E1 213: Pattern Recognition and Neural Networks **Spring 2021**

Assignment 3: Non-Linear Models

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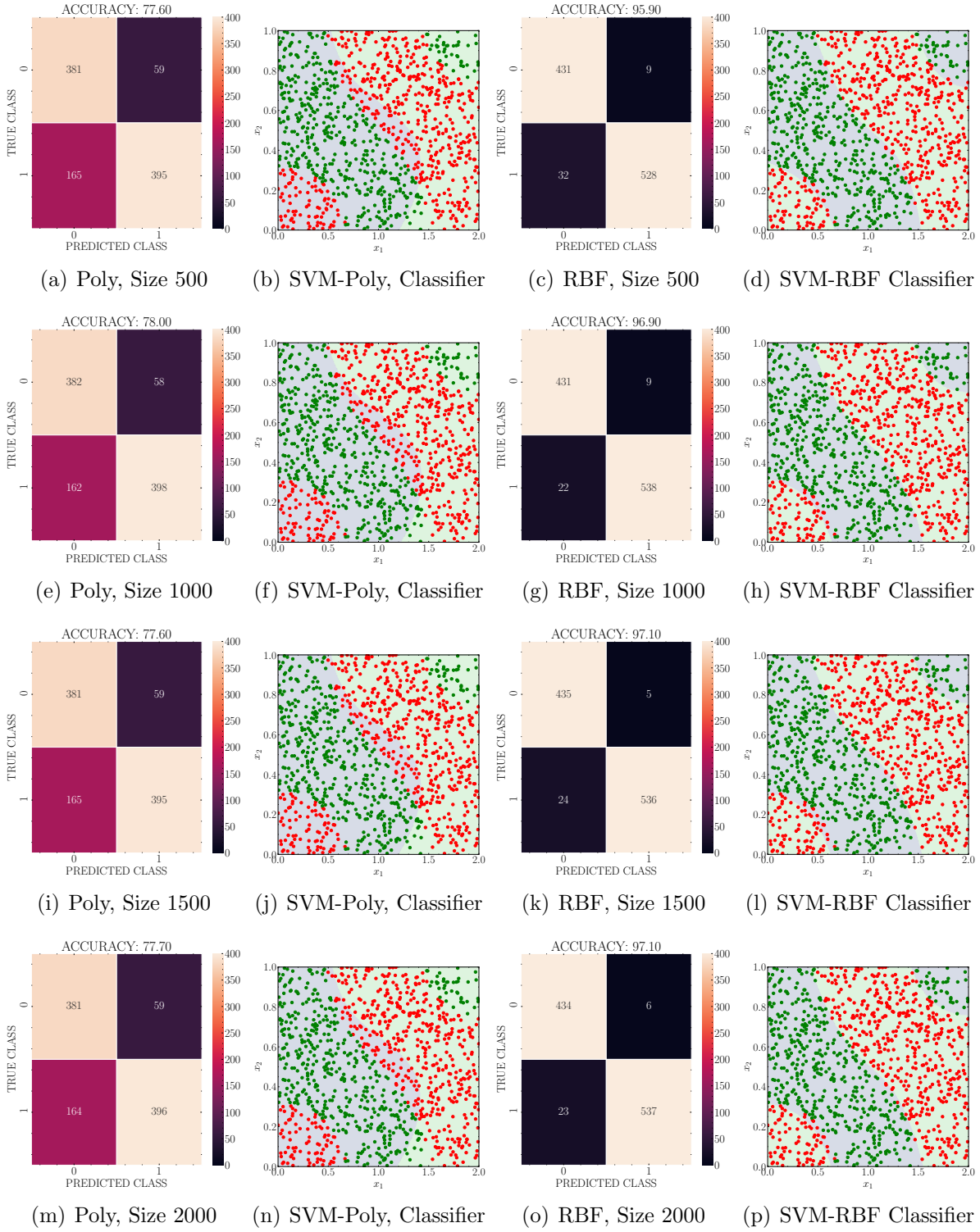
1 SVM for Classification on 2D Synthetic Data

The classification task is to classify 2D features in two classes. Support vector machines (SVM) with polynomial and Gaussian kernel are used classification along with logistic regression for comparison.

Results: Figure **??** shows the accuracies of classification in confusion matrices and the samples along with the discriminant function. The first and third columns shows the confusion matrices of the linear classifier and logistic regression, respectively with varying training sizes. The second and fourth column shows the samples along with the discriminant function. The accuracies reported are averaged over 10000 realisations and one of the discriminant functions is plotted.

Inferences: It can be seen that the accuracy increases with increasing training size from 10, 50, 100, 500 and 999 in both classifiers. Between the classifiers, logistic regression consistently gives better accuracy. Since the x_1 and x_2 coordinates are independent and Gamma distributed, it is known that the linear classifier has a slope of -1. It can be seen that logistic regression achieves this with fewer training samples. This is reflected in the accuracy.



