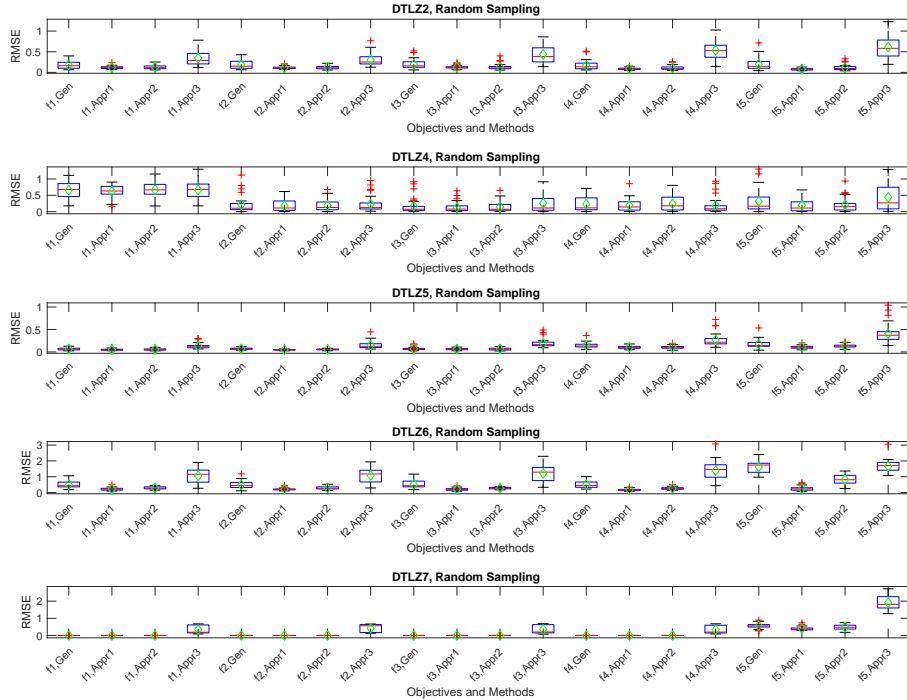


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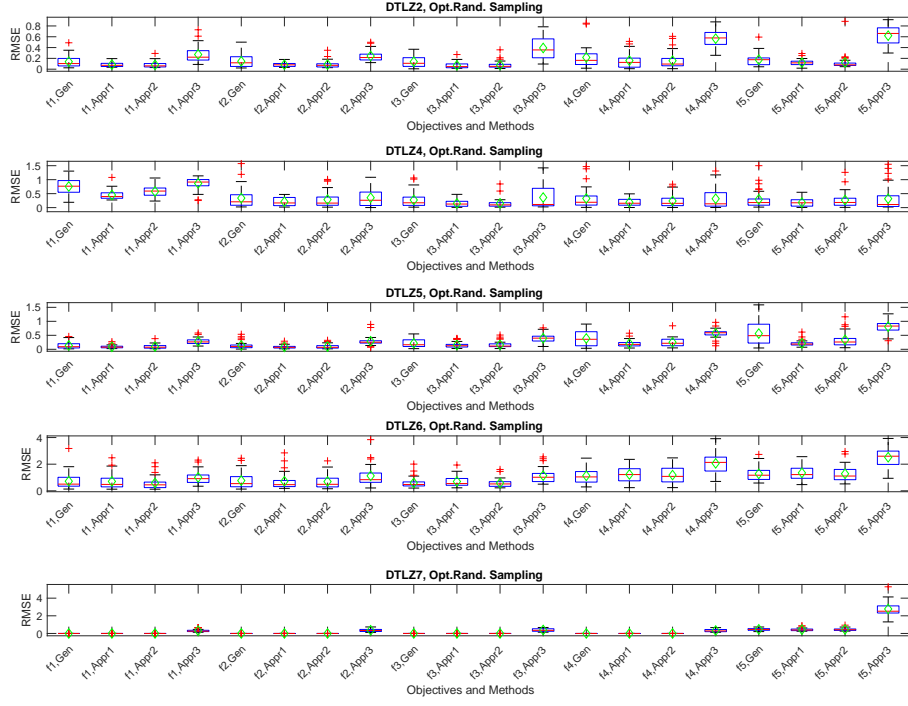


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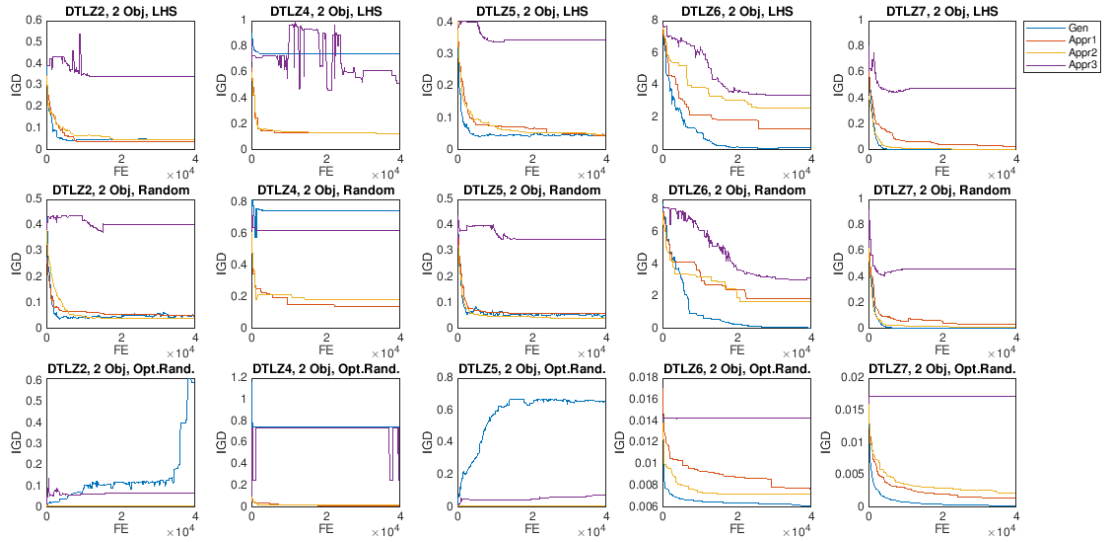


Figure 23: IGD variation with function evaluations for DTLZ problems for 2 objective problems. Here "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

