*International Journal for Modern Trends in Science and Technology*, 9(05): 660-664, 2023

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0905112
Available online at: http://www.ijmtst.com/vol9issue05.html

# Handwritten Mathematical Equation Recigniser and Solver using CNN

**Dr. N. Saranya, N. Ramya, P. Akshitha Reddy, Sk. Washma Zayb, T. Yamini, U. Sharone**

Department of Comuter Sciecne Engineering, Narayana Engineering College, Nellore, Andhra Pradesh, India

**To Cite this Article**
Dr. N. Saranya, N. Ramya, P. Akshitha Reddy, Sk. Washma Zayb, T. Yamini, U. Sharone. Handwritten Mathematical Equation Recigniser and Solver using CNN. International Journal for Modern Trends in Science and Technology 2023, 9(05), pp. 660-664. https://doi.org/10.46501/IJMTST0905112

**Article Info**
Received: 21 April 2023; Accepted: 18 May 2023; Published: 22 May 2023.

## ABSTRACT

***Mathematical Equations are frequently entered by hand on computer which is slower than writing them on paper or writing software. Researchers usually go through an arduous process of learning the nuances and syntactic complexities of a mathematical tool in order to solve or process mathematical equations. Through this project we aim to develop a user friendly website that captures the image of mathematical equation, recognize the equation and present the user with required solution. We aim to make the whole experience of experimenting with equations very user friendly and to remove the hassle of learning a mathematical tool just for mathematical experimentation. Since mathematics itself is a very wide field, digitizing and evaluating all of the mathematical symbols becomes a very complex and tedious task. Therefore, only a subset of these mathematical symbols is considered in this paper which are digits (0-9), arithmetic operators (+, -, *, ÷), characters(y). This Project will be entirely dedicated to the digitization and evaluation of handwritten mathematical expressions.***

.

***KEYWORDS:CNN, Tensorflow, OpenCv, PiLSympy, Html, CSS, JavaScript, Flask***

## INTRODUCTION

Calculator which is used instead of manually working out mathematical methods thus reducing the percentage of human error associated with it. But using the calculator to solve the humongous equations and find answers for them is a tedious task since it requires the equations to be entered accurately. Therefore, another need for innovation came to life and thus technology which could scan documents and interpret what is written and further find the answer for it to ease the daily humdrum. If the syntax rules are not followed properly, one might not get the desired output. This is precisely the tool we have developed and discussed throughout this paper. Computers can be made to think and act like a human would, by forming a neural network and also retaining their computational superiority. In our project, we have attempted to simplify the interaction between humans and computers pertaining to the processing and solving mathematical equations.

We have focused on building a model which is simple to understand, by not restricting the user with various syntax rules and complexities. In today's world there are many tools, simulators which are available for mathematical purposes. However, more the features, more the awareness about the particular tool is required from the user. To shorten this gap of excessive awareness on the user's side, the machine could be trained to

understand the user's needs more accurately with very less effort from the concerned user. This being the ideology we have tried to build a machine learning model which will take the image input of the mathematical expression written by the user and identify the input expression and provide the answer with accuracy achieved while building the model.

## RELATEDWORK

Methods for Lines and Matrices Segmentation in RNN-based Online Handwriting Mathematical Expression Recognition Systems by Oleg Yakovchuk 2020 shows that Shallow Neural Networks (RNN) uses single Hidden layer. RNN is able to achieve this with the help of a hidden layer. It is heavily used in speech recognition, video tagging, generating image descriptions, but it also gives a satisfying performance with a test accuracy of 96% and an error rate of 0.13% when trained on 8,00,000 data points while predicting the solution for simple mathematical operations. Because of the Markov assumption, RNNs with LSTM blocks can integrate the influences of previous nodes without suffering from the gradient vanishing problem, whereas MRFs can only consider neighbouring points.

Stroke Extraction for Offline Handwritten Mathematical Expression Recognition ByChungkwong Chan 31 March 2020 also tells that a stroke extraction algorithm is required to convert a bitmap image to a sequence of strokes, so that online recognition engines are applicable afterward. The set of strokes is reconstructed by finding a set of paths on a graph-based representation of skeleton, in which vertexes and edges represent junctions and segments respectively. A stroke extraction algorithm is required to convert a bitmap image to a sequence of strokes, so that online recognition engines are applicable afterward.

