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Handwritten digit recognition using Machine Learning

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ABSTRACT

Handwriting is one of the mode available for communication. In today's world every domain like medical, business etc (for example-in storing the data) seems to be digitizing. But for currently available non digital form of data to be digitalized, usage of manual labour for this process will be quite expensive and tedious as well. To solve the above problem, pattern recognition applications can be helpful. In the text that is available, both digits and alphabets will be present from which we choose to solve the problem of digit recognition (0-9).Handwritten digit recognition is a technique or technology for automatically recognizing and detecting handwritten data into machine editable text through a Machine Learning model. The goal is to implement a pattern classification method to recognize the handwritten digits provided in the dataset containing images of handwritten digits based on the K Nearest Neighbors machine learning algorithm.We convert the given train image into grey scaled images and train the classifier and using the validation set generalizing it to reduce any kind of validation error. Finally, we will test the classifier using the testdata and see the outcome of the algorithm which will be a digit. For confirmation, we display the images using matplot library provided by python. Also, a database can be created with the digits written by us and they are tested.

***KEYWORDS:** Grey scale image, K –NN Classification algorithm, machine learning, matplot, MNIST dataset, hand-written digits.*

1. INTRODUCTION

Handwritten digit and letter recognition is a very important topic in the field of image processing and pattern recognition. Offline handwritten digit and letter recognition has numerous applications in different fields. Various algorithms using Machine Learning have been developed for classification and recognition of handwritten digits. There are four steps to be followed to solve a Machine Learning problem. They are conversion of domain problem to machine learning problem, data collection, training and deployment. Conversion of the problem to ML problem involves steps like consulting the domain experts etc. In the data collection step, data is collected and prepared for training the model. Training step makes use of the data and prepares the model. Finally, in the deployment step, the model is made available to the end users. For the samples available in the test data, the outputs are correctly identified. But due to the non-uniform presence of the samples of the digits, an external output may results in an incorrect output. So, a database of the samples in equal number is made and when tested, results in correct output. The process of creating own database is mentioned in the algorithm step. This can further be developed with more number of user samples for proper working of the algorithm.

STRUCTURE OF PAPER

The paper is organized as follows: In Section 1, the introduction of the paper is provided along with the structure, important terms and overall description. In Section 2 we discuss about Machine Learning. In Section 3 we have the complete information about workflow. Section 4 shares information about the dataset. Section 5 tells us about the methodology and the algorithm also about creating own database. Section 6 gives information regarding the performance metrics. Section 7 tells us about the future scope and concludes the paper with acknowledgement and references.

2. MACHINE LEARNING

Machine Learning had mainly four types of learning as follows:

A. Supervised Learning B. Unsupervised Learning C. Semisupervised Learning and D. Reinforcement Learning

A. Supervised Learning

This kind of learning uses a training set to teach models to yield the desired output. This training dataset includes inputs and correct outputs, which allow the model to learn over time. Examples of some of the Supervised Learning algorithms are Neural networks, Naive bayes, Linear regression, Support vector machine, K nearest neighbor, Random Forest etc. Supervised learning can be separated into two types of problems. They are Classification and Regression. Classification uses an algorithm to accurately assign test data into specific categories. It recognizes specific entities within the dataset and attempts to draw some conclusions on how those entities should be labelled or defined. Regression is generally used to make estimation for sales revenue for a given business. Also, it describes the relationship between dependent and independent variables. The problem of digit recognition comes under Supervised Learning.

B. Unsupervised Learning

This kind of learning uses machine learning algorithms to analyze and cluster unlabeled datasets. These algorithms discover hidden patterns from the data without the need for human interference. Its ability to discover similarities and differences in information make it the ideal solution for exploratory data analysis, cross-selling strategies, customer segmentation, and image recognition. Unsupervised learning models are utilized for tasks like clustering, association and dimensionality reduction. Examples of some of the Unsupervised machine learning algorithms include K-means clustering, Hierarchial clustering, Anomaly detection etc.

C. Semisupervised Learning

This is another class of machine learning process and technique that also makes use of unlabeled data for training (as unsupervised learning) but, typically, a small amount of labelled data with a large amount of unlabeled data is present and used by the model. This is usually referred to as partly labeled data.Semi-supervised learning programs do attempt to use certain standard assumptions to help them make use of unlabeled data. Different types of machine learning algorithms include self-training, graph based, low density separation etc.

D. Reinforcement Learning

Reinforcement learning is the training of machine learning models to make a sequence of decisions. In reinforcement learning, an artificial intelligence faces a game-like situation. The computer employs trial and error to come up with a solution to the problem. To get the machine to do what the programmer wants, the artificial intelligence gets either rewards or penalties for the actions it performs. Its goal is to maximize the total reward. By leveraging the power of search and many trials, reinforcement learning is currently the most effective way to hint machine's creativity. Examples include Q-learning, Deep Q network etc.

