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Modified National Institute of Standards and Technology (MNIST) Handwritten Digit Classification using CNN

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ABSTRACT: Traditional method for handwritten recognizing systems has historically based on handcrafted features and substantial prior knowledge, making training a Recognition (OCR) system a challenging task. However, recent advancements in the field have focused on deep learning techniques, which have significantly improved performance. Despite this progress, the rapid increase in data and the availability of great processing power necessitate further improvements in accuracy of recognition.

Convolutional Neural Networks (CNN) is particularly used for recognizing the pattern in characters and letters or words which are handwritten. They facilitate the automatic extraction of distinct features, making CNNs an ideal approach for resolving problems in handwriting recognition. Our aim is to achieve remarkable accuracy using a CNN architecture, potentially surpassing traditional methods.

To this end, we propose a CNN architecture designed to achieve superior accuracy. Additionally, we compare the accuracy of various traditional methods with that of the CNN architecture. Through extensive experiments, we have achieved a remarkable accuracy of 99.36% on the dataset of MNIST data.

In conclusion, the transition from traditional methods to CNN-based approaches in handwriting recognition is well-justified by the substantial improvements in accuracy and efficiency. CNNs provide a powerful solution for automatic feature extraction and recognition in handwritten text, significantly outperforming traditional methods.

I.INTRODUCTION

Handwritten recognition refers to a machine's capability to identify handwritten input from humans. The task is particularly challenging due to the variability in handwriting styles, spacing, and inconsistencies. Despite these hurdles, machine learning models have advanced significantly, achieving high performance and accuracy. These models are now used in various applications, including reading postal addresses, processing bank checks, and data entry from forms.

Convolutional Neural Networks (CNNs) are especially effective for recognition of image and tasks such as classification. As a specialized type of neural network, CNNs process input images by assigning importance to different features and distinguishing between images. Recent research has applied CNNs to areas such as facial recognition, document analysis, speech detection, and license plate recognition. The construction and training of different models using convolution operations are crucial for achieving high accuracy, which depends on factors like the dataset and network architecture used.

Our experiment is focused on different methods on the accuracy of handwritten digit recognition using the MNIST dataset. MNIST is a comprehensive database of handwritten digits, comprising 70,000 grayscale images, each sized 28×28 pixels. The dataset includes 10 classes, representing the numbers 0 through 9. The images are normalized in size and cantered, making MNIST an excellent benchmark for evaluation.

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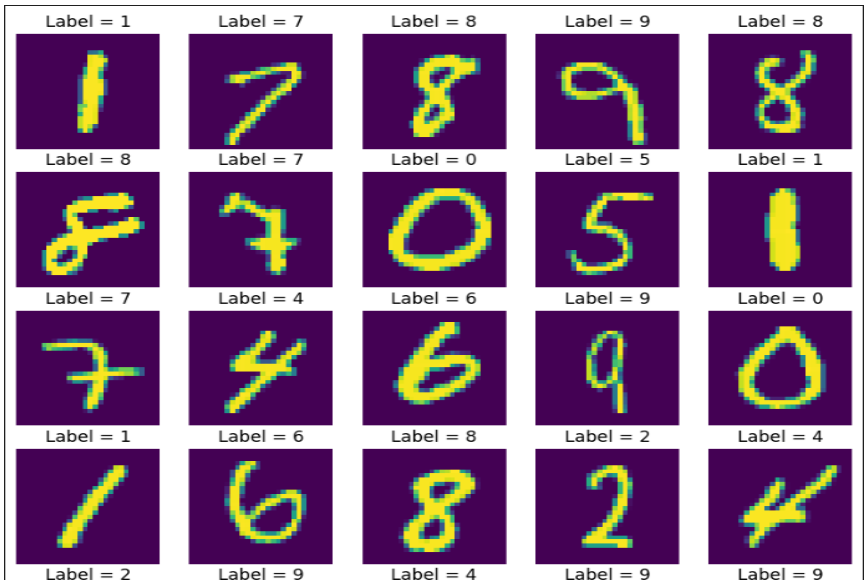

Figure 1: MNIST dataset for handwritten digits from 0 to 9

In current age handwriting classification or recognition is essential for efficient information processing. Although a significant amount of information remains on paper, digital file processing is more cost-effective than handling traditional documents or files. The goal of a recognition model is to convert traditional paper files and characters into machine-readable formats. Important applications include postal letter sorting system, license plate recognition, CTS scanning, preservation in archaeology departments, and automating old documents in libraries and banks.

Deep neural architectures, like Convolutional Neural Networks (CNNs), offer notable advantages over traditional methods. CNNs are widely used in classification and object recognition, signal processing, recommendation systems, natural language processing face recognition and computer vision. They are more efficient than traditional methods due to their ability to automatically detect important features. The hierarchical feature learning capability of CNNs results in high efficiency.

The reliance on machines has never been higher, with deep learning and machine learning algorithms enabling a wide range of tasks from object classification in photographs to adding sound to silent movies. Handwritten text recognition is a significant area of research and development, offering numerous possibilities.

In this paper, we conduct handwritten digit recognition using the MNIST dataset and Convolutional Neural Network (CNN) models. Our primary objective is to compare the accuracy and execution time of these models to identify the best possible model for digit recognition. Handwritten digit recognition allows a computer to recognize human handwritten digits from various sources such as images, paper documents, and touchscreens, classifying them into 10 predefined classes (0-9). This topic has been extensively researched in deep learning. Applications of digit recognition include number plate recognition, postal mail sorting, and bank check processing. A major challenge in handwritten digit recognition is the variability in individual handwriting styles, which differs from Optical Character Recognition (OCR).