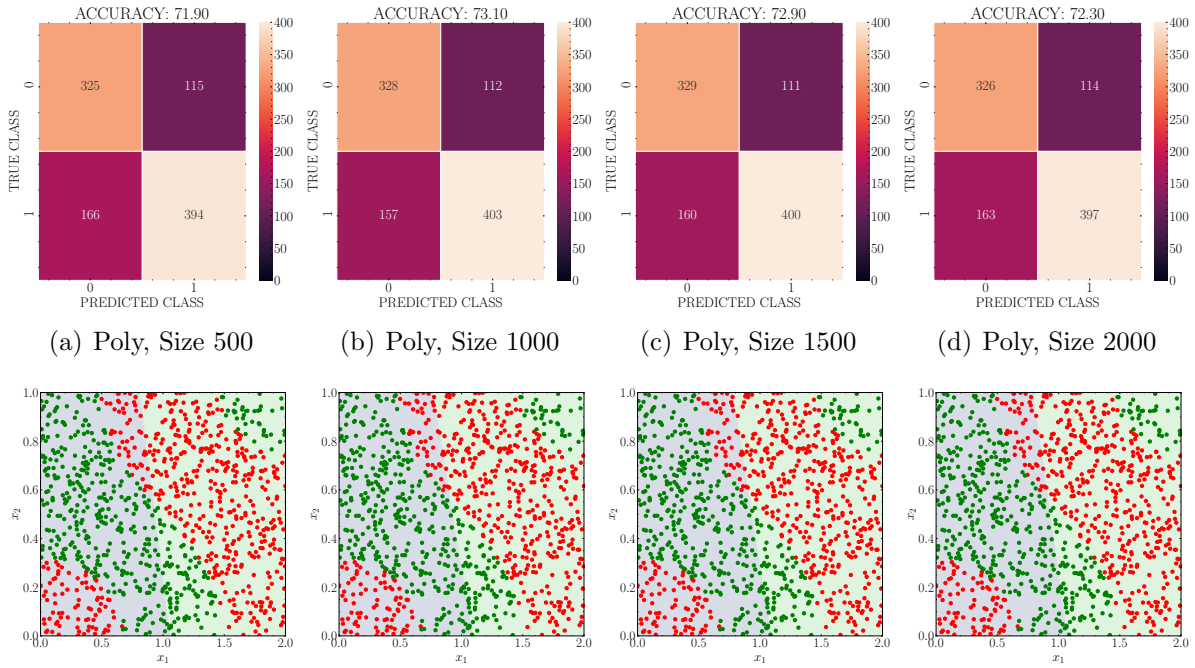
(a) Poly, Size 500 (b) SVM-Poly, Classifier (c) RBF, Size 500 (d) SVM-RBF Classifier

(e) Poly, Size 1000 (f) SVM-Poly, Classifier (g) RBF, Size 1000 (h) SVM-RBF Classifier

(i) Poly, Size 1500 (j) SVM-Poly, Classifier (k) RBF, Size 1500 (l) SVM-RBF Classifier

(m) Poly, Size 2000 (n) SVM-Poly, Classifier (o) RBF, Size 2000 (p) SVM-RBF Classifier

Figure 1: Support vector machines with polynomial kernel of degree 3 and Gaussian kernel on 2D data with no label noise.



(a) Poly, Size 500 (b) Poly, Size 1000 (c) Poly, Size 1500 (d) Poly, Size 2000

(e) LOG, Classifier (f) LOG, Classifier (g) LOG, Classifier (h) LOG, Classifier

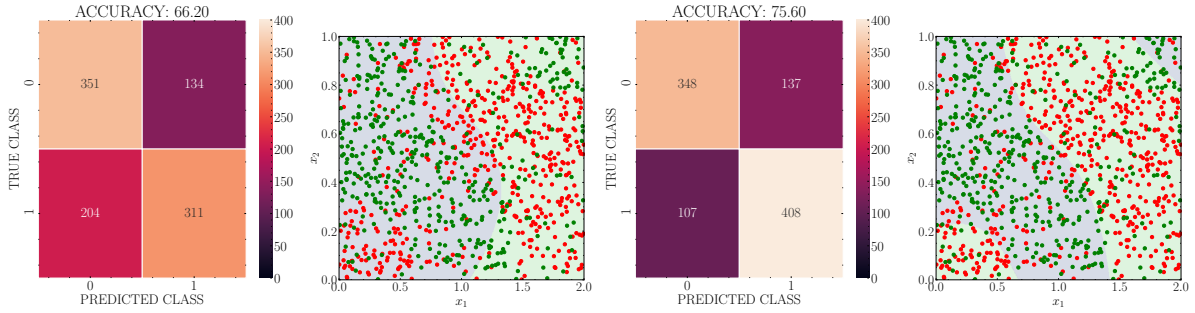
Figure 2: Logistic regression on 2D data with no label noise.

2 Neural Network for Classification on 2D Board Data

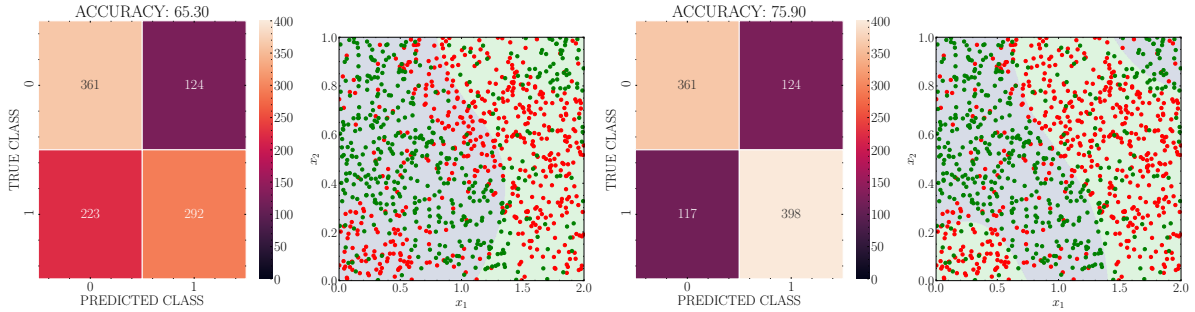
3 Convolutional Network for Classification on MNIST

