

# Introduction to Python Programming

## Mini Project

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**Problem 1.** Many modern machine learning models rely on Deep Neural Networks (DNNs) to fit complex functions defined by real-world data sets. In practice, thousands of weights parameterize a DNN, and we train a model by finding optimal values for the machine learning model parameters. The optimal parameter values are determined by minimizing the model error as measured by a given loss function. The following example will motivate the usefulness of neural networks in data fitting. Let us consider the following data set.

input	data 1	data 2	data 3	data 4
$x_1$	0	0	1	1
$x_2$	0	1	0	1
$x_3$	1	1	1	1
output or prediction $\hat{y}$	0	1	1	0

Table 1: Data table

The data in Table 1 represents a sample of  $m = 4$  input-output pairs, corresponding to the function  $\hat{y}$  defined by

$$\hat{y} = \begin{cases} 0, & \text{if } x_1 + x_2 + x_3 \text{ is odd,} \\ 1, & \text{if } x_1 + x_2 + x_3 \text{ is even.} \end{cases}$$

Each  $x_i$  ( $1 \leq i \leq 3$ ) is either 0 or 1. We would like to design a deep-learning model that takes three inputs ( $x_i$ ) and outputs (or predicts) 1 if the summation of these three inputs is even and outputs (or predicts) 0 if the summation of these three inputs is odd. Specifically, we use a neural network with one hidden layer (see Fig. 1). The code of the neural network is given to you (`NN.py` and `NN.ipynb`). Your task is to investigate the role of different parameters.

- Investigate the role of the number of neurons in the hidden layer.
- Plot the evolution of the loss.
- Investigate the accuracy of the network prediction for the case of  $x_1 = 1, x_2 = 0, x_3 = 0$ .
- Investigate the role of adding more data, listed in Table 2 in the accuracy of the prediction.

input	data 5	data 6
$x_1$	1	1
$x_2$	1	0
$x_3$	0	0
output or prediction $\hat{y}$	1	0

Table 2: Data table

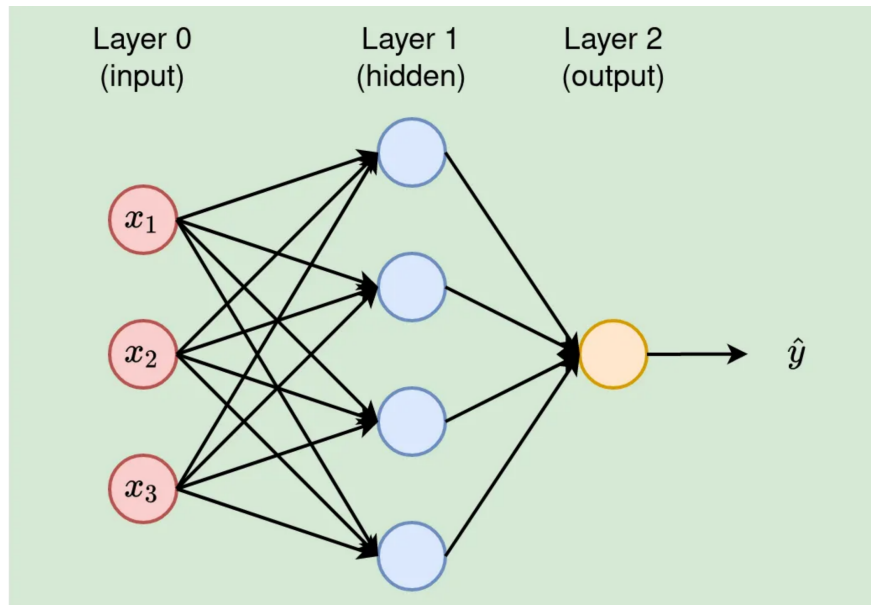


Figure 1: A deep neural network with one hidden layer. The image is taken from <https://towardsdatascience.com>