**Multilayer Perceptron Classification**

Here we demonstrate some geometric classifications using a multilayer perceptron (MLP) classifier. In these experiments, we'll use one hidden layer with two neurons. Let's start with a simple example, a linear classification where we separate points above and below the line y=x. The two features input into the model are simply the x location and the y location. We train the model with 100,000 examples, and test with 1000. The results are shown in Figure 1. You may need to zoom in a bit on the figure to make it out fully, but we have one wrong classification, right on the line y=x. Other than that, the MLP performs very well, an accuracy of 0.999.

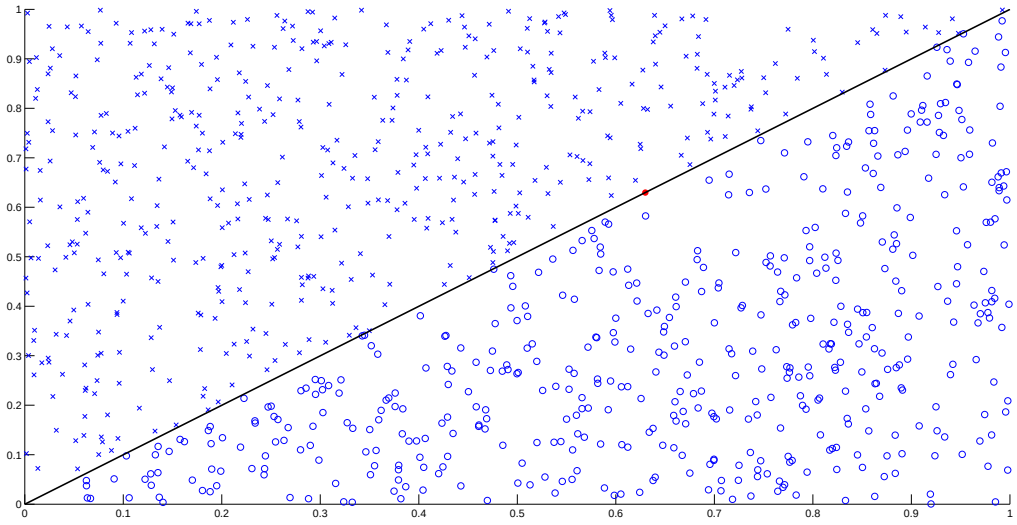


Figure 1: Classifying points above and below the line y=x. Blue X indicates correctly classified as 1, blue O indicates correctly classified as 0, and the red circle indicates incorrectly classified.

Next, we will try a more difficult classification: points inside and outside a unit circle. We will use the same train and test sizes as before, as well as the same two features. Results are shown in Figure 2 (top). Here, the MLP didn't do too well. It's clearly having a difficult time determining the correct non-linear boundary. In order to improve on this result, let's engineer a couple of additional features. If we take polynomial terms, $x^2$ and $y^2$, and add them to our features, we can significantly improve performance (Figure 3 (bottom)). Now, only 3 points right on the boundary are incorrectly classified, giving an accuracy of 0.997. We can also extend this into higher dimensions. For example, classifying inside and outside a unit sphere. If we use the same idea to add additional features, the accuracy remains high, $> 0.99$.

This was a quick demonstration of an MLP classifier, including an example of how feature engineering can greatly improve the predictive value of a model. Obviously, neural networks and the strategies behind creating additional features can be extended to tackle much more difficult problems as well.

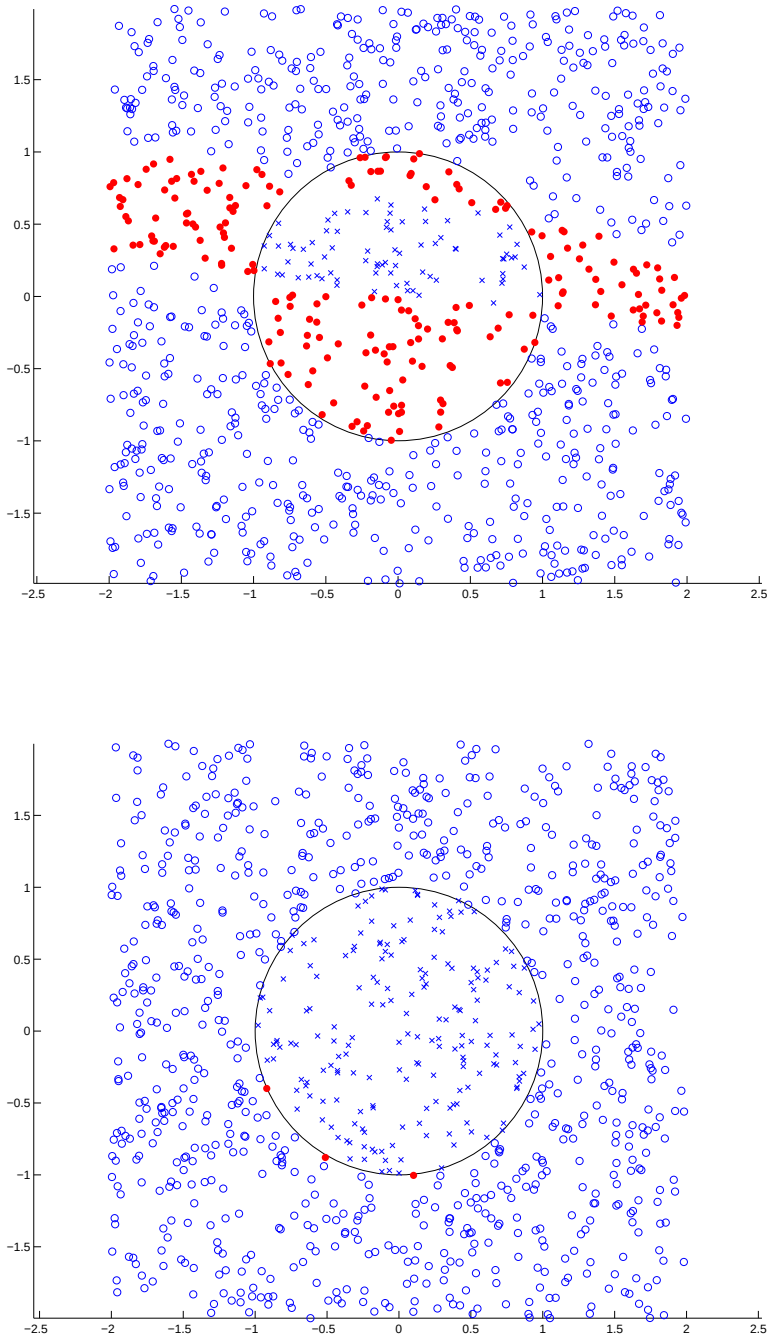


Figure 2: Classifying points inside and outside a unit circle. Blue X indicates correctly classified as 1, blue O indicates correctly classified as 0, and the red circles indicate incorrectly classified. (Top) Using two features, x and y, (Bottom) Using four features, x, y, $x^2$, and $y^2$ .