KNN:

Validation test error: 0.0408 and k = 1

Validation test error: 0.0506 and k = 2

Validation test error: 0.0405 and k = 3

Validation test error: 0.0425 and k = 4

Validation test error: 0.0425 and k = 5

Validation test error: 0.0433 and k = 6

Validation test error: 0.0449 and k = 7

Validation test error: 0.0457 and k = 8

Validation test error: 0.0469 and k = 9

Best k-value: 3

Robust Linear Classifier training error = 0.17646

Robust Linear Classifier test error = 0.1672

Least Squares L2 Training Error: 0.75206

Least Squares L2 Test Error: 0.7554

Least Squares Classifier Validation Error: 0.16078 with lammy: 0.0001

Least Squares Classifier Validation Error: 0.16072 with lammy: 0.001

Least Squares Classifier Validation Error: 0.16055999999999998 with lammy: 0.01

Least Squares Classifier Validation Error: 0.16024 with lammy: 0.1

Least Squares Classifier Validation Error: 0.15986000000000003 with lammy: 1.0

Least Squares Classifier best lammy value: 1

Least Squares Classifier Training Error: 0.1501 with lammy: 1

Least Squares Classifier Test Error: 0.146 with lammy: 1

Polynomial Kernel Validation Error: 0.7575999999999999 with lammy: 0.0001 and polynomial degree: 1

Polynomial Kernel Validation Error: 0.74 with lammy: 0.001 and polynomial degree: 1

Polynomial Kernel Validation Error: 0.7283999999999999 with lammy: 0.01 and polynomial degree: 1

Polynomial Kernel Validation Error: 0.6792 with lammy: 0.1 and polynomial degree: 1

Polynomial Kernel Validation Error: 0.9148000000000002 with lammy: 1.0 and polynomial degree: 1

Polynomial Kernel Validation Error: 0.07 with lammy: 0.0001 and polynomial degree: 2

Polynomial Kernel Validation Error: 0.0704 with lammy: 0.001 and polynomial degree: 2

Polynomial Kernel Validation Error: 0.0704 with lammy: 0.01 and polynomial degree: 2

Polynomial Kernel Validation Error: 0.0704 with lammy: 0.1 and polynomial degree: 2

Polynomial Kernel Validation Error: 0.0704 with lammy: 1.0 and polynomial degree: 2

Polynomial Kernel Validation Error: 0.062 with lammy: 0.0001 and polynomial degree: 3

Polynomial Kernel Validation Error: 0.062 with lammy: 0.001 and polynomial degree: 3

Polynomial Kernel Validation Error: 0.062 with lammy: 0.01 and polynomial degree: 3

Polynomial Kernel Validation Error: 0.062 with lammy: 0.1 and polynomial degree: 3

Polynomial Kernel Validation Error: 0.062 with lammy: 1.0 and polynomial degree: 3

Polynomial Kernel Validation Error: 0.0724 with lammy: 0.0001 and polynomial degree: 4

Polynomial Kernel Validation Error: 0.0724 with lammy: 0.001 and polynomial degree: 4

Polynomial Kernel Validation Error: 0.0724 with lammy: 0.01 and polynomial degree: 4

Polynomial Kernel Validation Error: 0.0724 with lammy: 0.1 and polynomial degree: 4

Polynomial Kernel Validation Error: 0.0724 with lammy: 1.0 and polynomial degree: 4

Polynomial Kernel Validation Error: 0.08519999999999998 with lammy: 0.0001 and polynomial degree: 5

Polynomial Kernel Validation Error: 0.08519999999999998 with lammy: 0.001 and polynomial degree: 5

Polynomial Kernel Validation Error: 0.08519999999999998 with lammy: 0.01 and polynomial degree: 5

Polynomial Kernel Validation Error: 0.08519999999999998 with lammy: 0.1 and polynomial degree: 5

Polynomial Kernel Validation Error: 0.08519999999999998 with lammy: 1.0 and polynomial degree: 5

Polynomial Kernel Validation Error: 0.1016 with lammy: 0.0001 and polynomial degree: 6

Polynomial Kernel Validation Error: 0.1016 with lammy: 0.001 and polynomial degree: 6

