

# HAND WRITTEN EQUATION SOLVER

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**Abstract**— in everything we do, we apply mathematics. It is entangled with the science. And, because polynomials are used in real-world problems, we need to figure out a simple approach to solve them. So, the goal here is to design an application that can take an image with handwritten equation as input and provides the solution for the equation contained in that image.

**Keywords:** Character Recognition, handwritten Equation, CNN, EasyOCR

## I. INTRODUCTION

With technological advances, everybody wants the chores to be automated. Nobody wants to solve the equations by themselves. If we were to find the solution for the equations through google, typing the equation is a tedious task in itself. So this simple application is created to take the image as input and solve the equation contained in the same and provide the result.

## II. SOFTWARE USED

### A. PYCHARM IDE:

Pycharm is a Python-specific Integrated Development Environment (IDE). It provides Python programmers with essential debugging tools. Pycharm can be used to create a variety of applications, including web apps and server models.

### B. CNN:

Convolutional Neural Network is an algorithm [7] which is being used in this application for classifying the handwritten equations as number, symbols, alphabets etc., A convolutional layer is capable of detecting patterns in the image, which in our case would be detecting the individual characters in the equation. Hence by using filters on each layer, we create a random square matrix with random values to multiply and compare with each pixel matrix of the same dimensions with the original picture.

## III. PYTHON LIBRARIES USED

### A. Numpy:

NumPy stands for Numerical Python. It is a python library used to store arrays of information. In our project it stores the information of the image.

### B. Pandas:

Built on top of the Python programming language, pandas is a quick, powerful, versatile, and easy-to-use open source data analysis and manipulation tool. It is also used for data analysis in machine learning. Pandas library along with the NumPy operates on the equations and gives the output.

### C. OpenCV:

We utilized OpenCV, a python tool, to create a more clear image for processing. It is also utilized in computer vision and Image Processing

### D. Sympy:

Here Sympy is a python library which is used to compute the Symbolic mathematics [7] which is used for the equation in our project this will use this to get the final result. A linear equation saved as a string is solved using a function solver() which returns the required values.

### E. EasyOCR:

Easy OCR (Optical Character Recognition) is a python package that used to perform Optical Character Recognition. In our project, we have this for extracting text from the user uploaded picture.

## IV. ARCHITECTURAL DESIGN

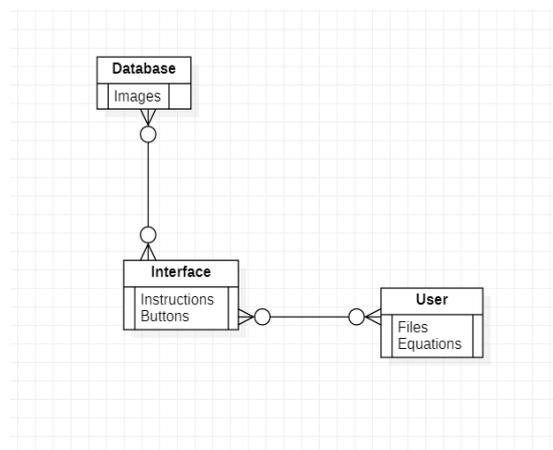
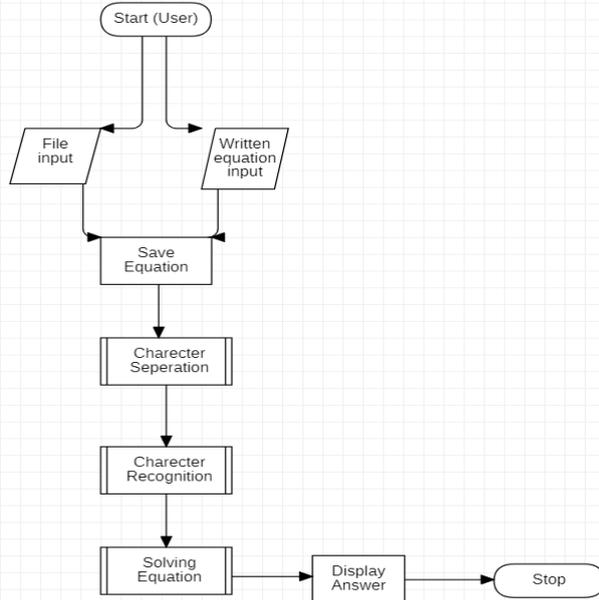


Fig.1. ER DIAGRAM

The Fig1. above represents Entity-Relation (ER) diagram for the application. There are 3 different entities represents: Kaggle database, Interface, user.

\*many to many: Interface to database and Interface and User.

