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A Novel Method for Handwritten Digit Recognition System

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Abstract: *Character recognition is crucial in the contemporary world. It can resolve more difficult issues while also simplifying human tasks. Character identification from handwriting is one illustration. This system is used extensively throughout the globe to identify zip codes or postal codes for mail sorting. Handwritten symbols can be recognized using a variety of methods. In this paper, two methods—pattern recognition and convolutional neural networks—are studied. (CNN). Both techniques are described, and various implementations of each strategy are also covered. Methods for pattern recognition include Bayesian Decision Theory, Nearest Neighbor Rule, and Linear Classification or Discrimination. Neural networks are used for shape identification, Chinese character recognition, and handwritten digit recognition.Use of neural networks for training and identification*

Key Word: *Digit Recognition, Handwritten digits recognition, Convolutional Neural Network.*

I.INTRODUCTION

Recognition is the process of recognizing something or someone based on prior knowledge or encounters. Similar to this, digit recognition consists solely of identifying or recognizing the digits in any text. A machine's ability to prepare itself or interpret the digits is all that the digit identification framework actually does. The ability of a computer to interpret manually written digits from various sources, such as messages, bank checks, papers, pictures, and so forth, and in various situations, such as web-based handwriting recognition on PC tablets, identifying vehicle number plates, handling bank checks, and digits entered in any forms, is known as handwritten digit recognition.

Character identification in handwriting has been a thing since the 1980s. The job of handwritten digit recognition using a classifier has extraordinary significance and use, including online digit recognition on PC tablets, reading zip codes from mail, processing bank check amounts, and processing numeric sections in structures filled out by hand (like tax forms). The difficulties in trying to solve this issue are numerous. The size, thickness, orientation, and placement of the handwritten numbers in relation to the margins are not always uniform. The primary goal was to actualize a technique for pattern characterization to recognise the handwritten numbers offered in the MNIST dataset of images of handwritten digits (0–9).

II.PROJECT OVERVIEW

The capacity of computers to recognise human handwritten digits is known as handwritten digit recognition. Because handwritten digits are imperfect and can be created with a variety of flavors, it is a difficult job for the machine. The answer to this issue is handwritten digit recognition, which utilises an image of a digit to identify the digit that is present in the image.However, these methods do not take into account the proper filter size selection, data preparation, dataset limitations, or noise. As a result, few systems have been able to significantly increase classification accuracy. Our paper makes the following contributions to resolve these algorithms' drawbacks:

- First, the size of the effective receptive field (ERF) is determined after taking domain expertise into account. We can choose a usual filter size with the aid of the ERF calculation, improving the classification accuracy of our CNN.
- Second, excessive data produces inaccurate findings, which has a detrimental impact on classification accuracy. Prior to carrying out the data classification mission, data preparation is applied to ensure that the dataset is free of any redundant or irrelevant variables to the goal variable.
- Thirdly, data augmentation has been suggested as a way to reduce training and validation mistakes and get around dataset limitations.
- Fourthly, we suggest adding an additive white Gaussian noise with a value of = 0.5 to the MNIST dataset in order to mimic the natural factors that can affect image quality in the real world.

With a recognition accuracy of 99.98% and 99.40% with 50% noise, our CNN algorithm gets state-of-the-art outcomes in handwritten digit recognition. A neural network is a representation of the brain's operations. It is made up of numerous layers with a variety of activations; these activations mirror the neurons in our brain. An attempt is made by a neural network to learn a set of parameters from a collection of data that might aid in understanding the underlying relationships. Since neural networks are capable of adapting to shifting input, the network can produce the best outcome without having to change the output criteria.

III.EXISTING PROBLEM

The capacity of computer programmes to recognise human handwritten digits is known as handwritten digit recognition. Because handwritten digits are not always accurate and can take many various forms and sizes, it is a difficult task for the machine. A solution to this issue is the handwritten digit recognition system, which utilises an image of a digit to identify the digit that is present in the image. To recognise handwritten numbers, a convolutional neural network model was developed using the Tensorflow framework and the MNIST dataset.

Handwritten Digit Recognition is the ability of a computer to identify and categorise human handwritten numbers from various sources, such as images, papers, touch screens, etc. into ten predefined categories. (0-9). The area of deep literacy has been the subject of bottomless exploration with this content. Numerous activities related to number recognition include processing bank checks, sorting postal mail, and number plate recognition.

