

Fig. 1. Properties of Benchmarks.

TABLE I
CLASSICAL SYMBOLIC REGRESSION BENCHMARKS(SRB).

FileNumber	FileName	Objective Function	Data Set
F1	Keijzer-5	$\log(x)$	U[0,2,20]
F2	Nguyen-8	\sqrt{x}	U[0,2,20]
F3	Korns-1	$1.57 + 24.3x$	U[-1,1,20]
F4	Korns-6	$6.87 + 11\cos(7.23x^3)$	U[-0.5,0.5,20]
F5	Nguyen-4	$x^6 + x^5 + x^4 + x^3 + x^2 + x$	U[-1,1,20]
F6	Nguyen-3	$x^5 + x^4 + x^3 + x^2 + x$	U[-1,1,20]
F7	Koza-1,Nguyen-2	$x^4 + x^3 + x^2 + x$	U[-1,1,20]
F8	Nguyen-1	$x^3 + x^2 + x$	U[-1,1,20]
F9	Koza-3	$x^6 - 2x^4 + x^2$	U[-1,1,20]
F10	Koza-2	$x^5 - 2x^3 + x$	U[-1,1,20]
F11	Nguyen-5	$\cos(x)\sin(x^2) - 1$	U[-1.6,1.6,20]
F12	Nguyen-6	$\sin(x) + \sin(x + x^2)$	U[-1,1,20]
F13	Nguyen-11	x^y	U[2,4,400]
F14	Keijzer-11	$xy + \sin((x - 1)(y - 1))$	U[-1,1,400]
F15	Nguyen-12	$x^4 - x^3 + y^2/2 - y$	U[-1,1,400]
F16	Keijzer-13	$6\sin(x)\cos(y)$	U[-1,1,400]
F17	Keijzer-15	$x^3/5 + y^3/2 - y - x$	U[-1,1,400]
F18	Nguyen-9	$\sin(x) + \sin(y^2)$	U[-1,1,400]
F19	Nguyen-10	$2\sin(x)\cos(y)$	U[-1,1,400]
F20	Vladislavleva-1	$\exp(-(x - 1)^2/(1.2 + (y - 2.5)^2))$	U[-1,1,400]
F21	Keijzer-3	$30xz/((x - 10)y^y)$	x,z:[-1,1,1000] y:U[1,3,1000]
F22	Korns-2	$0.23 + 14.2(x + y)/(3z)$	x,y:U[-1,1,1000] z:U[1,3,1000]
F23	Vladislavleva-5	$30((x - 1)(z - 1))/(y^2(x - 10))$	U[0,2,1000]

TABLE II
PENN MACHINE LEARNING BENCHMARKS(PMLB).

FileNumber	FileName	Samples	Variables	Task
F72	210_cloud	108	5	regression
F73	519_vinnie	380	2	regression
F74	573_cpu_act	1000	21	regression
F75	1027_ESL	488	4	regression
F76	1028_SWD	1000	10	regression
F77	1029_LEV	1000	4	regression
F78	analcatdata_boxing1	120	3	classification
F79	car-evaluation	1000	21	classification
F80	wine_quality_white	1000	11	classification
F81	towerData	1000	25	regression

TABLE III
FEYNMAN SYMBOLIC REGRESSION BENCHMARKS(FSRB).

