Recognition of Handwritten Digits Using Support Vector Machine and Neural Networks

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ABSTRACT

Optical Character Recognition (OCR) is the method of classification of optical patterns contained in an exceedingly digital image. The character recognition is achieved through segmentation, feature extraction, and classification. one of all the foremost used tools for optical character recognition may well be a tesseract. During this project we try to create an alternate of tesseract which is our model ready to} recognize different handwritten digits which don't seem to be printed but written manually and since tesseract is solely able to recognize printed digits, it'll be a valuable feature for several developers. We use the Support Vector Machine during this process. Support Vector Machine could also be a classification tool at home with recognizing handwritten digits. We also use a Neural network for Data analysis and classification of knowledge. In particular, handwritten digit recognition has been applied to acknowledge amounts written on checks for banks and zip codes on envelopes for postal services. The handwritten digit recognition system may be divided into four stages, Data acquisition, Pre-processing, Feature extraction, and Classification. Support Vector Machines, within the machine learning theory, are used for classification and analysis. they've supervised learning models with associated learning algorithms that analyze data and recognize patterns. As per the requirement of the information into consideration, the Support Vector Machines are modeled to classify. Support Vector and naive Bayes, both don't require the maximum amount of computation power compared to deep learning which makes it possible for the developers to deploy the model natively instead of running it in a server container.

Keywords: - *Support Vector* Classifier, Confusion Matrix, Accuracy Score, Classification Report, Data Analysis, Neural Networks.

1. INTRODUCTION

Handwriting recognition is one in all the compelling and interesting works because every individual during this world has their type of writing. it is the potential of the pc to identify and interpret handwritten digits or characters automatically. In real-time applications, a bit like the conversion of handwritten information into digital format, postcode recognition, cheque processing, verification of signatures, number plate recognition, this recognition is required.

This recognition was implemented using many Machine Learning techniques like Random Forest, Naive Bayes, and Support Vector Machine, etc. Yet 100% accuracy is some things that are to be achieved and also the research continues to be actively happening so on in the reduction of the error rate. The accuracy and

correctness are very crucial in handwritten digit recognition applications. Even a 1% error may cause inappropriate results in real-time applications.

The MNIST data set is widely used for this recognition process. The MNIST data set has 70,000 handwritten digits. Among these 60,000 are training examples and 10,000 are testing examples. All the digits are already normalized to a normalized size and also centered. Each image during this data set is represented as an array of 28x28. The array has 784 pixels having values ranging from 0 to 255. If the pixel value is '0' it indicates that the background is black and if it's '1' the background is white.

Handwritten character recognition might be a field of image processing additionally to pattern recognition. There are two approaches for pattern recognition like statistical and structural. In the statistical approach, the ser of characteristic measurements of the pc file is generated on a statistical basis and is assigned to 1 of the n classes. The structural description of the article is based on the interconnections and interrelationships of features of the data file. In general, both approaches are widely utilized within the pattern recognition.

Since the handwriting of assorted writers is different, building a general recognition system that may recognize all characters with good reliability isn't possible in every application. Thus, recognition systems are developed to realize reliable performances to the actual applications. particularly, the handwritten digit recognition has been applied to acknowledge amounts written on checks for banks and zip codes on envelopes for postal services. The handwritten digit recognition system is split into four stages.

- Data acquisition
- Pre-processing
- Feature extraction
- Classification
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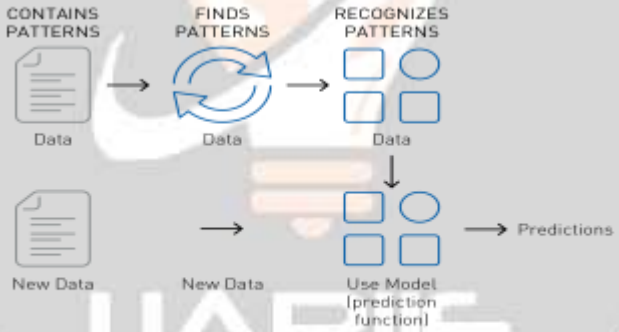

Fig-1 Support Vector Machine

2. RELATED RESEARCH

In [1] 1959, Grimsdale attempted within the area of character recognition. Later in 1968 Eden suggested an approach termed as an analysis-by-synthesis method to hold on the research work. Eden showed that each handwritten character has some schematic features.

