An Exploration of Neural Networks

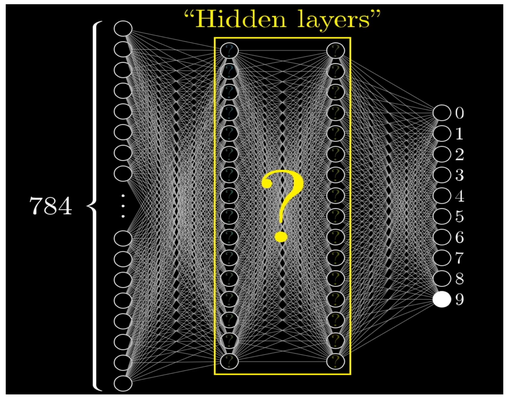
Jingyuan Chen, Sean Eva
Georgia Tech MATH 4803 Spring 2022 Dr. Liao

Georgia Tech School of Mathematics
College of Sciences

About This Project

We are going to be learning about a new method for data analysis beyond our class. In this project we are going to specifically learn more about Neural Networks and compare it against other methods that we have learned throughout this year.

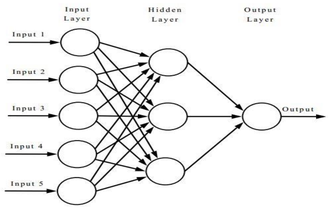
This method is designed after the way our brain works. We take certain inputs that are processed through **layers** of **nodes** that will pick up different key features of the input that will then attempt to place it into a certain output category.



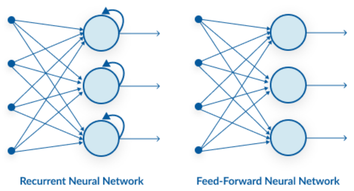
Different Kinds of Neural Networks

There are three main types of Neural Networks that we explored during this project:

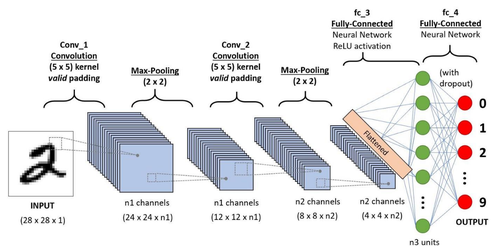
Artificial Neural Network:



Recurrent Neural Network:



Convolutional Neural Network:



How Are We Using Neural Networks?

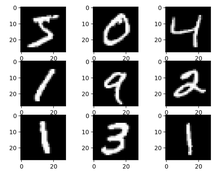
We are using PyTorch and Tensorflow in Python to develop Convolutional Neural Networks on each of these data sets.

TensorFlow

Data Sets

We attempted to implement Neural Networks on three main datasets of increasing complexities:

THE MNIST DATABASE of handwritten digits:

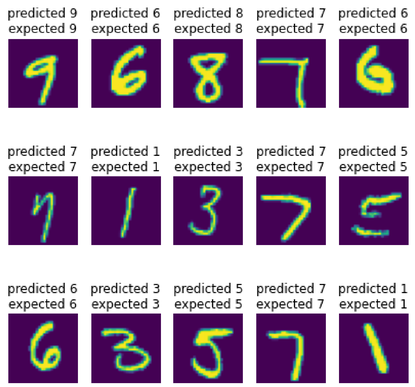


The Chars74K dataset Character Recognition in Natural Images:

Petals to the Metal – Flower Classification on TPU:

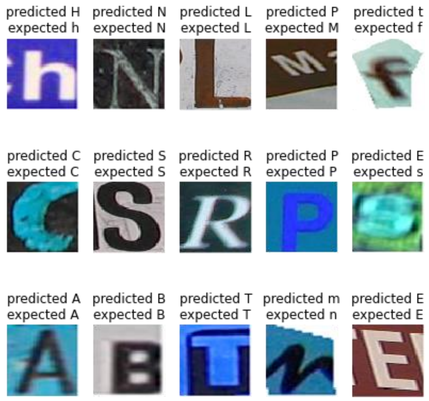
Comparing Effectiveness on MNIST

MNIST is our simplest dataset being that it is only numbers, and this is easily seen in our accuracy rate using a Convolutional Neural Network. Using a basic Neural Network on the MNIST dataset, even the tutorial provided by Tensorflow, we are able to achieve 98%-99% accuracy.



