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PAINT ORIENTED DIGIT RECOGNITION

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ABSTRACT:

The reliance of humans over machines has never been so high such that from object classification in photographs to adding sound to silent movies everything can be performed with the help of deep learning and machine learning algorithms. Likewise, Handwritten text recognition is one of the significant areas of research and development with a streaming number of possibilities that could be attained. Handwriting recognition (HWR), also known as Handwritten Text Recognition (HTR), is the ability of a computer to receive and interpret intelligible handwritten input from sources such as paper documents, photographs, touch-screens and other devices. Apparently, in this project, we have performed handwritten digit recognition with the help of MNIST datasets using Support Vector Machines (SVM), Multi-Layer Perceptron (MLP) and Convolution Neural Network (CNN) models. Our main objective is to compare the accuracy of the models stated above along with their execution time to get the best possible model for digit recognition.The field of machine learning is a rapidly developing one. Recent developments in the field of image processing and machine learning has led to efficient extraction of features from images of peoples' faces. Recognizing handwritten digits from images isn't easy. It involves the difficulty of visual pattern recognition which becomes very apparent when an attempt is made to write a computer program to recognize digits. The goal of our work will be to create a model that will be able to recognize and determine the handwritten digits from its image. We aim to complete this by using the concepts of Convolution Neural Network. The aim of our study is to open the way to digitalization. Though the goal is to just to create a model which can recognize the digits but it can be extended to letters and then a person's handwriting. Through this work, we aim to learn and practically apply the concepts of Machine Learning and Neural Networks. Moreover, digit recognition is an excellent prototype problem for learning about neural networks and it gives a great way to develop more advanced techniques like deep learning.

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I. INTRODUCTION

Handwritten digit recognition is the ability of a computer to recognize the human handwritten digits from different sources like images, papers, touch screens, etc, and classify them into 10 predefined classes (0-9). This has been a topic of boundless-research in the field of deep learning. Digit recognition has many applications like number plate recognition, postal mail sorting, bank check processing, etc… In Handwritten digit recognition, we face many challenges because of different styles of writing of different peoples as it is not an Optical character recognition. This research provides a comprehensive comparison between different machine learning and deep learning algorithms for the purpose of handwritten digit recognition. For this, we have used Support Vector Machine, Multilayer Perceptron, and Convolutional Neural Network. The comparison between these algorithms is carried out on the basis of their accuracy, errors, and testing-training time corroborated by plots and charts that have been constructed using matplotlib for visualization.

The accuracy of any model is paramount as more accurate models make better decisions. The models with low accuracy are not suitable for real-world applications. Ex- For an automated bank cheque processing system where the system recognizes the amount and date on the check, high accuracy is very critical. If the system incorrectly recognizes a digit, it can lead to major damage which is not desirable. That's why an algorithm with high accuracy is required in these realworld applications. Hence, we are providing a comparison of different algorithms based on their accuracy so that the most accurate algorithm with the least chances of errors can be employed in various applications of handwritten digit recognition.

This paper provides a reasonable understanding of machine learning and deep learning algorithms like SVM, CNN, and MLP for handwritten digit recognition. It furthermore gives you the information about which algorithm is efficient in performing the task of digit recognition. In further sections of this paper, we will be discussing the related work that has been done in this field followed by the methodology and implementation of all the three algorithms for the fairer understanding of them. Next, it presents the conclusion and result bolstered by the work we have done in this paper. Moreover, it will also give you some potential future enhancements that can be done in this field. The last section of this paper contains citations and references used.

Recognition is distinguishing a thing or an individual from the past experiences or learning. Digit Recognition is recognizing or identifying the digits in any document. Digit recognition framework is the working of a machine to prepare itself or interpret the digits.

