Report

Function

mytrain_binary: do training on train dataset
mytest_binary: do testing on test dataset
my_cross_validation: cross validation with k-fold data-split

Added functions

avg_score_by_cross_val: do cross validation and compute average score
grid_search: do grid search to find the best C and kpar
compute_RBF: compute Gaussian kernel function

Formula for implementation

$$f(x) = sign\left(\sum_{SV} \alpha_i y_i k(x_i, x) + b\right)$$

For linear kernel

$$k(x, x') = x^T x'$$

For polynomial kernel

$$k(x, x') = (1 + x^T x')^d$$

For Gaussian kernel

$$k(x, x') = e^{-\frac{\|x - x'\|^2}{2\sigma^2}}$$

Evaluation for different parameters on different data sets

1. Linear kernel

dataset	kpar	C	train time(ms)	test time(ms)	accuracy
synthetic-easy	-1	0.03	0.6	0.2	1
synthetic-medium	-1	1	0.6	0	0.9
synthetic-hard	-1	3	0.4	0	0.76
moons	-1	1	0.4	0	0.86
circles	-1	0.001	3.4	0	0.4
breast_cancer	-1	3	1718.8	0.2	0.975438

2. Polynomial kernel

dataset	kpar	C	train time(ms)	test time(ms)	accuracy
synthetic-easy	1	0.03	0	0	1
synthetic-medium	2	0.3	0	0	0.86
synthetic-hard	2	0.01	0	0	0.68
moons	1	1	0	0	0.86
circles	3	10	3.119993	0	0.4
breast_cancer	1	3	1684.560013	0	0.975438

3. Gaussian kernel

dataset	kpar	C	train time(ms)	test time(ms)	accuracy
synthetic-easy	0.1	0.3	1.2	0	1
synthetic-medium	10	3	3.119993	0	0.88
synthetic-hard	10	1	0	0	0.88
moons	0.1	1	0	0	0.98
circles	1	1	3.119993	0	0.9
breast_cancer	0.001	0.001	15.600014	0	0.656140351

For detail. see tables below for each kernel function with different parameters and datasets.

1. Linear kernel

dataset	C	score	train time(ms)	test time(ms)	test score
synthetic-easy	0.001	0.6	0.6	0	1
	0.003	0.6	0	0	
	0.01	0.68	0.6	0	
	0.03	1	0.6	0.2	
	0.1	1	0.6	0	
	0.3	1	0.4	0	
	1	1	0.4	0	
	3	1	0.4	0	
	10	1	0.4	0.2	
	30	1	0.4	0	
synthetic-medium	0.001	0.54	0.6	0	0.9
	0.003	0.54	0.4	0	
	0.01	0.7	0.6	0	
	0.03	0.78	0.6	0	

	0.1	0.78	0.6	0	
	0.3	0.8	0.4	0.2	
	1	0.82	0.6	0	
	3	0.8	0.2	0	
	10	0.8	0.4	0	
	30	0.8	0.6	0	
synthetic-hard	0.001	0.52	1.2	0	0.76
	0.003	0.52	0.2	0.2	
	0.01	0.6	0.6	0	
	0.03	0.66	0.4	0	
	0.1	0.66	0.2	0.2	
	0.3	0.68	0.6	0	
	1	0.7	0.6	0	
	3	0.72	0.4	0	
	10	0.72	0.6	0	
	30	0.72	1	0	
moons	0.001	0.48	5	0	0.86
	0.003	0.48	0.8	0	
	0.01	0.48	0.4	0	
	0.03	0.64	0.6	0	
	0.1	0.82	0.6	0	
	0.3	0.86	0.4	0	
	1	0.88	0.4	0	
	3	0.88	0.4	0	
	10	0.88	1	0	
	30	0.86	1.8	0	
circles	0.001	0.6	3.4	0	0.4
	0.003	0.6	0.4	0	
	0.01	0.6	0.6	0	
	0.03	0.6	0.4	0	
	0.1	0.6	0.6	0	
	0.3	0.6	0	0.4	
	1	0.6	0.4	0.2	
	3	0.6	0.4	0	
	10	0.6	0.4	0	
	30	0.6	0.4	0	
breast_cancer	0.001	0.918985	28.6	0	0.975438
	0.003	0.92594	8.6	0	