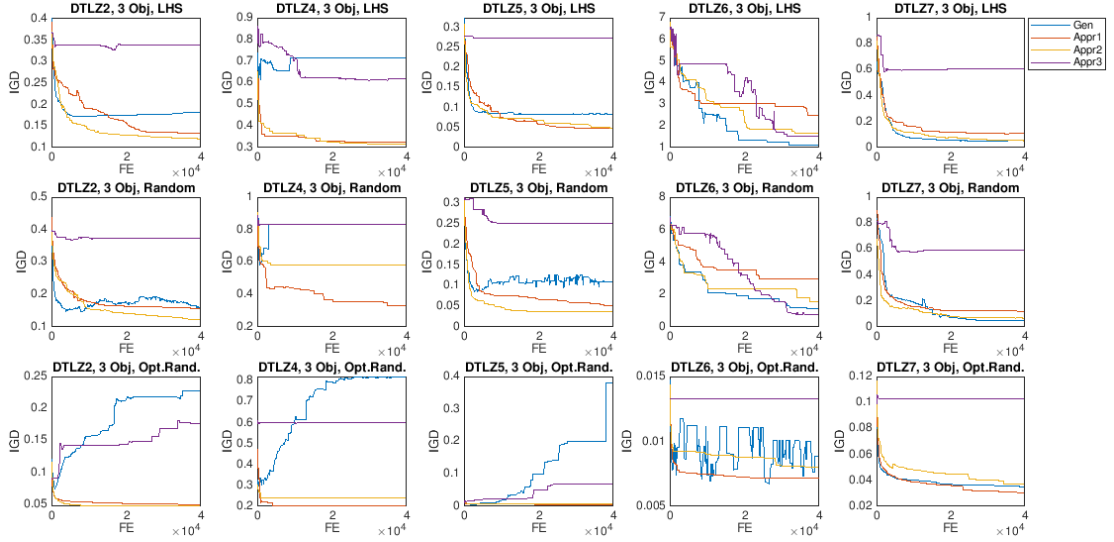


Figure 24: IGD variation with function evaluations for DTLZ problems for 3 objective problems. Here "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

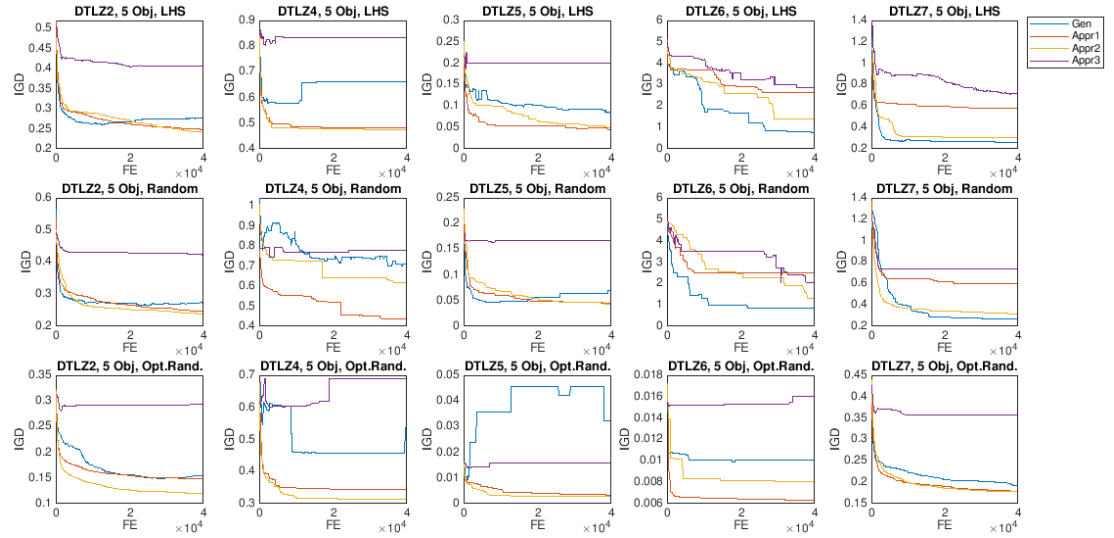


Figure 25: IGD variation with function evaluations for DTLZ problems for 5 objective problems. Here "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

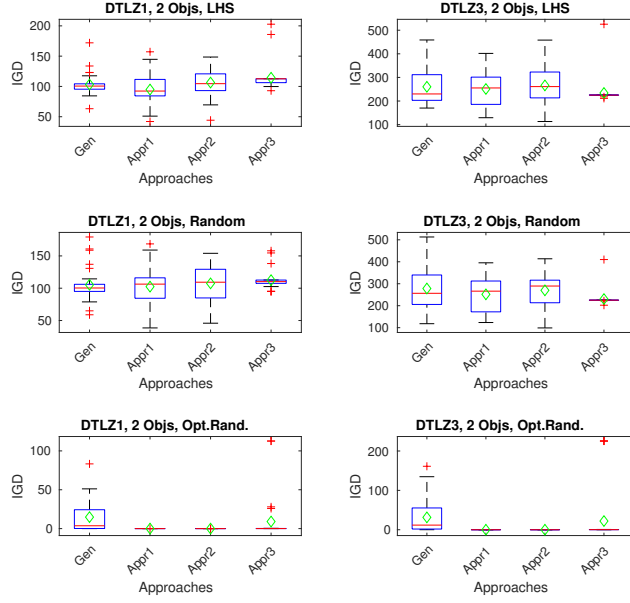


Figure 26: Box plot of IGD for 31 runs for DTLZ 1 and 3 problems for 2 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

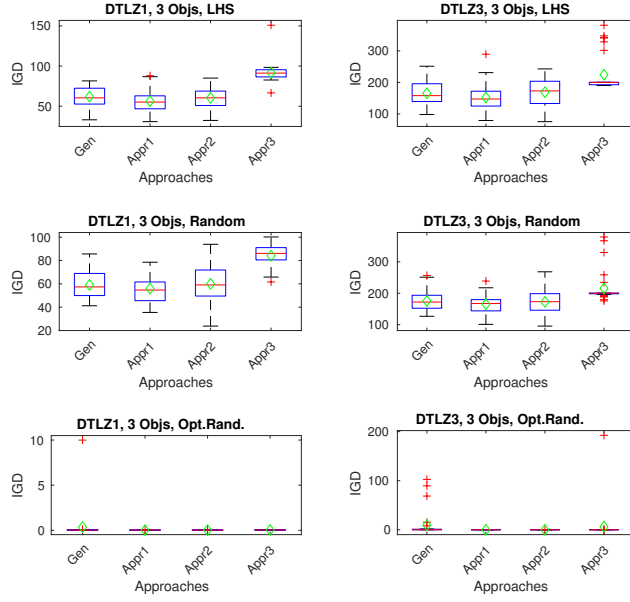


Figure 27: Box plot of IGD for 31 runs for DTLZ 1 and 3 problems for 3 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