FileNumber	FileName	Objective Function	Data Set
F24	I.6.2a	f	$\exp(-\theta^2/2)/\sqrt{2\pi}$ U[1,3,20]
F25	I.6.2	f	$\exp(-(\theta/\sigma)^2/2)/(\sqrt{2\pi}\sigma)$ U[1,3,400]
F26	I.12.1	F	muN_n U[2,4,400]
F27	I.12.5	F	q_2Ef U[2,4,400]
F28	I.14.4	U	$1/2k_{spring}x^2$ U[2,4,400]
F29	I.25.13	$Volt$	q/C U[2,4,400]
F30	I.26.2	θ_1	$\arcsin(ns \sin(\theta_2))$ $n:U[0,1,400]$ $\theta_2:U[2,4,400]$
F31	I.29.4	k	ω/c U[2,4,400]
F32	I.34.27	E_n	$(h/(2\pi))\omega$ U[2,4,400]
F33	I.39.1	E_n	$3/2prV$ U[2,4,400]
F34	II.3.24	$flux$	$Pwr/(4\pi r^2)$ U[2,4,400]
F35	II.8.31	E_{den}	$\epsilon Ef^2/2$ U[2,4,400]
F36	II.11.28	θ	$1+n\alpha/(1-(n\alpha/3))$ U[0,1,400]
F37	II.27.18	E_{den}	ϵEf^2 U[2,4,400]
F38	II.38.14	mus	$Y/(2(1+\sigma))$ U[2,4,400]
F39	III.12.43	L	$n(h/(2\pi))$ U[2,4,400]
F40	II.37.1	E_n	$mom(1+chi)B$ U[2,4,1000]
F41	I.18.12	tau	$rF \sin(\theta)$ U[2,4,1000]
F42	I.6.2b	f	$\exp(-((\theta-\theta_1)/\sigma)^2/2)/(\sqrt{2\pi}\sigma)$ U[1,3,1000]
F43	I.10.7	m	$m_0/\sqrt{1-v^2/c^2}$ $m_0, c:U[3,5,1000]$ $v:U[1,2,1000]$
F44	I.12.4	Ef	$q_1r/(4\pi\epsilon r^3)$ U[2,4,1000]
F45	I.14.3	U	mgz U[2,4,1000]
F46	I.15.1	p	$m_0v/\sqrt{1-v^2/c^2}$ $m_0, c:U[3,5,1000]$ $v:U[1,2,1000]$
F47	I.16.6	v_1	$(u+v)/(1+uv/c^2)$ U[2,4,1000]
F48	I.27.6	foc	$1/(d_1+n/d_2)$ U[2,4,1000]
F49	I.30.3	Int	$\text{Int}_0 \sin(n\theta/2)^2/\sin(\theta/2)^2$ U[2,4,1000]
F50	I.30.5	θ	$\arcsin(\lambda/(nd))$ $\lambda :U[1,2,1000]$ $d, n:U[2,4,1000]$
F51	I.34.1	ω	$\omega_0/(1-v/c)$ $c, \omega_0 :U[3,5,1000]$ $v:U[1,2,1000]$
F52	I.34.14	ω	$(1+v/c)/\sqrt{1-v^2/c^2}\omega_0$ $c, \omega_0 :U[3,5,1000]$ $v:U[1,2,1000]$
F53	I.37.4	Int	$I_1 + I_2 + 2\sqrt{I_1 I_2} \cos(\delta)$ U[2,4,1000]
F54	I.39.11	E_n	$1/(\gamma-1)prV$ U[2,4,1000]
F55	I.43.31	D	$mob_k b_T$ U[2,4,1000]
F56	I.47.23	c	$\sqrt{\gamma pr/\rho}$ U[2,4,1000]
F57	II.4.23	$Volt$	$q/(4\pi\epsilon r)$ U[2,4,1000]
F58	II.8.7	E_n	$3/5q^2/(4\pi\epsilon d)$ U[2,4,1000]
F59	II.10.9	Ef	$\sigma_{den}/\epsilon/(1+chi)$ U[2,4,1000]
F60	II.13.23	rho_c	$\rho_{co}/\sqrt{1-v^2/c^2}$ $\rho_{co}, c:U[3,5,1000]$ $v:U[1,2,1000]$
F61	II.13.34	j	$\rho_{co} v/\sqrt{1-v^2/c^2}$ $\rho_{co}, c:U[3,5,1000]$ $v:U[1,2,1000]$
F62	II.27.16	$flux$	ϵEf^2 U[2,4,1000]
F63	II.34.2a	I	$qv/(2\pi r)$ U[2,4,1000]
F64	II.34.2	mom	$qvr/2$ U[2,4,1000]
F65	II.34.29a	mom	$qh/(4\pi m)$ U[2,4,1000]
F66	III.7.38	ω	$2momB/(h/(2\pi))$ U[2,4,1000]
F67	III.8.54	$prob$	$\sin(E_n t/(h/(2\pi)))^2$ U[1,2,1000]
F68	III.15.12	E_n	$2U(1-\cos(kd))$ U[2,4,1000]
F69	II.15.4	E_n	$-momB \cos(\theta)$ U[2,4,1000]
F70	II.15.5	E_n	$-pdEf \cos(\theta)$ U[2,4,1000]
F71	I.18.14	L	$mrvsin(\theta)$ U[2,4,4000]

