**ABSTRACT:**

Image recognition is widely used in the field of computer vision today. As a kind of image recognition, digit recognition is widely used. Today, the online recognition technology in digit recognition is relatively mature while the offline recognition technology is not. This paper mainly introduces an offline recognition system for handwritten digits based on convolutional neural networks. The system uses the MINST dataset as a training sample and pre-processes the picture with the Opencv toolkit. Then it uses LeNet-5 in the convolutional neural network to extract the handwritten digit image features, repeatedly convolution pooling, and pull the result into a one-dimensional vector. And finally find the highest probability point to determine the result to achieve handwritten digit recognition with the Softmax regression model. The application of this system can greatly reduce labor costs and improve work efficiency, which is of great significance in many fields.

Hand-written character and digit recognition have been one of the most exigent and engrossing field of pattern recognition and image processing. The main aim of this paper is to demonstrate and represent the work which is related to hand-written digit recognition. The hand-written digit recognition is a very exigent task. In this recognition task, the numbers are not accurately written or scripted as they differ in shape or size; due to which the feature extraction and segmentation of hand-written numerical script is arduous. The vertical and horizontal projections methods are used for the purpose of segmentation in the proposed work. SVM is applied for recognition and classification, while Convex hull algorithm is applied for feature extraction.

**INTRODUCTION:**

With the rapid development of electronic information, computer input has become more and more common, but handwriting is still an irreplaceable way for people to transfer information. As a link combining handwritten characters and computer input, handwriting recognition has received more and more attention for its practicability. Handwriting recognition technology is the basis of handwriting interpolation and handwriting identification. In the past decade, machine learning and pattern recognition have extended many highly intelligent handwriting recognition classifications, including artificial neural networks (ANN) [1], support vector machine (SVM) [2], modified quadratic discriminant function (MQDF) [3] and hidden Markov model [4], etc. Arabic numerals are the only universal symbols in the world, and they have an indelible contribution to the development of world science and culture. Convolutional neural networks have advantages in image processing in all neural networks, so this paper designs a handwritten digit recognition system based on convolutional neural networks.

Handwritten digit recognition is divided into online recognition and offline recognition. online recognition refers to letting the computer recognize the characters written on the handwriting device, and recognize it on the basis of handwriting strokes and stroke order. The theoretical research of this technology is very mature. Offline recognition is the recognition of characters written on paper by the computer. There is no stroke and stroke order as the basis. Only the picture recognition provides less information, so it is still facing greater challenges. The system designed in this paper is a handwritten digit recognition system that can realize offline recognition. The flow chart of the handwritten digit recognition system based on convolutional neural network designed in this paper

The identification system in this paper can be divided into two modules, a data source module and a digital identification module. The data source module includes the provision of original handwritten digits and the feature extraction of handwritten digit pictures. Digit recognition module includes convolutional neural network (CNN) and recognition.

Optimal Character Recognition (OCR), can be defined as the method which is capable to recognise and identify the text by the conversion of typed images, hand-written or the text which is in the printed form into machine-encoded text. The machine-encoded text is in the form of ASCII or Unicode.[1] The pixel representation of a letter is obtained after the conversion from equivalent character or digit representation. The process is a simulation by the machine of human reading. Digit recognition can be stated as the research of how observation of the environment by the machines is able to distinguish the digit of interest and predicts the accurate decision related to the digits and characters.[2] OCR, (Optical Character Reader) can be defined as the device which is capable of translating the images into machine recognisable formats which could be in the form of ASCII or Unicode.[3] The process of character or digit recognition of text which is hand-written is more difficult than text generated by machines, as the digits in hand-written text are non-uniform and due to which it is variable in shape and size; while the machine printed text are simple and uniformly spaced which are aligned fixed.[4] The process contributes in the automation process, as it increases the necessary interaction among the machines and humans.[5] In OCR, there are two types of OCR Datasets: Offline and Online. In ‘Offline’ dataset, the datasets are loaded and provided to the classifier or training model as an input, but in ‘Online’ dataset, the co-ordinates of the detection of drawing the digit is recorded to instantiate the prediction. The OCR technique involves numerous benefits as the printed text or hand-written text involves conversion process which is aimed for generation of machine generated and machine recognisable text due which it is space efficient.[6] The technique is so, well developed that it has various applications, like as it is efficiently utilised by the visionless and visually impaired, also used by banks to digitize documents.[7] Also, the ‘Barcode Recognition’ technique has a closely linked foundation with OCR technique; Moreover, used in ‘Number Plate Recognition’, education, finance and other fields.[8] The various factors which are responsible for the difference in the hand writing such as multiple orientations, skewness of the lines, pressure points of the connected components, overlapping characters etc. [9] Every character in the language could be expressed in many different forms, which depends on hand-writing of an individual, which offers difficulty to recognise the digit accurately.

**EXISTING PAPER 1:** Handwritten Digit Recognition System Based on Convolutional Neural Network

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**Project Summary:**

1. MNIST Dataset

The MNIST dataset comes from the National Institute of Standards and Technology (NIST). The training set consists of numbers handwritten by 250 different people. 50% of them are high school students and 50% are from the Census Bureau staff. The test set is also the same proportion of handwritten digits. The MINST library contains two parts, SD1 and SD3, from which 30000 words are taken as the training set. The test set has a total of 10,000 test samples, and SD1 and SD3 each have 5000. All digit pictures in the MINST dataset are standardized by the central composite size, and the size of each picture is 28 \*28 pixels. This system completes the process of training sample pictures based on the MNIST data set. This system completes the process of training sample pictures based on the MNIST data set. The handwritten digit recognition system extracts the features of the handwritten digit pictures in the MINST data set, performs recognition training, and then inputs the handwritten digits to be recognized for identification.