Parveen Kumar, Nitin Sharma, and Arun Rana[2] endeavored to acknowledge a handwritten character using the SVM classifier and MLP Neural Network. Different kernel-based SVM just like the linear kernel, polynomial kernel, and quadratic kernel-based SVM classifiers are used. within the SVM classifier model, there are two phases of coaching and testing. From each character, about 25 features are extracted with the assistance of which SVM is trained. Amongst the three kernels used the linear kernel gives an accuracy of 94.8%.

Reena Bajaj, Lipika Dey and Santanu Chaudhury [3] in 2002 decided to present well built and systematic methodology for handwritten numeral recognition. during this paper, connectionist networks are used for building recognition architecture.

Patrice Y. Simard, Dave Steinkraus, John C. Platt [4] narrated that the convolutional neural networks are better for the visual document analysis like handwriting recognition task. the most essential practices for this task are the expansion of the info sets using elastic distortions and therefore the use of convolutional neural networks.

T.Siva Ajay[5] also proposed that the upper rate of accuracy in handwritten digit recognition task will be achieved by the utilization of convolutional neural networks. The implementation of CNN is created easy and easy by the employment of LeNet engineering. As a result of this accuracy greater than 98% is obtained during this paper.

Shobhit Srivastava, SanjanaKalani, Umme Hani, and SayakChakraborty[6] illustrated the handwritten recognition using Template Matching, Support Vector Machine, and Artificial Neural Networks. Among the methods used, Artificial Neural Networks clothed to administer more accurate results.

Shashank Mishra, D.Malathi, and K.Senthil[7] Kumar attempted the handwritten recognition using Deep Learning. They used Convolutional Neural Network as a result of which they concluded that accuracy is increased and there's a discount within the computation time. The accuracy of 99.2% is obtained.

3. PROPOSED METHOD

We are proposing a far lighter algorithm for the matter, Support Vector to cater to this Digit Recognition. An SVM model may be a representation of the examples as points in space, mapped therefore the samples of the separate categories are divided by a transparent gap that's as wide as possible..

3.1 SUPPORT VECTOR MACHINES

Support Vector Machines, within the machine learning theory, are used for classification and analysis. they've supervised learning models with associated learning algorithms that analyze data and recognize patterns. As per the requirement of the data into consideration, the Support Vector Machines are modeled to classify. The commencement is to model the SVM then find the data set to teach this model. The Hyperplane is generated during the training of the SVM model. This hyperplane classifies data into different classes. After the formation of the hyperplane, offline data is given as an input to the SVM model and classified output is checked for the correctness of its classification. the web data is given as an input to the SVM model if offline data classification is optimized, if it isn't, then kernel and other parameters are modified to induce an optimal classification.

In addition to performing linear classification, SVMs can efficiently perform a non-linear classification, implicitly mapping their inputs into high-dimensional feature spaces

Algorithm:

Within the case of binary classification:

1. Identify the right hyperplane which segregates the two classes better.
2. Look for the foremost distance between the closest datum (of either any class) and hyperplane, space is measured as margin. explore for hyperplane with maximum margin on either side equally. Hyperplane with the next margin is more robust, whereas the low margin has changed for misclassification.
3. SVM selects the classifier accurately to the maximized margin.
4. SVM is powerful to the classifier and contains a feature to ignore outliers and appearance for a hyperplane with maximum margin.