Handwritten Digit Recognition is the role of a computer to interpret the manually written

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digits from the sources like messages, bank cheques, papers, pictures for web based handwriting recognition On the tablet, recognize license plates, process bank checks, enter numbers in any form, etc. Machine learning provides many techniques that can reduce the work involved in recognizing handwritten digits. Deep learning is a machine learning technique that teaches computers to do things that humans do easily: learning by example. Using deep learning technology, human efforts in perception, learning, recognition, and many other areas may deteriorate. Deep learning teaches computers to perform classification tasks based on the content of an image or any document. Deep learning models can achieve the highest accuracy beyond human capabilities. The digit recognition model uses large datasets in order to recognize digits from distinctive sources. In order to locate these areas, pattern recognition uses various types of area scanning techniques. The problem of recognizing handwritten characters is mainly related to the diversity of personal writing styles. Therefore, reliable feature extraction is very important to improve the performance of the handwriting recognition system.

II. RESEARCH STATUS

This chapter will show us how image pre-processing, feature selection, and the relevant classification techniques contribute to handwritten digit recognition in real life. In addition, it provides an in-depth and detailed overview of the recent literature, corresponding to this study, which is useful to know. The first part of this section presents an overview with references to the approaches to digit recognition and the template matching Deep Learning (DL) techniques. The second part contains, an analysis of the factors, which affect the recognition error rate, is expressed. More, the applied classification techniques in DL and the evaluation of design will bae reviewed in the later part. The final part will provide a summary of the next stage in the study and what will do next and what will come in the design of the experiment in the future.

A. The Importance of Handwritten Digit Recognition

Many people are focusing on the use of the personal computer rather than acquiring excellent handwriting skills. The one reason is that the internet and applications are becoming more intelligent than before and it is increasing day by day. Additionally, poor quality or illegible handwriting is the main reason for inaccurate handwritten digit recognition. HWR refers to the recognition of characters on optical scanning and digital digits pages by computer. Although many systems are available for identifying printed digits, identifying handwritten digits is still a challenge in the field of pattern recognition. Despite its problems, it widely contributes to the progress of improving the interface between humans and machines in

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many applications. Due to a large number of potential applications such as the reading of postal codes, medical prescription reading, interpreting handwritten addresses, processing bank checks, credit authentication, social welfare, forensic analysis of crime evidence, which includes a handwritten note, handwritten digital recognition, is still an active area of research. In upcoming years, the availability of devices has further broadened the range of applications for handwritten digital recognition for multiple personal uses such as notetaking and extracting data from filling out forms.

The handwritten analysis is a tough and organized process that relies on a wide knowledge of the way people form digits or letters, and which exploits the unique 10 characteristics of

numerals, for example, the shapes, sizes, and individual writing styles that people use. Even personal writing styles might change with the writing tools and environment and leave clues about the identity of the author.

In the field of forensic analysis, which includes crime scene investigations, DNA testing, fibre analysis, fingerprint analysis, to name but a few disciplines, etc., the study of handwriting plays an important role in real life. Questioned document examiners (QDEs) analyse files for signs of changes and written comparisons to identify or exclude authorship.

Typically, handwriting experts use sophisticated classification models to analyse and detect printed or handwritten character images. As part of this process, they extract features from the samples, which include slants, orientation, and the centre alignment of the letters given in it. Offline digital recognition has many practical applications in real life. For instance, the handwritten sample is analysed and recognized by the handwriting expert to identify the zip code, etc. in an address written or printed on an envelope in an extra. As a result, the benefits of applying this system at the post office are enormous in real life. The system can realize the automatic sorting of millions of emails automatically, thus reducing the human burden and speeding up the whole process.