	0.01	0.936529	18	0	
	0.03	0.939975	52.6	0.2	
	0.1	0.936466	132.8	0.2	
	0.3	0.946992	308.6	0	
	1	0.950501	943.4	0	
	3	0.957581	1718.8	0.2	
	10	0.95401	4093.8	0	
	30	0.950501	4895.2	0	

2. Polynomial kernel

dataset	kpar	C	score	train time(ms)	test time(ms)	test score
synthetic-easy	1	0.001	0.6	0	0	1
		0.003	0.6	0	0	
		0.01	0.68	0	0	
		0.03	1	0	0	
		0.1	1	3.119993	0	
		0.3	1	0	0	
		1	1	0	0	
		3	1	0	0	
		10	1	0	0	
		30	1	0	0	
	2	0.001	0.6	0	0	
		0.003	0.68	3.119993	0	
		0.01	1	0	0	
		0.03	1	0	0	
		0.1	1	0	0	
		0.3	1	0	0	
		1	1	0	0	
		3	1	3.119993	0	
		10	1	0	0	
		30	1	0	0	
	3	0.001	0.72	0	0	
		0.003	1	0	0	
		0.01	1	0	0	
		0.03	1	3.119993	0	
		0.1	1	0	0	
		0.3	1	0	0	

		1	1	0	0	
		3	1	0	0	
		10	1	0	0	
		30	1	0	0	
synthetic-medium	1	0.001	0.54	0	0	0.86
		0.003	0.54	0	0	
		0.01	0.7	3.119993	0	
		0.03	0.78	0	0	
		0.1	0.78	0	0	
		0.3	0.8	0	0	
		1	0.82	0	0	
		3	0.8	0	0	
		10	0.8	3.119993	0	
		30	0.8	0	0	
	2	0.001	0.68	0	0	
		0.003	0.82	0	0	
		0.01	0.8	0	0	
		0.03	0.8	0	0	
		0.1	0.78	0	0	
		0.3	0.84	0	0	
		1	0.82	0	0	
		3	0.66	3.119993	0	
		10	0.64	3.119993	0	
		30	0.64	9.360027	0	
	3	0.001	0.8	3.119993	0	
		0.003	0.8	0	0	
		0.01	0.8	0	0	
		0.03	0.78	0	0	
		0.1	0.7	0	0	
		0.3	0.68	3.119993	0	
		1	0.66	6.240034	0	
		3	0.64	18.719959	0	
		10	0.58	28.080034	0	
		30	0.62	100.239992	0	
synthetic-hard	1	0.001	0.52	0	0	0.68
		0.003	0.52	0	0	
		0.01	0.6	0	0	
		0.03	0.66	0	0	

		0.1	0.66	0	0	
		0.3	0.68	3.120422	0	
		1	0.7	0	0	
		3	0.72	0	0	
		10	0.72	0	0	
		30	0.72	3.120375	0	
	2	0.001	0.6	0	0	
		0.003	0.68	0	0	
		0.01	0.66	0	0	
		0.03	0.68	0	0	
		0.1	0.76	3.120422	0	
		0.3	0.7	0	0	
		1	0.68	3.120375	0	
		3	0.64	3.120422	0	
		10	0.62	12.481594	0	
		30	0.62	43.685579	0	
	3	0.001	0.58	0	0	
		0.003	0.64	3.120422	0	
		0.01	0.64	0	0	
		0.03	0.7	3.120375	0	
		0.1	0.6	9.361219	0	
		0.3	0.6	46.806002	0	
		1	0.62	124.815989	0	
		3	0.66	427.494812	0	
		10	0.68	720.812416	0	
		30	0.66	2198.161888	0	
moons	1	0.001	0.48	262.080002	0	0.86
		0.003	0.48	0	0	
		0.01	0.48	0	0	
		0.03	0.64	3.119993	0	
		0.1	0.82	0	0	
		0.3	0.86	0	0	
		1	0.88	0	0	
		3	0.88	0	0	
		10	0.88	3.119993	0	
		30	0.86	0	0	
	2	0.001	0.48	0	0	
		0.003	0.48	0	0	