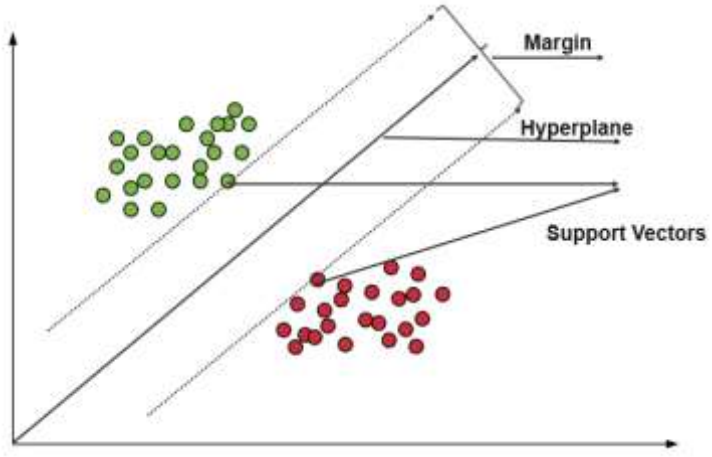

Fig-2 Hyperplane

3.1.2 DESCRIPTION

The task of digit recognition is divided into two groups, printed digit recognition, and handwritten digit recognition. Recognition of printed digits is easier compared to the handwritten digit recognition because printed digits have regular shape and differences between images of the identical number are just within the angle of view, size, color, etc. On the alternative hand, there are numerous handwriting styles which mean that the identical digit could also be written in many different ways, hence more effort is required to hunt out the similarity between instances of the identical digit. one all told the oldest techniques for beholding is template matching. this method isn't suitable for handwritten digit recognition due to numerous variants in communication, angle of writing, etc. In general, nowadays digit recognition contains three parts

• Preprocessing

• Feature extraction

• Classification.

The image Acquisition task is taken into consideration thanks to the opening of user-provided handwritten digit recognition. The image acquisition process is principally concern with obtaining text images from a scanner or a pre-stored image file where the format of the image could even be PNG, BMP, JPEG, etc. A camera, scanner, webcam, or any input devices is utilized to capture the input image. to create the image as readable format .some preprocessing and thresholding task is performed thereon image.

The acquired input image is subjected to a range of prefatory processing steps to make it functional to the descriptive stages of the popularity process. Pre-processing intends to produce data that are readable for the recognition systems to figure precisely. Preprocessing prepares images for feature extraction. variety of the common preprocessing steps are binarization, centering, morphological operations, and more.

Feature extraction is an incredibly important step and therefore the success of the classification strongly depends thereon. many different features were proposed within the literature. In horizontal and vertical projection with dynamic thresholding was proposed. Projection histograms are usually used for printed digit recognition and combined with other feature sets. Invariant moments like geometric moments, affine invariant moments, Legendre moments, Zernike moments, Hu moments, etc. are the common choices for features.

One of the foremost important parts of seeing algorithms and handwritten digit recognition algorithms is Classification. Classification in the subject area represents the prediction of sophistication or label for an object that supported its similarity with previous objects. In machine learning, each object or instance is represented

with an identical set of features. supported the academic algorithm, classifiers could also be divided into unsupervised and supervised classifiers. Supervised learning uses knowledge of labels for instances used for building the model while instances for unsupervised learning are unlabeled. Today, many techniques for building a classification model are used.

3.1.3 TRAINING ALGORITHMS

The main decision-making task of recognizing a digit is performed by the classifier model. Using the extracted features followed by previous stages identify the digits. during this work SVM, a machine learning algorithm is proposed as a classifier model.

Support Vector Machine (SVM) a binary classifier creates a hyperplane or group of hyperplanes in a very very high or infinite-dimensional space for separating data from different classes.

3.1.4 CONFUSION MATRIX

This is also the identical because the error matrix, by confusion matrix it's easily shown that what percent of predictions made by our classifier was correct and where it was difficult for the classifier to predict the actual classification. so on shown confusion matrix, it's better to practice to represent within the fashion of the table. Well for creating a confusion matrix for digits, would face 10 classes say 10 rows and 10 columns where every digit is compared with other digits, and might easily show where the classifier predicted wrong and where it predicted correctly along with the overall number times.