**a.**

The proposed stroke extraction method consists of three stages: pre-processing, tracing, and postprocessing. Furthermore, given a trainable online recognition system, retraining it with extracted strokes resulted in an offline recognizer with the same level of accuracy. On the other hand, the speed of the entire pipeline was fast enough to facilitate on-device recognition on mobile phones with limited resources. To conclude, stroke extraction provides an attractive way to build optical character recognition software.

## METHODOLOGY

In the proposed architecture, the methodology can be divided into these parts.

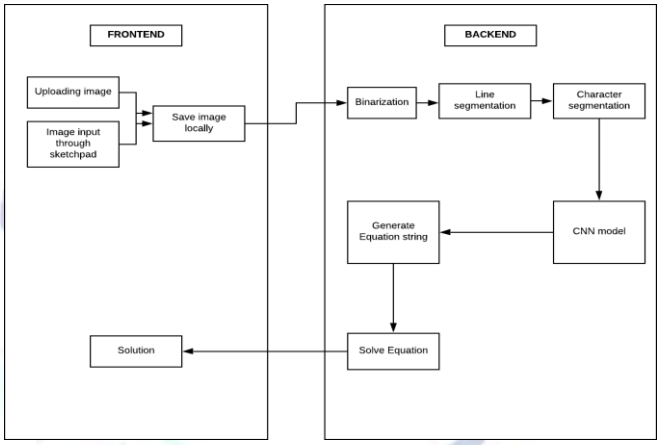


Fig 1 : Block Diagram

### 1. Pre-processing Input Image

**Binarization** is the method of converting any grayscale image, RGB Image into a black-white image. In a simple example, transforming an image's grey-scale from the 0-255 spectrum to a 0-1 spectrum is binarization.Now this is shown in the Fig-2.

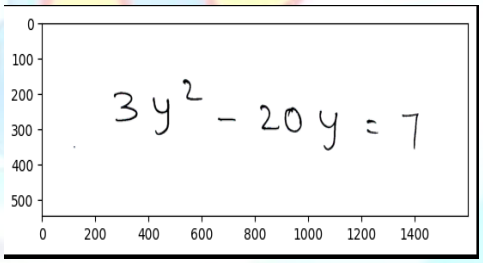


Fig-2: Binarization of coloured text to 0-1 spectrum

### 2. Segmenting Pre-processed Images

**Bounding Box**

In digital image processing, the bounding box is merely the coordinates of the rectangular border that fully encloses a digital image as shown in Fig-3.

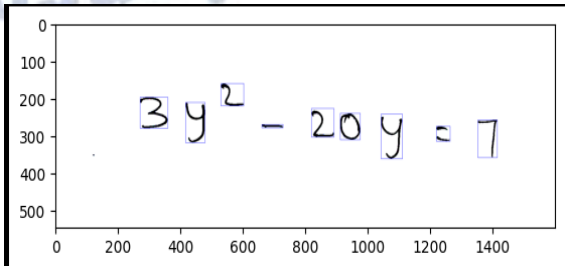


Fig-3 : Bounding Box applied to individual Characters

**b. Countour Based Segmentation**

Each image was resized 45x45, to match the size of images of the training dataset. Contours are defined as the line connecting all the points along an image's borders that have the same intensity as seen in Fig-4.

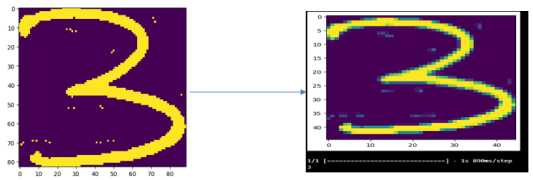

Fig-4: Resizing of images

**4. Expression Evaluation**

- The segmented characters need to be recognized in order to be digitized.
- These characters will be sorted and stored in the same order as they appear in the image of the expression.
- The Expression is formatted properly and evaluated using Sympy Library.

**5. Deployment**

- Deployed the trained model and the solver as an application that can take input images of handwritten equations, recognize them, parse them, and solve them.
- This is done using a web-based interface created using Flask module in python.

