

# **Deep Neural Networks for Recognizing Handwritten Mathematical Symbols**

## **Domain Background**

Given the importance of mathematics in all branches of science (physics, engineering, medicine, economics, etc.), the recognition of handwritten mathematical expressions has become a very important area of scientific research. However, recognition of mathematical symbols and expressions is a tough problem in the fields of computer vision and machine learning. Part of the reason is due to the variety in writing styles and enormous amount of mathematical symbols. As a student from mathematical department, diving in this problem is a meaningful thing to me.

## **Problem Statement**

In this project, the mission for me is to let my trained model to recognize the single mathematical handwritten symbol. The possible solution to the problem could be SVM and CNN. I am going to use the accuracy to be the evaluation metrics, which is the same with deep learning project.

## **Datasets and Inputs**

The dataset can be easily obtained from kaggle([here](#)).

Dataset consists of (45x45) .jpg images. DISCLAIMER: dataset does not contain Hebrew alphabet at all. It includes basic Greek alphabet symbols like: alpha, beta, gamma, mu, sigma, phi and theta. English alphanumeric symbols are included. All math operators, set operators. Basic pre-defined math functions like: log, lim, cos, sin, tan. Math symbols like:  $\int$ ,  $\sum$ ,  $\sqrt{\phantom{x}}$ ,  $\Delta$  and more.

This dataset is the whole dataset I need for training and testing.

## **Solution Statement**

The solution that I is convolutional neural network. The most commonly used architecture had 3 convolutional layer each with 128, 64 and 32 filters respectively. These filters were of size  $4 * 4$ ,  $3 * 3$  and  $2 * 2$  respectively for each layer and had a stride of  $2 * 2$ ,  $2 * 2$  and  $1 * 1$  respectively for each layer. The activation function between each convolutional neural network should be ReLU.

## **Benchmark Model**

After CHROME(the Competition on Recognition of Online Handwritten Mathematical Expressions), papers and research flourish. Xinyan et al used a combination of Genetic algorithm and neural network to classify the mathematical symbols and got accuracies close to 90.6%.

Another work in this area was done by Lu et al who used a convolutional Neural network to classify the symbols. They got accuracies close to 83%.

## **Evaluation Metrics**

The main evaluation metrics that I am going to use is accuracy. However the training time and cross validation loss would also be considered. Besides, in order to evaluate the model thoroughly, F1-score would also be an option.

## **Project Design**

The workflow:

1. Data cleaning and preprocessing
2. Model construction
3. Model evaluation and optimization
4. Future work