		0.01	0.5	0	0	
		0.03	0.68	3.119993	0	
		0.1	0.8	0	0	
		0.3	0.76	0	0	
		1	0.72	0	0	
		3	0.74	0	0	
		10	0.74	0.199986	0	
		30	0.72	0	0	
	3	0.001	0.48	0	0	
		0.003	0.52	0	0	
		0.01	0.74	0.400019	0	
		0.03	0.78	6.439972	0	
		0.1	0.82	0	0	
		0.3	0.82	0	0	
		1	0.74	0	0	
		3	0.68	0	0	
		10	0.6	0	0	
		30	0.58	3.120041	0	
circles	1	0.001	0.6	9.35998	0	0.4
		0.003	0.6	0	0	
		0.01	0.6	0	0	
		0.03	0.6	0	0	
		0.1	0.6	0	0	
		0.3	0.6	3.119993	0	
		1	0.6	0	0	
		3	0.6	0	0	
		10	0.6	0	0	
		30	0.6	0	0	
	2	0.001	0.6	3.119993	0	
		0.003	0.6	0	0	
		0.01	0.6	0	0	
		0.03	0.6	0	0	
		0.1	0.58	0	0	
		0.3	0.46	3.119993	0	
		1	0.5	0	0	
		3	0.46	0	0	
		10	0.4	0	0	
		30	0.44	0	0	

	3	0.001	0.6	0	0	
		0.003	0.6	3.120041	0	
		0.01	0.6	0	0	
		0.03	0.6	0	0	
		0.1	0.6	3.119993	0	
		0.3	0.6	0	0	
		1	0.6	0	0	
		3	0.6	0	0	
		10	0.64	3.119993	0	
		30	0.64	0	0	
breast_cancer	1	0.001	0.918985	12.479973	0	0.975438
		0.003	0.92594	9.360027	0	
		0.01	0.936529	18.720007	0	
		0.03	0.939975	49.919987	0	
		0.1	0.936466	139.120007	0	
		0.3	0.946992	320.639992	0	
		1	0.950501	942.320013	0	
		3	0.957581	1684.560013	0	
		10	0.95401	3909.279966	0	
		30	0.950501	4651.240015	0	
	2	0.001	0.922243	25169.40002	3.119993	
		0.003	0.922243	30363.67998	0	
		0.01	0.922243	55744.04001	0	
		0.03	0.922243	92021.24	0	
		0.1	0.922243	104500.2	0	
		0.3	0.922243	118171.44	0	

		1	0.922243	132637.96	0	
		3	0.922243	160932.4	0.199986	
		10	0.922243	178352.8	0	
		30	0.922243	199498.6491	0.199986	
	3	0.001	0.932832	38703.41959	0	
		0.003	0.932832	39412.4639	0	
		0.01	0.932832	39613.54494	3.119993	
		0.03	0.932832	42598.65108	0.200033	
		0.1	0.932832	39215.59067	0	
		0.3	0.932832	39442.47999	0	
		1	0.932832	38750.16003	0	
		3	0.932832	39098.28	0	
		10	0.932832	38724.79997	0	
		30	0.932832	38713.72004	0	