4 Code Repository

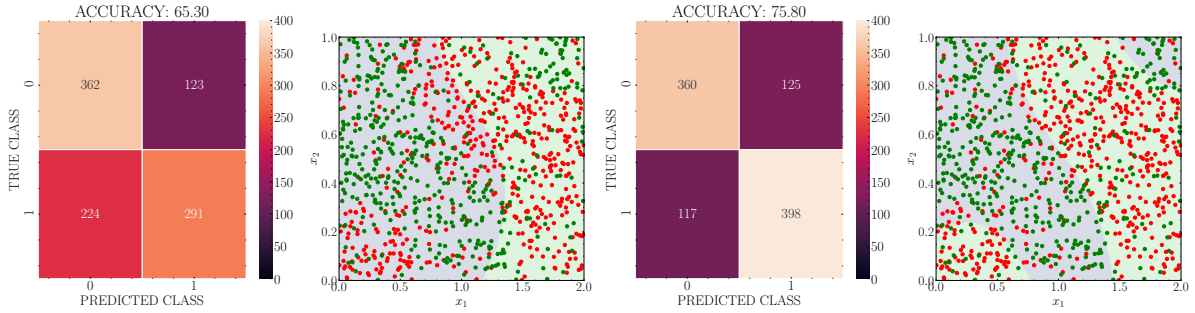
The Python codes to reproduce the results can be found in the GitHub repository `https://github.com/kamath-abhijith/Linear_Models`. Use `requirements.txt` to install the dependencies and the shell scripts to generate the figures.



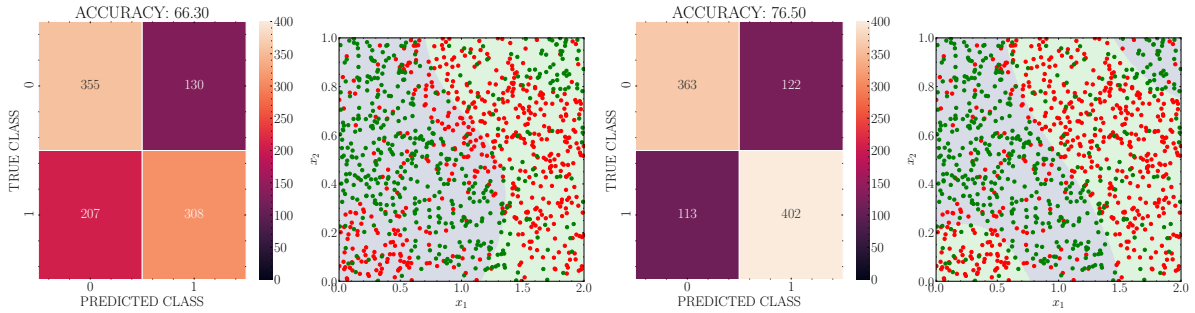
(a) Poly, Size 500 (b) SVM-Poly, Classifier (c) RBF, Size 500 (d) SVM-RBF Classifier



(e) Poly, Size 1000 (f) SVM-Poly, Classifier (g) RBF, Size 1000 (h) SVM-RBF Classifier

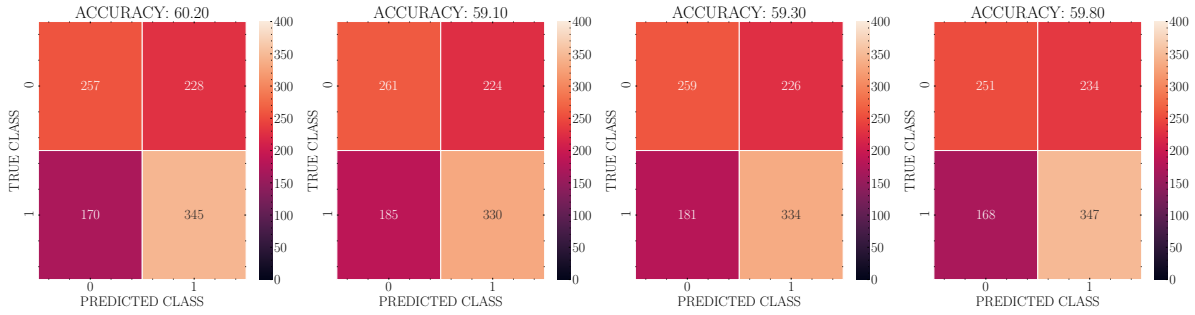


(i) Poly, Size 1500 (j) SVM-Poly, Classifier (k) RBF, Size 1500 (l) SVM-RBF Classifier

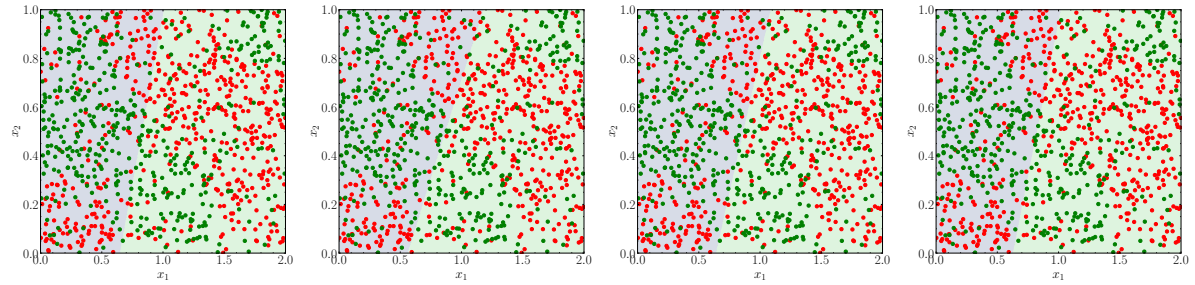


(m) Poly, Size 2000 (n) SVM-Poly, Classifier (o) RBF, Size 2000 (p) SVM-RBF Classifier

Figure 3: Support vector machines with polynomial kernel of degree 3 and Gaussian kernel on 2D data with 20% label noise.