With the humanization of machines, there has been a substantial amount of research and development work that has given a surge to deep learning and machine learning along with artificial intelligence. With time, machines are getting more and more sophisticated, from calculating the basic sums to doing retina recognition they have made our lives more secure and manageable. Likewise, handwritten text recognition is an important application of deep learning and machine learning which is helpful in detecting forgeries and a wide range of research has already been done that encompasses a comprehensive study and implementation of various popular algorithms like works done by S M Shamim Anuj Dutt, Norhidayu binti and Hongkai Wang to compare the different models of CNN with the fundamental machine learning algorithms on

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different grounds like performance rate, execution time, complexity and so on to assess each algorithm explicitly concluded that the Multilayer Perceptron classifier gave the most accurate results with minimum error rate followed by Support Vector Machine, Random Forest Algorithm, Bayes Net, Na¨ıve Bayes, j48, and Random Tree

respectively while presented a comparison between SVM, CNN, KNN, RFC and were able to achieve the highest accuracy of 98.72% using CNN (which took maximum execution time) and lowest accuracy using RFC did the detailed study-comparison on SVM, KNN and MLP models to classify the handwritten text and concluded that KNN and SVM predict all the classes of dataset correctly with 99.26% accuracy but the thing process goes little complicated with MLP when it was having trouble classifying number 9, for which the authors suggested to use CNN with Keras to improve the classification.

While has focused on comparing deep learning methods with machine learning methods and comparing their characteristics to know which is better for classifying mediastinal lymph node metastasis of non-small cell lung cancer from 18 F-FDG PET/CT images and also to compare the discriminative power of the recently popular PET/CT texture features with the widely used diagnostic features. It concluded that the performance of CNN is not significantly different from the best classical methods and human doctors for classifying mediastinal lymph node metastasis of NSCLC from PET/CT images. However, CNN does not make use of the import diagnostic features, which have been proved more discriminative than the texture features for classifying smallsized lymph nodes. Therefore, incorporating the diagnostic features into CNN is a promising direction for future research. All we need is lots of data and information and we will be able to train a big neural net to do what we want, so a convolution can be understood as ”looking at functions surrounding to make a precise prognosis of its outcome.” [6], [7] has used a convolution neural network for handwritten digit recognition using MNIST datasets. [6] has used 7 layered CNN model with 5 hidden layers along with gradient descent and back prorogation model to find and compare the accuracy on different epochs, thereby getting maximum accuracy of 99.2% while in [7], they have briefly discussed different components of CNN, its advancement from LeNet-5 to SENet and comparisons between different model like AlexNet, DenseNet and ResNet. The research outputs the LeNet-5 and LeNet-5 (with distortion) achieved test error rate of 0.95% and 0.8% respectively on MNIST data set, the architecture and accuracy rate of AlexNet is same as LeNet-5 but much bigger with around 4096000 parameters and ”Squeeze-and-Excitation network” (SENet) have become the winner of ILSVRC-2017 since they have

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reduced the top-5 error rate to 2.25% and by far the most sophisticated model of CNN in existence.

V. Existing System:

These days, an ever-increasing number of individuals use pictures to transmit data. It is additionally main stream to separate critical data from pictures. Image Recognition is an imperative research area for its generally used applications. In general, the field of pattern recognition, one of the difficult undertakings is the precise computerized recognition of human handwriting. Without a doubt, this is a very difficult issue because there is an extensive diversity in handwriting from an individual to another individual. In spite of the fact that, this difference does not make any issues to people, yet, anyway it is increasingly hard to instruct computers to interpret general handwriting. For the image recognition issue, for example, handwritten classification, it is essential to make out how information is depicted onto images. Handwritten Recognition from the MNIST dataset is well known among scientists as by utilizing different classifiers for various parameters, the error rate has been decreased, for example, from linear classifier (1-layer NN) with 12% to 0.23% by a board of 35 convolution neural systems.

The scope of this is to implement a Handwritten Digit Recognition framework and think about the diverse classifiers and different techniques by concentrating on how to accomplish close to human performance. For an undertaking of composing diverse digits (0-9) for various people the general issue confronted would be of digit order issue and the closeness between the digits like 1 and 7, 5 and 6, 3 and 8, 9 and 8 and so forth. Additionally, individuals compose a similar digit from various perspectives, the uniqueness and assortment in the handwriting of various people likewise impact the development and presence of the digits.

