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EVALUATION OF HANDWRITTEN MATHEMATICAL EQUATIONS

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Abstract: - During the lockdown we find difficulties a lot in offline education. So, we will develop an algorithm using machine learning, neural networks in python to recognize the handwritten mathematical expression, digits and symbols. We will check for the hand written mathematical equation on paper, and algorithm will validate each step using neural network and machine learning. The final answer will be shown when the algorithm will finish its task that if the hand written equation on the paper is correct or not. If the validate steps will be right it will mark as green if the steps are solved wrong it will be mark as red, the algorithm will draw rectangle boxes around each valid step.

Keywords: *Neural Network, Deep Learning, SVM, MATLAB, OpenCV*

I.INTRODUCTION

Mathematical expressions constitute an essential part in most scientist and engineering disciplines. The input of mathematical expressions into computers is often more difficult than that of plain text, because mathematical expressions typically consist of special symbols and Greek letters in addition to English letters and digits. With such a large number of characters and symbols, the commonly used type of keyboard has to be specially modified in order to accommodate all the keys needed, as done in evaluation. Another method is to make use of some extra keys in the keyboard (e.g., function keys) along with a set of unique key sequences for representing other special symbols. Yet another method is to simply done a set of keywords to represent special characters and symbols, as in LATEX. [5]

II.IMPLEMENTION

A.Dataset Description:

We have used the mathematical symbols dataset provided by CROHME (Competition on Recognition of Online Handwritten Mathematical Expressions). This dataset is a collection of mathematical handwritten symbols which can be used to form mathematical expressions.[1]

The dataset consists of inkml files which contain the traces of the mathematical symbols gathered by taking input from multiple users across the world. This dataset is used to train the neural network model used for recognizing the mathematical expressions. We are also using MNIST as .jpg – Kaggle Digit Recognizer Competition as .jpg Images Files.[2]

The Digit Recognizer competition uses the popular MNIST dataset to challenge Kaggler's to classify digits correctly. In this dataset, the images are represented as strings of pixel values in train.csv and test.csv. Often, it is beneficial for image data to be in an image format rather than a string format. Therefore, I have converted the aforementioned datasets from text in .csv files to organized. jpg files.

Sample of MNIST dataset as Image

We are also using HASY dataset - HASY contains 32px x 32px images of 369 symbol classes. In total, HASY contains over 150,000 instances of handwritten symbols. [3]

Image of HASY dataset.

B.Neural Network Model

The proposed model is a single deep and wide neural network architecture that offers near state--of- the-art performance like ensemble models on various image classification challenges, such as MNIST. [2]

Wide architecture the proposed model utilizes a large number of maps per layer, stacked in both horizontal (fork) and vertical (merge) layers. These vertical layers allow the model to see two versions of input at the same time thereby preventing the network from loss of information.

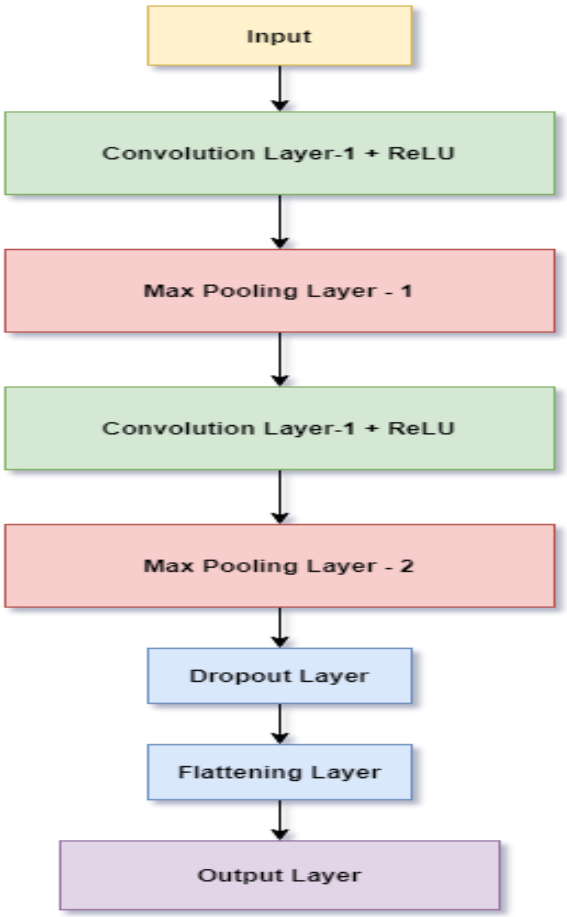
Pooling via Convolutional Subsampling using max-pooling reduces the dimensions of the image thereby reducing the no of parameters but at the cost of losing some important features. Instead, some of the max-pooling layers are replaced by convolutional layers with increased strides.