**RESULTSANDANALYSIS**

There are two ways to provide input for the system, one is by uploading image and the other being Image input through canvas. For Uploading image the user can take a picture of handwritten mathematical equation and save the image locally the choose file button is clicked then the user should get the interface of local system option. Then select the image from local system should and click on the upload button. Now the image displayed on the screen turned into grayscale. Then click on the predict button which display the handwritten mathematical equation in the system form. Finally by clicking on the solve button it displays the solution of the equation. Now if you want to select the image input through Canvas, The user can write the equation on the canvas board and then save the equation. Then click on the predict button which shows the system recognized equation in the system form. At last click on the solve button it displays the solution of the equation.

*1.Welcome Page*

The welcome page to the sytem, consists of a page with or to write in the canvas the eponymous title and two buttons below which will take us to the pages to either upload a image or to write in the canvas.

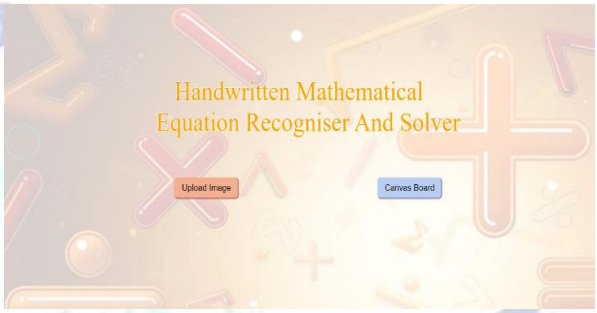


Fig-5:Welcome Page

**2.Upload Image Page**

After clicking the "Upload Image" button on welcome page we get the start page where we can select any handwritten image from local storage as shown in Fig-5 and its result predicted by clicking predict button as shown in Fig-6.

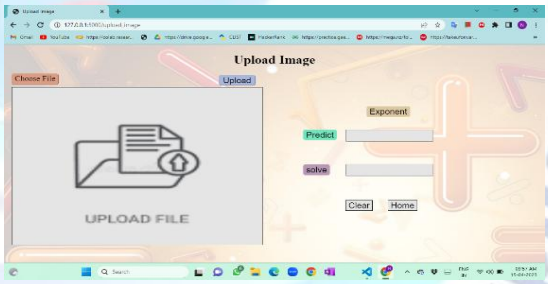


Fig-6: Upload Image page 1

As soon as you click the upload button your selected file/equation is shown as follows

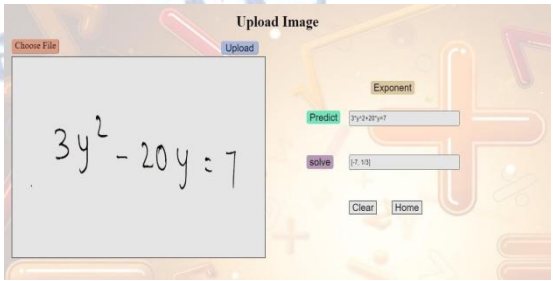


Fig-7: Upload Image page 2

### 3. Canvas Board Page

If you pressed the "Canvas Board" button, it takes you to the Canvas page where you can write an equation on screen through your curser and its answer is predicted as depicted in Fig-8 and Fig-9.

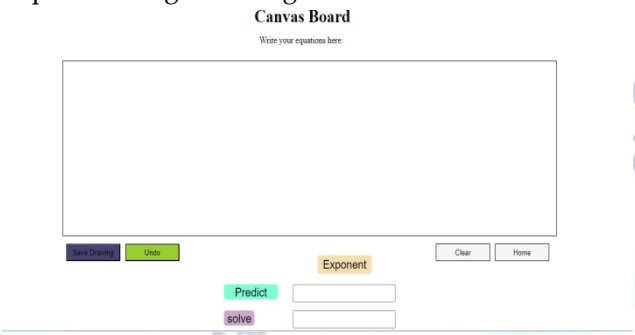


Fig-8: Canvas Page 1

As soon as you click Save drawing button you text is now stored in the backend to start predicting.