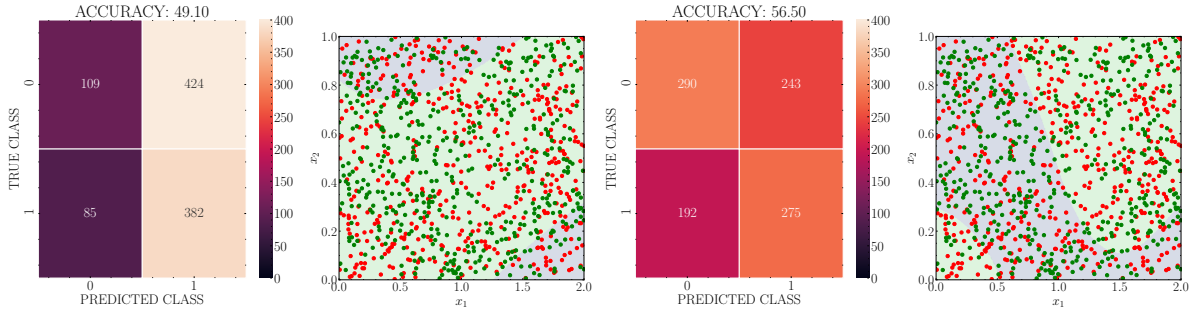


(a) Poly, Size 500 (b) Poly, Size 1000 (c) Poly, Size 1500 (d) Poly, Size 2000

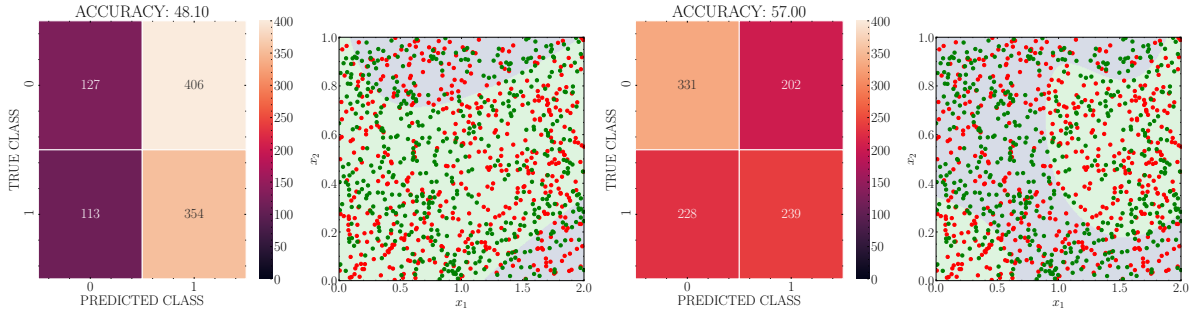


(e) LOG, Classifier (f) LOG, Classifier (g) LOG, Classifier (h) LOG, Classifier

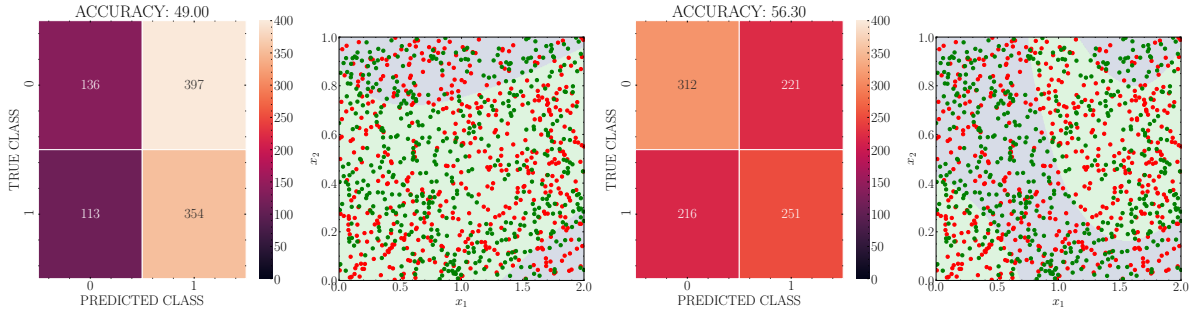
Figure 4: Logistic regression on 2D data with 20% label noise.



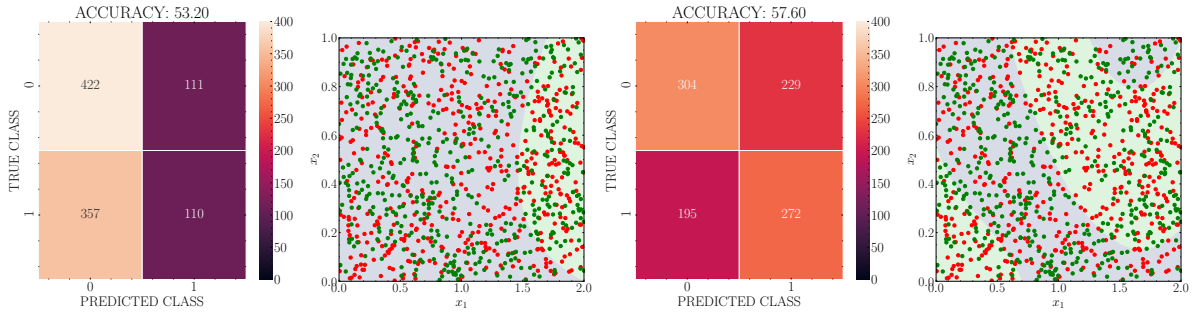
(a) Poly, Size 500 (b) SVM-Poly, Classifier (c) RBF, Size 500 (d) SVM-RBF Classifier



