

LAB 8  
NEURAL NETWORKS AND DEEP LEARNING  
ADVANCED MACHINE LEARNING  
DATA 442/642

**Exercise 1**

Consider a two-dimensional class problem that involves two classes  $\omega_1(+1)$  and  $\omega_2(-1)$ . Each one of them is modeled by a mixture of equiprobable Gaussian distributions. Specifically, the means of the Gaussians associated with  $\omega_1$  are  $[-5, 5]^\top$  and  $[5, -5]^\top$ , while the means of the Gaussians associated with  $\omega_2$  are  $[-5, -5]^\top$ ,  $[0, 0]^\top$ , and  $[5, 5]^\top$ . The covariances of all Gaussians are  $\sigma^2 \mathbf{I}$ , where  $\sigma^2 = 1$ .

- (a) Generate and plot a data set  $X_1$  (training set) containing 100 points from  $\omega_1$  (50 points from each associated Gaussian) and 150 points from  $\omega_2$  (again 50 points from each associated Gaussian). In the same way, generate an additional set  $X_2$  (test set).
- (b) Based on the training set  $X_1$ , train a two-layer neural network with two nodes in the hidden layer, each one having the rectified linear activation function or ReLU and a single output node with linear activation function using the standard backpropagation algorithm for 6000 iterations and step size equal to 0.01. Compute the training and test errors, based on  $X_1$  and  $X_2$  respectively. Also, plot the test points as well as the decision lines formed by the network.
- (c) Repeat step (b) for step size equal to 0.0001 and comment on the results.
- (d) Repeat step (b) for step size equal to 0.0001 and  $k = 1, 4, 20, 50$  hidden layer nodes and comment on the results.