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Handwritten Digits Recognition

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Abstract-One of the very significant problems in pattern recognition applications is the recognition of handwritten characters. Building an automatic handwritten digit recognition technique is the major goal of this project, which will be used to recognise handwritten digit strings. The segmentation of the digits into separate digits is the first step in completing the recognition challenge. The handwritten digit string recognition challenge is then completed by using a digit recognition module to categorise each segmented digit. Applications for digit recognition include filling out forms, processing bank checks, and sorting mail. The capacity to create an effective algorithm that can detect users' handwritten digits sent via a scanner, tablet, and other digital devices is at the core of the issue.

Keywords: Pattern Recognition, Handwritten Recognition, Digit Recognition, Machine Learning, Offline Handwritten Recognition, Machine Learning Algorithm, Neural Network, Classification Algorithm.

INTRODUCTION

Machine learning and deep learning play an important role in computer technology and artificial intelligence. Using deep learning and machine learning, human effort can be reduced in recognition, learning, prediction and many other areas. This paper presents recognition of handwritten digits (0 to 9) from the famous mnist dataset, comparing classifiers like knn, psvm, nn and convolutional neural network based on performance, accuracy, time, sensitivity, positive productivity and specificity using different parameters. with classifiers. To make machines more intelligent, developers are delving into machine learning and deep learning techniques. One learns to perform a task by practicing it over and over again to remember how to perform the tasks. Then the neurons in his brain automatically fire and he can quickly carry out the task he has learned. Deep learning is also very similar to this. It uses different types of neural network architectures for different types of problems. For example – object recognition, image and audio classification, object detection, image segmentation, etc. Handwritten digit recognition is the ability of computers to recognize human handwritten digits. This is a difficult task for a machine because handwritten numerals are not perfect and can be made in many different flavors. The solution to this problem is handwritten digit recognition, which uses an image of a digit and recognizes the digit present in the image.

Conventional Neural Network: In deep learning, a convolutional neural network (CNN or ConvNet) is a class of artificial neural network (ANN) most commonly used to analyze visual images. CNNs are also known as Shift Invariant or Space Invariant Artificial Neural Networks (SIANN), based on a shared-weight architecture of convolutional kernels or filters that shift along the input features and provide translation-equivalent responses known as feature maps. Counterintuitively, most convolutional

neural networks are not translation invariant because of the downsampling operation they apply to the input. They have applications in image and video recognition, recommender systems, image classification, image segmentation, medical image analysis, natural language processing, brain-computer interfaces, and financial time series.

CNNs are regularized versions of multilayer perceptrons. Multilayer perceptrons usually mean fully connected networks, that is, each neuron in one layer is connected to all neurons in the next layer. The "full connectivity" of these networks makes them susceptible to data overload. Typical ways to regularize or prevent congestion include penalizing parameters during training (such as weight loss) or pruning connectivity (missed connections, dropouts, etc.). CNNs take a different approach to regularization: they take advantage of the hierarchical pattern in the data and build patterns of increasing complexity using smaller and simpler patterns stamped in their filters. Therefore, on the scale of connectivity and complexity, CNNs are at the lower extreme.

Convolutional networks were inspired by biological processes in that the pattern of connectivity between neurons resembles the organization of the visual cortex of animals. Individual cortical neurons respond to stimuli only in a limited area of the visual field known as the receptive field. The receptive fields of different neurons partially overlap to cover the entire visual field.

CNNs use relatively little pre-processing compared to other image classification algorithms. This means that the network learns to optimize filters (or kernels) using machine learning, whereas in traditional algorithms these filters are created manually.

Digit Recognition System:

Digit recognition system is the operation of a machine that is trained or recognizes digits from various sources such as e-mails, bank checks, papers, images, etc. And in various real-world scenarios for online handwriting recognition on computer tablets or systems, recognize license plates, numeric entries in manually filled forms and so on.

LITERATURE REVIEW

[1] Author Fathima Siddique thought that CNN plays an important role in many industries such as image processing. It has a strong impact on many areas. Even in nanotechnology such as semiconductor manufacturing, CNN is used for fault detection and classification. Handwritten digit recognition has become a topic of interest among researchers. A large number of articles and articles are currently published on this topic. Research shows that Deep Learning algorithm like multi-layer CNN using Kera's with Theano and TensorFlow provides the highest accuracy compared to the most common machine learning algorithms like SVM, KNN and RFC. Recently, with the rise of artificial neural network (ANN), deep learning has brought a dramatic revolution in machine learning by making it more artificially intelligent. Deep learning is remarkably used in a wide range of fields as it has a diverse range of applications such as surveillance, health, medicine, sports, robotics, drones, etc. In deep learning, Convolutional Neural Network (CNN) is at the center of spectacular progress. which combines artificial neural network (ANN) and current deep learning strategies. It is widely used in pattern recognition, sentence classification, speech recognition, face recognition, text categorization, document analysis, scene analysis, and handwritten digit recognition. The aim of this paper is to observe the variation of CNN accuracies, classify handwritten digits using different number of hidden layers and epochs and

compare the accuracies. For this CNN performance evaluation, we conducted our experiment using the Modified National Institute of Standards and Technology (MNIST) dataset. Next, the network is trained using stochastic gradient descent and backpropagation algorithm.

