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# A Survey on Handwritten Digit Recognition

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**ABSTRACT:** As technology is growing as fast as to reach the sky and the developments occurring in all fields, it can't beat human skills and it has certain limits this shows the understanding between humans and technology by identifying handwritten digits from 0-9. To identify handwritten digits many methods have been used to get the accuracy. Handwritten digit recognition has so many issues like thickness, position, direction, and size. To overcome all these we used many methods to perfect Keras, TensorFlow, CNN, and MNIST datasets. The survey may help us to overcome various issues and this help in the recognition of bank checks, emails, texts, and many more.

**KEYWORDS:** CNN (Convolutional Neural Network), MNSIT dataset (Modified National Institute of Standards and Technology), SVM (Support Vector Machine), HWDR (Hand-Written Digit Recognition).

## I. INTRODUCTION

The rapid development in the technology and high performance of social sites and public interests in the technology make this project a grand success with a lot of thirst to manage handwritten format to networking and deep learning mechanisms. The unstructured data is converted into the structured network and vitally makes use of technology. The advantage of - a convolutional neural network helps in image processing all its way. For this perspective, we are using handwritten digit recognition as the method and enormously detecting all its formats through its suspected method. The enhancement in the field of technology the system input is user friendly and this project can be managed easily by accepting the user inputs it also attracts the user interest towards its background process. This project is managed by CNN and its particulars and its accuracy level are highly acceptable at all phases of development.

As we know the digit can be identified using online and offline methods, in the survey many are using an offline method for easy availability and high performance. The offline has no interruptions and picture recognition has a greater effect on its outcome and it can be measured through the below flow diagram.

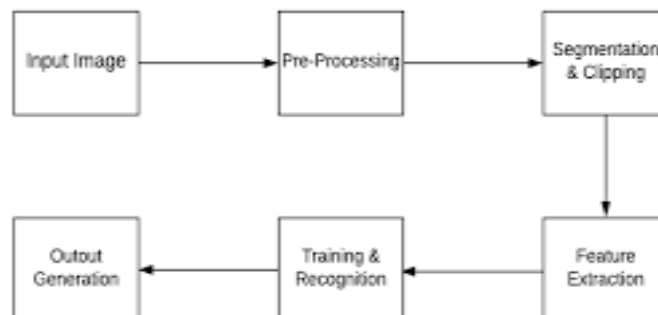


Fig 1: Flow chart for handwritten digit recognition [13].

## II. LITERATURE SURVEY

There are several papers available on the internet and many theses are written based on recognition of handwritten digit recognition based mostly on CNN and MNIST datasets.

Jinze Li, HongboSun, Leiye Yi, Qian Cao, FusenLiang, and Yu Sun [1]in this paper they design a handwritten digit recognizer using CNN and methods like MNIST testing and training datasets with deep learning techniques. The process of recognition is done by LeNet-5 which is one of the methods in CNN.CNN is mainly meant for image recognition it plays a vital role in this paper and they achieved their success.

Wenfei Liu-, and Jingcheng Wei [2] in this paper used KNN, SVM,BP, and CNN methods to recognize the digits and compare the accuracy level to obtain the most accurate value provider, which makes the project move in the way of success and he concludes that CNN has recognized the image through various angles and help to recognize with the most accurate level when compared to other recognition methods.

Matthew Y.W. Teow [3]has proposed the minimal CNN method and it is used to design mimic the main mathematical functions of CNN, and in his paper, he has used LeNet-5, MNIST datasets,extended minimal CNN, and multilayer perceptron to recognize the digits. Finally, he showed that LeNet-5 has 99.5% of accuracy.

Ciresan. D., Meier, U. and Schmidhuber, J [4]in this paper at the earliest stages of image recognition is 7-net it is used to get99.77% of accuracy and later on they focused on using 35-net committed the survey of this paper shows that has the time changes the accuracy increases approximately and technology may also put on weight.

Jarrett, K., Kavukcuoglu, K., Ranzato, M., and LeCun, Y [5]in this paper they discussed the success rate of recognition as approximately 98 to 99%.Here the leading methods like MNIST are used and which has two types of testing and training datasets that help in the recognition.