According to the definition given in the scikit-learn Confusion matrix, C is such c(i,j) is up to the number of observations are known to be in the group I but predicted to be in group j.

Terminologies used are

• TP = True positive

• TN = True negative

• FP = False positive

• FN = False negative

TP is that the proper identification of positive labels, TN is that the correct identification of negative labels, FP is that the wrong identification of positive labels, FN is inaccurate identification of negative labels.

3.1.5 ACCURACY

The overall effectiveness of the classifier, best defines the accuracy or portion of true results (meaning with verity positives and true negatives) from the entire.

Accuracy = (TP + TN) / N, where N is sum of TP, TN, FN, FP.

The maximum value that accuracy can do is 1.

```
[1014    0    2    0    0    2    2    0    1    3]

 [   0 1177    2    1    1    0    1    0    2    1]
 [   2    2 1037    2    0    0    0    2    5    1]
 [   0    0    3 1035    0    5    0    6    6    2]
 [   0    0    1    0  957    0    1    2    0    3]
 [   1    1    0    4    1  947    4    0    5    1]
 [   2    0    1    0    2    0 1076    0    4    0]
 [   1    1    8    1    1    0    0 1110    2    4]
 [   0    4    2    4    1    6    0    1 1018    1]
 [   3    1    0    7    5    2    0    4    9  974]]
```

Fig-3 Confusion Matrix

3.2 NEURAL NETWORKS

The structure of the human brain inspires a Neural Network. it's essentially a Machine Learning model (more precisely, Deep Learning) that's utilized in unsupervised learning. A Neural Network could also be online of interconnected entities called nodes wherein each node is liable for easy computation.

3.2.1 DATA ANALYSIS

Data analysis may be a process of inspecting, cleansing, transforming, and modeling data to discover useful information, informing conclusions, and supporting decision-making.

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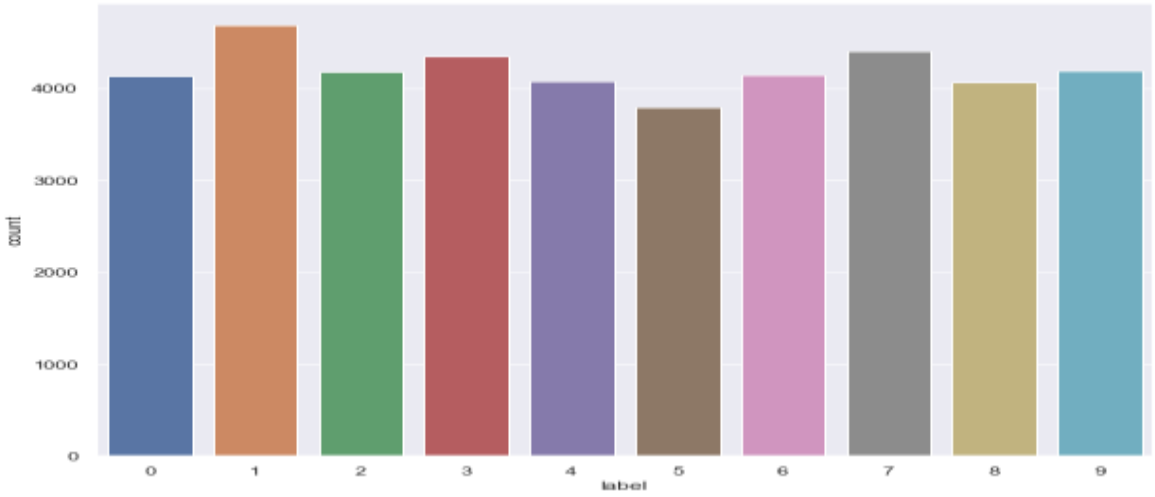

