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A Comparative Study on Handwriting Digit Recognition by using Convolutional Neural Network and Python

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Abstract - *Handwriting Digit Recognition had gotten more interest in the field of pattern recognition and machine learning. Optical Character Recognition (OCR) and Handwritten Digit Recognition (HDR) each have specific domains in which they can be used for Digit Recognition in a HDR System. Some various strategies has been proposed, although there are enough research and papers that outline the ways for transferring textual content from a paper document to machine-readable form. Digit Recognition systems may play a crucial role in creating a paperless world in future by digital conversion and processing the remaining paper documents. This paper provides all-inclusive overview of HDR.*

Deep learning has recently taken a radical turn in the field of machine learning by making it more artificially intelligent, thanks to the rise of Artificial Neural Networks (ANN). Because of the widely extended range of applications, deep learning is employed in a broad range of industries, including surveillance, health, medicine, sports, robots, and drones. Convolutional Neural Network (CNN) is the core of astonishing developments in deep learning, combining ANN and cutting-edge deep learning algorithms. Pattern recognition, phrase classification, audio recognition, face recognition, text classification, document analysis, a scene recognition, and HDR are one of the few applications. The purpose of this research is to differentiate the accuracies of the CNN in classifying handwritten digits by using varying numbers of hidden layers and epochs. We experimented to evaluate CNN's performance.

Keywords: Handwritten Digit Recognition, Artificial Neural Network, Convolutional Neural Network, MNIST Dataset.

1. INTRODUCTION

Handwritten Digit Recognition is fundamental but most challenging in the field of Digit Recognition with a good number of useful applications. It has been an intense field of study from the ancient era of computer science. It is the natural way of the interactions between computers and humans. More precisely Digit recognition is a process of detecting and recognizing the digit from the given image and converting it into the ASCII or another equivalent machine editable form. The technique from which the computer system can recognize digits and other symbols which is written by a human hand in its natural handwriting is called a HDR. Handwritten recognition is further classified into offline handwritten recognition and online handwritten recognition. If the writing is scanned and then understood by the computer, that is called offline handwriting recognition.

In case, if the handwriting is recognized while it was written through a touchpad by using the stylus pen and then it is called online handwritten recognition. From a classifier perspective, digit recognition systems are further divided into two types i.e. segmentation free (global) and segmentation based (analytic).

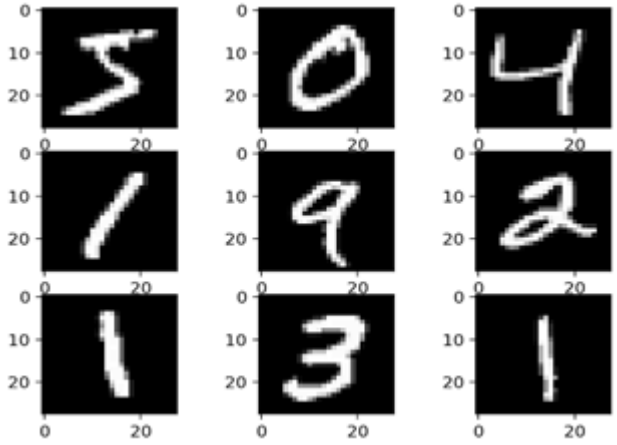

Fig 1: MINT Data Set

The divided part is also known as a holistic approach for recognizing the digit without dividing it into subgroups or digits. Each word is appeared as a set of global features, e.g. ascender, loops, etc. Whereas the segmentation based on approach of each of the word is divided into other subgroups either they are uniform or non-uniform or then subunits are considered independent. The Handwritten Digit processing system is the domain and the application-specific like it's not possible for designing a generic system of which we can process all of the types of handwritten scripts and languages. There is a lot work has been done on the European languages and Arabic (Urdu) language. Where the domestic languages which are Hindi, Punjabi, Bangla, Tamil, Gujarati, etc. are very less or looked into them due to the limited usage. In this paper, section II has described the basic principle of HDR which is generally followed by a detailed

literature survey. Further, in the next section the conclusion has been written.

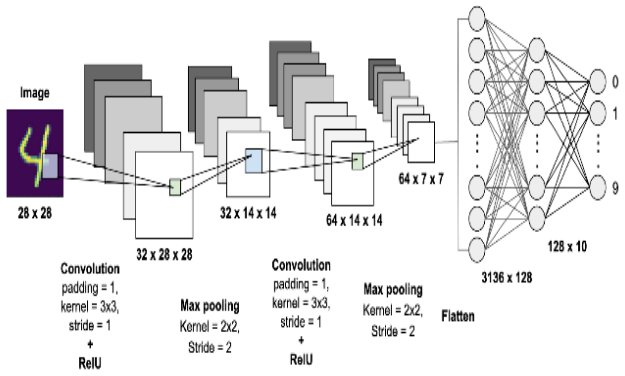

Fig 2: Convolutional Neural Network

2. LITERATURE REVIEW

This study by K. Gaurav, P. K. Bhatia [1] et al. discusses the various pre-processing approaches used in HDR with various types of pictures, ranging from simple handwritten forms to papers with colored and complicated backgrounds and varying intensities. Different preprocessing approaches are described, including skew detection and its correction, contrast stretching, binarization, noise removal techniques, normalization and segmentation, and morphological processing techniques. It was determined that we couldn't fully load the image by using only a single pre-processing technique. However, even with all of the aforementioned strategies in place, maybe it is impossible to attain 100% accuracy in a preprocessing system.