Variable Kernel size All forked convolutional layers which accept a pre-processed image possess a 5x5 kernel. This improves the convergence speed and the accuracy of the network. All middle tier fork layers utilize either a 4x4 or 3x3 kernel, while simultaneously increasing the number of maps. The final tier fork and merge layer use a 3x3 kernel to improve performance, and often have the largest map size.[7]

Soft Max is a logistic classification function which is used for multiclass classification. It calculates probabilities for each target class over all target classes. The target class can be later easily identified using these calculated probabilities for given inputs. SoftMax provides us with a range of 0 to 1 with the sum of all probabilities equal to 1. The class with highest probability is the target class.

The SoftMax formula is as follows:

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



Layers of Neural Network [8]

C.Data Preparation

•Binarizing the images

•Removing unnecessary noises

•Dilated and eroded by a 3 * 3 kernel

•Applied Gaussian Blur with sigma equals to 1

•Removing rows and columns where all the pixels are black

•After making the aspect ratio same padded to a 20 * 20 image

•Padded to 28 * 28 by centre of mass

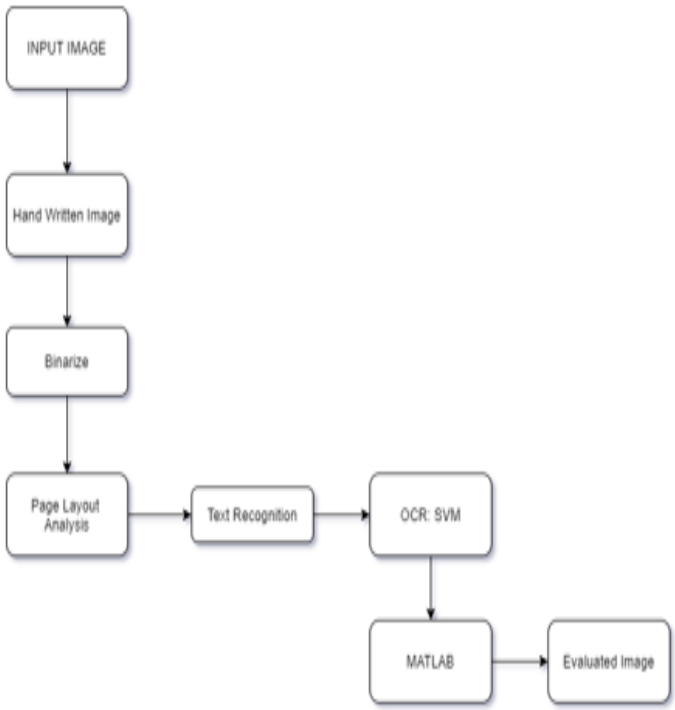
This model evaluates every step of the equation and predict that which step is wrong or which step is right.

The handwritten image or scanned sheet will be converted to the latex text using DCCNN and OCR SVM method, after that MATLAB will be used to check each step.[6]

Since we are using this model for handwritten equation, we are not using OCR tesseract because it only gives 50% of detection rate whereas SVM gives 80-90% if of detection rate.

For recognizing handwritten text:

Initially Tesseract performed well for printed text, with a detection rate better than 85% for fonts within its database. However, its detection rates for handwritten text are below 50%, likely due to size variations in the writing and a lack of matching fonts in its database. [5]



System Architecture

A machine learning algorithm based on support vector machines (SVM) is applied instead. SVM is a supervised learning method that analyses data and recognizes patterns. It is often used for classification and regression analysis. The

prediction model was created using libSVM, a set of tools for training and modelling SVM developed at National Taiwan University. The objective of applying SVMs is to find the best line in two dimensions or the best hyperplane in more than two dimensions in order to help us separate our space into classes. The hyperplane (line) is found through the **maximum margin**, i.e., the maximum distance between data points of both classes.

D.Training:

•**Activation Function** SoftMax is used in the final layer, all other layers contain ReLU activation function.

•**Optimizers:**

AdaDelta optimizer is an adaptive learning rate method which requires no manual tuning of a learning rate performed well compared to other optimizers.

The parameters used are,

 Learning Rate = 1.0

 Rho = 0.95 (decay factor)

•Batch Normalization is used to overcome vanishing gradient problem

•Dropout of 50 % is used before the final dense layer

•Model is trained for only 10 epochs with accuracy up to 96 %

•Augmentation only slightly improved accuracy in this case (Random rotations, width shift, height shift)

o Rotation degree = 20

o Width shift = 20% of image width

o Height shift = 20% of image height

III GOALS AND OBJECTIVE

1.It helps teachers and create a comfortable learning experience for students.

2.In future we can extend the work to develop mobile application through which user can scan input from camera of the mobile device. The accuracy of the project can be increased by further research on neural networks and using the most efficient way to recognize mathematical symbols.

IV CONCLUSION

In this paper we mainly focused on recognizing handwritten mathematical equation and evaluation of the handwritten solved equation on the paper. The scanned sheet is processed through number of modules and finally the red and green box will be drawn for each step predicting the steps are right or wrong.

This algorithm can be developed for predicting the correctness of more complex mathematical problems, chemical equations and handwritten text.

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