Proposed System:

The task here is to automatically detect and identify the digit image acquired from database. Given a handwritten character, the system needs to predict the type of the digit. In other words if we can write the digit “1” the system predict the digit that it is truly “1” or the input digit is nearer to “1” or something else.

The purpose of this project is to take the hand written digit as an input process the digit, train effectively by using the algorithm to recognize the pattern, where digit is detected under natural lighting conditions.

Flow Chart:

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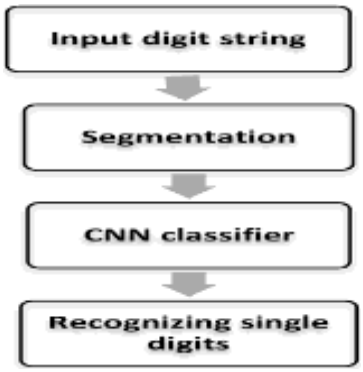
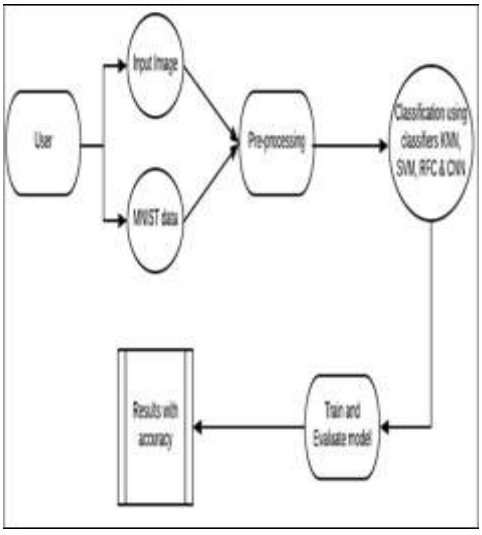


Methodology:

The following Figure describes the data flow diagram of the proposed system model. There are two ways to provide input to the system. The user can either upload the image of the digit he wants to detect or the data from the MNIST dataset. The input images are pre-processed.

Using the different classifiers the recognized digits' accuracy is compared and the result is obtained. The results obtained are displayed along with the accuracy.



MNIST Dataset

The MNIST dataset (Modified National Institute of Standards and Technology) is a large dataset of handwritten digits that is widely used for training and testing in the field of machine learning and deep learning

The MNIST dataset contains 60,000 training images and 10,000 testing images of handwritten digits from zero to nine(0 to 9). So, the MNIST dataset has 10 different classes. Each image is represented as a 28×28 matrix where each cell contains grayscale pixel value.

Convolutional Neural Network (CNN):

It is a type of feed-forward artificial network where the connectivity pattern between its neurons is inspired by the organization of the animal **visual cortex**. Convolutional neural network is composed of multiple building blocks, such as convolution layers, pooling layers, and fully connected layers, and is designed to automatically and adaptively learn spatial hierarchies of features through a backpropagation algorithm. Familiarity with the concepts and advantages, as well as limitations, of convolutional neural network is essential to leverage its potential to improve radiologist performance and, eventually, patient care.

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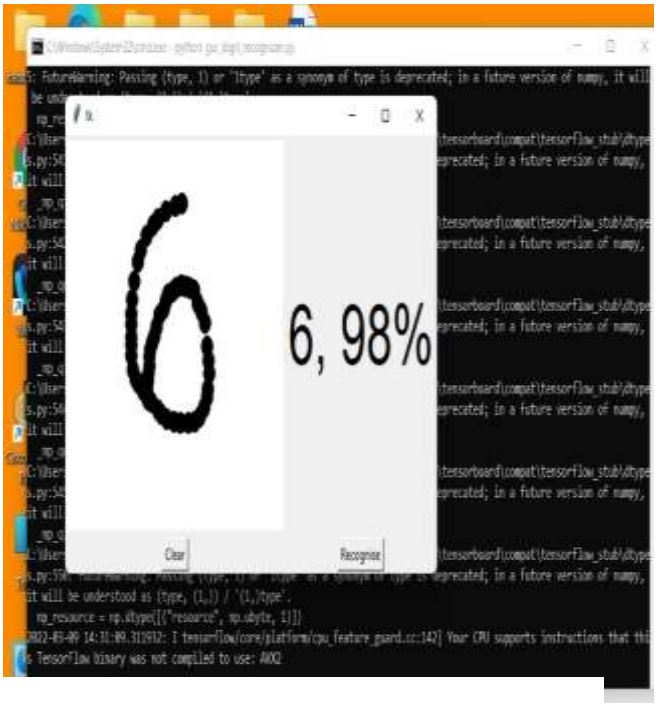
Steps to implement the CNN handwritten digit recognition GUI :