3. Gaussian kernel

dataset	kpar	C	score	train time(ms)	test time(ms)	test score
synthetic-easy	0.001	0.001	0.56	1.8	0	1
		0.003	0.56	1.6	0.2	
		0.01	0.56	1.4	0	
		0.03	0.56	1.2	0	
		0.1	0.56	1.4	0	
		0.3	0.56	1.4	0	
		1	0.68	1.6	0	
		3	0.7	1.6	0	

		10	0.7	1.6	0.2	
		30	0.7	1.6	0	
	0.01	0.001	0.6	1.6	0	
		0.003	0.6	1.2	0.2	
		0.01	0.6	2.4	0	
		0.03	0.6	1.6	0	
		0.1	0.6	1.4	0	
		0.3	0.76	1	0.4	
		1	0.9	1.6	0	
		3	0.92	1.6	0	
		10	0.92	1.6	0.2	
		30	0.92	1.4	0	
	0.1	0.001	0.6	1.4	0	
		0.003	0.6	1.8	0	
		0.01	0.6	1.2	0.2	
		0.03	0.6	2	0	
		0.1	0.92	1.2	0	
		0.3	1	1.2	0	
		1	1	1.2	0	
		3	1	1.6	0	
		10	1	1.4	0	
		30	1	1.4	0	
	1	0.001	0.6	1.4	0	
		0.003	0.6	1.4	0	
		0.01	0.6	1.2	0	
		0.03	0.6	1.2	0	
		0.1	1	1.2	0.2	
		0.3	1	1	0	
		1	1	0.8	0	
		3	1	0.6	0.2	
		10	1	0.8	0	
		30	1	0.8	0	
	10	0.001	0.6	1.2	0	
		0.003	0.6	1.2	0	
		0.01	0.6	1.4	0	
		0.03	0.6	1.4	0	
		0.1	0.62	1.4	0	
		0.3	1	1.2	0	

		1	1	1	0	
		3	1	0.6	0.2	
		10	1	0.8	0	
		30	1	0.6	0.2	
synthetic-medium	0.001	0.001	0.54	3.119993	0	0.88
		0.003	0.54	3.119993	0	
		0.01	0.54	0	0	
		0.03	0.54	3.120041	0	
		0.1	0.54	3.119993	0	
		0.3	0.54	3.119993	0	
		1	0.52	3.119993	0	
		3	0.52	0	0	
		10	0.52	3.119993	0	
		30	0.52	3.119993	0	
	0.01	0.001	0.54	3.119993	0	
		0.003	0.54	0	0	
		0.01	0.54	0	3.120041	
		0.03	0.54	3.119993	0	
		0.1	0.54	0	0	
		0.3	0.54	3.119993	0	
		1	0.5	0	0	
		3	0.48	3.119993	0	
		10	0.48	0	0	
		30	0.48	3.119993	0	
	0.1	0.001	0.5	0	0	
		0.003	0.5	0	0	
		0.01	0.5	3.119993	0	
		0.03	0.5	0	0	
		0.1	0.5	3.119993	0	
		0.3	0.56	0	0	
		1	0.68	3.120041	0	
		3	0.68	0	0	
		10	0.68	3.119993	0	
		30	0.72	0	0	
	1	0.001	0.56	3.119993	0	
		0.003	0.56	0	0	
		0.01	0.56	3.119993	0	
		0.03	0.56	0	0	