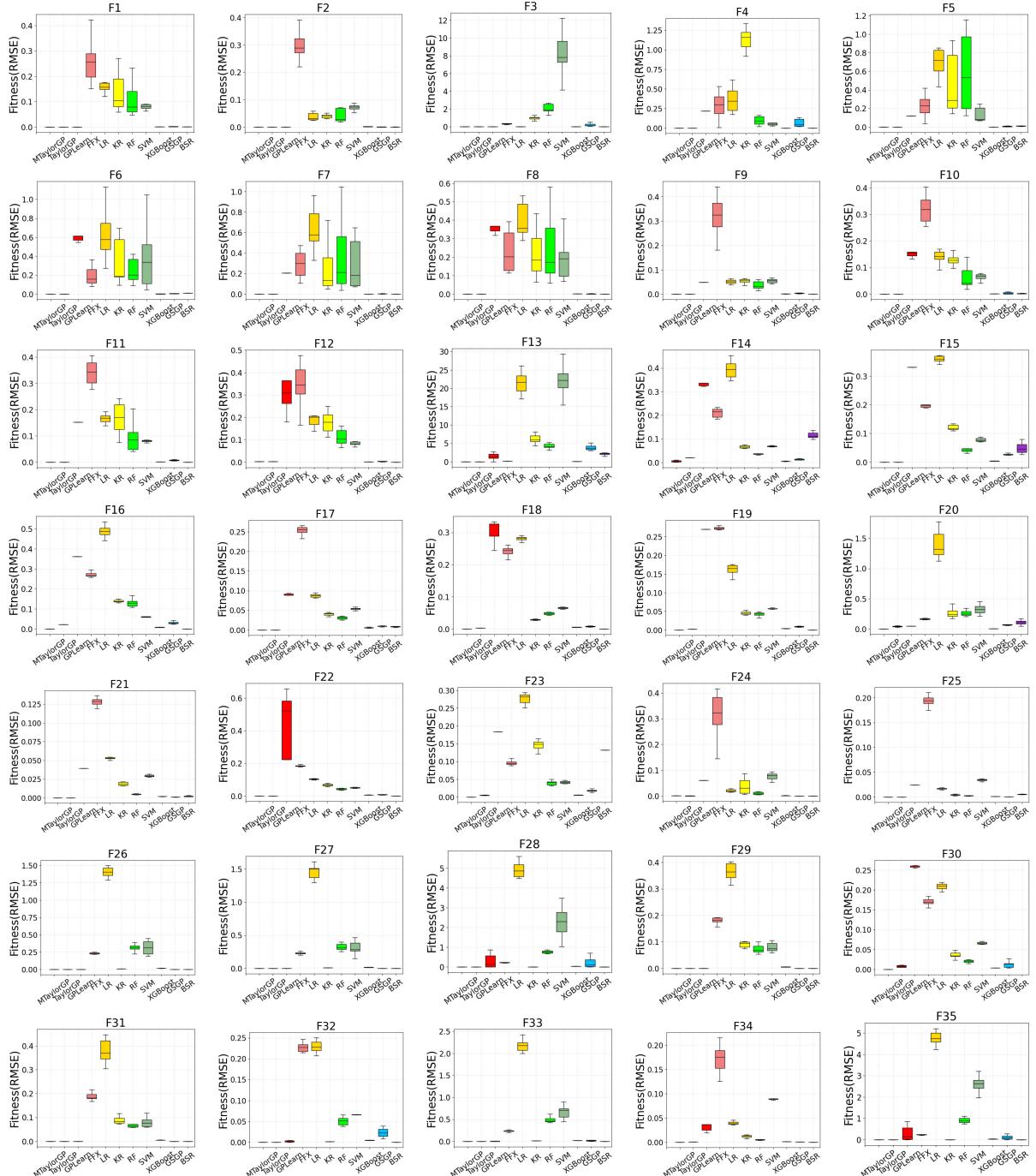


Fig. 2. Fitness comparison. The RMSE results on the benchmarks F1-F35.

