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Handwritten Digit Recognition Using Deep Learning

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***Abstract*: In recent times, with the increase of Artificial Neural Network (ANN), deep learning has brought a dramatic twist in the field of machine learning by making it more artificially intelligent. The handwritten digit recognition problem becomes one among the most famous problems in deep learning and computer vision applications. Handwritten digit recognition is a crucial issue in pattern recognition applications. The applications of digit recognition includes in postal mail sorting, check processing, form data entry, etc. the root of the problem lies within the ability to develop an efficient algorithm which will recognize hand written digits and which is submitted by users by the way of a scanner, tablet, and other digital devices. This paper presents an approach to off-line handwritten digit recognition supported different deep learning technique. The objective of this paper is to make sure effective and reliable approaches for recognition of handwritten digits.**

***Keywords*: Handwritten digit recognition, Convolutional Neural Network, Keras, Deep Learning.**

1. Introduction

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 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. Recognizing numbers based on extractable discriminative features is one of the main tasks of digital recognition systems. 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. Nowadays handwritten digit recognition has obtained lot of concentration in the area of pattern recognition system sowing to its application in diverse fields. In the days to come, character recognition systems may become the cornerstone of creating a paperless environment by digitizing and processing existing paper documents. Handwritten digit sets are inherently fuzzy, because they are not always clear, perfect straight lines. The main purpose of digital identifier extraction is to eliminate data redundancy and use set of digital attributes to get a more effective realization of word images. The point is to extract most of the important information from the original image data. In addition, the curve should not be as smooth as printed characters. In addition, characters dataset can be drawn in different sizes. This should always be written on the guide in a straight or vertical position. Therefore, it is possible to design an efficient handwriting recognition system in consideration of these limitations. It is overtire that sometimes to identify hand written characters as it can be seen that most of the human beings can't even recognize their own written scripts. Therefore, the author obviously has limitations in recognizing handwritten documents. Since the 1980s, handwriting recognition has popular. The task of recognizing handwritten digits with the help of a classifier is particularly important for the following applications such as online digit recognition on a tablet computer, recognize zip codes on mail, processing bank check applications. Various problems arise when trying to solve this problem. The size, thickness, direction, and position relative to the edge of handwritten numbers are not always the same. The main goal is to update the method of describing perception patterns characterization method to Note the handwritten digits represented in the MNIST Handwritten Digit Image Record (0-9).

A. CNN (convolutional Neural Network)

CNN is a multi-layered neural network with deep supervised learning architecture, which can be regarded as a two-part combination: automatic feature extractor and trainable classifier. Convolutional networks are simple neural networks

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that use convolution on at least one layer instead of general matrix multiplication. Convolutional neural networks has input and output layers and several hidden layers.

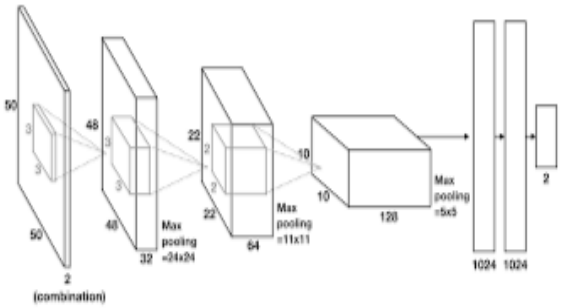

Fig. 1. Basic CNN architecture

CNN hidden layers usually consist of a series of convolutional layers that coexist with multiplication or other dot products. The activation function is usually a RELU layer, followed by additional folds, such as a packet layer and a fully connected layer and normalization layers are called hidden layers because their inputs and outputs are masked by the activation function and the final convolution. In turn, final folding usually involves back propagation to more accurately weigh the final product.

2. Literature Review

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 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 note-taking 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.

3. Problem Statement

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.

4. Methodology

The comparison of the algorithms (Support vector machines, Multi-layered perceptron & Convolutional neural network) is based on the characteristic of each algorithm on common grounds like dataset, the number of epochs, complexity of the algorithm, accuracy of each algorithm, specification of the device used to execute the program and runtime of the algorithm, under ideal condition.

A. Dataset

Handwritten character recognition is a research area that

already contains detailed ways of implementation which involve major learning datasets, popular algorithms, features scaling & feature extraction methods. MNIST dataset is the subset of NIST dataset which is a combination of two of NIST's databases: Special Database 1 and Special Database 3. Special Database 1 and Special Database 3 consist of digits written by the high school students and employees of the United States Census Bureau, respectively. MNIST contains total of 70,000 handwritten digit images (60,000 - training set & 10,000 - test set) in 28x28 pixel bounding box and anti-aliased. All these image have corresponding Y values which apprises what the digit is given.

B. Multilayer Perceptron

A multilayer perceptron (MLP) is a class of artificial neural networks (ANN). It consists of three layers that is input layer, hidden layer & output layer, each layer consists of several nodes that are also formally referred to as neurons and each node is interconnected to every other node of the next layers. In basic MLP there are three layers but the number of hidden layers can increase to any number as per the problem with no restriction on the number of nodes. The number of nodes in the input & output layer depends on number of attributes & apparent classes in the dataset respectively. The specific number of hidden layers or numbers of nodes in the hidden layer is difficult to determine due to the model erratic nature and therefore selected experimentally. Every hidden layer of the model can have various activation functions for processing. In the MLP, the connections of the nodes consists of a weight that gets adjusted to synchronize with each connection in the training process of the model.