[2] Author Ritidixit believed that with the humanization of machines, there has been a significant amount of research and development work that has given impetus to deep learning and machine learning along with artificial intelligence. From computing basic sums to retinal recognition, machines are becoming more sophisticated over time, making our lives safer and more manageable. Similarly, handwritten text recognition is an important application of deep learning and machine learning that is useful in forgery detection, and a wide range of research has already been done, which includes the comprehensive study and implementation of various popular algorithms. People's trust in machines has never been so high that everything from classifying objects in photos to adding sound to silent movies can be done using deep learning and machine learning algorithms. Similarly, handwritten text recognition is one of the significant areas of research and development with a number of possibilities that can be achieved. Handwriting recognition (HWR), also known as handwriting recognition (HTR), is the ability of a computer to receive and interpret intelligible handwritten input from sources such as paper documents, photographs, touch screens, and other devices. In this paper, we have apparently performed handwritten digit recognition using MNIST datasets using Support Vector Machines (SVM), Multi-Layer Perceptron (MLP), and Convolution Neural Network (CNN) models. Our main goal is to compare the accuracy of the above models along with their execution time to get the best possible model for digit recognition

[3] Author S M Shamim opined that handwritten digit recognition is a well-researched subfield of the field that deals with learning models to discriminate prewritten handwritten digits. It is one of the most important questions in data mining, machine learning, pattern recognition, along with many other disciplines of artificial intelligence. A major application of machine learning methods in the last decade has shown that they are effective in adapting decision-making systems that compete with human performance and that achieve much better results than hand-written classical artificial intelligence systems used in the early days of optical character recognition technology. Handwritten character recognition is one of the practically important problems in pattern recognition applications. Digit recognition applications include mail sorting, bank check processing, form entry, etc. The main challenge lies in the ability to develop an efficient algorithm that can recognize handwritten digits that users enter through scanners, tablets, and other digital devices. This paper presents an off-line handwritten digit recognition approach based on various machine learning techniques. The main goal of this paper is to ensure the efficiency and reliability of approximate handwritten digit recognition. Several machine learning algorithms (i.e.

Multilayer Perceptron, Support Vector Machine, Naïve Bayes, Bayes Net, Random Forest, J48 and Random Tree) were used for digit recognition using the Waikato Environment for Knowledge Analysis (WEKA). The experimental results showed that the Multilayer Perceptron obtained the highest accuracy with a value of 90.37%.

[4] However, author Vijayalakshmi thought that not all the features of these particular models had been checked before. A big machine learning and data mining researcher experiment was devised. Efficient approaches for

approximating recognition from data. In the twenty-first century, handwritten digit communication has its own standard, and most cases in daily life are used as a means of conversation and recording information to be shared with individuals. One of the challenges in handwritten character recognition lies entirely in the variation and distortion of the handwritten character set, as a different community may use different handwriting styles and controls to draw a similar character pattern of their recognized script. Digit recognition is a remarkable and important problem. Since handwritten digits are not similar in size, thickness, position, and direction, different difficulties must be considered in this way to determine the handwritten digit recognition problem. The uniqueness and variety in the compositional styles of different individuals additionally influences the example and presence of numerals. It is a strategy for perceiving and arranging transcribed digits. It has a wide range of applications such as programmed bank checks, postal locations and tax documents and so on. The goal of this project is to implement a classification algorithm for recognizing handwritten digits. After effects of probably the most widespread machine learning algorithms like SVM, KNN and RFC and with Deep Learning computation like multi-layer CNN using Keras with Theano and Tensorflow. Using them, the accuracy is 98.70% using CNN (Keras + Theano) compared to

Obtained 97.91% using SVM, 96.67% using KNN, 96.89% using RFC.

[5] Author Pranit Patil believed that identifying the digit from which the best distinguishing characters can be obtained is one of the main tasks in the field of digit recognition system. Different kinds of region sampling techniques are used in pattern recognition to find such regions. The problem in recognizing handwritten characters is primarily caused by the great variability of individual writing styles. - Handwritten digit recognition is a technique or technology for automatically recognizing and detecting handwritten digital data through various machine learning models. In this paper, we use different machine learning algorithms to increase the productivity of the technique and reduce the complexity using different models. Machine Learning is an application of artificial intelligence that learns from previous experience and automatically improves through experience. We illustrate various machine learning algorithms such as Support Vector Machine, Convolutional Neural Network, Quantum Computing, K-Nearest

Neighbor algorithm, deep learning used in recognition technique.