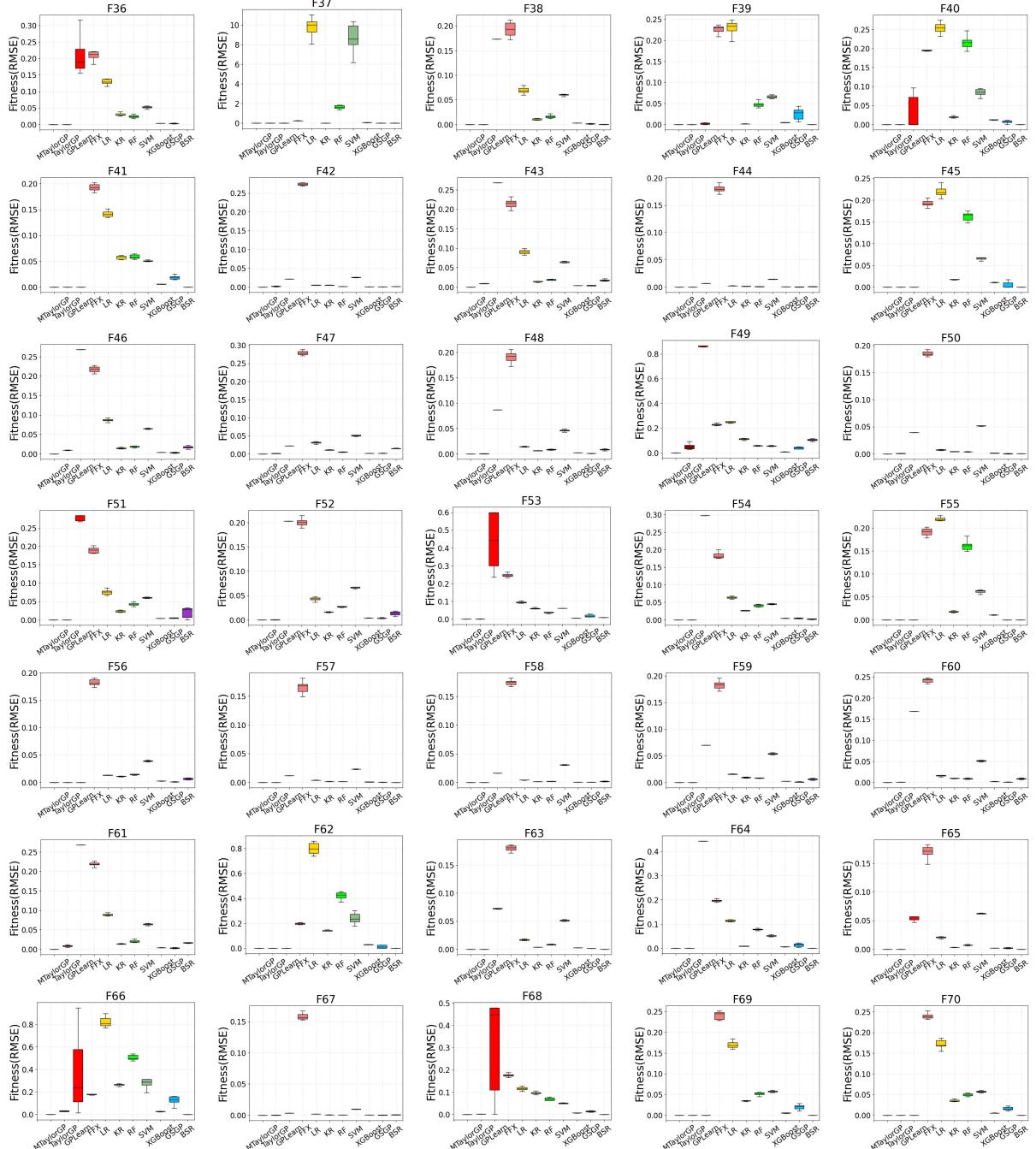


Fig. 3. Fitness comparison. The RMSE results on the benchmarks F36-F70.