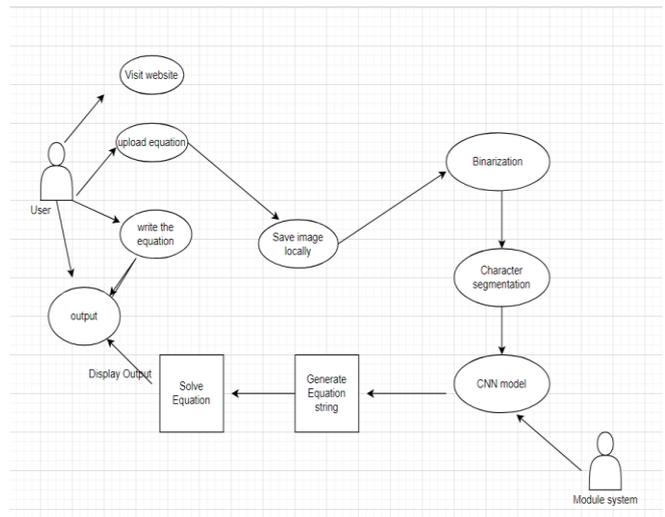


**Fig.2 DATA FLOW DIAGRAM**

The Fig.2. above shows the flow of data for solving the handwritten equation automatically. This includes the following steps:

- Step1: Run the application. Use interface will be displayed.
- Step2: User can give the input using scratch pad or image of the handwritten equation.
- Step3: Save the equations locally.
- Step4: Character separation and Character recognition will take place in the backend.
- Step5: The equation is solved automatically using some string and mathematical functions.
- Step6: Display the answer to the user.

The architecture design of the handwritten equation solver consists of various steps. Firstly data is collected from the input equation. It processes the data using various technique like Convolutional Neural Network, Image Processing and some string functions. The equation is solved and gives answer to the user automatically.



**Fig 3. USER CASE DIAGRAM**

Fig.3 shows the Use case of our project. The description of use case is as follows:

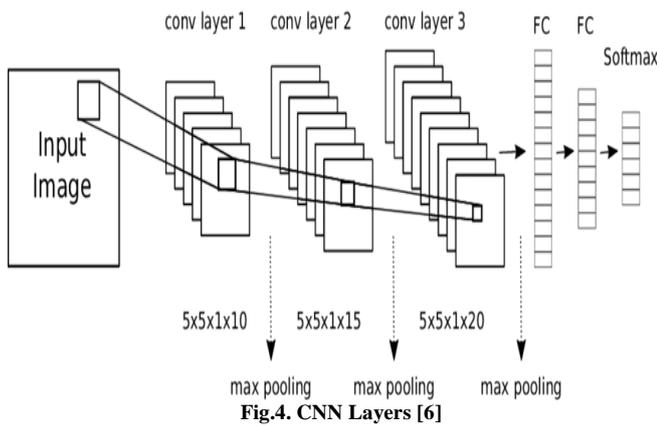
- 1. use case: user enter to the site  
Summary: user can enter to the website using the required link.  
Actor: user
- 2. use case: upload image  
Summary: one must upload the image in .png format.  
Actor: user
- 3. use case: written equation  
Summary: user can enter the equation in written format  
Validation: The equation must be written in English and not in cursive or any other script.
- 4. use case: module system  
Summary: producing the output in backend works by CNN model  
Actor: CNN Module system
- 5. use case: Displays output  
Summary: output is displayed to the user

**V.UNDERSTANDING THE CNN**

A Convolution Neural Network, also known as CNN or ConvNet, is a class of neural network that specializes in processing data that has a grid-like topology, such as an image. A digital image is a binary representation of visual data. It contains a series of pixel values to denote how bright and what color each pixel should be.

The second we see an image, our brain analyses a massive amount of data. Each neuron works in its receptive field and is connected to other neuron in a way that they cover the entire visual field. Each neuron in a CNN processes data only in its receptive field as well. The layers are arranged in such a way so that they detect simpler patterns first and more complex patterns further along.

We are using the CNN to identify the image and to the line segmentation and binarization .and then it is sent to EasyOCR for further implementation part.



CNN layers are the building block of whole system. Each layer will consist of K number of filters, which contains height and width. The Image will pass through each layer in that feature extraction, line and character segmentation and other processes will takes place to get the required output.

### VI. UNDERSTANDING EASYOCR

OCR stands for Optical Character Recognition [2], and it is a game-changing technology in today's digital age. OCR is a comprehensive procedure that converts scanned paper documents, PDF files, and digital camera images into editable, searchable data. Here we have image in white and black pixels for identification of the character. Using Easy OCR[2] we can identify digits and alphabets by comparing it to database. Also this stores the data. It will eliminate the crosschecking step. Some of the CNN filters can be used to identify unique components of the symbol, like curves or edges in this phase.