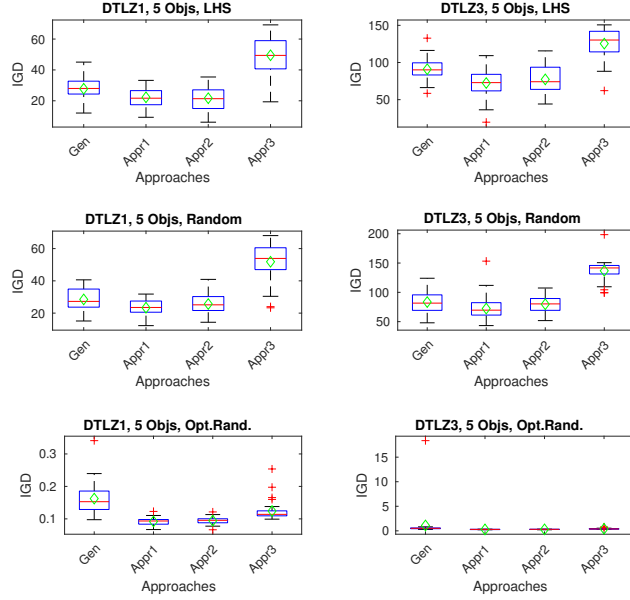


Figure 28: Box plot of IGD for 31 runs for DTLZ 1 and 3 problems for 5 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

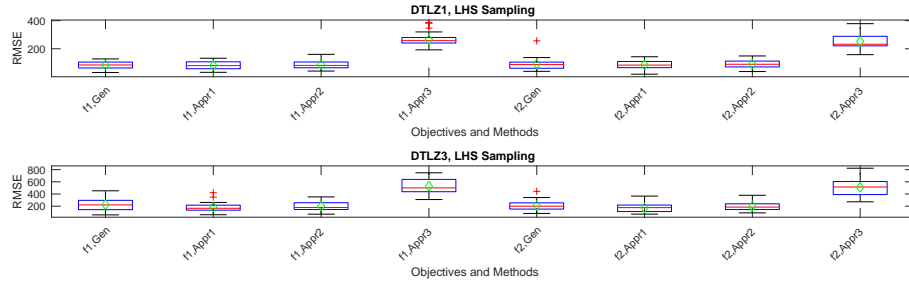


Figure 29: RMSE of the final solutions for DTLZ1 and 3 , 2 objective problems, LHS sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

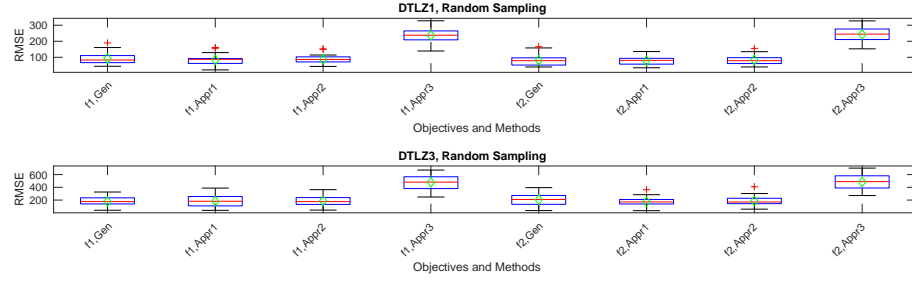


Figure 30: RMSE of the final solutions for DTLZ1 and 3 , 2 objective problems, Random sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

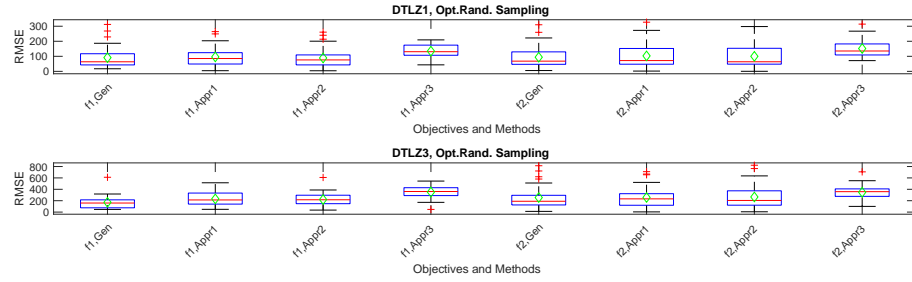


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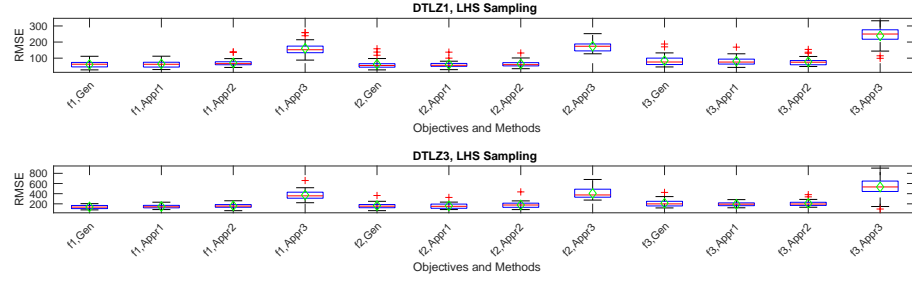


Figure 32: RMSE of the final solutions for DTLZ1 and 3 , 3 objective problems, LHS sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

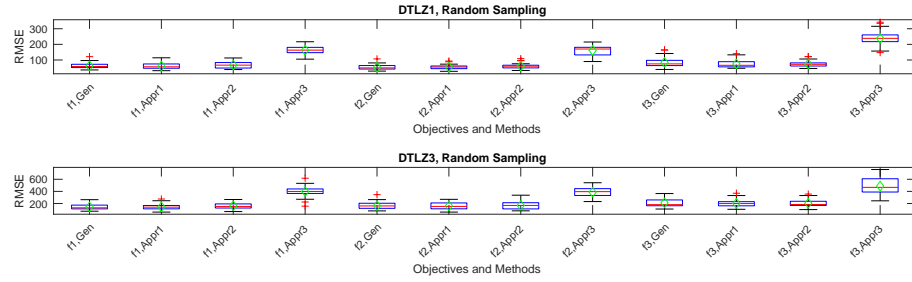


Figure 33: RMSE of the final solutions for DTLZ1 and 3 , 3 objective problems, Random sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