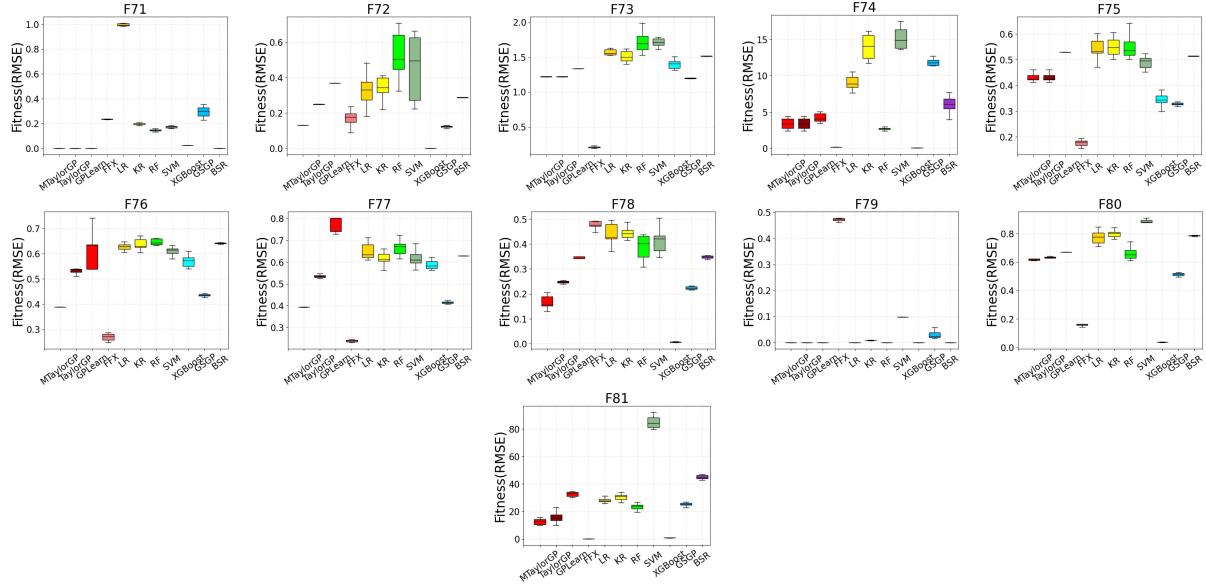


Fig. 4. Fitness comparison. The RMSE results on the benchmarks F71-F81.