Fig-4 The given chart depicts Data with different Labels and the Count values

As shown within the above diagram, of the dataset we've, we depict data with different labels and also the Count values

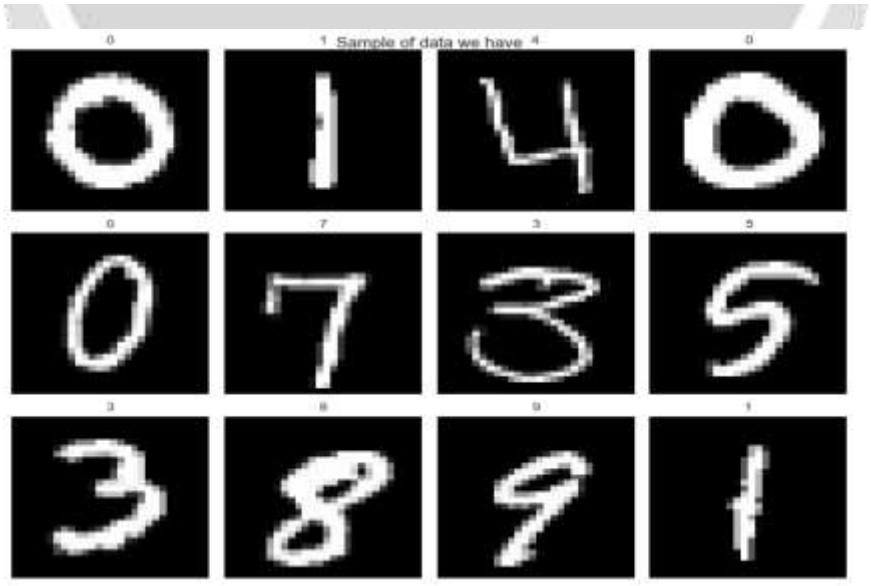

Fig-5 Sample data

The above diagram depicts the sample data we've and supported this data, how we are visiting train, and test the information to form the machine learn.

3.2.2 PREEPROCESSING, BUILDING, AND TRAINING OF NEURAL NETWORK

Using library sklearn.model.selection, import the train data. Based on that, the building of neural networks is done and also training of the neural network. After evaluation, we will be able to know the accuracy of the algorithm used.

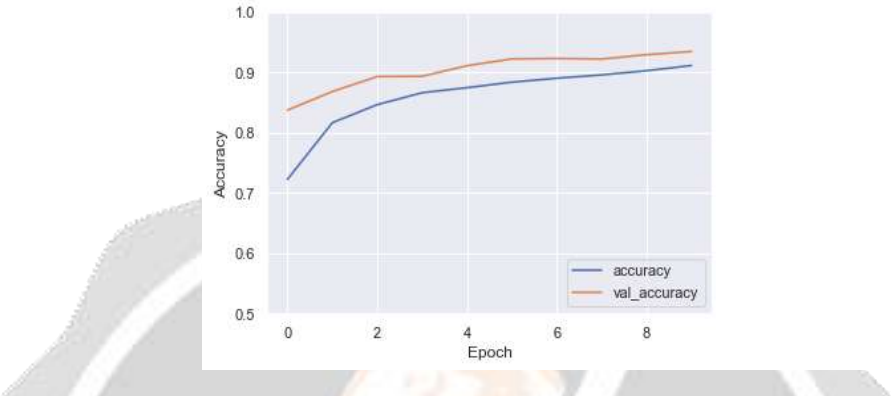

Fig-6 Accuracy

4. CONCLUSIONS

We proposed a novel algorithm for handwritten digit recognition. The goal was to use a simple feature set as input for the support vector machine that was used for classification. Building a neural network and training was done. We tested our proposed method on the standard MNIST dataset and achieved global accuracy of 93.043. We compared our method with other methods and our proposed method obtained better accuracy with a rather simple feature set. This establishes this approach as very robust and by using more complex features the results may perhaps be further improved. Additional validation is also done using other databases.

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