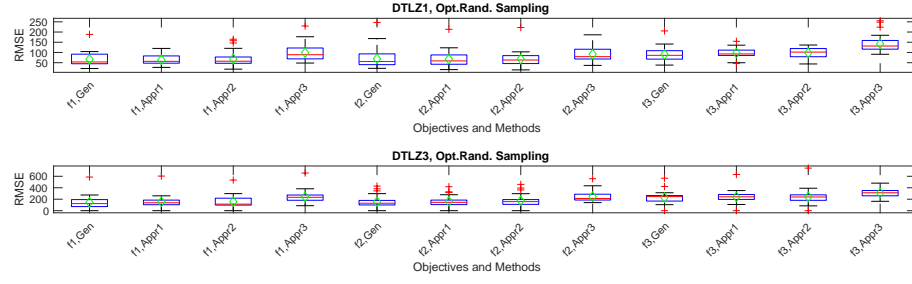


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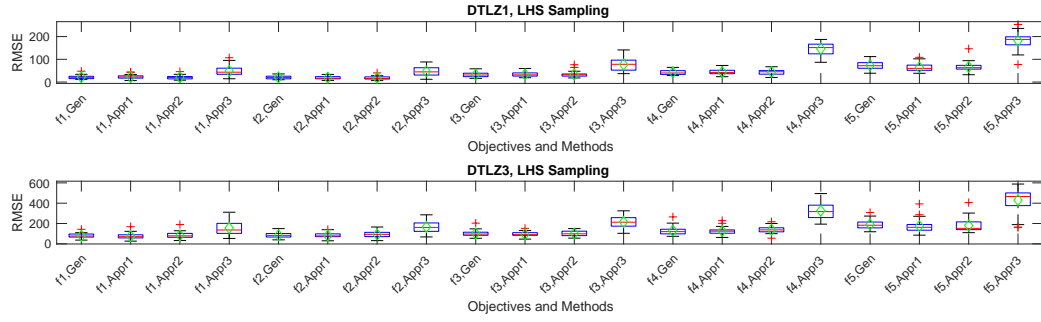


Figure 35: RMSE of the final solutions for DTLZ1 and 3 , 5 objective problems, LHS sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

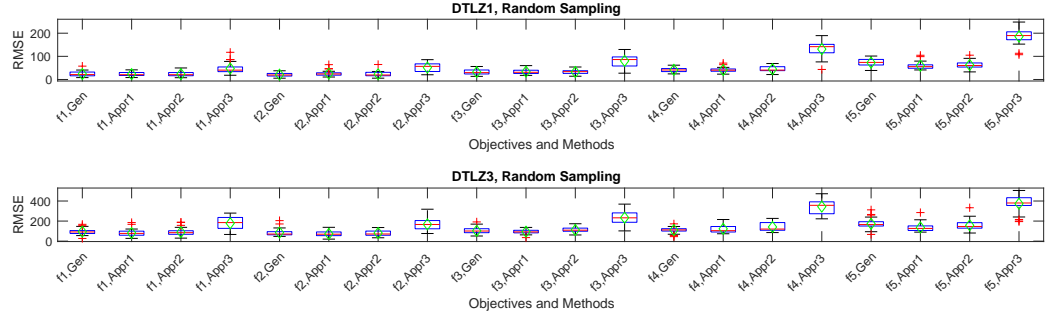


Figure 36: RMSE of the final solutions for DTLZ1 and 3 , 5 objective problems, Random sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

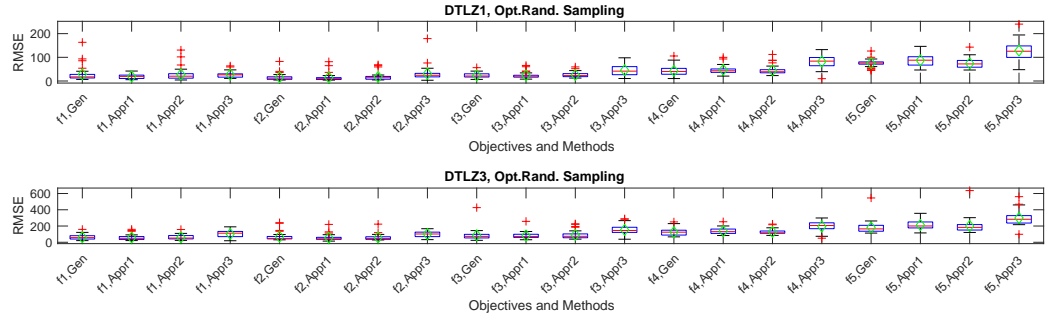


Figure 37: RMSE of the final solutions for DTLZ1 and 3 , 5 objective problems, Optimal-Random sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

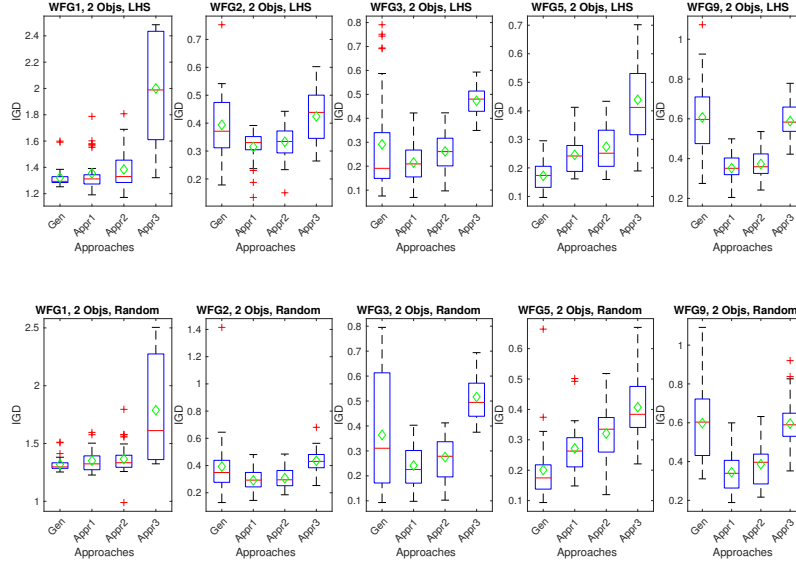


Figure 38: Box plot of IGD for 31 runs for WFG1-3, WFG5 and WFG9 problems using LHS and uniform random sampling, for 2 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

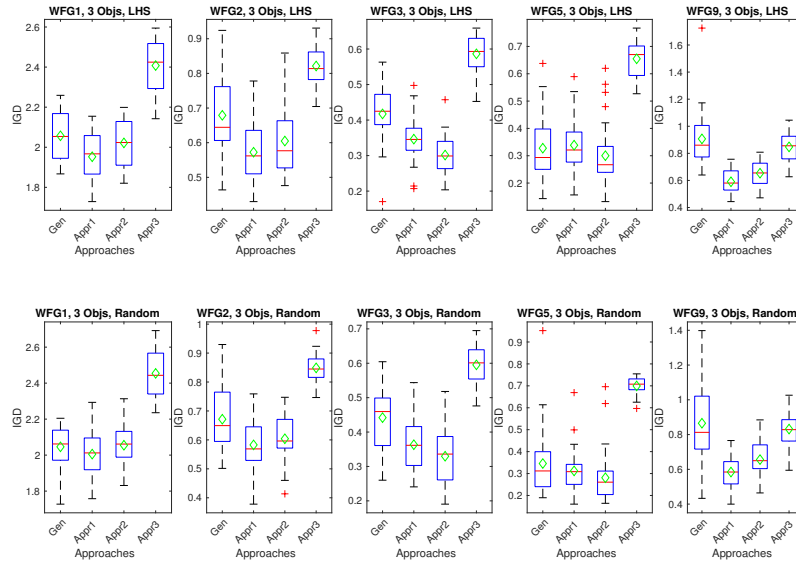


Figure 39: Box plot of IGD for 31 runs for WFG1-3, WFG5 and WFG9 problems using LHS and uniform random sampling, for 3 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