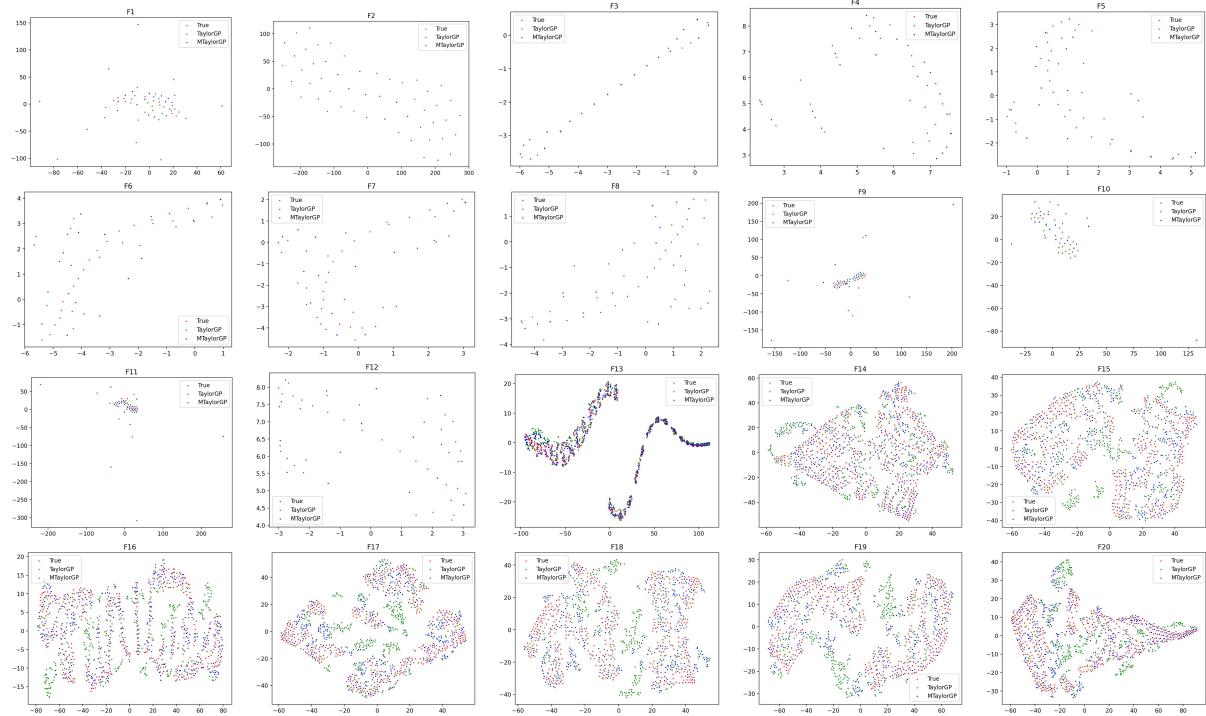


Fig. 5. t-SNE comparison. The comparison of visual effects of dimension reduction on the benchmarks F1-F20.

