

# Introduction to Deep Learning Final Report

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## 1 Introduction

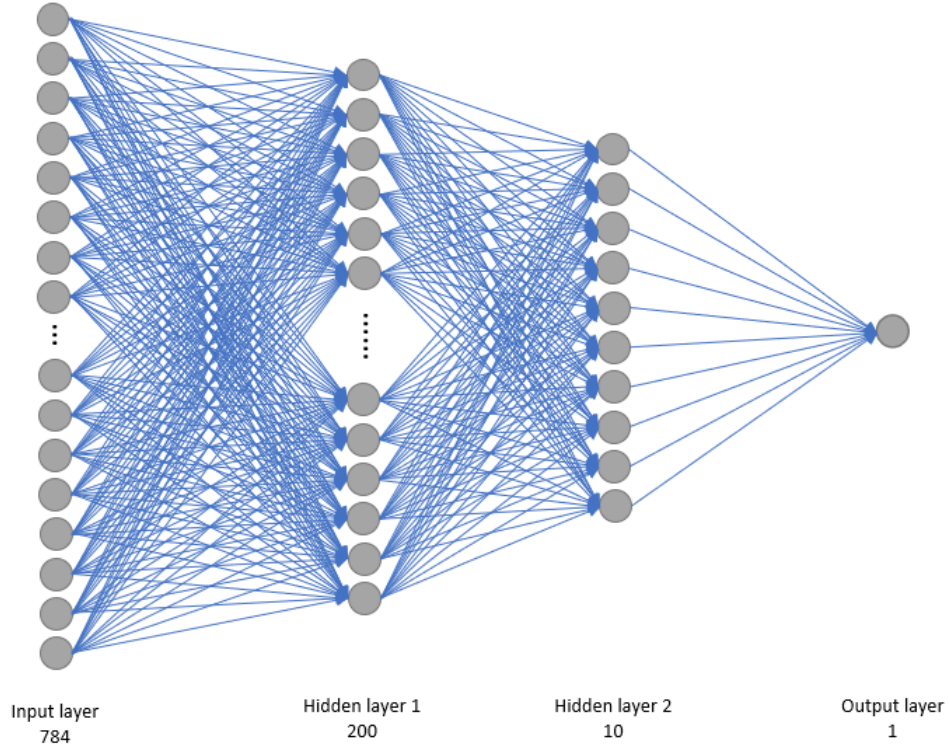
The topic our team chooses is that manually implement a fully-connected NN using Numpy. And we finally implement a four-layer fully connected neural network. According to the requirement, we are training this model on the MNIST dataset and get accuracy above 90% at around 200 epoch.

## 2 Dataset

The dataset we are using is MNIST. This is a large dataset of handwritten digits from 0-9 that is commonly used for training various image processing systems. And these numbers are from 250 different people, which 50% of them are middle school students, and 50% of them are faculty of the Census Bureau. The dataset itself is divided into a training set that has 60000 samples, and a testing set has 10000 samples. Each image in this dataset has 28x28 pixels. So in the training process, we will falt each image into a 784 dimension vector.

## 3 Model

As mentioned in the last section, we build a four-layer network. Considering the image data will be taken, the first layer has 784 neurons and will output 200 neurons. The two hidden layers have 200 and 10 dimensions, respectively.



## 4 Methods

### ReLU

For ReLU we choose to use the Ramp function, which is a widely used rectifier in the machine learning field. As its name showed, the graph of ramp function looks like a ramp. And can be described mathematically as follow:

$$R(x) := \max(0, x)$$

## Softmax

The softmax function takes as input a vector of  $k$  real numbers and normalizes it into a probability distribution consisting of  $K$  probabilities proportional to the exponentials of the input numbers. And it can be mathematically defined as follow:

$$\sigma(z)_i = \frac{e^{z_i}}{\sum_{j=1}^K e^{z_j}}$$

## Loss Function

We choose to use cross-entropy as

$$H(p, q) = - \sum_{i=1}^n p(x_i) \log(q(x_i))$$

## 5 Result

As we can see from the graph, the accuracy raise rapidly from epoch 0 to 80 and slow down after the accuracy reaches 80%. And also we can see that the accuracy reach above 90% at around 200 epoch. However, since we initiate the weights and bias randomly, the process might be much slower if we got bad luck and initiate a series of bad weights.