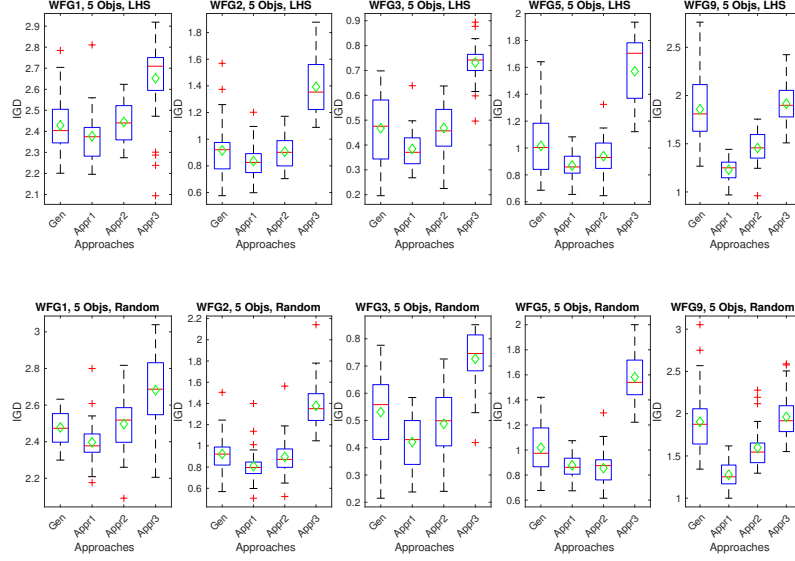


Figure 40: Box plot of IGD for 31 runs for WFG1-3, WFG5 and WFG9 problems using LHS and uniform random sampling, for 5 objective problems. "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

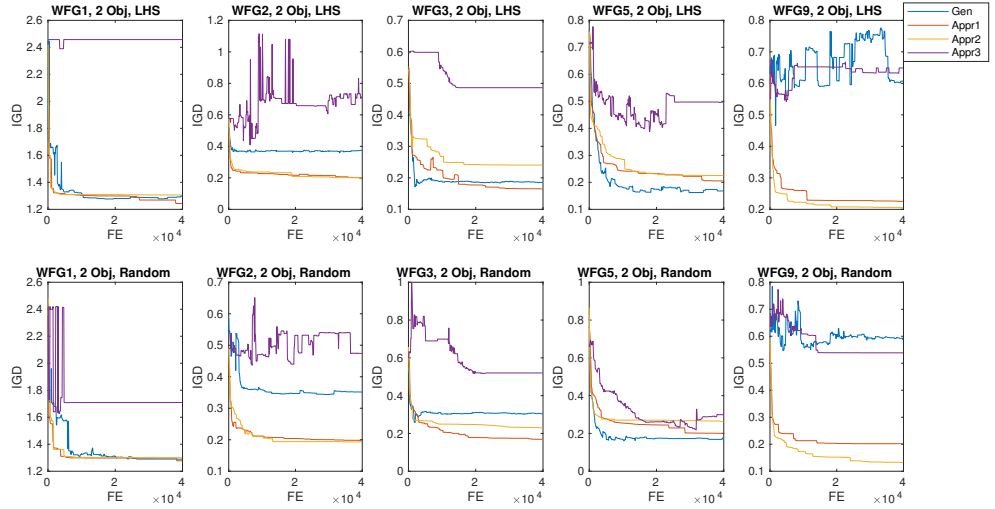


Figure 41: IGD variation with function evaluations for WFG1-3, WFG5 and WFG9, for 2 objective problems for LHS and uniform random sampling. Here "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

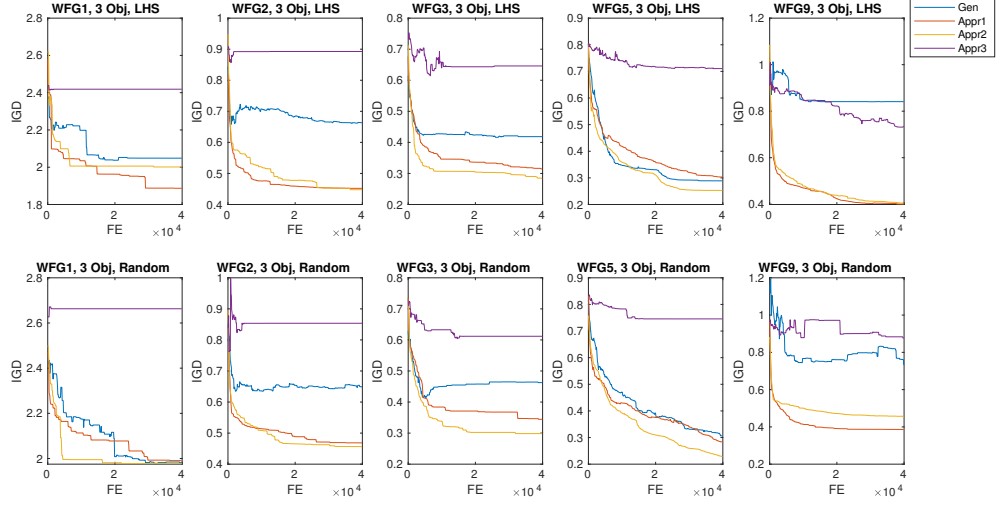


Figure 42: IGD variation with function evaluations for WFG1-3, WFG5 and WFG9, for 3 objective problems for LHS and uniform random sampling. Here "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