Least Squares Training Error: 0.75138

Least Squares Test Error: 0.7557

Least Squares L2 Training Error: 0.75206

Least Squares L2 Test Error: 0.7554

5000 sample size

Validation Error Poly Kernel 0.9972 for p = 1 and lammy = 0.0

Validation Error Poly Kernel 0.7854 for p = 1 and lammy = 0.5

Validation Error Poly Kernel 0.7848 for p = 1 and lammy = 1.0

Validation Error Poly Kernel 0.6104 for p = 2 and lammy = 0.0

Validation Error Poly Kernel 0.6098 for p = 2 and lammy = 0.5

Validation Error Poly Kernel 0.61 for p = 2 and lammy = 1.0

Validation Error Poly Kernel 0.6017 for p = 3 and lammy = 0.0

Validation Error Poly Kernel 0.6017 for p = 3 and lammy = 0.5

Validation Error Poly Kernel 0.6017 for p = 3 and lammy = 1.0

Validation Error Poly Kernel 0.6694 for p = 4 and lammy = 0.0

Validation Error Poly Kernel 0.6694 for p = 4 and lammy = 0.5

Validation Error Poly Kernel 0.6694 for p = 4 and lammy = 1.0

Validation Error Poly Kernel 0.72 for p = 5 and lammy = 0.0

Validation Error Poly Kernel 0.72 for p = 5 and lammy = 0.5

Validation Error Poly Kernel 0.72 for p = 5 and lammy = 1.0

Validation Error Poly Kernel 0.7644 for p = 6 and lammy = 0.0

Validation Error Poly Kernel 0.7644 for p = 6 and lammy = 0.5

Validation Error Poly Kernel 0.7644 for p = 6 and lammy = 1.0

Validation Error Poly Kernel 0.7848 for p = 1 and lammy = 1

Validation Error Poly Kernel 0.7822 for p = 1 and lammy = 6

Validation Error Poly Kernel 0.7808 for p = 1 and lammy = 11

Validation Error Poly Kernel 0.61 for p = 2 and lammy = 1

Validation Error Poly Kernel 0.6081 for p = 2 and lammy = 6

Validation Error Poly Kernel 0.6079 for p = 2 and lammy = 11

Validation Error Poly Kernel 0.6017 for p = 3 and lammy = 1

Validation Error Poly Kernel 0.6017 for p = 3 and lammy = 6

Validation Error Poly Kernel 0.6017 for p = 3 and lammy = 11

Validation Error Poly Kernel 0.6694 for p = 4 and lammy = 1

Validation Error Poly Kernel 0.6694 for p = 4 and lammy = 6

Validation Error Poly Kernel 0.6694 for p = 4 and lammy = 11

Validation Error Poly Kernel 0.72 for p = 5 and lammy = 1

Validation Error Poly Kernel 0.72 for p = 5 and lammy = 6

Validation Error Poly Kernel 0.72 for p = 5 and lammy = 11

Validation Error Poly Kernel 0.7644 for p = 6 and lammy = 1

Validation Error Poly Kernel 0.7644 for p = 6 and lammy = 6

Validation Error Poly Kernel 0.7644 for p = 6 and lammy = 11

Validation Error Poly Kernel 0.4794 for p = 3 and lammy = 1 for 25000 sample size

Validation Error Poly Kernel 0.4957 for p = 3 and lammy = 1 for 25000 random sample size

Sample size: 4500

Validation Error Poly Kernel 0.902 for sigma = 0.01 and lammy = 0.0001

Validation Error Poly Kernel 0.902 for sigma = 0.01 and lammy = 0.001

Validation Error Poly Kernel 0.902 for sigma = 0.01 and lammy = 0.01

Validation Error Poly Kernel 0.902 for sigma = 0.01 and lammy = 0.1

Validation Error Poly Kernel 0.902 for sigma = 0.01 and lammy = 1.0

Validation Error Poly Kernel 0.902 for sigma = 0.1 and lammy = 0.0001

Validation Error Poly Kernel 0.902 for sigma = 0.1 and lammy = 0.001

Validation Error Poly Kernel 0.902 for sigma = 0.1 and lammy = 0.01

Validation Error Poly Kernel 0.902 for sigma = 0.1 and lammy = 0.1

Validation Error Poly Kernel 0.902 for sigma = 0.1 and lammy = 1.0

Validation Error Poly Kernel 0.8783 for sigma = 1.0 and lammy = 0.0001

Validation Error Poly Kernel 0.8783 for sigma = 1.0 and lammy = 0.001

Validation Error Poly Kernel 0.8786 for sigma = 1.0 and lammy = 0.01

Validation Error Poly Kernel 0.8818 for sigma = 1.0 and lammy = 0.1

Validation Error Poly Kernel 0.8959 for sigma = 1.0 and lammy = 1.0

Validation Error Poly Kernel 0.5234 for sigma = 10.0 and lammy = 0.0001

Validation Error Poly Kernel 0.5221 for sigma = 10.0 and lammy = 0.001

**Validation Error Poly Kernel 0.518 for sigma = 10.0 and lammy = 0.01**

Validation Error Poly Kernel 0.5319 for sigma = 10.0 and lammy = 0.1

Validation Error Poly Kernel 0.6553 for sigma = 10.0 and lammy = 1.0

Validation Error Poly Kernel 0.6754 for sigma = 100.0 and lammy = 0.0001

Validation Error Poly Kernel 0.758 for sigma = 100.0 and lammy = 0.001

Validation Error Poly Kernel 0.7918 for sigma = 100.0 and lammy = 0.01

Validation Error Poly Kernel 0.8292 for sigma = 100.0 and lammy = 0.1

Validation Error Poly Kernel 0.9065 for sigma = 100.0 and lammy = 1.0

Validation Error Poly Kernel 0.3809 for sigma = 10.0 and lammy = 0.01 for 25,000 samples