C. Convolutional Neural Network

CNN is a deep learning algorithm that is used for image recognition and classification. It is a class of deep neural networks that require minimum preprocessing. It inputs the image in the form of small chunks rather than inputting a single pixel at a time, so the network can detect uncertain patterns in the image more efficiently. CNN contains three layers namely, an input layer, an output layer, and multiple hidden layers which include Convolutional layers, Pooling layers, Fully connected layers (FC), and normalization layers. CNN uses a filter which is an array of weights to extract features from the input image. Further, we observe the height and width decrease while the number of channels increases. Finally, the generated column matrix is used to predict the output.

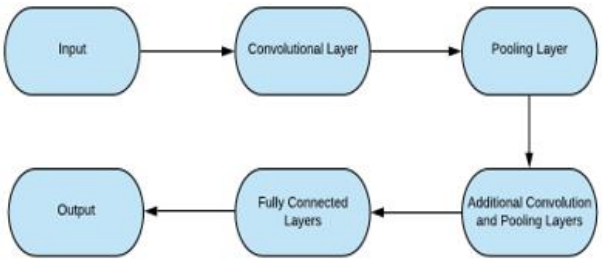

Fig. 2. Architectural design of CNN layers

D. Visualizations

This paper has used the MNIST dataset (i.e. handwritten digit dataset) to compare different level algorithm of deep and machine learning on the basis of execution time, complexity, accuracy rate, number of epochs and number of hidden layers (in the case of deep learning algorithms). To visualize the information obtained by the detailed analysis of algorithms we have used tabular format charts using module matplotlib, which gives us the most precise visuals of the step by step advances of algorithms in recognizing the digits.

5. Result

The result of our work shows that the maximum accuracy of 99.87% in the MNIST database was achieved using deep learning technology. Our model is built in such a way that it works with real data and the real word images do not even come close to the MNIST raster images. A lot of preprocessing was done to make a real image look like a raster image. The experiment result shows that the CNN classifier is effective in recognition of handwritten digits.

6. Conclusion

The result of our work shows that the maximum accuracy of 99.2% was obtained in the MNIST dataset using the deep learning technique and an appropriate learning rate at 15000 iterations. It is observed that accuracy slowly starts decreasing or remains constant after 15000 iterations. The performance ratio of GPU: CPU is found to be 30:1. It is concluded that computation time in GPU exponentially decreases as compared to CPU.

The main objective of this investigation is to find a representation of isolated handwritten digits that allow their effective recognition. In any recognition process, the most important problem is addressing the feature extraction and correct classification approaches, which we have tried to do in our project. The given algorithm that we have used tries to address both the factors and well in terms of accuracy and time complexity. This work is carried out as an initial attempt Compared with other research, this study focused on exploring which image preprocessing and feature extraction techniques based on OCR can work for improving the accuracy of classification models by more than 99%. In the initial experiment, the CNN algorithm won with a recognition accuracy of 99.2%, followed by K-NN with 96.68%, so we have gone with the CNN algorithm and got the better result.

7. 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 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.

References

[1] Hyeranbyun, Seong-whan Lee, "A survey on pattern recognition applications of support vector machines", International Journal of Pattern Recognition and Artificial Intelligence (AI), Vol. 17, No. 3 459–486, 2003.

[2] Li Deng, "The MNIST Database of Handwritten Digits images for Deep Learning Research", MIT press, November 2012.

[3] Xuefeng Xiaoa, Lianwen Jina, Yafeng Yanga, Weixin Yanga, Jun Sunb, Tianhai Chang, "Building Fast and compact Convolutional Neural Networks for Offline handwritten Recogntion", 2017.

[4] Ayush Purohit, Shardul Singh Chauhan, "A Literature Survey on Handwritten Character Recognition", International Journal of comp. Science and Information Technologies, Vol. 7 (1), 1-5, 2016.

[5] Dan Claudiu Ciresan, Ueli Meier, Luca Maria Gambardella, Jurgen Schmidhuber, "Deep big simple neural Nets Excel On Handwritten Digit Recognition", MIT Press, March 2010.

[6] Pooja Yadav, Nidhika Yadav, "Handwriting Recognition System- A Review", International Journal of Computer Applications, Vol. 114, No. 19, March 2015.

[7] L. Bottou, C. Cortes, "Comparison of Classifier methods a case study in handwritten digit recognition", Pattern Recognition, 1994. Vol. 2 Conference B; Image Processing, Proceedings of the 12th IAPR International. Conference IEEE, 06 August 2002.

[8] Mahmoud M. Abu Ghosh, Ashraf Y. Maghari, "Promising Electronic Technologies" (ICPET), 2017 International Conference on, Comparative Study on Handwriting Digits Recognition Using Neural Networks, 16-17 Oct. 2017.