		0.1	0.68	0	0	
		0.3	0.78	0	0	
		1	0.76	0	0	
		3	0.76	3.119993	0	
		10	0.78	0	0	
		30	0.72	0	0	
	10	0.001	0.56	0	3.119993	
		0.003	0.56	0	0	
		0.01	0.56	3.120041	0	
		0.03	0.56	0	0	
		0.1	0.62	3.119993	0	
		0.3	0.78	0	0	
		1	0.78	0	0	
		3	0.8	3.119993	0	
		10	0.8	0	0	
		30	0.8	0	0	
synthetic-hard	0.001	0.001	0.52	0	0	0.88
		0.003	0.52	3.119993	0	
		0.01	0.52	0	0	
		0.03	0.52	3.120041	0	
		0.1	0.52	0	0	
		0.3	0.52	3.119993	0	
		1	0.52	0	0	
		3	0.52	3.119993	0	
		10	0.52	0	0	
		30	0.52	3.119993	0	
	0.01	0.001	0.52	0	0	
		0.003	0.52	0	0	
		0.01	0.52	3.119993	0	
		0.03	0.52	0	0	
		0.1	0.52	3.119993	0	
		0.3	0.52	0	0	
		1	0.48	3.119993	0	
		3	0.46	0	0	
		10	0.46	3.119993	0	
		30	0.46	0	0	
	0.1	0.001	0.52	0	0	
		0.003	0.52	3.120041	0	

		0.01	0.52	0	0	
		0.03	0.52	3.119993	0	
		0.1	0.52	0	0	
		0.3	0.52	3.119993	0	
		1	0.42	0	0	
		3	0.44	0	0	
		10	0.48	3.119993	0	
		30	0.46	0	0	
	1	0.001	0.52	3.119993	0	
		0.003	0.52	0	0	
		0.01	0.52	3.119993	0	
		0.03	0.52	0	0	
		0.1	0.52	0	0	
		0.3	0.62	3.119993	0	
		1	0.66	0	0	
		3	0.64	3.120041	0	
		10	0.54	0	0	
		30	0.54	0	0	
	10	0.001	0.52	3.119993	0	
		0.003	0.52	0	0	
		0.01	0.52	3.119993	0	
		0.03	0.52	0	0	
		0.1	0.52	0	0	
		0.3	0.62	3.119993	0	
		1	0.66	0	0	
		3	0.66	0	0	
		10	0.64	3.119993	0	
		30	0.64	0	0	
moons	0.001	0.001	0.44	237.120008	3.119993	0.98
		0.003	0.44	0	0	
		0.01	0.44	0	0	
		0.03	0.44	3.119993	0	
		0.1	0.44	0	0	
		0.3	0.44	3.119993	0	
		1	0.54	0	0	
		3	0.54	3.120041	0	
		10	0.54	0	0	
		30	0.54	3.119993	0	

	0.01	0.001	0.46	0	0	
		0.003	0.46	0	0	
		0.01	0.46	3.119993	0	
		0.03	0.46	0	0	
		0.1	0.46	3.119993	0	
		0.3	0.46	0	0	
		1	0.86	0	0	
		3	0.86	3.119993	0	
		10	0.86	0	0	
		30	0.86	3.119993	0	
	0.1	0.001	0.5	0	0	
		0.003	0.5	0	0	
		0.01	0.5	3.119993	0	
		0.03	0.5	0	0	
		0.1	0.5	3.120041	0	
		0.3	0.94	0	0	
		1	0.96	0	0	
		3	0.92	3.119993	0	
		10	0.92	0	0	
		30	0.92	0	0	
	1	0.001	0.5	3.119993	0	
		0.003	0.5	0	0	
		0.01	0.5	3.119993	0	
		0.03	0.5	0	0	
		0.1	0.74	0	0	
		0.3	0.86	3.119993	0	
		1	0.94	0	0	
		3	0.94	0	0	
		10	0.92	3.119993	0	
		30	0.92	0	0	
	10	0.001	0.48	0	0	
		0.003	0.48	3.119993	0	
		0.01	0.48	0	0	
		0.03	0.48	3.120041	0	
		0.1	0.48	0	0	
		0.3	0.56	0	0	
		1	0.84	3.119993	0	
		3	0.86	0	0	