B. Opencv Toolkit Opencv (Open Source Computer Vision Library) is an open source library that is allowed in the case of BSD and covers many computer vision algorithms. The system in this paper uses the Opencv toolkit to perform image preprocessing and feature extraction on the digits to be recognized. Due to the uneven size of the handwritten pictures, we need to use the Opencv toolkit to compress the pictures into 28 \* 28 pixels of the same size as the MNIST dataset. In addition, in terms of image processing, Opencv can achieve linear and non-linear image filtering, graphics changes (including setting size, radiation and perspective, using basic table settings mapping), color space changes, histograms, etc. [5]. This system uses Opencv toolkit to filter grayscale pictures of handwritten digits, do grayscale histogram, threshold extraction and binarization, and finally extract the outline features of handwritten digital pictures.

**EXISTING MODEL 2:**Hand Written Digit Recognition using Machine Learning

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**Project Summary:**

The hand-written digit classification or recognition, for the cursive hand-written document, the study demonstrated that off-line hand-written analysis of the document occurs through skew recognition, writing pressure detection and segmentation. The segmentation method which was proposed, was based on modified vertical and horizontal projections; moreover, in the existence of multi-skewed and over-lapped text lines these projections are capable to segment the text lines and the words accurately.The testing of the method was executed on more than 550 images of text which were of IAM database and sample images of handwriting of different writers on different back-grounds. This proposed method was capable of performing correct segmentation of around 92.56% words and 95.65% lines from the IAM dataset. Moreover, around 96% lines are perfectly normalized with a minute error correction. The method of skew normalization demonstrates the skew angle accurately and compares it to different hands on techniques efficiently . The segmentation of lines, of the text is processed on the basis of information energy targeted individually for the calculation of every pixel and “Artificial Neural Network” recognised the characters and digits. The accuracy of recognition was around 92% . The execution of feature set which is hull based and of convex form which implies, 125 features to be computed according to the consideration of diverse attributes of bays of a pattern of the convex hull, isolated Bangla basic characters and digits were also recognised and this technique was also included in this field of study. The accuracy rate of recognition of hand-written Bangla characters was 76.86% and for Bangla numerals it was 99.45% . In this field, unprecedented technique is applied for the recognition of Bangla cursive words. For, the recognition purpose MLP classifier is used. The categorization of words at the initial stage of recognition analysis actually is carried out in three parts i.e. upper, middle and lower parts. The features which are diversified, are designed after considering octant-centroid features, shadow features which are modified and features, which are in the long -run. The accuracy rate of 80.58% was recorded when the experiments were carried out on 300 samples . The study of different segmentation techniques was included in hand-written character recognition. There are three levels of segmentation process discussed, which includes character, word and text-lines; the needs and the factors which leads to any affect to the segmentation process are discussed. The study which involves the work in this field demonstrates entirely a fresh approach which targets the use of series of algorithms for recognition and segmentation for the OCR of handwritten script and digits. Hidden Markov Model (HMM) is processed with precision rate of 92.3% for recognition with lexicon size 50. The word-level segmentation is derived from the combination of Lexicon and HMM . The discussion of various segmentation levels has been existent in this field of work study. ‘Hough Transformation’ can be defined as the level used for segmentation of text lines. The skeletonization process occurs due to the fact that vertically connected components are separated. The experiments which were implemented were on IC-DAR2007 dataset. The strength function of connectivity involves the process of segmentation in this field of study. “Connectivity strength parameter” can be defined as the parameter which decides the constituents of the text-line. This approach is adaptive to the language in nature with precision rate of around 97.3%.

**CONCLUSION:**

This Project designs a handwritten digit recognition system based on convolutional neural network. The system adopts the method of deep learning and uses the MNIST data set as a training sample. After the training is completed, the handwritten digits in the picture can be recognized through the Softmax regression model. The training and recognition process of this system is completed by LeNet-5 based convolutional neural network repeated convolution operation and pooling operation. Handwriting recognition is of great significance. Handwriting recognition is a bridge between handwriting and machines, and can play a huge role in finance, accounting, education and other fields, greatly reducing labor costs. The recognition results given by the existing recognition technology often still need manual review, and the accuracy needs to be improved. The design in this article also has the problem of too long recognition time. How to improve the recognition accuracy and reduce the recognition delay is still an important issue today.

**References**

[1] Pritam Dhande, Reena Kharat. "Recognition of cursive English handwritten characters" 2017 International Conference on Trends in Electronics and Informatics (ICEI), 2017.

[2] Mandal\*, S Shahnawazuddin, Rohit Sinha\*, S. R. Mahadeva Prasanna \*, Suresh Sundaram\*,“ Exploring Sparse Representation for Improved Online Handwriting Recognition” 2018 16th International Conference on Frontiers in Handwriting Recognition , 2018.

[3] Yuanzhi Zhu , Zecheng Xie , Lianwen Jin, Xiaoxue Chen, Yaoxiong Huang and Ming Zhang, “SCUT-EPT : New Dataset and Benchmark for Offline Chinese Text Recognition in Examination Paper” IEEE Access , 2018.

[4] O. Agaton, S. Kustrin, R. Beresford, “Basic concepts of artificial neural network (ANN) modeling and its application in pharmaceutical research”, Journal of biomedical analysis, vol. 22, no. 5, pp. 717-727, 2000.

[5] Reza Tavoli , Mohammadreza Keyvanpour , “A method for handwritten word spotting based on particle swarm optimisation and multi-layer perceptron” , IET (The Institution of Engineering and Technology) Journals , 2018.