(e) Poly, Size 1000 (f) SVM-Poly, Classifier (g) RBF, Size 1000 (h) SVM-RBF Classifier

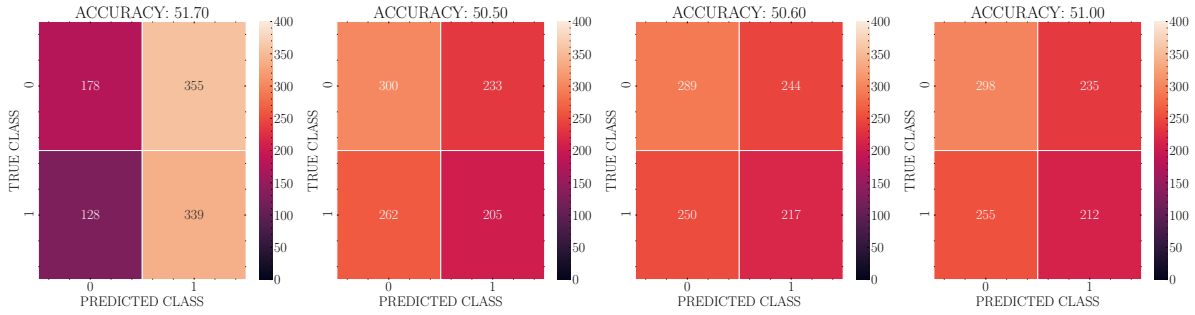


(i) Poly, Size 1500 (j) SVM-Poly, Classifier (k) RBF, Size 1500 (l) SVM-RBF Classifier

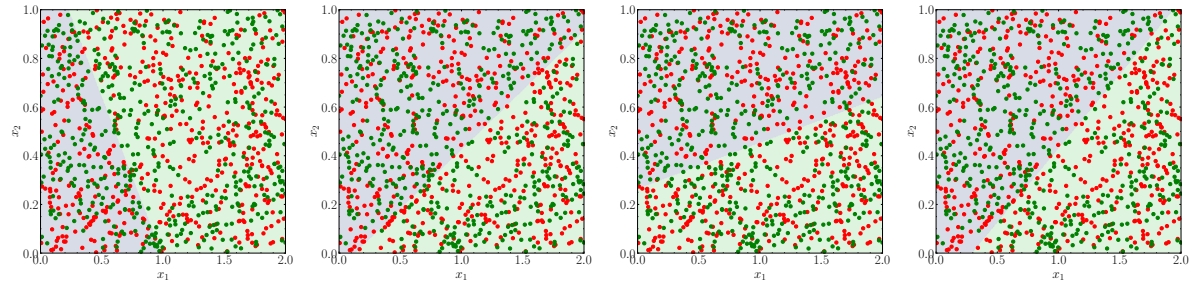


(m) Poly, Size 2000 (n) SVM-Poly, Classifier (o) RBF, Size 2000 (p) SVM-RBF Classifier

Figure 5: Support vector machines with polynomial kernel of degree 3 and Gaussian kernel on 2D data with 40% label noise.