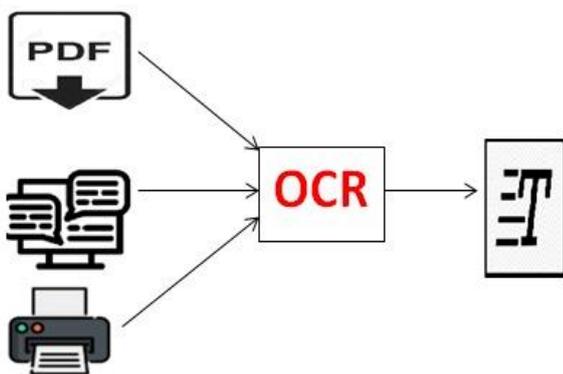


Fig.6. Easy OCR Operation

### VII. UNDERSTANDING THE APPLICATION

Equations are also employed in a variety of sectors these days. To reduce the time and efforts faced by users, we are trying to create an application which will help to recognize and solve handwritten mathematical equations automatically.

We can use the mouse to manually write the equation here. Alternatively, scan the written equation. Then upload it into the system. The system will recognize and solve the equations using Convolutional Neural Network and image recognition.

It will process the image first and then solve it automatically, then it will give the final answer of the equation as the result.

### Implementation of Binarization, line and character segmentation [4].

Image Binarization is the conversion of document image into bi-level document image. Image pixels are separated into dual collection of pixels, i.e. black and white. The main goal of image binarization is the segmentation of document into foreground text and background. Fig.5 shows character and line segmentation.

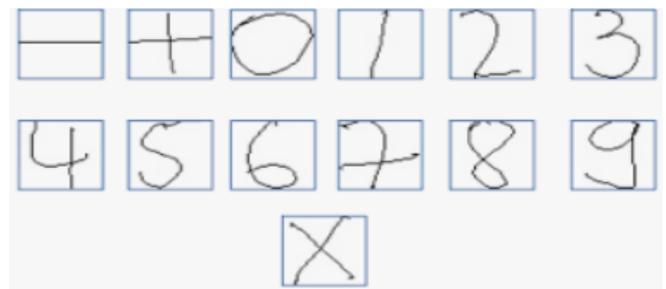


Fig. 5. Character and line Segmentation

We are given a skew corrected image with text written in the form of lines at the line level of segmentation. The objective of Line Level Segmentation is to segment the image into lines. At character level of segmentation, we are provided with an image containing a single word (segmented in the previous step) which consists of a sequence of characters. The objective of Character Level Segmentation [4] is to segment the image into individual characters.

### Implementation of CNN model for character recognition.

Convolutional Neural Network (CNN) have made great progress in handwritten character recognition and learning discriminatory characteristics from large amounts of raw data. In this paper, CNN is implemented to recognize the characters from a test dataset. CNN recognizes the characters by considering the forms and contrasting the features that differentiate among characters. Our CNN implementation is experimented is done using the dataset which is taken from Kaggle to obtain the accuracy of handwritten characters.

### Generating equation string and using string operation for equation solving.

The string will be generated by CNN model. Then using string operations the equations will be solved automatically. The solved equation will give the final result of the handwritten equation.

### Software Requirements

- PyCharm
- Python
- MySQL/PHP

### Hardware Requirements

- To Install PyCharm minimum RAM: 2 GB of available digital storage minimum, 6 GB recommended
- To install Python 3 or above version Minimum RAM:124 MB
- To install CNN models minimum RAM: Minimum 4GB of RAM

### VIII. RESULT

Input image containing hand written equation:



Output showing the addition of 87 and 95:

```
Copyright (C) Microsoft Corporation. All rights reserved.
Try the new cross-platform PowerShell https://aka.ms/pscore6

(venv) PS C:\Users\ADMIN\PycharmProjects\tkinterproject> python mian2.py
Using CPU. Note: This module is much faster with a GPU.
Enter Path: G:\Author-Project\project\dataset\b.png
Extracted :['87+95']
Equation : 87+95
ANSWER 182
```

### IX. LIMITATIONS

- The limitations of the project are that the user must have PyCharm in their environment to use this application.
- This project is only works for mathematical and linear equation.
- The handwritten equation must be clearly written and cursive writings are not allowed.

### X. CONCLUSION

This user-friendly application can solve handwritten mathematical equations by using many techniques like CNN, Open CV. This will take image as input from the user and gives accurate result of the equation. Time has been important factor in everyone's life. This application will help to reduce the time for solving equation manually. Also it will reduce human work.

### XI. FUTURE SCOPE

The application is developed to solve simple mathematical equations like algebraic equations. The future scope will be to

create a model which can solve difficult logarithmic equations and also complex equations. And the system cannot recognize cursive handwriting. So, to build a model that can identify all styles of handwriting.

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