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Rashmi Deshpande
Assistant Professor, Department of IT, Siddhant COE Maval, Pune, Maharashtra, India

Correspondence
Rashmi Deshpande
Assistant Professor, IT Department, Siddhant COE Maval, Pune, Maharashtra, India

Handwritten formula recognition using CNN

Rashmi Deshpande

Abstract
This paper presents a machine intelligence approach for recognizing handwritten formulas. The process involves three steps: acquiring data, training data, extracting features using a Convolution Neural Network, and matching the features and calculating the probability. The Convolution Neural Network is used to improve the data rate of recognition of handwritten formula symbols, compensating for information loss in the formula. The experimental results show that the Convolution Neural Network is effective for feature extraction and improving the data recognition rate. The paper also proposes an alternative method for converting handwritten mathematical formulas into computer-readable text using horizontal and vertical projections and convolution neural networks. This method successfully segmented and identified each character in handwritten equations from lined papers, allowing them to be converted into a digital format for data processing like editing. This method is time-efficient.

Keywords: Convolution neural network, handwritten formula recognition, feature extraction

Introduction
Machine learning, Deep Learning, and Artificial Intelligence are crucial technologies in various fields such as artificial intelligence, robotics, computer vision, natural language processing, and handwritten recognition. These technologies require machine training to learn and make predictions. Handwritten formula recognition involves three steps: acquiring data, extracting features, and feature matching. The solving phase involves identifying the formula for the machine for all formulas, key-board characters, mathematical signs, and digits.

Using Convolution Neural Network (CNN) to create a robust handwritten formula solver is challenging in image processing and computer vision. The system aims to create the handwritten alphabet, mathematical signs, and symbols, and arrange them properly as a formula. The goal is to recognize the formula and solve the equation.

Arithmetic is used in various fields, including science, physical science, and finance. Convolution Neural Network is the best grouping model in computer vision, with great execution in the field. In personal computer vision, numerical articulation acknowledgment is a challenging task, and image division and recognition precision are crucial for English characters and digits in electronic books.

Artificial Intelligence (AI) has various applications in various fields, including picture grouping, object recognition, and writing recognition. Picture grouping interprets manual handwritten characters and mathematical symbols into machine-readable designs, making it useful in various fields such as vehicle tag recognition, postal letter arranging, and check truncation framework (CTS). Convolution Neural Organization (CNN) is a deep neural network used in picture grouping, object recognition, proposal frameworks, signal handling, normal language handling in Computer Vision, and face recognition. CNN is a component of The Math Equation solver is an AI-based system designed to solve simple mathematical equations, motivating students to solve problems independently and providing a system for parents to check their children's performance. The system also answers academic questions, including introductions, literature reviews, system diagram presentations, testing, and conclusion.

Writing recognition technology enables computers to interpret and digitize handwritten text, enabling applications in education, finance, healthcare, and law enforcement. This process involves analyzing and interpreting handwritten images, converting them into machine-readable text, and converting addresses into typed text. Handwriting recognition faces challenges due to the vast variety of writing styles and the complexity of penmanship scripts.

Related Work

Mathematical expression recognition remains a challenging task due to their two-dimensional structure and the ability to be written along horizontal lines, above or below, defining new baselines. Symbols in mathematical expressions can vary in size, such as summation and integral symbols, and even within the same expression. Recognizing spatial r remains a challenge in this field.

The reliance on humans over machines has increased significantly, with deep learning and machine learning algorithms enabling tasks such as object classification in photographs and adding sound to silent movies. Handwritten text recognition (HWR) is a significant area of research and development, with numerous possibilities. This paper focuses on performing handwritten digit recognition using MNIST datasets, using Support Vector Machines (SVM), Multi-Layer Perception (MLP), and Convolution Neural Network (CNN) models. The main objective is to compare the accuracy and execution time of these models to find the best model for digit recognition. The study explores the potential of these models in enhancing human-machine interaction and enhancing the efficiency of human-machine interaction.

This paper discusses image processing technology based on machine learning, focusing on its increasing importance in science and technology. The paper introduces machine learning algorithms, uses Convolution Neural Networks for feature extraction, and conducts simulations on various datasets. The voc 2007 dataset is used for image segmentation, ImageNet for target detection, Cifer100 for image classification, and ROC curve for performance evaluation. The results show that the deep learning algorithm achieves high accuracy in image segmentation, classification, and target detection. The accuracy of image segmentation is 0.984, image classification is 0.987, and target detection is 0.986. The paper concludes that image processing based on machine learning has great advantages, such as improved accuracy in segmentation, classification, and target detection.

This paper presents a novel Convolution Neural Network (CNN)-based algorithm for solving ill-posed inverse problems in imaging. Regularized iterative algorithms have been the standard approach to ill-posed inverse problems, but they can be challenging to apply due to high computational costs and difficulty in selecting hyper parameters. The paper proposes an inversion followed by a CNN to solve normal convolution inverse problems, which encapsulates the physical model of the system but leads to artifacts. The CNN combines multi-resolution decomposition and residual learning to remove these artifacts while preserving image structure. The proposed network outperforms total variation-regularized iterative reconstruction for more realistic phantoms and requires less than a second to reconstruct a 512 x 512 image on the GPU. The paper highlights the potential of unrolled iterative methods in solving ill-posed inverse problems.