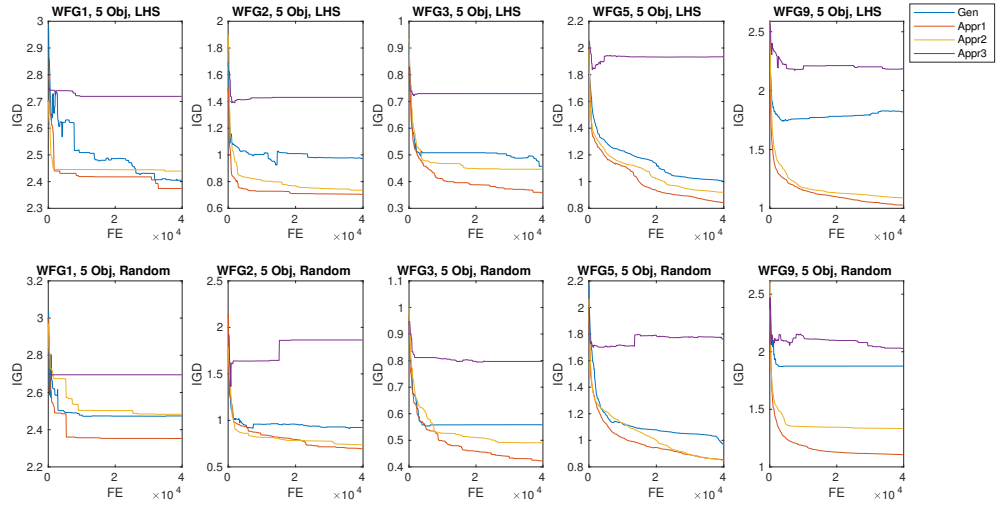


Figure 43: IGD variation with function evaluations for WFG1-3, WFG5 and WFG9, for 5 objective problems for LHS and uniform random sampling. Here "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

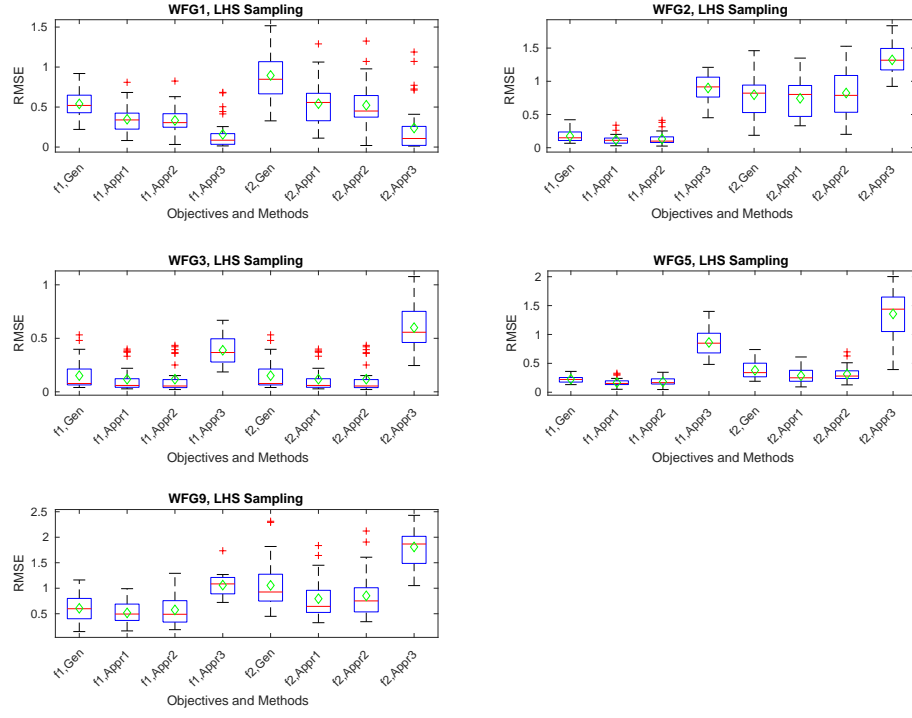


Figure 44: RMSE of the final solutions for two objective problems, LHS sampling. Here f1 and f2 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

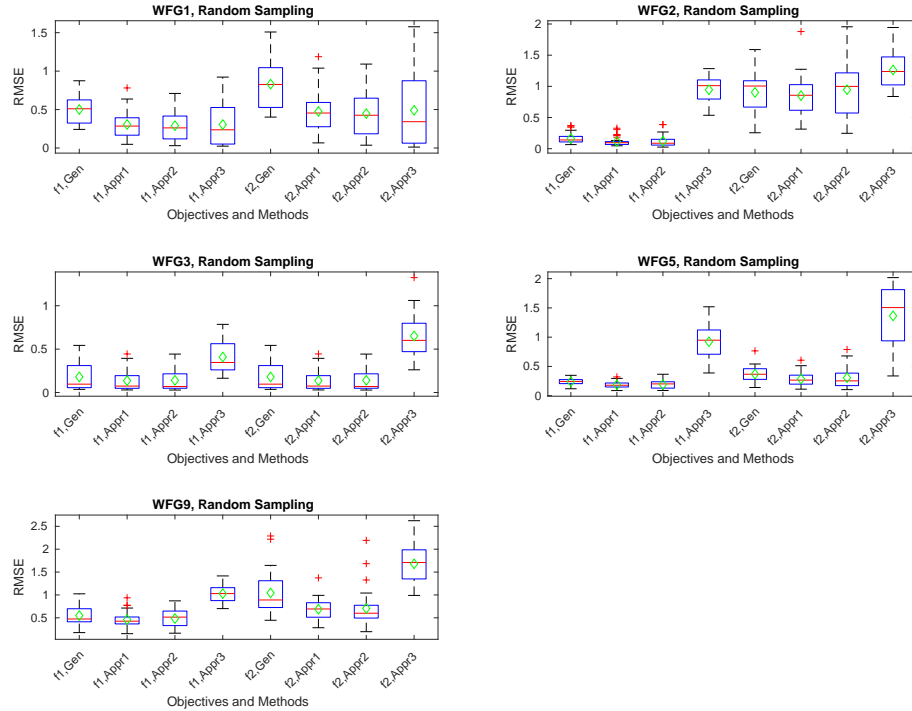


Figure 45: RMSE of the final solutions for two objective problems, uniform random sampling. Here f1 and f2 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