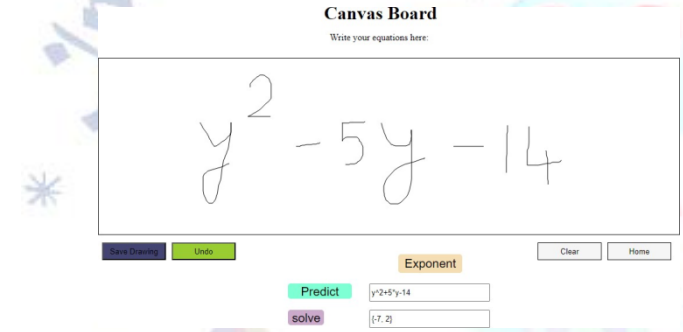


Fig-9: Canvas Page 2

## FUTURE ENHANCEMENT

There are many possibilities for this project in future. Recently this project is developed torecognize limited number of symbols such as +, -,*and /. There are many other symbols usedin mathematics such as brackets (), {}, [].The system can be developed to solve the equation and also plotthe graph as the solution. As Math equation solver gives the final solution to the user it can befurther developed to give the solution step wise so that the user can get the knowledge of whothe solution is generated.Extend the system Recognize multiple Equations in one Image.It can further be extended to solve more complex calculations like system of linear equations, trigonometric calculations differential equations and integrations. In future days the main focus will be to try to raise the precision level and build a segmentation system that can successfully segment two connected digits, and also increase the performance level of the dataset.

## CONCLUSION

Through this project we aim to develop a user-friendly website that captures the image of mathematical equation, recognize the equation and present the user with required solution. We aim to make the whole experience of experimenting with equations very user friendly and to remove the hassle of learning a mathematical tool just for mathematical experimentation. Since mathematics itself is a very wide field, digitizing and evaluating all of the mathematical symbols becomes a very complex and tedious task. For Recognition Dense layers are used to extract features from input images with Relu as an activation function for the hidden layers and softmax for the final layer for predicting numbers and operators is a multi-class classification problem.

This model is trained with an adam optimizer which is reported to have a faster convergence rate than normal stochastic gradient descent (SGD) with momentum. Through this we got good training and testing accuracy. It reduces the task on user side as direct images can be given to the application and then get the equivalent solution for it. The discussed web application can solve all the basic arithmetic calculations, polynomial Equations.


## ACKNOWLEDGMENT

We express our gratitude to our seniors for providing mechanism and the base paper which are used to successfully complete the an efficient "HANDWRITTEN MATHEMATICAL EQUATION RECIGNISER AND SOLVER USING CNN" and we also express our sincere gratitude to Narayana Engineering College for providing infrastructure and services which helped us to complete the project.


## Conflict of interest statement

Authors declare that they do not have any conflict of interest.

## REFERENCES


[1] Recognition of Handwritten Mathematical Expression and Using Machine Learning Approach Prathamesh Tope1, Sarvesh Ransubhe2, Mohammad Abdul Mughni3, Chinmay Shiralkar4, Mrs. Bhakti Ratnaparkhi.

[2] Handwritten mathematical equation solverRajwardhan Shinde, Onkar Dherange, Rahul Gavhane, Hemant Koul, Nilam Pati
[3] Salma ShofiaRosyda and Tito Waluyo Purboyo ,"A Review of Various Handwriting Recognition Methods", International Journal of Applied Engineering Research ISSN 0973- 4562 Volume 13, Number 2 (2018) pp. 1155- 1164.
[4] Lyzandra D'souza and Maruska Mascarenhas, "Offline Handwritten Mathematical Expression Recognition using Convolutional Neural Network", 2018 International Conference on Information, Communication, Engineering and Technology (ICICET) Zeal College of Engineering and Research, Narhe, Pune, India.
[5] C. Lu and K. Mohan. "Recognition of Online Handwritten Mathematical Expressions" cs231n Project Report Stanford (2015).
[6] Dae Hwan Kim, Jin H. Kim , "Top-down search with bottom-up evidence for recognizing handwritten mathematical expression" ,2010 12th International Conference on Frontiers in Handwriting Recognition
[7] Dmytro Zhelezniakov, Viktor Zaytsev and Olga Radyvonenko. "Online Handwritten Mathematical Expression Recognition and Applications: A Survey" IEEE Accesd, acceptedFebruary 17, 2021, date of publication March 2, 2022
[8] https://www.kaggle.com/datasets/xainano/handwrittenmathsymbols?resource= download
[9] https://github.com/sabari205/Equation-Solver
[10] https://towardsdatascience.com/building-a-handwritten-multi-digit-calculator- f03cf5028052
[11] https://vipulgupta73921.medium.com/handwritten-equation-solver-using-convolutional-neural-network-a44acc0bd9f8