Project Proposal: Triple MNIST Recognition with Neural Networks

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1 Project Idea

We are working with the triple MNIST and the task is to build a CNN that can recognize the digits in an image.

The solution we came up with, is to build a standard CNN architecture, but we use a genetic algorithm to optimize the number of filters as well as the size of the filters.

We also consulted with papers such as [1], [2]

2 Method/Technique

We define a neural network architecture, with parameters which are the number of filers and the size of each filter. The CNN architecture has 3 layers, a Convolution layer followed by a Pooling layer and in each layer, we leave the number of filters to be optimized by the Genetic Algorithm, as well as the size of the filter.

We split the training set into training set and optimization set. The optimization set is used to run the genetic algorithm and it's 20 % of the the training set. This is because the dataset we are using is very huge, about 100,000 images, and the training set is about 60,000 images. This will be computationally ineffective. Moreover, we make the assumption that with a random choice of the optimization set, it should be representative of the whole dataset.

For the genetic algorithm, each individual is represented as an array of real numbers. The first three array indexes represent the number of filters in the first three layers. the next three indexes represent the size of filters in the next three array positions, such that an array $[a_1, a_2, a_3, a_4, a_5, a_6]$ means that

$$a_1 - a_3 = \text{number of filter in layer 1, 2, and 3}$$

$$a_4 - a_6 = \text{size of kernels in later 1, 2, and 3}$$

Fitness function is gotten by evaluating accuracy on the optimization set.

Mutation is achieved by randomly selecting a random layer and and adding or subtracting a random number, but then, the result should still be a valid individual, so we set the upper and lower bounds.

Crossover is fixed. We select half of parent 1 and half of parent 2, to form a new individual.

Parent selection is done by ranking the individuals and choosing the top x amount to crossover with the next x individuals.

3 Dataset Explanation

The dataset is the MNIST, but instead of a single digit, it's three digits. We didn't generate the script, but we found a page for generating the script and it's provided below.

Link to dataset

Script for dataset generation.

4 Timeline

- 26th and 27th, March : Delibrate on the trade offs to make and which approach to go with.
- 28th, March to 2, April : We split the program into different parts, based on the specifications we define by 27th of March, so that each team member contributes to the coding, with as rigorous testing as possible.
- 3rd, April to 7th, April : Initial integration and testing of the code base. Everyone will also be involved in this.
- 8th, April to 15th, April : Further optimization, everyone will be involved in this as well.
- 15th, April till submission date : Preparation of report by Chulpan Valiullina
- 15th, April till submissin date : Tiding up the code base, Khush Patel and Israel Adewuyi. This is the tentative timeline we are working with. By the final presentation, we will be able to report how it actually went and report all of it to the course instructors.

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References

[1] S. Lee, J. Kim, H. Kang, D.-Y. Kang, and J. Park, "Genetic algorithm based deep learning neural network structure and hyperparameter optimization," *Applied Sciences*, vol. 11, no. 2, 2021, ISSN: 2076-3417. DOI: 10.3390/app11020744. [Online]. Available: https://www.mdpi.com/2076-3417/11/2/744.

[2] O. Salih and K. J. Duffy, "Optimization convolutional neural network for automatic skin lesion diagnosis using a genetic algorithm," *Applied Sciences*, vol. 13, no. 5, 2023, ISSN: 2076-3417. DOI: 10.3390/app13053248. [Online]. Available: https://www.mdpi.com/2076-3417/13/5/3248.