This paper discusses the importance of handwritten mathematical expressions in engineering and science, particularly in touch-screen devices. It emphasizes the need for further study and improvement in these technologies, especially in light of the widespread adoption of online recognition and the challenges posed by distance learning and remote work due to the pandemic. The paper also discusses the classification of recognition methods, their merits and limitations, and the use of end-to-end approaches based on encoder-decoder architecture. It also compares recognition performance based on open competition results using evaluation protocols and benchmark datasets.

The International Conference on Trends in Electronics and Informatics (ICOEI) published a study on handwritten recognition, which has gained significant success in various applications such as equation solvers and automation. Researchers have demonstrated the use of machine learning algorithms for recognizing handwritten language characters, such as SVM, K-means, Naive Bayes, and Decision Trees. However, recognizing handwritten text is challenging due to variations in handwriting styles and poor image resolution. Deep learning models have been found to provide better efficiency and accuracy in image segmentation, object detection, speech recognition, and image classification. The study focuses on handwritten mathematical equation solving using the CNN model, which solves offline handwritten polynomial equations. The objective of this work is to make it easier for programmers to invoke handwritten formulas as a formula in programming. This system simplifies the process of writing or converting handwritten formulas into typed formulas, making it easier for programmers to use.

Proposed Method

The proposed model consists of two phases mainly, first the handwritten expression recognition and second is expression evaluation phase. The input image provided by the user is pre-processed and segmented to recognize and predict each individual character, number and symbols. After recognition the mathematical expression is formed which is further processed using python libraries to provide the calculations. The Block Diagram (Fig. 1) represents the procedure in which entire processing is carried out. Discovery, that is the word we associate with finding something new. The reason for this is that this universe already has everything it requires, it's just in a form that mankind has yet to comprehend or discover. Mathematics is the simplest way to understand the universe's transformations and intricacies. The language of mathematics which can describe the nature of the universe to the shapes and structure and pattern of almost all objects that we perceive through our senses. Take any aspect and you will find a mathematical description for it. For years mankind has tried to decipher this mathematical code by numerous methods and formulae which were worked upon for years and years. And today we have reduced the time gap to get answers for tedious methods and procedures with the help of new technologies and gadgets. The most general example would be a 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. This is where machine learning and neural networks come into the picture, where a model is built in such a way that it can think and solve the problems in the same way a human brain would do but swiftly and efficiently. Mathematical equations form an integral part of most research work, so researchers use such mathematical tools to save time and boost efficiency keeping in mind the

complexities and syntax of the chosen tool. If the syntax rules are not followed properly, one might not get the desired output. Another concern is the task of entering all the equations and expressions properly leaving no gap for human error since the system will be performing the calculations based on the input given. This requires a lot of time and human intervention and also good knowledge of the tool being used. A convenient solution to this can be to build a user-friendly tool that would capture the image of a mathematical equation, recognize the equation embedded in it and present the user with the required solution. 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 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.

Fig 1: Blocked diagram of propoesed system

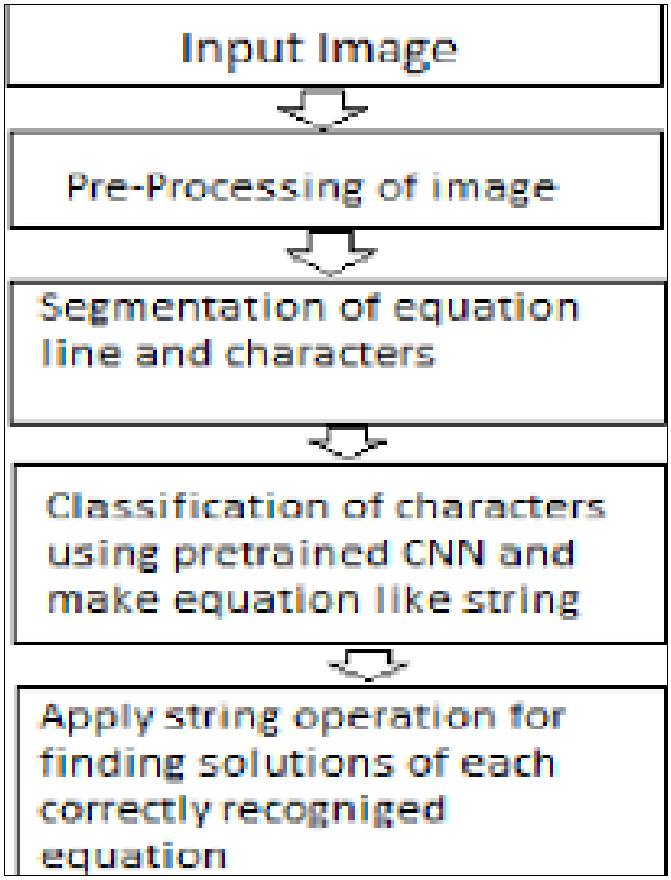

Fig 2: Steps In execution in proposed model

Conclusion

The recognition of various writing styles in various regional languages can be achieved using HCR systems using appropriate algorithms and strategies. The recognition of English characters is particularly challenging due to the presence of odd characters or similar shapes. Scanned images are pre-processed to produce a clean, noise-free output. The evolution algorithm, managed with proper training and evaluation, leads to successful system output with better efficiency. Using statistical and geometric features through neural networks can improve English character recognition. This work will be beneficial for researchers working on other scripts.

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