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Exercise 2 – Handwriting Recognition
COMP24111

Part 1: k-Nearest Neighbour – Training and Testing

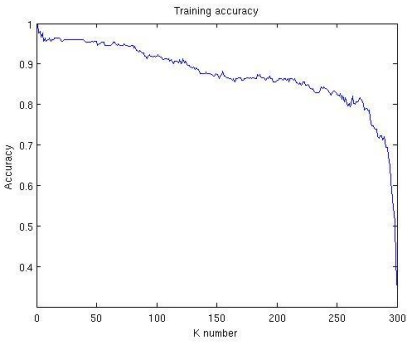


Figure 2

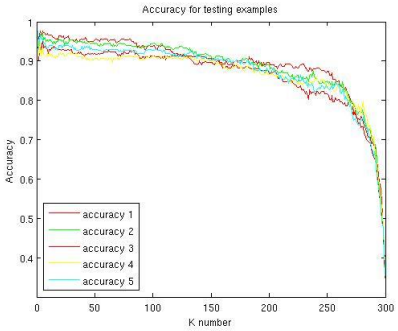


Figure 1

Figure 1 illustrates the training for k-NN classifier for three digits when k =1:300. It can be observed that when k=1 (you only consider 1 neighbour) the accuracy is 100% and it decreases as 'k' gets bigger.
In figure 2 it can be observed the testing of 5 different testing datasets in against the training from part b. Also the highest accuracy it is obtained when k is smaller than 100 and it decreases drastically when k out pass 250 because the neighbours will include to many samples from other classes.

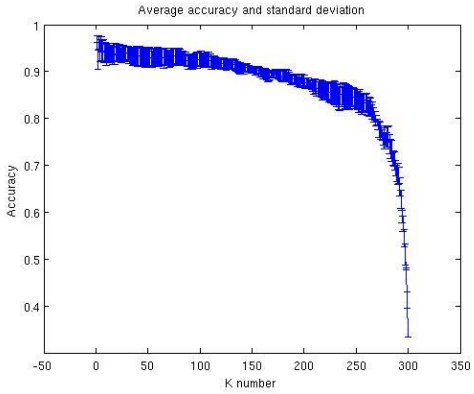
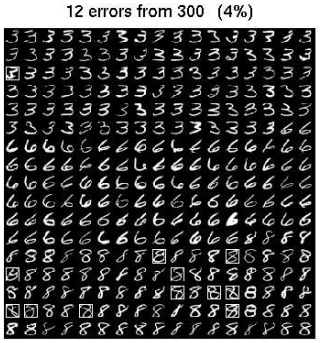


Figure 3

When repeating the testing multiple times we observe that the result is mostly the same. The differences are visible because we are changing the testing data. We used error-bar plot to expose the standard deviation for the average accuracy.

Figure 4

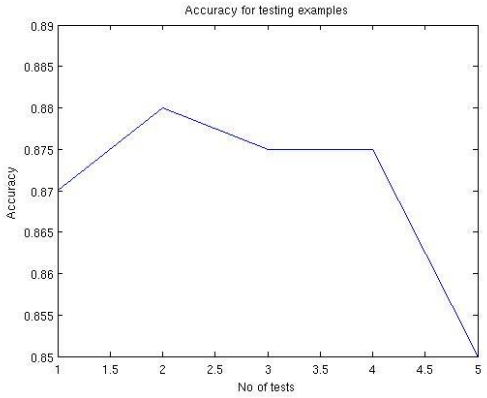


Here is an example of the 'showData' method in which we can visualise the actual errors made by the classifier. The problem with this is that we cannot see what the digits were mistaken with, therefore it is useful to create a confusion matrix.
The accuracy is high as k is set to 3.

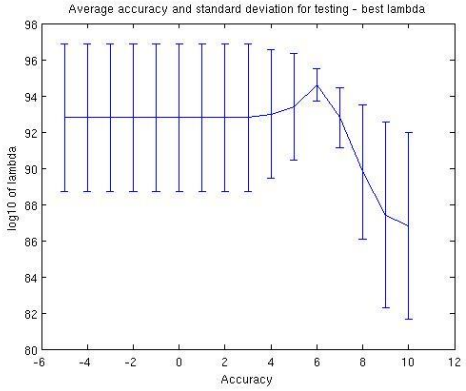
```
ans =

    99     0     1
     0   100     0
    10     1    89
```

Part 2: Regularised Least Squares – Training, Testing and Hyperparameter Selection

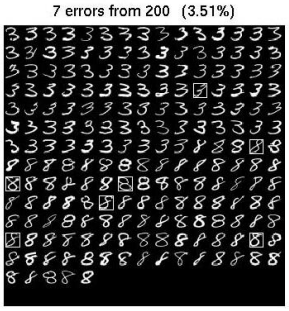
In part a) when training the binary classifier using the provided 'RegLS' function and $\lambda = 0$ the accuracy is 100%, the same as for K-NN classifier for k = 1.
When $\lambda = 0$ it is unregularized because we do not take into account the weight in the RLS formulae.



Testing accuracy is smaller than the one at k-NN classifier because we haven't chosen the right lambda yet. The executing process of the code is much faster than the previous classifier. We call the function in order to find out the predicted labels using the training dataset from part one, a target with '1' and '-1' labels for the two classes and $\lambda = 0$.



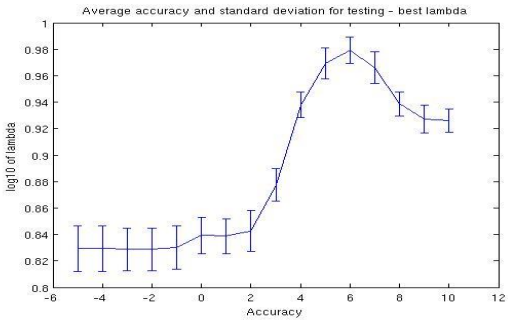
When executing multiple testing with varying λ from 10^{-5} to 10^{10} the error bar is showing that the best accuracy is obtained when $\lambda = 6$. The training and testing datasets are obtained by randomly splitting the initial dataset.



When $\lambda = 0$ the accuracy is not that high, but when we select the best λ we can see that the errors are minimal.

Part 3: Regularised Least Squares – Multi-class Classification

This part is basically the same as the previous one, the only difference is that we are building the target differently because we have multiple classes. For three digits we are creating a matrix of 0's and 1's where 1 determines the label class.



By multiple testing and trying different values for λ, according to the error bars the most efficient accuracy is when $\lambda = 6$.
In conclusion RLS classifier is more accurate and faster than k-NN Classifier when it is used with suitable λ, at the same time the standard deviation error is smaller.