Nafiz Arica and colleagues [2] suggested an approach that avoids most pre-processing activities, which results in the loss of essential data. One-off the method's significant accomplishments is the creation of a powerful segmentation algorithm. Character boundaries, local maxima, and minima, slant angle, upper and lower baselines, stroke height and breadth, ascenders and descenders are all used to optimize the search method for the best segmentation route on a grayscale image. This strategy reduces over-segmentation. The use of the Hidden Markov Models (HMM) training, not only for the estimate of model parameters but also for the estimation of some global and feature space parameters, is another contribution. HMM, probabilities are also utilized to rank the candidate character and measure the shape information. The HMM shape recognizer's power is increased by representing a two-dimensional character picture in one dimension.

In their paper, G. Pirlo and D. Impedovo [3] introduced a new family of membership functions for zoning-based classification called Fuzzy membership functions (FMFs). For maximizing classification performance, these FMFs could be simply changed to specific parameters of a classification task. The real coded genetic algorithms. is proposed for finding the optimal FMF and the ideal zoning is explained by Voronoi tessellation a single optimizing step. The results of the experiments, which were conducted in the field of HDR and character recognition, shows that the optimal FMF outperforms alternative membership functions which are based on abstract level, the ranked level, and the measurement-level weighting the models in the literature.

In 1959, [4] Grims dale made a major endeavor in the field of character and digit recognition research. In the 1960s, a method is known as analysis-by-synthesis method, given by Eden in the year 1968, was the core of a loads of research. Eden's work was significant because he formally established that all the handwritten characters are generated by a limited number of schematic features, a point that had previously been implied. This concept was then applied to all syntactic (structural) character recognition algorithms.

With supervised learning methods, multiple strategies are used for removing slope and slant from the handwritten text and to normalize the size of the text images in this study. The development of a system with high accuracy in preprocessing and recognition, both are based on ANNs, was some of the important features of the recognition system. It proposes a method for creating a handwritten Digit character by executing a sequence of strokes. The stroke was represented as the string of shape features using a structural or shape-based representation. There was an unrevealed stroke detected using the string representation by collate it to the database of strokes using a string matching process. All the parts of the strokes of a whole character were identified.

In this study, Salvador Espaa-Boqueria et al [5] offer a (HMM) model for identifying the unconstrained offline handwriting texts. Where the structural element of the optical model was represented by Markov chains and emission probabilities were estimated by using a Multilayer Perceptron.

It proposes the altered quadratic classifier-based technique for offline handwritten numeral recognition (HNR) in six of the popular Indian scripts. Handwritten English characters have been recognized using a multilayer perceptron. The Boundary tracing and associated Fourier Descriptors were used to retrieve the features. The character is set on by examining the shape and analyzing its distinguishing characteristics. To obtain high performance in the backpropagation network, an analysis was also conducted to identify the no. of the hidden layer's nodes. Handwritten English alphabets or characters have been claimed to have a recognizing accuracy of 94% with minimal training time.

M. Hanmandlu and O.V. Ramana Murthy [6] published a study that demonstrated the identification of handwritten Hindi and English numerals using growing membership function as a fuzzy model. Altering the expanding membership functions suited to the fuzzy sets allows for recognition. This fuzzy sets are created using of the Box

technique and features including of normalized distances. The membership function is influenced from the two structural factors that are calculated by help of the entropy to achieve unity in the membership function. Overall, 95 percent of Hindi numbers are recognized, while 98.4% of English numerals are recognized.

This work by Mohammed Z. Khedher, Gheith [7] A. Abandah, and Ahmed M Al Khawaldeh et al. illustrates how the HDR is highly dependent on the attribute utilized. Several characteristics of handwritten Arabic numerals are highlighted and examined. Based on the selected features offline recognition system was created. With genuine examples of handwritten Arabic characters, the system was taught and evaluated. The significance and accuracy of the sorted out features are assessed. The recognition precision for numerals and letters is 88 % and 70 %, respectively, based on the selected attributes. Using feature weight based on intuition obtain from the accurateness of individual features, further improvements can be made.