The topic of research provides a detailed comparison of various machine learning algorithms for handwritten recognition of digits, focusing on CNNs. The comparison is based on with results visualized using matplotlib.

II.LITERATURE REVIEW

A writing overview (audit) is a content in a insightful paper that incorporates current information, substantive discoveries, and hypothetical and methodological commitments to a specific subject. Writing surveys utilize auxiliary sources and do not report unused or unique test work. The essential purposes of a writing overview are to:

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- Give a setting on the existing research
- Perform task to Legitimize the research
- Guarantee that investigate was not done some time recently.
- Appear that the inquire about fits into the existing body of knowledge
- Empower the analyst to study from past hypothesis on subject
- Outline how the topic is been considered previously
- Highlight blemishes in past research
- Layout holes in past research topic.
- Appear the work is including to the understanding and information of the domain.
- Offer assistance or indeed alter the domain.

To get it the space of MNIST manually written digit classification frameworks, a writing survey was conducted. This chapter points to clarify different approaches to creating a manually written digit classification framework based on the MNIST dataset. Various considers have been conducted on this subject.

From the research analysis we have identified that using Convolutional Neural Network (CNN) for Handwritten digit classification has always outperformed with providing relatively higher accuracy in comparison to the use of traditional algorithms.

• In the existing system using CNN algorithm the systems have achieved very good accuracy but keeping in mind the continuous improvement in technology. Further investigation in improvement of accuracy is deserved.

• The existing systems build using traditional algorithms using KNN, Decision tree classifier, Random Forest classifier and LGBM tends to give us the accuracy in the range of 96%.

• There was a need to contribute a system that can provide a comparative better accuracy that can help us achieve an accuracy ranging between 98% to 99% accuracy on the dataset.

• I saw it as an opportunity to compare the different types of traditional models such as KNN, Decision tree classifier, Random Forest classifier and LGBM with CNN architecture and use it to develop a CNN model to achieve better accuracy from the existing systems.

• Hence the points covered here can be of great help in building a desired Handwritten digit classification system

III.METHODOLOGY OF PROPOSED SURVEY

• Display the MNIST image dataset was normalized in size into a settled picture of estimate 28 × 28.

• MNIST is a expansive database of written by hand digits that contains 70,000 grayscale pictures, each of 28×28 pixels. Through and through there are 10 classes speaking to numbers from 0 to 9.

• The input shape has to be in the frame of width x stature x channel. Here the width = stature = 28 and the number of channels = 1 since it is a dark and white picture. If we needed to prepare the demonstrate for a coloured picture, we would have set number of channels to 3.

• The train-test dissemination contrasts for this extend as 90% pictures are utilized in the preparing set and 10% pictures in the test set.

The acknowledgment handle of the written by hand digits comprises of the taking after steps:

- 1. Secure or gather the MNIST transcribed handwritten digit data images.
- 2. Isolate the data pictures for preparing the test data pictures.
- 3. Apply the pre-processing procedure to all the preparing dataset.
- 4. Normalize the information so that the ranges is between 0 to 1.
- 5. Separate preparing dataset for clumps of appropriate dimension.
- 6. Prepare CNN show and variations utilizing named information.
- 7. Utilize prepared, demonstrate for the purpose of classification.
- 8. Analyse the acknowledgment precision, preparing time for each and every variant.

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The to begin with convolutional layer has:

- Filter = 32
- Kernel estimate = 3
- Padding = same: It applies cushioning to the input picture so that the input picture gets completely secured by the channel and the indicated walk. If the walk = 1 at that point the layer's yield will have the same spatial measurements as its input.
- Activation = 'relu' is the actuation work for the layer of the CNN.
- MaxPooling2D is utilized to offer assistance the part extricates the most extreme esteem of the range it convolves.
- Flatten offer assistance straighten the multi-dimension inputs into a single dimension.
- Dropout: A Dropout of 0.20 implies that 20% of irregular chosen neurons are overlooked amid preparing. They are dropped out randomly.
- Dense layer has 128 units. This is same as number of neurons. It too has the relu actuation function.

IV.CONCLUSION AND FUTURE WORK

Convolutional Neural Networks is widely applied for image classification problems. With the continuous advancements in technology and the increasing complexity of datasets, more sophisticated and efficient CNN architectures are being developed. Given the abundance of CNN model choices, it is crucial to select the right design for the specific problem at hand.

To address this, comparisons of various conventional algorithms and CNNs on datasets are conducted to determine which one is best suited for the task. We have achieved an exceptional accuracy of 99.35% on the MNIST dataset, slightly surpassing existing systems.

The scope of "MNIST Handwritten Digit Classification using CNN" is extensive and ever-evolving. Future work could explore different models of CNN, such as hybrid CNNs, including CNN-RNN and CNN-HMM models, as well as specific recognition models. Different algorithms could be investigated to improve CNN learning.

With the achievement of high accuracy, this system can be applied to enhance existing applications. In the future, it could be implemented to improve postal letter-sorting services, vehicle license plate recognition, Cheque Truncation System (CTS) and the preservation of documents in archaeology section, as well as the automation of ancient records in libraries and banks.

Due to the presence of numerous real-time applications, this handwritten digit classification system has an ever-expanding scope.

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