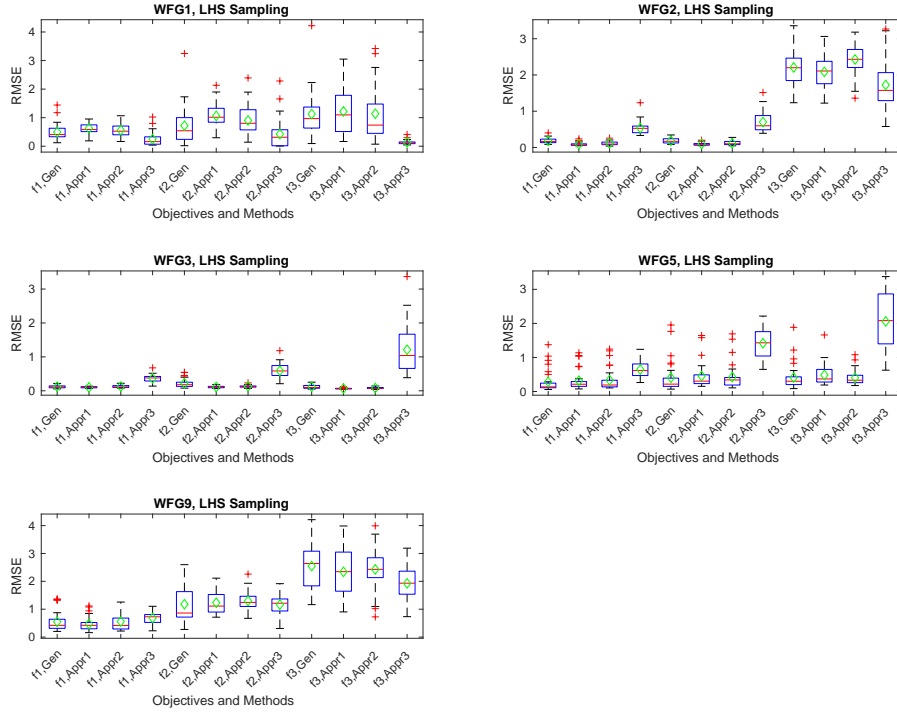


Figure 46: RMSE of the final solutions for three objective problems, LHS sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

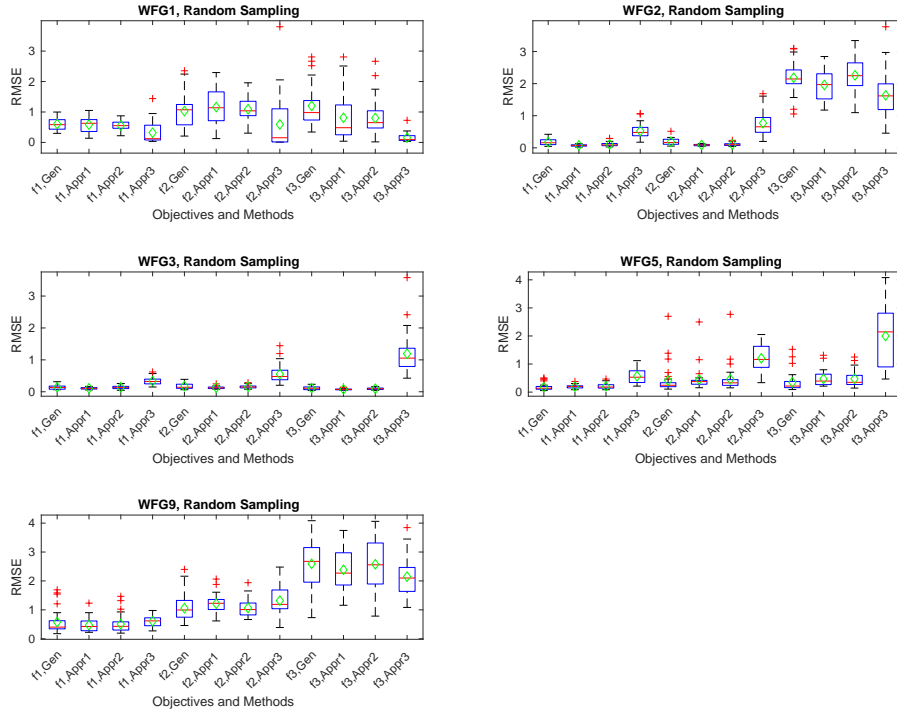


Figure 47: RMSE of the final solutions for 3 objective problems, uniform random sampling. Here f1, f2 and f3 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

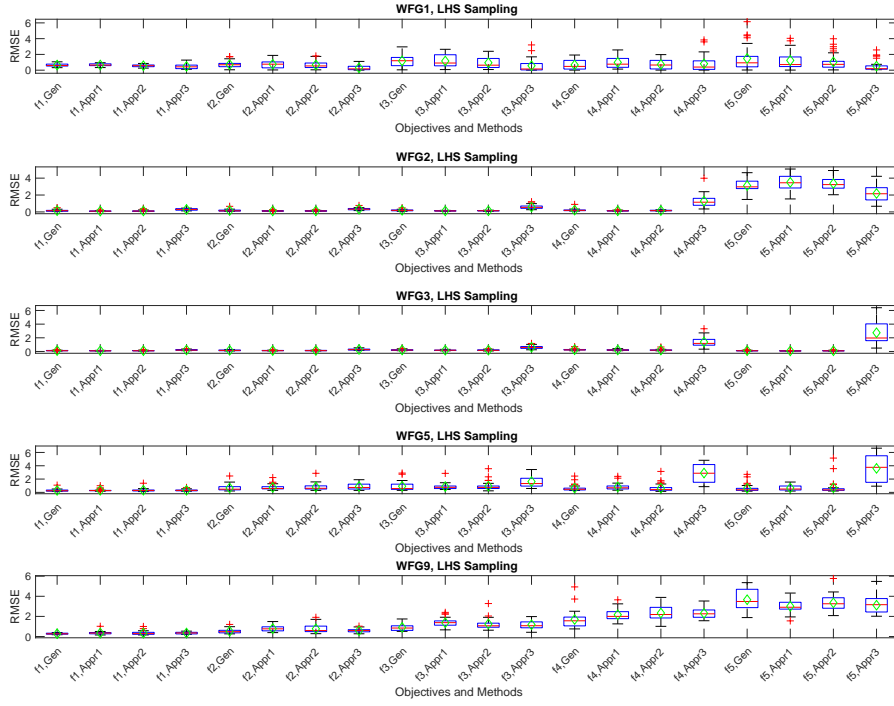


Figure 48: RMSE of the final solutions for five objective problems, LHS sampling. Here f1 - f5 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

