Assignment 3

EE 468: Selected Topics on Communications and Signal Processing
Neural Networks and Deep Learning
Due on: Monday April 12th, 2022

Coding Part

As we have learned in Lecture 3, neural networks are built by stacking neurons to form layers and, then, stack those layers to form networks of varying architectures. The goal of this assignment is to get you to learn *Python classes* and use them to construct a pre-defined fully-connected neural network; you do not need to worry about designing the network (i.e., designing the architecture) or its training, for they have been done for you.

I Dataset and Network Architecture

Let $\mathcal{D} = \{(\mathbf{x}, t)_u\}_{u=1}^{U}$ be a spiral training dataset such that $\mathbf{x} \in \mathbb{R}^2$ is a vector of observed variables and $t \in \{1, 2, 3\}$ is the class label. The dataset is visualized in Figure 1. It is clear from the figure that the three classes are not linearly separable. Hence, a neural network of the architecture shown in Figure 2 is designed and trained to classify the spiral data. The network comprises four main layers. The first three has are dense layers with ReLU activation. The fourth, i.e., the output layer, is designed to produce a probability distribution over the three classes of the dataset. This is done by employing the so-called softmax layer. The softmax layer is defined for an input vector $\mathbf{h} \in \mathbb{R}^{Q_L}$ as

$$y_i = \frac{e^{h_i}}{\sum_{j=1}^{Q_L} e^{h_j}} \quad i \in \{1, 2, \ldots, Q_L\} \tag{1}$$

Where Q_L is the breadth of the last layer, which is number of outputs of the network. The above equation states that the output of the softmax has the same dimensionality as its input, i.e., $\mathbf{y} \in \mathbb{R}^{Q_L}$. Furthermore, it states that the output vector $\mathbf{y}$ takes values from 0 to 1 and sums to 1, which makes it a valid probability mass function (pmf).

II What You Should Do?

Visit the course GitHub website at: `https://github.com/ModernMLCourse`. Go to the repository (repo) "Assignment_3," and download it. You should get the following

- Script files: (1) main.py, (2) layers.py, and (3) build_net.py
- Two ".mat" files: (1) assig3_dataset.py and (2) trained_parameters.mat.

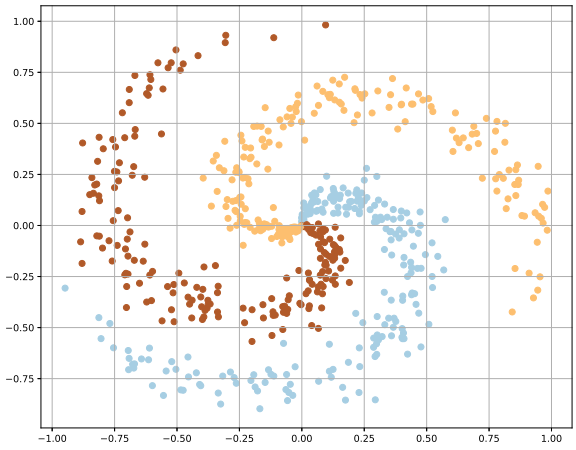

Figure 1

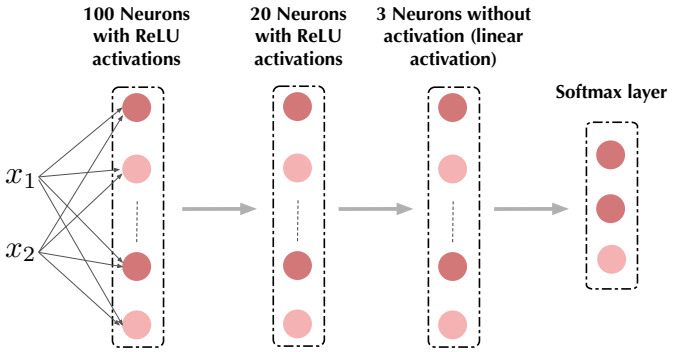

Figure 2

- A "README.md" file with some instructions.

Read the README.md file carefully to understand what you are expected to do, and make sure you review all the notes and comments provided in all script files.

> **REMARK:** you are required to understand the whole script and not only those lines you complete; moving forward, I will assume you are familiar with everything you have seen in an assignment script

III Accuracy

You are required in this assignment to compute the prediction accuracy of the designed neural network. The accuracy is defined as

$$\text{Acc} = \frac{1}{U} \sum_{u=1}^{U} \mathbb{1}\{y = t\}, \tag{2}$$

where y is the label predicted by the network, t is the groundtruth label, and $\mathbb{1}\{y = t\}$ is the indicator function given by

$$\mathbb{1}\{y = t\} = \begin{cases} 1, & y = t, \\ 0, & \text{otherwise} \end{cases} \tag{3}$$