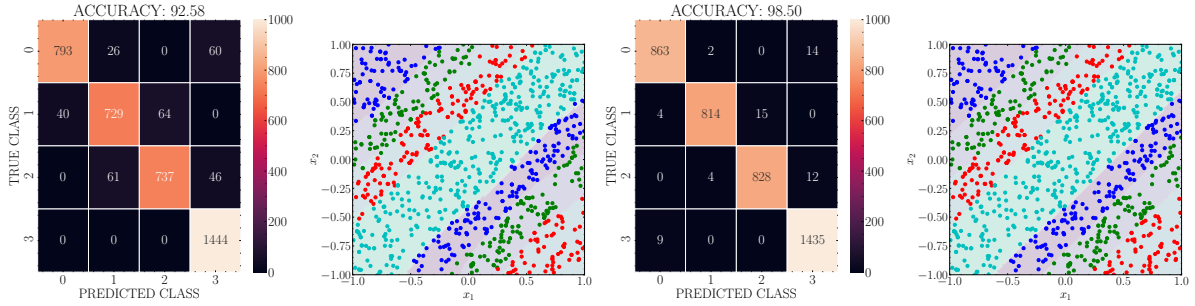


(a) Poly, Size 500 (b) Poly, Size 1000 (c) Poly, Size 1500 (d) Poly, Size 2000

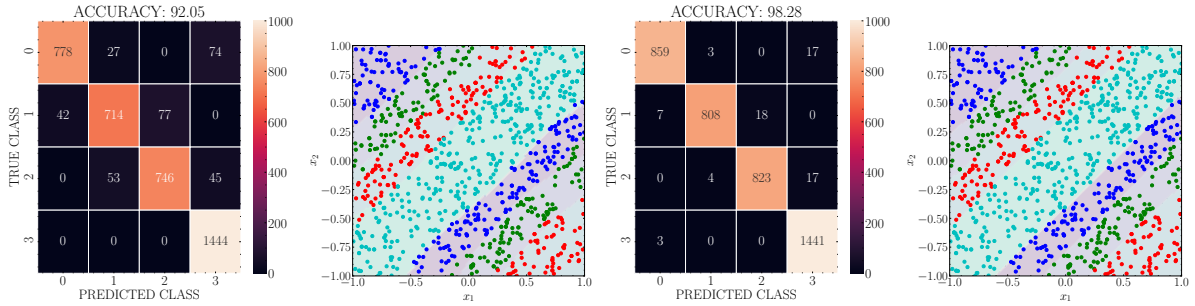


(e) LOG, Classifier (f) LOG, Classifier (g) LOG, Classifier (h) LOG, Classifier

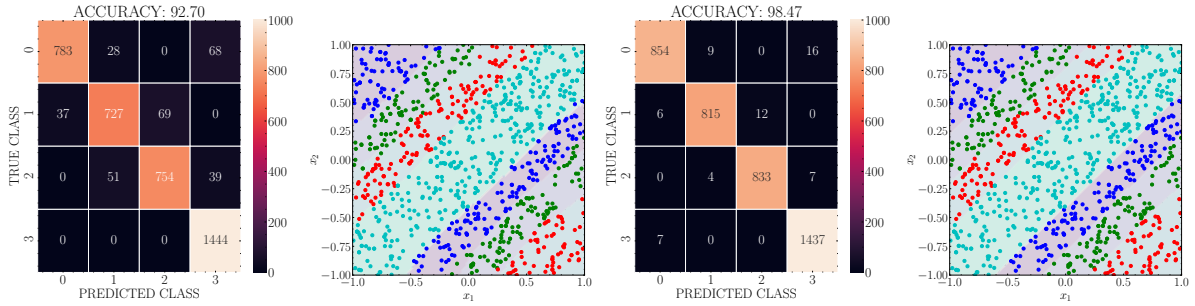
Figure 6: Logistic regression on 2D data with 40% label noise.



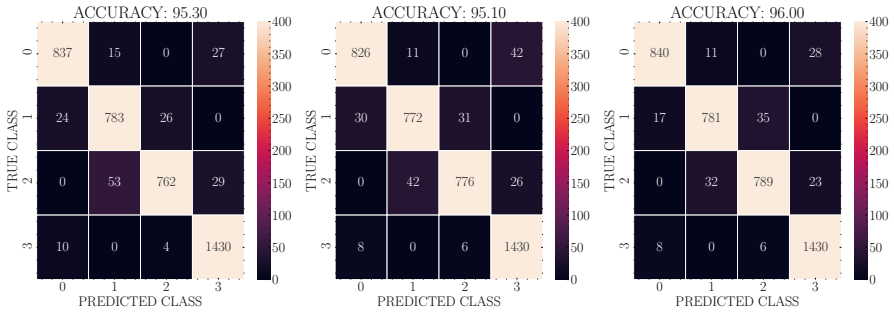
(a) SGD, Size 2000 (b) SGD Classifier (c) Adam, Size 2000 (d) Adam Classifier



(e) SGD, Size 3000 (f) SGD Classifier (g) Adam, Size 3000 (h) Adam Classifier

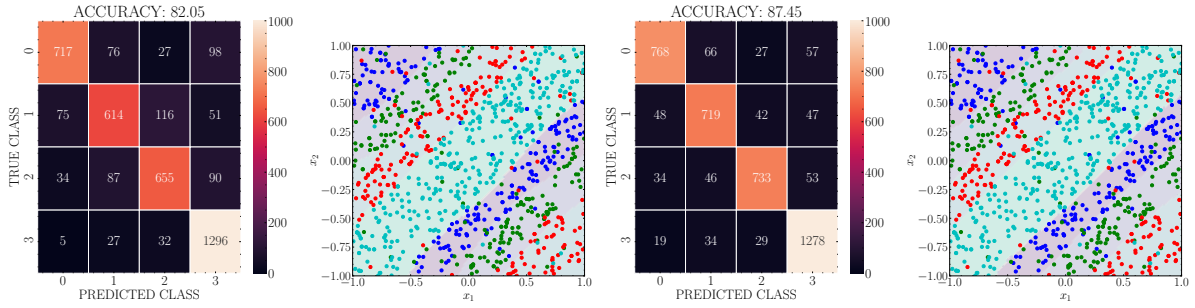


(i) SGD, Size 4000 (j) SGD Classifier (k) Adam, Size 4000 (l) Adam Classifier



(m) SVM, Size 2000 (n) SVM, Size 3000 (o) SVM, Size 4000

Figure 7: Feedforward network on 2D data with no label noise.

