Computer Science NEA Proposal

Image Recognition from scratch

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1 Introduction

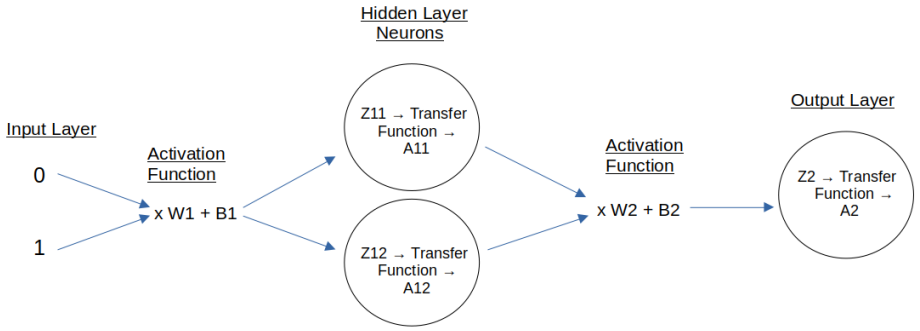

Figure 1: Artificial Neural Network

My project will be an investigation into how Artificial Neural Networks (ANNs) work and their applications in Image Recognition, by documenting all theory behind the project and developing applications of the theory, that allow for experimentation via a Graphical User Interface.

2 Main project objectives

- Develop and document the theory behind the project:
  - To achieve this, I will derive the mathematics behind ANNs and learn the theory behind how they work. Including topics such as the following:
    - Gaining a strong understanding in Matrice operations and Calculus (Such as the Chain rule, Multivariable differentiation and other laws)
    - Learning the basic structure of ANNs, consisting of the following:
      - Weights and biases
      - Structure of layers, consisting of an input layer, hidden layer/s and an output layer
      - The number of neurons that each layer consists of

    * Learning the process of Forward Propagation, where data is inputted into the feedforward ANNs to get a prediction
    * Learning the process of Back Propagation, consisting of the following:
        · The process of calculating the error/loss of the prediction, in order to show the improvement in the performance of the model as it is trained.
        · The process of Gradient descent, in order to adjust/train the weights and biases of ANNs and learn the effects of the learing rate

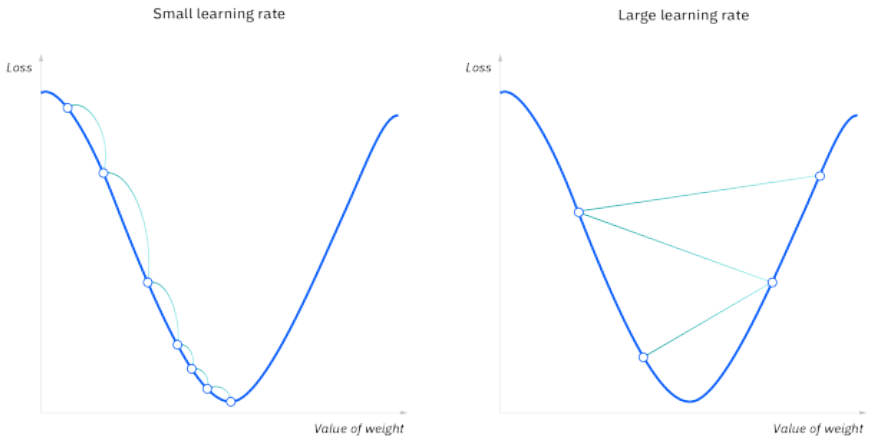

Figure 2: Gradient Descent
sourced from https://www.ibm.com/topics/gradient-descent

        · The process of optimising the training, such as avoiding getting stuck in a local minima for the loss value (instead of the global) and the problem of exploding gradients (where the gradient used to update the weights and biases grows exponentially to the point of overflow errors)
    * Investigate the different types of ANNs, such as Perceptron and Shallow ANNs (different layer structures)

- Create ANNs:
    - Create ANNs by programming them from scratch, without the use of any 3rd party Machine Learning libraries, with an object-orientated approach
- Train models on datasets:
    - Train the ANNs to create trained models, by learning how to provide input and output data to train the ANNs.

  - I plan to first train an ANN model to predict the outputs of a XOR gate on two inputs of 1s and 0s, then I plan to source datasets of images from online, such as the MNIST dataset (a famous dataset of images of handwritten numbers used to test the performance of ANN models), to train ANN models to predict both binary and multi-class classification of images.

- Create GUI to control ANNs:
  - Present theory behind the project
  - Allow for experimentation with the attributes of each ANN model (such as the learning rate and number of hidden neurons in hidden layers)
  - Give control for training the ANNs
  - Present the results of the trained models, such as how its prediction error/loss value changes with the number of training epochs and also show its final prediction accuracy on test inputs after training.

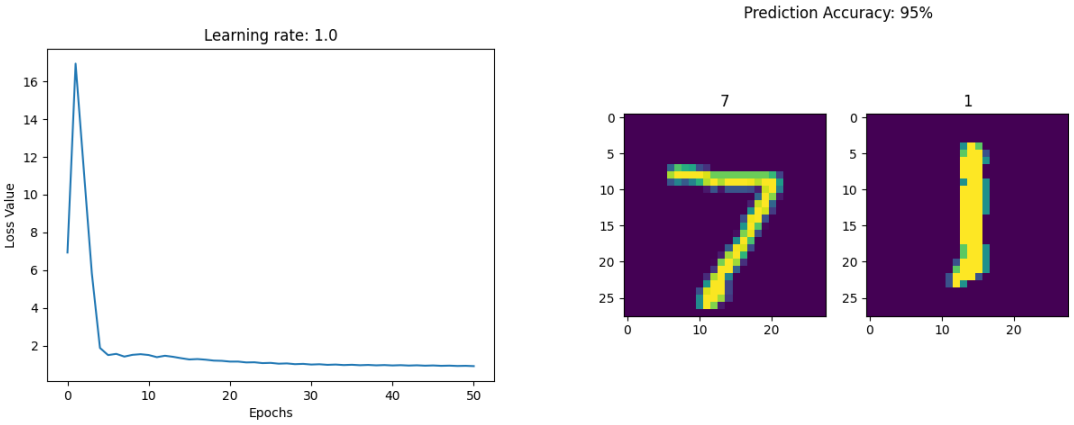

Figure 3: Example results of a trained model

- Experiment with expanding the project further, such as in the following ways:
  - Experimenting with new ANN models, such as in the following ways:
    * Effects of different Transfer Functions in training
    * Experimenting in developing more expandable ANNs (Eg: Allowing for adding as many layers as needed and control over the number of hidden neurons in each hidden layer)
  - Testing improving computational power to allow for more training epochs, layers and hidden neurons (Eg: Using a GPU for calculations via Remote Access to a PC)

3 Programming Languages used

- I will use Python 3 for programming the ANNs and the GUI, due to its high abstraction and simple syntax to let me focus on translating the theory into code. Also Python 3 has many usefull libraries for Data Science, such as NumPy for matrice manipulation and multiplication, Matplotlib for displaying data and libraries for loading datasets.
- I will also use Markdown, LaTex and makefile language for developing the Documentation and PDFs for the theory behind the project.

4 Conclusion

I believe that learning Artificial Neural Networks and their applications in Image Recognition is a suitable focus for an Investigation project, due to the large quantity of content and complexity behind it and the many possible applications with it. Moreover, Artificial Intelligence is a huge field and is continuing to grow larger, so learning the fundamentals behind it, will help eductate the user in understanding the newest advancements in the field.