D.C. Ciresan, U. Meier, J. Masci, L.M Gambardella, andJ.Schmidhuber [6] “Flexible, high performance convolutional neural networks for image classification,” in 22<sup>nd</sup> International Joint Conference on AI,2011.In this conference they share their thoughts on neural networks and the research they made yet and the yield of their project is elaborated.

Hinton, G. E., Osindero, S., and the.Y.M, [7] in their paper reported an accuracy of 98.75% using MNIST datasets. Whereas the MNIST mainly proposed for image recognition and it has 70,000 datasets and 60,000 were training and 10,000 were testing datasets. Though MNIST mainly includes the images to identify the different shapes.

AshadullahShawon, Md. Jamil-Ur Rahman, Firoz Mahmud, M .M ArefinZaman [8] these people proposed a technique to identify Bangla Handwritten Digit Recognition using deep learning CNN, and unbiased datasets. They achieved 92.72% accuracy using NumtaDB.

Niu, X.X. and Suen, C. Y., [9]they made the fusion of SVM and CNN to recognize the digits. This model got the highest accuracy of 99.81%.In 1991 the SVM has used in recognition for the first time and later SVM classifier opted as the default choice for digit recognition, character recognition and face recognition.

Ankit Sharma, YogirajBarole, and KaustubhKerhalkar [10] designed the method of extraction of characters based on digit forms, and combined it with a k-Nearest Neighbour to recognize the digits, and this is tested based on MNIST isolated dataset, and all these processes based on Principal Component Analysis (PCA) which is divided into five components i.e., north, south, east, west and central zones.

Some papers use deep nets to perform better and they use simple back-propagation, which results in the lowest error rate on MNISTand CNN are comparable to other methods [15-17]. Some papers gave us a

knowledge of perfection through the various methods and this helps to gain the satisfying result for the users [18-19].

### III. METHODOLOGIES

As we have seen in the survey CNN has helped to identify an image through many methods, CNN has an accuracy of 93.75% and the combination of CNN and SVM comparatively made the highest accuracy, the k-nearest method obtain the accuracy of 86.5%.The combination of CNN - SVM makes the process long but CNN has various methods. So, here we optfor CNNas the main method to recognize images.

i. Convolutional Neural Network(CNN)

The idea of CNN was first proposed by YannLeCun [11] and it is applied to authenticating images and went through various steps in 1980. The type of artificial neural network used in the recognition of images and processing to design images to process through pixel data. It is a composition of multiple layer format and after particular phase activations, it gives the values by multiplying the image by its pixels and dimensions. This is also referred to as the core building block of CNN.Image to its handwritten digit recognition.

The extraction of an original image to its final output is depicted in the below diagram, image to its handwritten digit recognition. The extraction of an original image to its final output is depicted below diagram,

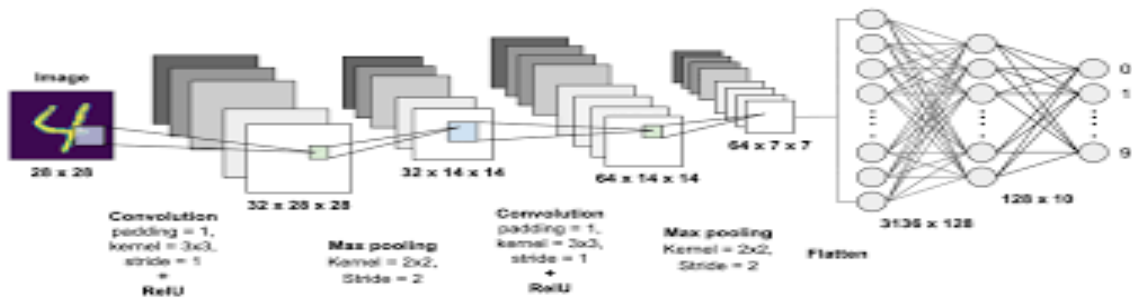


Fig 2: Extraction of digit through image processing [14].