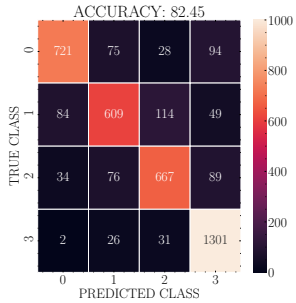


(a) SGD, Size 2000

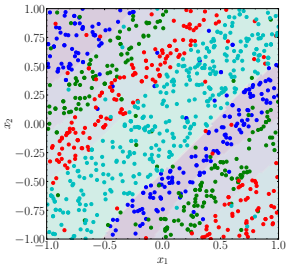
(b) SGD Classifier

(c) Adam, Size 2000

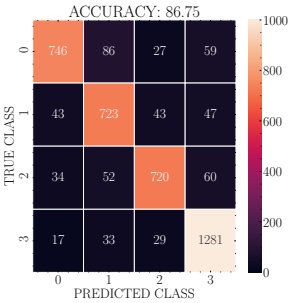
(d) Adam Classifier



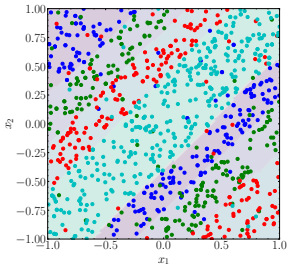
(e) SGD, Size 3000



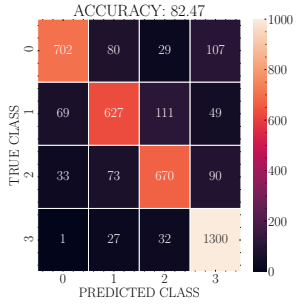
(f) SGD Classifier



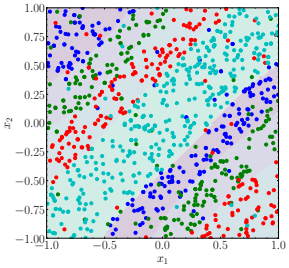
(g) Adam, Size 3000



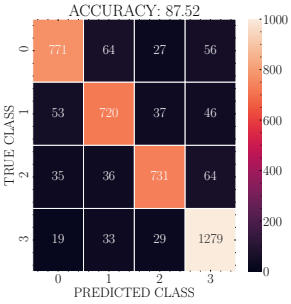
(h) Adam Classifier



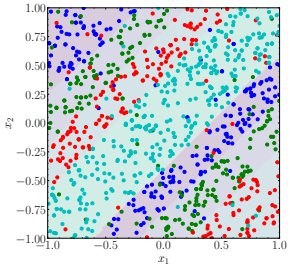
(i) SGD, Size 4000



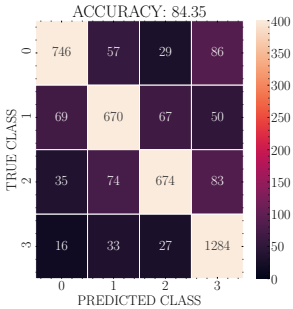
(j) SGD Classifier



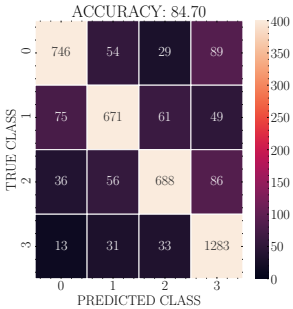
(k) Adam, Size 4000



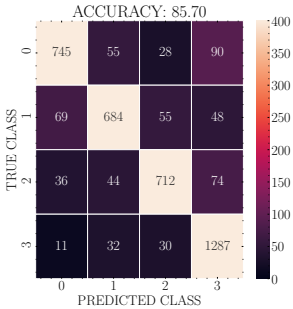
(l) Adam Classifier



(m) SVM, Size 2000

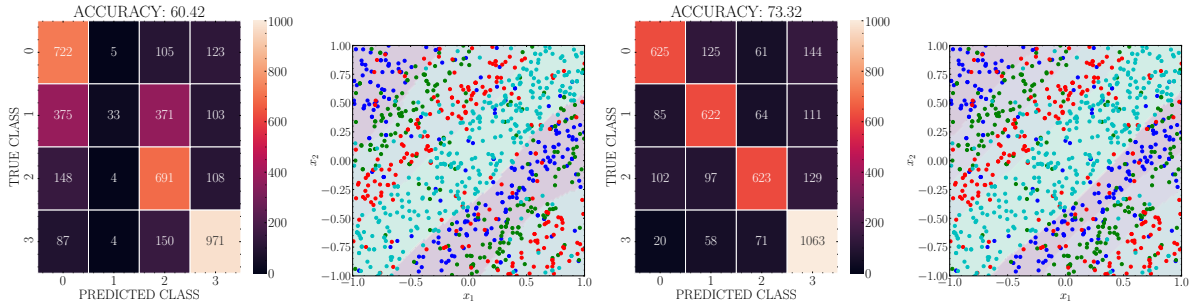


(n) SVM, Size 3000

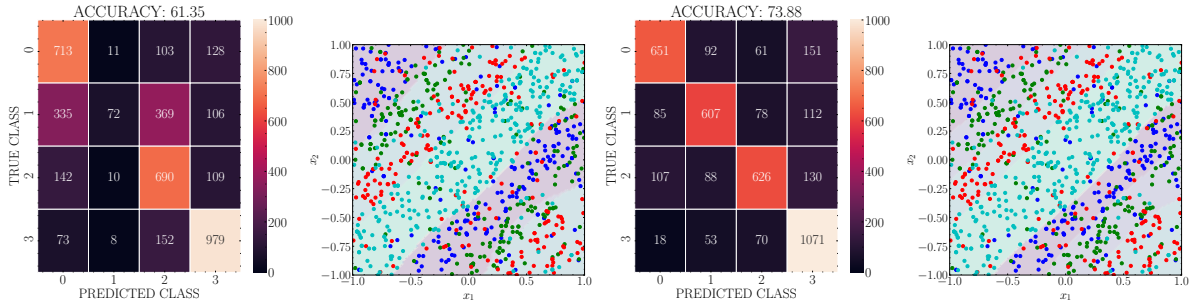


(o) SVM, Size 4000

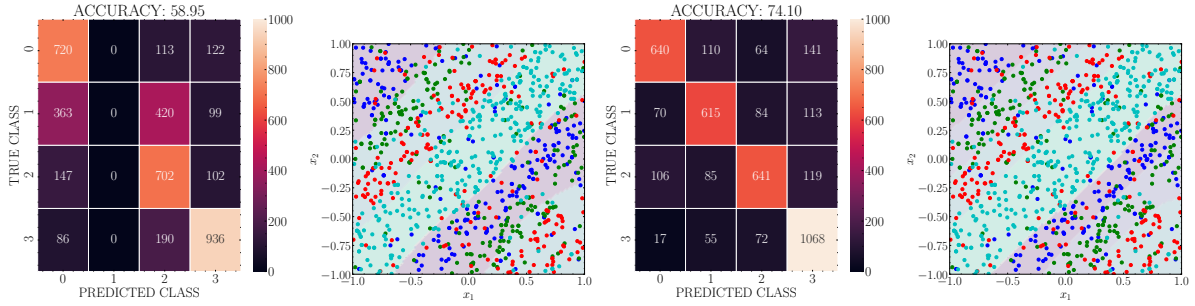
Figure 8: Feedforward network on 2D data with 10% label noise.