1. Import the libraries and load the MNIST dataset
2. Data Preprocess and Normalize
3. Create the model
4. Train the model
5. Evaluate the model



Conclusion

In this work, with the aim of improving the performance of handwritten digit recognition, we evaluated variants of a convolutional neural network to avoid complex pre-processing, costly feature

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extraction and a complex ensemble (classifier combination) approach of a traditional recognition system. Through extensive evaluation using a MNIST dataset, the present work suggests the role of various hyper-parameters. We also verified that fine tuning of hyperparameters is essential in improving the performance of CNN architecture. We achieved a recognition rate of 99.89% with the Adam optimizer for the MNIST database, which is better than all previously reported results. The e_ect of increasing the number of convolutional layers in CNN architecture on the performance of handwritten digit recognition is clearly presented through the experiments. The novelty of the present work is that it thoroughly investigates all the parameters of CNN architecture that deliver best recognition accuracy for a MNIST dataset. Peer researchers could not match this accuracy using a pure CNN model. Some researchers used ensemble CNN network architectures for the same dataset to improve their recognition accuracy at the cost of increased computational cost and high testing complexity but with comparable accuracy as achieved in the present work. In future, di_erent architectures of CNN, namely, hybrid CNN, viz., CNN-RNN and CNN-HMM models, and domain-specific recognition systems, can be investigated. Evolutionary algorithms can be explored for optimizing CNN learning parameters, namely, the number of layers, learning rate and kernel sizes of convolutional filters.

FUTURE SCOPE

In this paper we have discussed, although the method of addressing the research question was found by training on the MNIST database, there are still some problems that need to be explored and solved in the future by us. For example, the accuracy of the KNN, SVM, and RF models based on the combination of preprocessing and HOG is smaller than the initial experiment in place of big data. Nevertheless, Ebrahim zadeh employed the linear SVM as the classifier, and the HOG feature descriptor on the MNIST database, and a 97.25% accuracy rate was obtained. So, the causes of these problems mentioned above should be analyzed and found to be resolved in the future. There are also some natural expansions to this research that would assist extend and reinforcing the results. The benchmark database of MNIST was developed for this work and its

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very useful, and it is an excellent database for machine learning and pattern recognition methods while making minimal efforts in preprocessing and formatting in real life. But, not all handwritten digit sets are normalized in size, or centered, written nicely, and stored sequentially as 28x28 pixel images in grayscale in the actual cases, so it iss difficult. Hence, it would be necessary to add similar experiments with distinct databases regarding the features array dimension and various language scripts such as Chinese, Arabic, French, etc., it can cover every language. The complex recognition problem associated with handwriting is an interesting topic for future research areas and it has a wide range. For instance, when some anonymous pieces of handwritten digit are found at a crime site, and it is possible to automatically identify that the writer may be a "left-handed man," that would reduce the set of suspects to be investigated the serious situation. These classification problems are extremely tough, since it is quite hard to detect which handwriting features correctly characterize each involved class. One clear example of this happens in the classification of gender. Even though feminine writing is more circular and uniform than masculine one, there are some examples in which masculine writing may exist with a "feminine" appearance. This could be another exact topic in the field of handwritten digit recognition for future work.

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