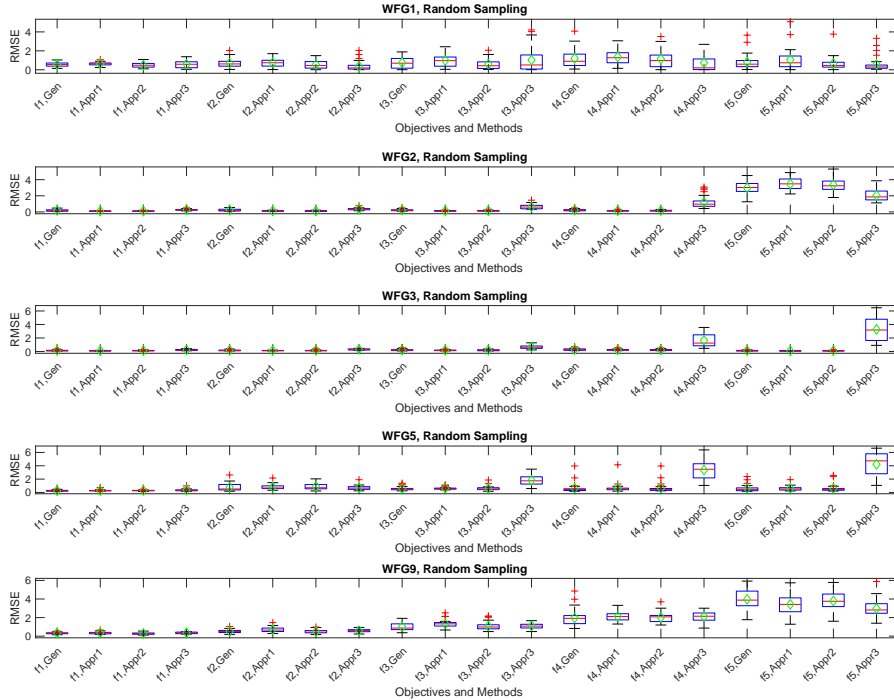


Figure 49: RMSE of the final solutions for five objective problems, uniform random sampling. Here f1 - f5 are the objectives and "Gen", "Appr1", "Appr2" and "Appr3" are the Generic, Approach 1, Approach 2 and Approach 3 respectively.

Table 1: Means and standard deviations of IGD values of the final archive, evaluated on the true objective functions, obtained by each approach, for various problems and sampling techniques. (Best values are in bold)

Sampling	Problems	k	Generic		Approach 1		Approach 2		Approach 3	
			Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
LHS	WFG1	2	1.3066	0.0389	1.4268	0.1739	1.4231	0.1963	2.0806	0.4640
		3	2.0587	0.1459	1.9582	0.1123	1.9678	0.1103	2.3788	0.1450
		5	2.3846	0.0810	2.3728	0.0922	2.3923	0.0779	2.6096	0.2338
	WFG2	2	0.4511	0.1527	0.3335	0.0538	0.3602	0.0643	0.4201	0.1017
		3	0.7286	0.1250	0.5917	0.1101	0.6386	0.1217	0.8464	0.0587
		5	1.0013	0.2688	0.8304	0.1493	0.9328	0.1528	1.4499	0.2560
	WFG3	2	0.3288	0.2438	0.2466	0.0971	0.2962	0.0828	0.4813	0.0626
		3	0.4291	0.0806	0.3558	0.0523	0.3036	0.0665	0.5764	0.0512
		5	0.4548	0.1631	0.3878	0.0936	0.4697	0.0734	0.7152	0.0930
	WFG5	2	0.1809	0.0544	0.2328	0.0510	0.2603	0.0857	0.4390	0.1333
		3	0.3137	0.1211	0.3378	0.1224	0.3118	0.1427	0.6655	0.0831
		5	1.0306	0.2586	0.8810	0.1047	0.9529	0.1786	1.7037	0.1969
	WFG9	2	0.6178	0.1862	0.3492	0.0457	0.3557	0.0529	0.5937	0.0960
		3	0.9004	0.1570	0.5606	0.0736	0.6274	0.0619	0.7987	0.1263
		5	1.8337	0.2581	1.2238	0.1325	1.4469	0.1406	1.9911	0.2685
	DTLZ1	2	101.6800	19.2220	95.9280	31.5570	102.7000	29.3710	118.2300	22.5140
		3	55.6690	14.0530	55.4780	15.8940	60.6140	17.3780	88.4570	8.4992
		5	28.0220	10.1230	20.9730	5.4951	19.8980	5.6203	49.9580	10.3520
	DTLZ3	2	257.6300	83.5280	226.4300	52.1530	235.1600	74.6160	250.5100	91.3070
		3	173.2800	38.0950	171.9700	54.3810	153.1500	40.5280	225.7400	67.6530
		5	86.3440	19.9320	64.3810	17.4950	77.0110	19.8540	126.2400	16.5810
Random	WFG1	2	1.3421	0.0713	1.3917	0.0975	1.3707	0.1593	1.9120	0.4290
		3	2.0685	0.0967	1.9967	0.1110	2.0775	0.1363	2.4802	0.1339
		5	2.4517	0.1091	2.3888	0.1045	2.4532	0.1456	2.6940	0.1639
	WFG2	2	0.4126	0.3478	0.2666	0.0717	0.2878	0.0747	0.4313	0.1091
		3	0.6876	0.0944	0.5958	0.0682	0.6181	0.0697	0.8511	0.0464
		5	0.9280	0.1510	0.8266	0.1372	0.9331	0.1393	1.3161	0.1665
	WFG3	2	0.3714	0.2535	0.2410	0.0954	0.2721	0.0979	0.4940	0.1001
		3	0.4285	0.0872	0.3744	0.0811	0.3206	0.0748	0.5846	0.0582
		5	0.5352	0.1392	0.4411	0.1069	0.4732	0.1243	0.7139	0.1384
	WFG5	2	0.2308	0.1624	0.3065	0.1048	0.3305	0.1164	0.4053	0.1068
		3	0.4081	0.2226	0.3337	0.1424	0.3461	0.1695	0.7097	0.0388
		5	1.0316	0.1956	0.8944	0.1119	0.9142	0.1669	1.5578	0.1552
	WFG9	2	0.6418	0.2136	0.3127	0.1192	0.3683	0.1145	0.5631	0.1308
		3	0.8617	0.2474	0.5999	0.0816	0.6818	0.0997	0.8450	0.1054
		5	2.1932	0.4376	1.3952	0.1762	1.7792	0.3174	2.1295	0.3066
	DTLZ1	2	103.0400	27.0450	97.2370	26.2210	97.4230	23.2970	114.6700	18.2860
		3	56.4280	14.6710	56.2860	10.5470	66.9150	15.9090	88.5730	9.2469
		5	26.2810	6.5748	22.1690	4.8264	25.2270	5.1023	48.7180	13.6880
	DTLZ3	2	278.9100	99.6570	223.5600	60.5690	255.4100	58.1410	242.0500	55.7540
		3	181.8100	32.6680	174.3400	34.1910	172.3100	35.0190	219.6400	41.5440
		5	89.4480	19.4750	72.1780	27.8800	79.3700	18.8420	133.9500	18.5340
Opt-Rand	DTLZ1	2	16.5910	26.5530	0.0048	0.0009	0.0054	0.0015	0.0764	0.0741
		3	0.0382	0.0187	0.0240	0.0031	0.0258	0.0028	0.0402	0.0032
		5	0.1699	0.0683	0.0928	0.0144	0.1005	0.0108	0.1364	0.0465
	DTLZ3	2	34.1030	34.3560	0.0102	0.0020	0.0099	0.0013	41.2650	90.9960
		3	16.2170	31.7970	0.0690	0.0095	0.0736	0.0130	17.6330	57.9900
		5	0.5160	0.1457	0.2839	0.0296	0.2936	0.0356	0.4054	0.0791