Comparing Effectiveness on Chars74K

The Chars74K dataset is slightly more complex than the MNIST dataset in that it not only includes integer digits, but it also includes letters. With this dataset we saw slightly less accuracy with 80% accuracy using the Convolutional Neural Network.



Comparing Effectiveness on Petals to the Metal

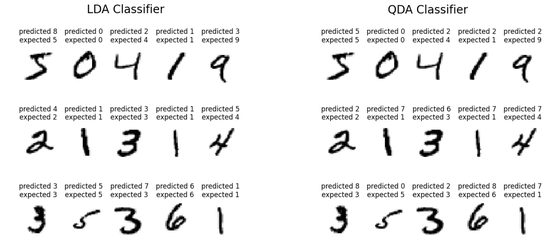
Since the Petals to the Metal is much more complex than the MNIST or the Chars74k data we were not able to get quite such a high percent of accuracy. Additionally, we had to use dimension reduction on this dataset because a lot of the images were very large. We reduced image size and color complexity to create more easily recognizable. A problem we noticed that we may have created when we did this is creating possibly less contrast between the background which often contained other foliage and the plant we are more focused on. Using the Convolutional Neural Network, we have achieved approximately 60% accuracy. This took the largest hit in accuracy. On top of this decrease in accuracy because we had to do preprocessing on the images and the general increase in complexity of the images, we found that the time to run the analysis on this dataset took much longer.

The Problems with Increased Complexities

When we moved to a slightly more complex dataset from MNIST to Chars74k, we saw that there was a slight decrease in accuracy and not a significant hit in processing time. However, when we moved to the much more complex Petals to the Metal dataset, the images were too complex, so we had to reduce the dimensions of the image and simplify their colors. We did this in order to combat processing time because as it was the dataset was going to take too long for us to process.

Other Tests

In addition to using Neural Networks to analyze this data, we have used other methods that we learned in class such as Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA), K-Nearest Neighbors (KNN), and Random Forests. So far we have found less success with these methods as can be seen in these example predictions.



Conclusions and Further Work

From these datasets we were able to get a good beginner understanding of how we can implement neural networks to different types of datasets. To summarize, we achieved 98% accuracy on the MNIST dataset, 80% accuracy on the Chars74K dataset, and 60% accuracy on the Petals to the Metal dataset. Throughout these three datasets we saw a drastic increase in data complexity. With this increase in data complexity, we saw a decrease in accuracy and an increase in processing time. In order to combat this, we tried dimension reduction which will also introduce areas for the program to create errors. Beyond this, we have performed many other tests on these datasets such as Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA), K-Nearest Neighbors (KNN), and Random Forests and we need to analyze their effectiveness in analyzing these datasets. However, we don't only need to evaluate their success rates, but we also need to consider how they impact analysis time. For example, when we try to run much larger and much more complex data sets like Petals to the Metal, we ran into problems processing the data into way that would not take too much time. This would obviously become a bigger factor as we increase dataset sizes and dataset complexity. We tried to work on a dataset involving whale and dolphin pictures, but because those images were very large and the dataset was about 60GB in size, it took too many resources for us to use it in our project. We might look at this again if we have the opportunity.

References

Campos, T. (n.d.). Character Recognition in Natural Images. The Chars74K image dataset. Retrieved from http://www.ee.surrey.ac.uk/CVSSP/demos/chars74k/

LeCun, Y., Cortes, C., & Burges, C. J. C. (n.d.). The MNIST Database of handwritten digits. MNIST Handwritten Digit Database. Retrieved from http://yann.lecun.com/exdb/mnist/

Petals to the metal - Flower Classification on TPU. Kaggle. (n.d.). Retrieved from https://www.kaggle.com/c/tpu-getting-started