For offline character recognition, [8] slanting features extraction was proposed. It is based on the ANN paradigm Ayush Purohit, et al., / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 7 (1), 2016, 1-5, chose two ways using 54 and 69 characteristics, respectively. This ANN Recognition system was built by www.ijcsit.com 2. The neural network recognition system is accomplished using the horizontal and vertical characteristic extraction ways to compare the recognition efficiency of the suggested diagonal approach of feature extraction. The diagonal approach of feature extraction offers recognition accuracy of 97.8% for 54 features & 98.5% for 69 features, according to the findings.

In this study, A. Brakensiek, J. Ross land, A. Kosmala, J. Rigoll [9] et al describe an off-line slant handwriting detection system based on HMM and distinct and hybrid designing techniques. The Handwriting recognition tests are contrasted utilizing discrete and two-hybrid techniques that combine discrete and semi-continuous patterns. To develop the system, a segmentation-free technique is being examined. It was discovered that a hybrid modeling technique for HMMs that relies on a neural vector quantizer (hybrid MMI) can increase recognition rate performance when collate to discrete and hybrid HMMs based on fatigued mixed structure (hybrid - TP), which could be due to a small data file.

For the classification of Devanagari Numerals, R. Bajaj, L. Dey, S. Chaudhary [10], et al used the three different types of characteristics: density features, moment features, and descriptive components features. For natural handwritten Devanagari numerals, they presented multi classifier probabilistic architecture to improve recognition reliability, and they achieved 89.6% accuracy.

Sandhya Arora [11] used four features of extraction techniques: intersection, shadow feature, chain code histogram, and straight-line fitting. Intersection features, chain code histogram features, and line fitting features are calculated by dividing the character image input into distinct segments, while shadow features are calculated globally for the character image. The total identification rate for Devanagari characters was 92.80 percent when tested with a data file of 4900 samples.

[12] Proposes a method for creating a handwritten Tamil character by executing a sequence of strokes. In this case, a structure or shape-based presentation of a stroke was used. Stroke was depicted as a string of shape features. Using an unidentified stroke was identified in this string representation by comparing it to a stroke database using a flexible string matching method by recognizing a complete character recognizing all of the component strokes.

Anup Kumar Panda and Sushree Sangita Patnaik [13] This research propose the execution of particle swarm optimization (PSO) and bacterial foraging optimization (BFO) methods for optimal harmonic recompense by minimizing the undesired losses happening within the APF itself, as published in May 2011 et al. For two different supply conditions, the efficiency and effectiveness of two different techniques are evaluated. By using BFO, the total harmonic distortion (THD) in the origin current, which is the measure of APF performance, is decreased to less than 1%. This results shows that BFO surpass conventional and PSO-based techniques by providing outstanding APF functionality and early dominance over harmonics in the origin current, even when the supply is imbalanced.

T. Som suggested a fuzzy membership [14] function-based technique for HCR in the literature. Normalized character pictures are 20x10 pixels. Each character's average picture (fused image) is formed up of ten images. The vertical and horizontal projections of the characters which are used to accept the bounding box surrounding the character. The image is downsized to 10x10 pixels after being cropped to the bounding box. After that, the decreased image is placed step by step in the raw of a 100x100 canvas. The test image's similarity score is compared to the fusion image's similarity score, and the characters are categorized.

Renata F. P. Neves [15] proposed offline HDR which is based on SVM. SVM beats the Multilayer Perceptron Classifier, according to the authors. The experiment uses the NIST SD19 dataset. MLP has the benefit of being able to divide non-linearly separated classes. On other hand MLP, can easily slip into a local minimum zone, where the training will stop presuming it has reached an optimal location on the error surface. Another stumbling block is determining the appropriate network design for solving the problem, taking into account the number of layers and perceptions in each hiding layer. Because of these drawbacks, digit recognition which is contingent on the MLP structure could not achieve the low error rate expected.

Ayush Purohit et al. 3 Yoshimasa Kimura [16] presented a paper on using a genetic algorithm to choose features for character recognition. Using genetic algorithms, the author offers a unique feature selection approach for character recognition (GA). The suggested method picks as candidates for the parent gene only those genes for which the recognition rate of training samples exceeds a predefined threshold, and uses a reduction ratio in the no. of features used for recognition as the fitness value.

3. CONCLUSION

In this paper, we study some Handwriting Digit Recognition and Artificial Neural Network based recognition algorithms to decide the finest algorithm in terms of many aspects such as accuracy and performance. Different authors proposed many models and they took some criteria such as implementation time has been also taken into consideration. Random and standard datasets of handwritten digits are used to calculate the algorithms. The results show that DNN is the finest algorithm in aspects of accuracy and performance. CNN algorithm and DNN are almost equal in terms of accuracy. DNN algorithm, however, was finer than CNN and DBN in aspects of execution time. By recognizing the correct digits, the margin of errors may take place with similarities between the digits.

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