The above figure shows the image processing to obtain the final result by many methods of CNN. The CNN has divided into two modules they are dataset module and the datasource module. The dataset module includes the identification of original digits.CNN is a combination of three layers that are mutually dependent on one another they are 1.Convolutional layer2.Pooling layer 3.Softmax layer.

ii. Datasource modules

a) MNIST datasets

Handwritten digit recognition is well known and it is utilizing various parameters for the identification it uses training sets of 60,000 examples and also a testing set of 10,000 examples. The dataset was centered in 28x28 pixels image by the center mass of pixels, and translating the image to its center position by 28x28 field.The MNIST dataset reduces the error rates, the primary stage of a training set of images that can be processed, and reduces the order of the data by thresholding them into a binary image which can be seen below figure,

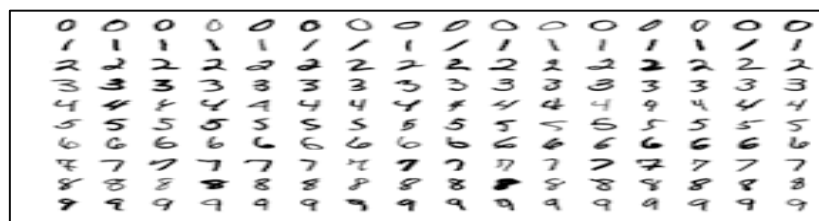


Fig 3: Sample images from MNIST dataset [11].

#### IV. RESULTS

Handwritten digits can be recognized on various methods and their accuracy, security, and time management differ from one to another. In the below table we are about to discuss,

Authors	Algorithm/Datasets	Accuracy in %
Jinze Li, Hongbo Sun, Leiye Yi, Qian Cao, Fusen Liang, Yu Sun [1]	CNN	97.89
Wenfei Liu, Jingcheng Wei, QingminMeng [2]	BP	96.6
Wenfei Liu, Jingcheng Wei, QingminMeng [2]	SVM	96.8
Matthew Y.W. Teow [3]	LeNet-5	99.5
Matthew Y.W. Teow [3]	Minimal	97.3
Matthew Y.W. Teow [3]	Extended minimal	98.50
Hinton, G. E., Osindero, S. and Teh, Y. W [7]	MNIST dataset	98.75
Wenfei Liu, Jingcheng Wei, QingminMeng [2]	KNN	94.6
Niu, X. X. and Suen, C. Y [9]	CNN-SVM	99.75

Table 1.1, Accuracy rate of methods used to recognize handwritten digits.

The below figure shows how the method has analyzed the digit and which helps to get the desired output for the client.

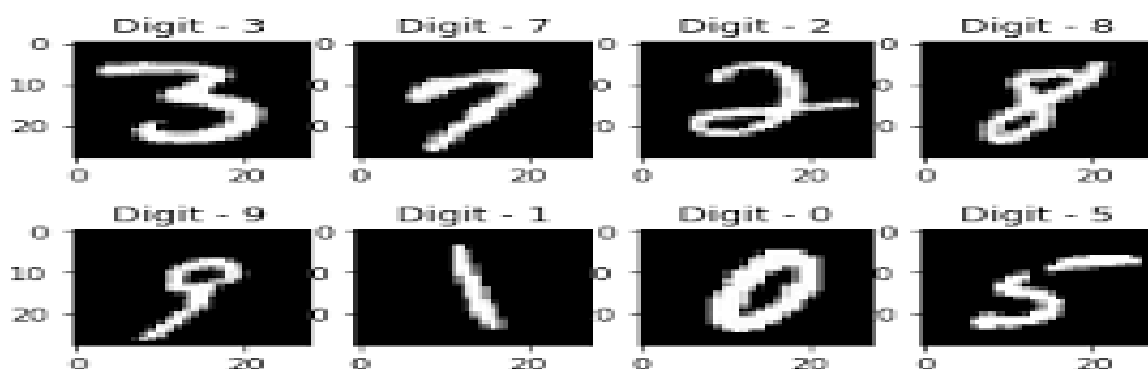


Fig 4: The digit analysis [12].

#### V. CONCLUSION

The recognition of Handwritten digits is hard to recognize as it's having different sizes, positions, thicknesses, and different dimensions to overcome these problems and make the work easier the recognition helps us at various fields. As we are seeing the data in table 1.1 gives accuracy rate for different methods CNN has the highest accuracy and is known for image recognition and MNIST is known for image classification. The CNN-SVM combiningly gives the second-highest accuracy and it is hard to implement both methods so CNN is the best choice for the handwritten recognition.

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