We encounter a number of difficulties in handwritten number recognition. Because everyone writes differently, optical character identification is not possible. The model's inability to recognise numbers with more than one digit is currently the primary issue. This investigation offers a thorough comparison of various deep literacy and machine literacy algorithms for handwritten number identification. Support, Multilayer Perceptron, and Convolutional Neural Network have all been used for this. These algorithms are compared based on their sophistication, crimes, and trial training time, which are supported by plots and maps created using the visualisation toolkit matplotlib.

Some other references on existing problems are,

TITLE	EXISTING PROBLEMS
Usage of Quantum K-Nearest Neighbor Algorithm to improve handwritten digit recognition.	Prior to this method, its time complexity was 12R, after it, it became O(kM2) for accuracy in the K-Nearest Neighbor algorithm.
A comparison of three classification algorithms for the identification of handwritten digits.	Following the evaluation of all algorithms on 46K instances with 10 cross-validations, K-star obtained a high accuracy score of 82.36%, followed by NB's accuracy score of 67.04% and MLP's accuracy score of 78.35%. K-Star algorithm
Recognition of handwritten digits with classification of decision tree: A machine learning method	With a standard dataset of 42K rows and 720 columns, this model was trained using the decision tree method, and the accuracy obtained was 83.4%. For 0–9 numbers, accuracy is as follows: 0 = 83.5%, 1= 93.7%, 2 = 83.6%, 3 = 83.1%, 4 = 83.8%, 5 = 83.6%, 6 = 83.4%, 7 = 83.8%, 8 = 84.1%, 9 = 83.7% The Algorithm is Decision Tree.
Development of a high precision handwritten digit recognition detector based on a Convolution-Neural Network.	The precision of the neural network was determined to be 92.6% for the training set and 90.1% for the test set after training with the dataset was complete. Convolutional neural networks have excellent efficiency and are much more accurate than other deep learning models. The algorithm is CNN
MCS HOG features and handwritten digit recognition system based on SVM.	In the trial, accuracy was established to be 99.26% and 99.36%, respectively, using the 10 fold cross and independent test set as validation. The algorithm is SVM

IV.PROPOSED SYSTEM

The User layer is the first layer of the architecture. People who engage with the app and for the desired outcomes will make up the user layer. The frontend architecture of the programme is made up of the following three layers. The HTML, CSS, and JavaScript development framework Bootstrap will be used to create the application. The localhost, which is displayed in the browser, is where the programme is deployed. The user will be able to submit images of their handwritten numbers into the app to have them digitalized. The business layer, which consists of logical computations based on the client's request, sits between the database and view layers. The utility interface is also present. Training Data and Test Data make up the backend layer's two collections. The training set, which consists of 60,000 examples, and the test set, which consists of 10,000 instances, have already been separated into the MNIST database. Convolution neural network training is the employed training method. By doing this, the trained model will be ready to be used to categorise the numbers found in the test data. As a result, the numbers in the images can be categorised as Class 0,1,2,3,4,5,6,7,8,9.

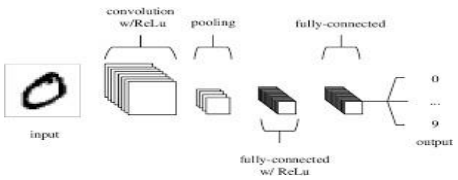
PARAMETERS	DESCRIPTION
Problem Statement (Problem to be solved)	User is a cashier, he needs a way to quickly enter the account details which are written by account holders in the challan so that account holders don't have to wait long.

Idea / Solution Description	Using MNIST dataset and Convolutional Neural Network to perform digits recognition. All of those digits can be converted into electronic words in a text document format, and this data only needs a fraction of the physical storage space of the physical copies.
Novelty / Uniqueness	Unlike OCR, which recognizes all the characters, it can accurately recognize the digits
Social Impact / Customer Satisfaction	This system saves time and workload in sectors which use this technology.
Business Model	It is very useful in the banking sectors, In the banking sector, numerical detail incheque can be easily recognized. Pincode details are easily obtained in the postal system.
Scalability	This system has no restriction on the number of digits to be recognized.

Algorithms:

Forward Propagation:

A sample workflow for the CNN module's feature extraction and picture classification process is shown below. The network's input layer, hidden layers, and output layer are all displayed in the design. Convolution and subsampling are used in the network's feature extraction process across a number of layers.