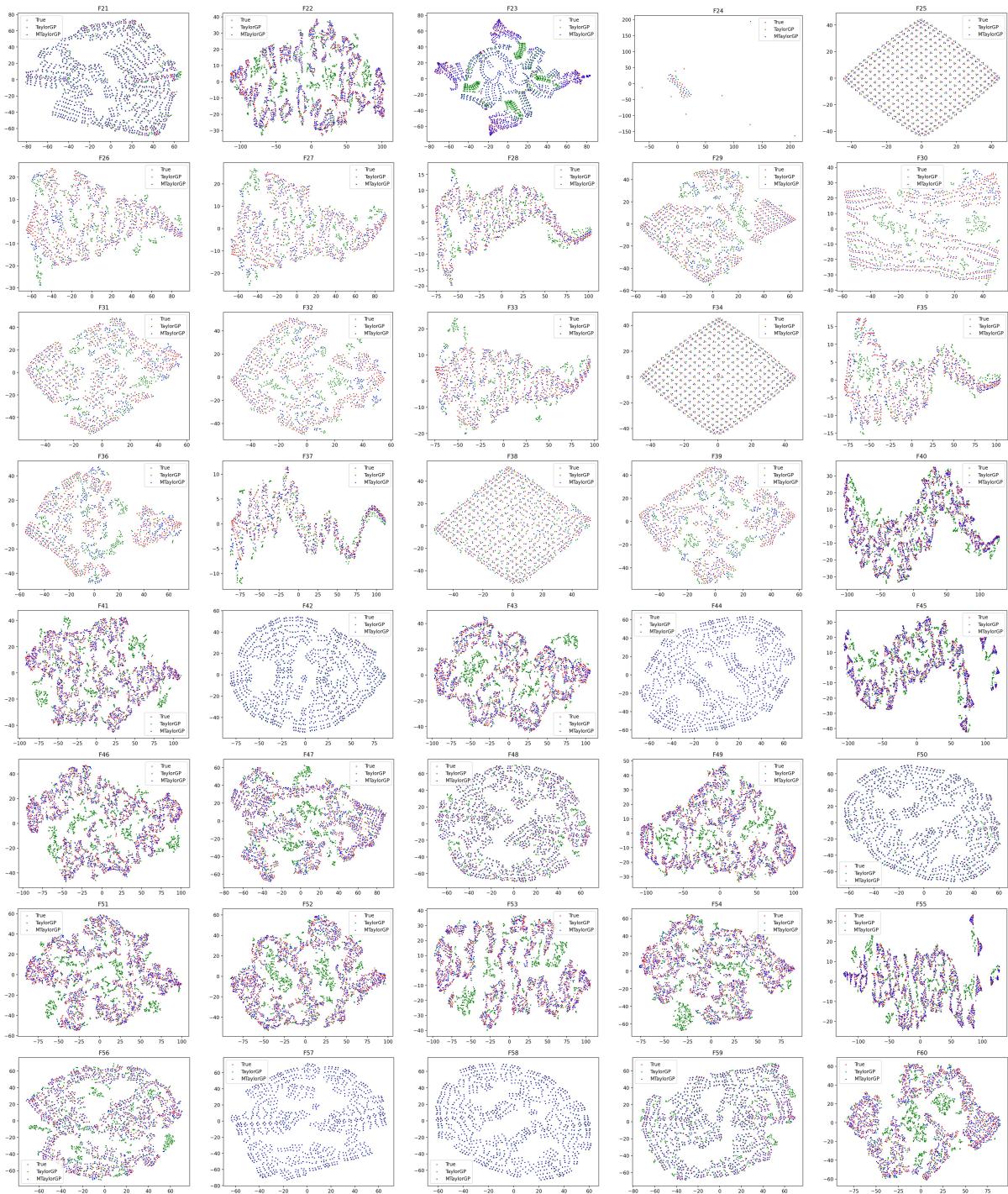


Fig. 6. t-SNE comparison. The comparison of visual effects of dimension reduction on the benchmarks F21-F60.