[6] Author Akanksha Gupta believed that character handwriting recognition has been around since the 1980s. The task of recognizing handwritten digits using a classifier is of extraordinary importance and use, such as online digit recognition on tablet PCs, recognition of postal codes at the post office, processing of bank check amounts, numerical sections in hand-filled structures (for example - tax forms) and so on. We face various challenges in trying to solve this problem. Handwritten digits are not always the same size, thickness, or orientation and position relative to the edges. The main goal was to update the pattern characterization method for handwritten digit perception provided in the MINIST dataset of handwritten digit images (0-9). In this digital world, everything including documents, notes are kept in digital form. The request to convert these digital documents into processed information is in demand. This process is called Handwritten Digit Recognition (HDR). A digital scanned document is processed and classified to identify the handwritten words into digital text so that it can be used to preserve the documents in computer font format so that anyone can read it correctly. This article discusses that classifiers like KNN, SVM, CNN are

used for HDR. These classifiers are trained using some predefined data set and then used to process any digital scanned document into computer document format. The scanned document goes through four different stages for recognition where the image is pre-processed, segmented and then recognized by a classifier. The MNIST dataset is used for training purposes. A complete CNN classifier is discussed in this article. CNN has been found to be very accurate for HDR, but there is still room for improvement in performance in terms of accuracy, complexity, and timing.

[7]   Author K. Swetha believed that robust feature extraction is therefore very important to improve the performance of a handwritten character recognition system. Nowadays, handwritten digit recognition has been much focused in the field of pattern recognition system and its application in various fields. Handwritten digit recognition (HDR) is the process of converting images of handwritten digits into a digital format. A lot of money is spent on converting information that is in paper form into digital format. This problem can be solved with HDR. The heart of our project lies in the ability to develop an efficient algorithm that can recognize handwritten digits that are scanned and submitted as user input. The aim of this paper is to trace the variations of different algorithms that can classify handwritten digits using different hidden layers, different number of epochs and make a comparison based on accuracy. This experiment is performed using Modified

National Institute of Standards and Technology (MNIST) dataset.

[8]   Author Apaar Chadha opined that handwritten numerals are not always the same size, thickness, or orientation and position relative to the edges. The main goal was to update the pattern characterization method for handwritten

digit perception provided in the MINIST dataset of handwritten digit images (0-9). The machine learning-based handwritten digit recognition system proposed in this research paper is a model that can be used to identify and recognize digits written by a user on an editable canvas widget within a graphical user interface (GUI). This research paper provides a detailed description of handwritten digit recognition systems, our approach to implementing them, and also compares the accuracy of different machine learning algorithms that can be used to implement such systems.

[9]   Author Gaurav Yadav opined that machine learning is one of the most compelling concepts that need to be emphasized to meet the ever-increasing day-to-day demands related to the IT industry. In order to understand machine learning more effectively and implement it in problem solving, we decided to create a handwritten digit recognition system using machine learning. This problem will allow us to learn machine learning techniques from the ground up and has various use cases that can prove beneficial to individuals or organizations. Machine learning includes different types of learning models

[10]   Author Shengfeng Chen believed that many techniques have been developed to recognize handwritten digits; most A.I. practitioners use this to test the performance of their model. In past decades, a segmentation-based approach was used to solve this problem, later with advances in machine learning, and a segmentation-free approach was introduced. Even if the implementation changes, the problem remains the same and open for anyone to solve. The problem of recognizing handwritten digits has long been an open problem in the field of pattern classification. Several studies have shown that neural network has great performance in data classification. The main goal of this paper is to provide efficient and reliable techniques for

recognizing handwritten digits by comparing different existing classification models. This paper compares the performance of five machine learning classifier models namely Neural Network, K-Nearest Neighbor (KNN), Random Forest, Decision Tree and Bagging with gradient boosting. The results indicate that the K-NN classifier outperforms the neural network with significantly improved computational efficiency without sacrificing performance. Both outperformed the other classifiers: Random Forest, Decision Tree, and Gradient Boost Bagging. We also find that as the training data increases, the accuracy of the classifier also improves. The result of this paper shows that K-NN has the same high accuracy of 96.7% compared to the neural network of 96.8%, but K-NN achieves a processing speed of almost 10 times faster. The analysis presented in this paper suggests that KNN combined with pre-processing methods is able to achieve great performance in addition to neural network when used as a classification algorithm in offline handwritten digit recognition..

REVIEW FINDINGS
•We have reviewed various research papers on handwritten digits recognition.
•In all of the research papers they used concepts of machine learning to analyse the patterns and recognize the digits.
•They used the convolutional neural network to recognize the digits.
•A particular dataset is provided and the machine is trained to recognise the digits.

CONCLUSION
1.Digit recognition system can be extended to a recognition system that can also able to recognize handwritten character and handwritten symbols.
2.It can be done using the machine learning techniques.
3.There are many techniques to perform recognition of digits.

Future enhancements:
1.In the future work, we look forward to increase the accuracy of the recognition of digits.

2.We also try to use better machine learning techniques to perform the recognition of the digits.
3.Better results will be obtained by using other machine learning techniques.

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