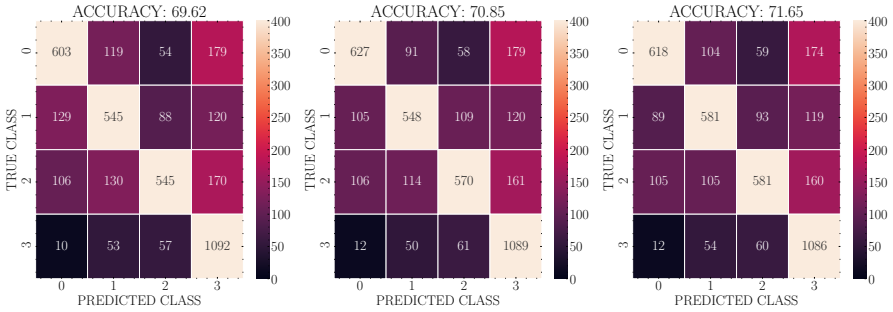
(a) SGD, Size 2000 (b) SGD Classifier (c) Adam, Size 2000 (d) Adam Classifier



(e) SGD, Size 3000 (f) SGD Classifier (g) Adam, Size 3000 (h) Adam Classifier

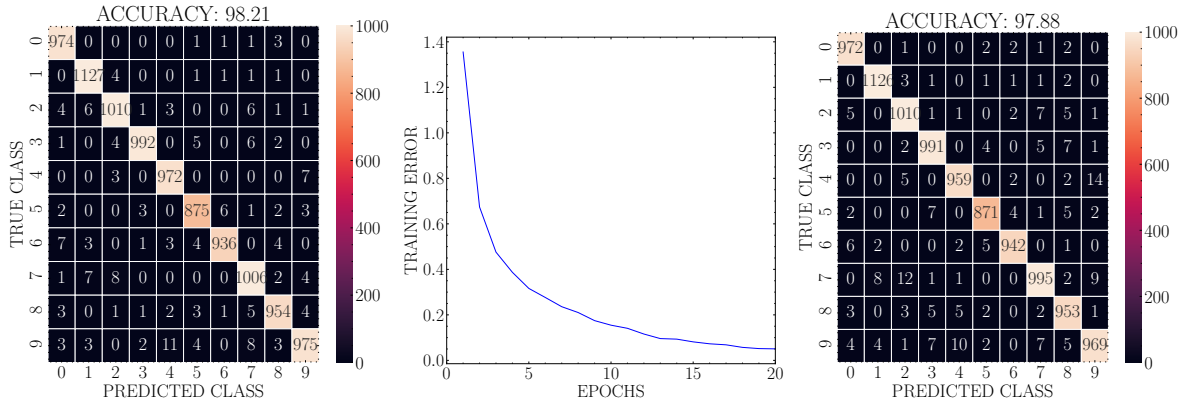


(i) SGD, Size 4000 (j) SGD Classifier (k) Adam, Size 4000 (l) Adam Classifier



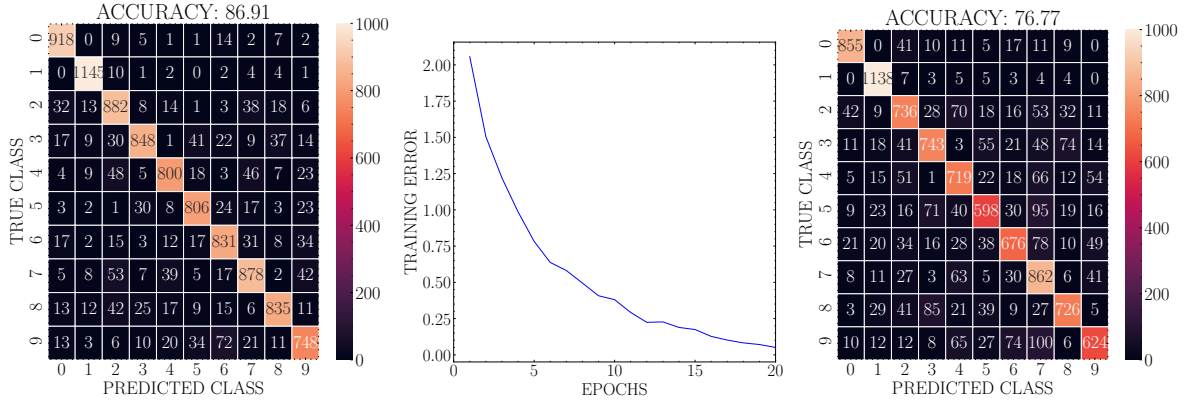
(m) SVM, Size 2000 (n) SVM, Size 3000 (o) SVM, Size 4000

Figure 9: Feedforward network on 2D data with 25% label noise.



(a) CNN with Adam (b) CNN Loss Function (c) SVM with RBF Kernel

Figure 10: Convolutional neural network and support vector machines for MNIST classification.



(a) CNN with Adam (b) CNN Loss Function (c) SVM with RBF Kernel

Figure 11: Convolutional neural network and support vector machines for MNIST-ROT classification.