Robust linear regression training error with 40 iterations using 500 batch size: 78.75%

Least Squares Classifier Training Error: 0.15028 with lammy: 0.0001

Least Squares Classifier Test Error: 0.1461 with lammy: 0.0001

Least Squares Classifier Training Error: 0.1502 with lammy: 0.001

Least Squares Classifier Test Error: 0.1463 with lammy: 0.001

Least Squares Classifier Training Error: 0.15012 with lammy: 0.01

Least Squares Classifier Test Error: 0.1462 with lammy: 0.01

Least Squares Classifier Training Error: 0.15002 with lammy: 0.1

Least Squares Classifier Test Error: 0.1461 with lammy: 0.1

Least Squares Classifier Training Error: 0.1501 with lammy: 1.0

Least Squares Classifier Test Error: 0.146 with lammy: 1.0

Robust Linear Regression training error = 0.17106

Robust Linear Regression test error = 0.1625

Robust Linear Classifier training error = 0.87066

Robust Linear Classifier test error = 0.877

Least Squares Classifier Training Error: 0.1501 with lammy: 1.0

Least Squares Classifier Test Error: 0.146 with lammy: 1.0

Least Squares L2 Training Error: 0.75206

Least Squares L2 Test Error: 0.7554

Training Error Poly Kernel 0.05976 for p = 3 and lammy = 1

Test Error Poly Kernel 0.0584 for p = 3 and lammy = 1

Training Error RBF Kernel 0.0584 for sigma = 10.0 and lammy = 0.01

Test Error RBF Kernel 0.0486 for sigma = 10.0 and lammy = 0.01

Training Error Poly Kernel 0.0405 for p = 3 and lammy = 1

Test Error Poly Kernel 0.043 for p = 3 and lammy = 1

Training Error RBF Kernel 0.043 for sigma = 10.0 and lammy = 0.01

Test Error RBF Kernel 0.0362 for sigma = 10.0 and lammy = 0.01

**SVM**

Training Error SVM - SUM Loss = 0.14324

Test Error SVM - SUM Loss = 0.1296

Epoch = 0.4

Training Error SVM - SUM Loss = 0.16356 with lammy = 0.0001

Test Error SVM - SUM Loss = 0.1497 with lammy = 0.0001

'fit' execution time: 32.2279s

Training Error SVM - SUM Loss = 0.16842 with lammy = 0.001

Test Error SVM - SUM Loss = 0.157 with lammy = 0.001

'fit' execution time: 31.1362s

Training Error SVM - SUM Loss = 0.16658 with lammy = 0.01

Test Error SVM - SUM Loss = 0.1514 with lammy = 0.01

'fit' execution time: 31.4643s

Training Error SVM - SUM Loss = 0.16942 with lammy = 0.1

Test Error SVM - SUM Loss = 0.1565 with lammy = 0.1

'fit' execution time: 30.9203s

Training Error SVM - SUM Loss = 0.17248 with lammy = 1.0

Test Error SVM - SUM Loss = 0.1592 with lammy = 1.0

**Epoch = 1**

**Training Error SVM - SUM Loss = 0.1533 with lammy = 0.01**

**Test Error SVM - SUM Loss = 0.1388 with lammy = 0.01**

**Epoch = 2**

**Training Error SVM - SUM Loss = 0.14426 with lammy = 0.01**

**Test Error SVM - SUM Loss = 0.1323 with lammy = 0.01**

**Epoch = 1**

**Training Error SVM - MAX Loss = 0.2367 with lammy = 0.01**

**Test Error SVM - MAX Loss = 0.2199 with lammy = 0.01**

**MLP**

Reached maximum number of function evaluations 100

Fitting took 82 seconds

Training error = 0.0392

Test error = 0.0465

**SGD with decaying learning rate**

Reached maximum number of function evaluations 5000

Fitting took 70 seconds

Training error = 0.18842

Test error = 0.1818

SGD with constant learning rate

Reached maximum number of function evaluations 5000

Fitting took 69 seconds

Training error = 0.07084

Test error = 0.0681

Batch size = 2500 and epoch = 20 and hidden layer size = 50

Reached maximum number of function evaluations 400

Fitting took 25 seconds

Training error = 0.05922

Test error = 0.0588

Hidden layer size = 83

Reached maximum number of function evaluations 400

Fitting took 29 seconds

Training error = 0.0607

Test error = 0.0599

Hidden layer size = 50

Reached maximum number of function evaluations 600

Fitting took 37 seconds

Training error = 0.0495

Test error = 0.0509

Reached maximum number of function evaluations 600

Fitting took 43 seconds

Training error = 0.0515

Test error = 0.0518

Reached maximum number of function evaluations 800

Fitting took 50 seconds

Training error = **0.04508**

**Test error = 0.0466**

**Gradient Descent**

Reached maximum number of function evaluations 250

Fitting took 205 seconds

Training error = 0.01434

Test error = 0.0324

Reached maximum number of function evaluations 500

Fitting took 410 seconds

Training error = 0.00264

Test error = 0.0293