Working:

After receiving an input, neural networks process it through a number of hidden levels. Each group of neurons in a hidden layer is completely connected to every other neuron in the layer above it. One layer of neurons have total independence from one another. The "output layer" is the final layer that is completely linked.

Convolutional Layer:

The foundational component of a CNN is the convolutional layer. The parameters of the layer are a collection of learnable filters (or kernels) that cover the entire depth of the input volume but have a small receptive field. Each filter is convolved across the breadth and height of the input volume during the forward pass, computing the dot product between each filter entry and the input to create a 2-dimensional activation map of the filter. As a result, the network picks up filters that turn on when they spot a particular kind of characteristic at a particular location in the input.

Feature Extraction:

The weights of each neuron in a characteristic are the same.In this manner, the same characteristic is recognised by all neurons at various locations in the input image. Limit the amount of unrestricted parameters.

Subsampling Layer:

The process of down-sampling or subsampling a signal involves making it smaller generally. Each feature map's spatial resolution is decreased by the subsampling levels. Shift or distortion invariance is attained, and the impact of sounds is lessened.

Pooling Layer:

In a ConvNet architecture, it is typical to sporadically introduce a Pooling layer between succeeding Conv layers. Its purpose is to gradually shrink the representation's spatial size in order to decrease the number of parameters and computations in the network and, as a result, to regulate overfitting. Every depth slice of the input is separately processed by the Pooling Layer, which then applies the MAX operation to resize each slice spatially.

V.PROBLEM STATEMENT DEFINITION

CNN uses the deep learning approach to calculate accuracy and efficiency. The findings from the aforementioned methods are compared, and the approach with the best performance and accuracy for handwritten digits is determined. In many industries, including image processing, CNN is playing a significant part. It has a significant effect on numerous fields. CNN is employed in nanotechnologies like semiconductor manufacturing for fault identification and classification. The recognition of handwritten digits has attracted the attention of academics. These days, a lot of papers and articles on this subject are being released. In contrastto the most popular machine learning algorithms, such as SVM, KNN, and RFC, research has shown that deep learning algorithms, such as multilayer CNN using Keras with Theano and Tensorflow, provide the greatest accuracy. Convolutional Neural Network (CNN) is widely used in picture classification, video analysis, etc. due to its high accuracy.

VI.REQUIREMENT ANALYSIS

i) Functional Requirements:

Image Data:

Handwritten digit recognition refers to a computer's capacity to identify human handwritten digits from a variety of sources, such as photographs, documents, touch screens, etc., and categorise them into ten established classifications (0-9). In the realm of deep learning, this has been the subject of countless studies.

WebPage:

Web hosting makes the code, graphics, and other items that make up a website accessible online. A server hosts every website you've ever visited. The type of hosting determines how much space is allotted to a website on a server. Shared, dedicated,VPS, and reseller hosting are the four basic varieties.

MNIST Dataset:

It is a collection of 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprising handwritten single digits between 0 and 9.

Digit Classifier Model:

To train a convolutional network to predict the digit from an image, use the MNIST database of handwritten digits and getthe training and validation data first

ii) Non Functional Requirements:

Usability:

One of the very significant problems in pattern recognition applications is the recognition of handwritten characters.

Applications for digit recognition include filling out forms, processing bank checks, and sorting mail.

Security:

The system generates a thorough description of the instantiation parameters, which might reveal information like the writing style, in addition to a categorization of the digit. The generative models are capable of segmentation driven by recognition.

Reliability:

The samples are used by the neural network to automatically deduce rules for reading handwritten digits. Furthermore, the network may learn more about handwriting and hence enhance its accuracy by increasing the quantity of training instances. Numerous techniques and algorithms, such as Deep Learning/CNN, SVM, Gaussian Naive Bayes, KNN, Decision Trees, Random Forests, etc., can be used to recognize handwritten numbers.

Accuracy:

With typed text in high-quality photos, optical character recognition (OCR) technology offers accuracy rates of greater than 99%. However, variances in spacing, abnormalities in handwriting, and the variety of human writing styles result in less precise character identification.