		10	0.86	0	0	
		30	0.88	3.119993	0	
circles	0.001	0.001	0.6	6.240034	0	0.9
		0.003	0.6	3.119993	0	
		0.01	0.6	0	0	
		0.03	0.6	3.119993	0	
		0.1	0.6	3.119993	0	
		0.3	0.6	0	0	
		1	0.6	3.119993	0	
		3	0.64	3.119993	0	
		10	0.64	3.119993	0	
		30	0.64	0	0	
	0.01	0.001	0.6	3.120041	0	
		0.003	0.6	0	0	
		0.01	0.6	3.119993	0	
		0.03	0.6	0	0	
		0.1	0.6	3.119993	0	
		0.3	0.6	0	0	
		1	0.76	0	0	
		3	0.78	3.119993	0	
		10	0.78	0	3.119993	
		30	0.78	0	0	
	0.1	0.001	0.6	0	0	
		0.003	0.6	3.119993	0	
		0.01	0.6	0	0	
		0.03	0.6	3.119993	0	
		0.1	0.6	0	0	
		0.3	0.74	3.120041	0	
		1	0.78	0	0	
		3	0.8	0	0	
		10	0.74	3.119993	0	
		30	0.74	0	0	
	1	0.001	0.6	0	0	
		0.003	0.6	3.119993	0	
		0.01	0.6	0	0	
		0.03	0.6	3.119993	0	
		0.1	0.6	0	0	
		0.3	0.6	0	0	

		1	0.88	3.119993	0	
		3	0.88	0	0	
		10	0.86	0	0	
		30	0.86	3.119993	0	
	10	0.001	0.6	0	0	
		0.003	0.6	0	0	
		0.01	0.6	3.119993	0	
		0.03	0.6	0	0	
		0.1	0.6	0	0	
		0.3	0.6	0	0	
		1	0.6	0	0	
		3	0.6	3.119993	0	
		10	0.6	0	0	
		30	0.68	3.119993	0	
breast_cancer	0.001	0.001	0.59881	15.600014	0	0.656140351
		0.003	0.59881	12.479973	0	
		0.01	0.59881	18.720007	0	
		0.03	0.59881	12.480021	0	
		0.1	0.59881	12.479973	0	
		0.3	0.59881	12.480021	3.119993	
		1	0.59881	15.600014	0	
		3	0.59881	9.35998	0	
		10	0.59881	15.600014	0	
		30	0.59881	15.600014	0	
	0.01	0.001	0.59881	12.479973	0	
		0.003	0.59881	15.600014	0	
		0.01	0.59881	15.599966	0	
		0.03	0.59881	9.560013	0	
		0.1	0.59881	18.919992	0	
		0.3	0.59881	18.720007	0	
		1	0.59881	12.480021	0	
		3	0.59881	15.600014	0	
		10	0.59881	15.599966	0	
		30	0.59881	15.600014	0	
	0.1	0.001	0.59881	15.600014	0	
		0.003	0.59881	12.479973	0	
		0.01	0.59881	9.360027	0	
		0.03	0.59881	12.479973	0	

		0.1	0.59881	12.480021	0	
		0.3	0.59881	18.720007	0	
		1	0.59881	12.479973	0	
		3	0.59881	15.600014	0	
		10	0.59881	15.600014	0	
		30	0.59881	12.479973	0	
	1	0.001	0.59881	9.560013	0	
		0.003	0.59881	16.799974	0	
		0.01	0.59881	12.480021	0	
		0.03	0.59881	15.600014	0	
		0.1	0.59881	15.599966	0	
		0.3	0.59881	15.600014	0	
		1	0.59881	12.480021	0	
		3	0.59881	12.479973	0	
		10	0.59881	15.600014	0	
		30	0.59881	15.600014	0	
	10	0.001	0.59881	6.239986	0.199986	
		0.003	0.59881	15.799999	0	
		0.01	0.59881	12.480021	0	
		0.03	0.59881	12.479973	0	
		0.1	0.59881	15.600014	0	
		0.3	0.59881	12.480021	0	
		1	0.59881	12.479973	0	
		3	0.59881	12.480021	0	
		10	0.59881	15.600014	0	
		30	0.59881	12.479973	0	