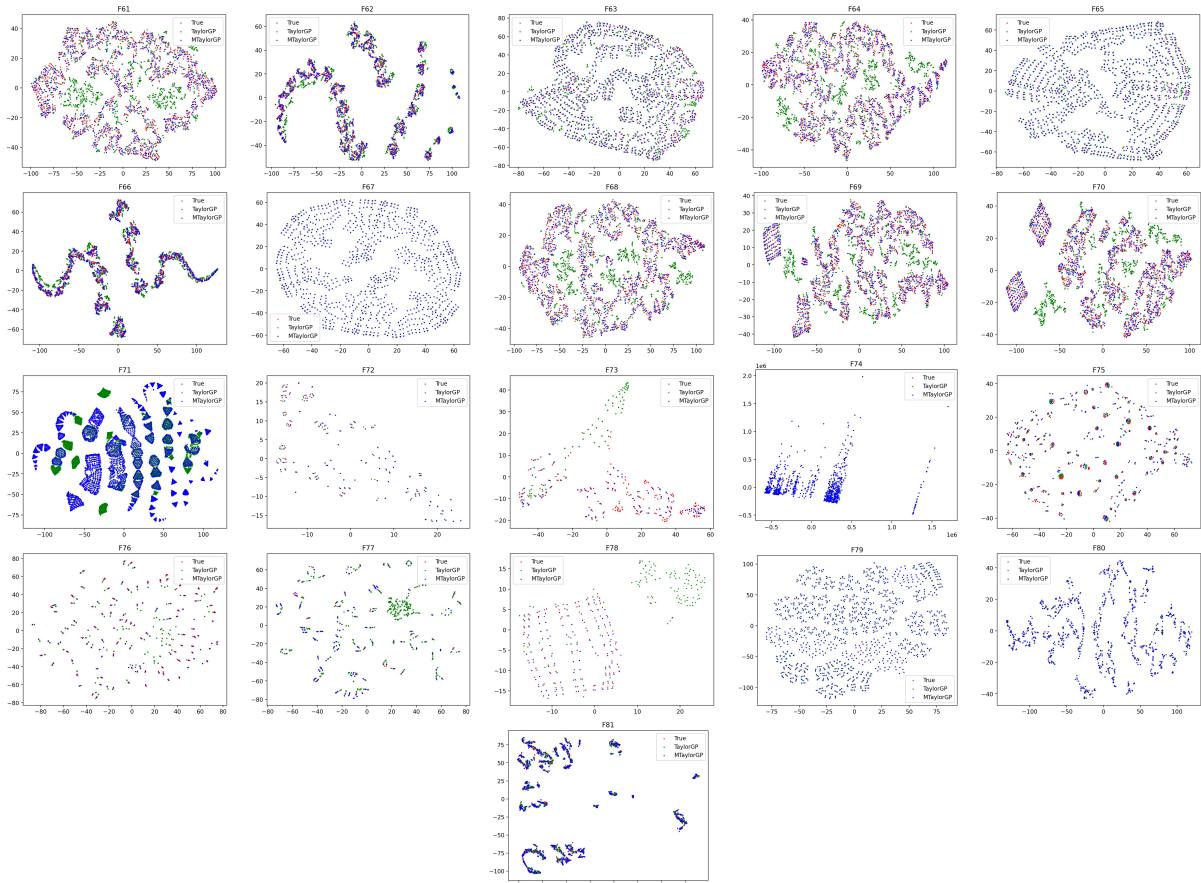


Fig. 7. t-SNE comparison. The comparison of visual effects of dimension reduction on the benchmarks F61-F81.

TABLE IV
ALGORITHM PARAMETERS

Name	Parameter	Value
MTaylorGP	Function Set	$+, -, \times, \div, \sin, \cos, \ln(n), \exp, \sqrt{}$
	Max Generations	10000
	Population Size	1000
	Crossover Rate	0.7
	Mutation Rate	0.2
	Copy Rate	0.1
	Stopping Threshold	1e-5
TaylorGP	Function Set	$+, -, \times, \div, \sin, \cos, \ln(n), \exp, \sqrt{}$
	Max Generations	10000
	Population Size	1000
	Crossover Rate	0.7
	Mutation Rate	0.2
	Copy Rate	0.1
	Stopping Threshold	1e-5
GPLearn	Function Set	$+, -, \times, \div, \sin, \cos, \ln(n), \exp, \sqrt{}$
	max generations	10000
	Population Size	1000
	Crossover Rate	0.7
	Mutation Rate	0.2
	Copy Rate	0.1
	Stopping Threshold	1e-5
GSGP	Function Set	$+, -, \times, \div$
	Max Generations	10000
	Population Size	1000
	Crossover Rate	0.7
	Mutation Rate	0.2
	Copy Rate	0.1
	Stopping Threshold	1e-5
BSR	Function Set	$+, -, \times, \div, \sin, \cos, \ln(n), \exp, \sqrt{}$
	MM	10000
	k	2
	Stopping Threshold	1e-5
	None	
	Normalize	FALSE
	Kernal	'linear', 'poly', 'rbf', 'sigmoid'
KR	Gamma	0.01,0.1,1,10
	Regularization	0.001,0.1,1
	Number of Estimators	10, 100, 1000
RF	Max Features	'sqrt','log2',None
	Kernal	'linear', 'poly', 'rbf', 'sigmoid', 'precomputed'
SVM	Learning Rate	0.0001,0.01, 0.05, 0.1, 0.2
	Gamma	0,0.1,0.2,0.3,0.4