Availability:

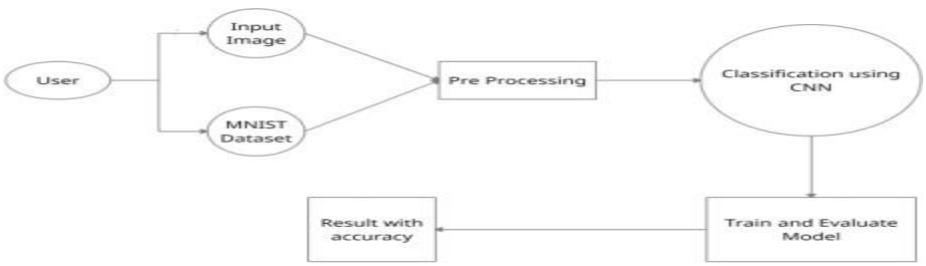
The features for handwritten digit recognition have been Acquainted. These features are based on shape analysis of the digit image and extract slant or slope information. They are effective in obtaining good recognition of accuracy.

Scalability:

The scalability in the task of handwritten digit recognition, using a classifier, has great importance and it makes use of online handwriting recognition on computer tablets, recognizing zip codes on mail for postal mail sorting, processing bank check amounts, and numeric entries in forms filled up manually.

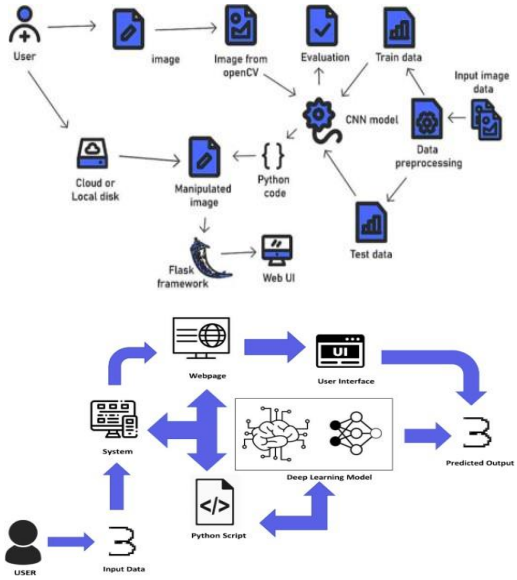
VII.PROJECT DESIGN

Dataflow Diagram:



Solution & Technical Architecture:

A complex process with numerous sub-processes, solution architecture connects business issues with technological answers. Its objectives are to identify the best technological solution to address current company issues. Describe to project partners the software's structure, traits, behavior, and other features. Define the solution's requirements, production stages, and features.Specifications for how the answer is defined, managed, and delivered should be provided.



VIII.RESULTS

Model Summary:

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320

 conv2d_1 (Conv2D)           (None, 24, 24, 64)        18496

 max_pooling2d (MaxPooling2D  (None, 12, 12, 64)       0
 )

 dropout (Dropout)           (None, 12, 12, 64)        0

 flatten (Flatten)           (None, 9216)              0

 dense (Dense)               (None, 128)               1179776

 dropout_1 (Dropout)         (None, 128)               0

 dense_1 (Dense)             (None, 10)                1290

=================================================================
Total params: 1,199,882
Trainable params: 1,199,882
Non-trainable params: 0
_________________________________________________________________
```

Accuracy:

Accuracy	0.9861000180244446
Loss	0.049150239676237106

IX.CONCLUSION

This paper uses deep learning techniques to perform handwritten digit recognition. In order to compare the classifiers, the most popular machine learning algorithms, KNN, SVM, RFC, and CNN, were trained and evaluated on the same dataset. It is possible to achieve a high level of accuracy by using these deep learning methods. By increasing the accuracy of classification models by more than 99%, this approach to research concentrates on which classifier performs better than others. An precision of about 98.72% can be obtained from a CNN model using Keras as the backend and Tensorflow as the software. In this first trial, CNN provides an accuracy of 98.72%, KNN provides an accuracy of 96.67%, and RFC and SVM do not provide accurate results.

X.FUTURE SCOPE

This project is far from complete and there is a lot of room for improvement. Some of the improvements that can be made to this project are as follows:

- Add support to detect digits from multiple images and save the results.
- Improve model to detect digits from complex images.
- Add support to different languages to help users from all over the world.

This project has endless potential and can always be enhanced to become better. Implementing this concept in the real world will benefit several industries and reduce the workload on many workers, enhancing overall work efficiency.

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