3. WORKFLOW

The first step deals with the extraction of data from the MNIST data set and the pre- processing of it. MNIST data set contains pictures of hand-written letters from different sources.The classification algorithm cannot work with the raw data which was extracted from the inputs directly. Indeed, a few changes need to be made to the data sets. So the raw data is converted into a single one-dimensional array. The second step deals with the classification of the data sets which is the training dataset being provided to it along with the validation set which will be used to generalize the classification algorithm and make it ready to deal with real-world problems. Thus, after training the classifier,the testdata which is similar to

the real-world problem is fed to the algorithm and what the classification algorithm does is to classify the data which is given. The testdata is also a type of traindata, in other words, the format of the data is the same as the traindata. Finally, the classification is done and the post processing takes place in which the data is converted back into the digital format and is displayed as an output.

4. DATASET

MNIST is short for modified national institute of standard and technology database. The MNIST dataset is a large database of handwritten digits. It is generally used for training various image processing problems. The MNIST dataset is used for training the model inorder to recognize the handwritten digits. This has an application in scanning for handwritten pin-codes on letters. MNIST contains a collection of 60,000, 28 x 28 images of handwritten digits from 0 to 9. The MNIST database contains 42,000 training images and 28,000 testing images. The digits from the databse have been size-normalized and centered in a fixed-size image. The original images (bilevel) from NIST set were size normalized to fit in a 20x20 pixel box while preserving their aspect ratio. The resulting images contain grey levels as a result of the anti-aliasing technique used by the normalization algorithm. The images were centered in a 28x28 image by computing the center of mass of the pixels, and translating the image so as to position this point at the center of the 28x28 field.

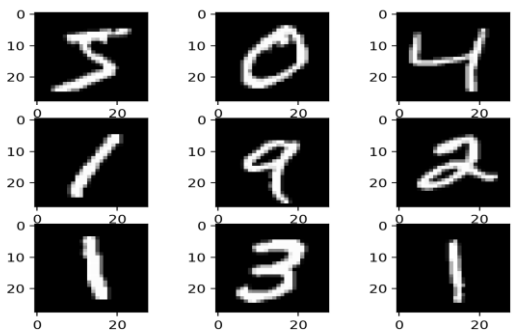

Figure 1: MNIST database sample images

5.ALGORITHM

To convert the image handwritten by us other than the ones in the database,

Step 1: Reading the image using PIL library.

Step 2: Convert the input image to grey scale image.

Step 3: Resizing the image to the required dimension of the classifier that is trained.

Step 4: Using the methods in numpy and pandas, we obtain the pixel values of the image.

Step 5: Store the label of each image along with the pixel values in the database.

Step 6: Give the trainset as input to the classifier. Step 7: Calculate the minimum distance using the Euclidean distances.

Step 8: Classify the given image to a label using minimum distance K-Nearest Classification Algorithm.

Step 9: End.

Classifier

K-nearest Neighbor is a non parametric and supervised machine learning algorithm used for both Classification and Regression. KNN works on the basic principle that "similar things are near to each to each other".

Figure 2: KNN Classification diagram

It predicts the class of the new data point by majority of votes of k nearest neighbors based on the similarity measure that is distance functions. Varying the value of the neighbours, differs the prediction class. It is commonly used for its easy of interpretation and low calculation time. K nearest neighbor algorithm is considered as the simplest classification technique. The classification of objects based on votes of its neighbors which represented by k. In K-NN test data is classified to a particular class which has majority of votes. Then we find the nearest neighbours of new-input data. We can specify how many neighbours we want. It returns the label given to new-comer depending upon the classifier which is built on the basis of the kNN theory we saw earlier. If you want single nearest neighbour algorithm, just specify k=1 where k is the number of neighbours. The working of the algorithm is as follows

• Compute the Euclidean distance between the test data point and all the training data.
• Sort the calculated distances in ascending order. • Get the k nearest neighbor labels by taking top k rows from sorted array of distances.
• Find the majority class of the returned rows.
• Return predicted class. Calculation of Euclidean distance: Euclidean distance is the square root of the sum of squared distance between two points.

6.PERFORMANCE METRICS

A Confusion matrix is an N x N matrix used for evaluating the performance of a classification model, where N is the number of target classes. The matrix compares the actual target values with those predicted by the machine learning model.The target variable has two values: Positive or Negative The columns represent the actual values of the target variable. The rows represent the predicted values of the target variable.

True Positive (TP) - The predicted value matches the actual value.The actual value was positive and the predicted value by the modela positive value. True Negative (TN) - The predicted value matches the actual value.The actual value was negative and the model predicted a negative value.

False Positive (FP) – Type 1 error.The value predicted was false. The actual value was negative but the model predicted a positive value.

False Negative (FN) - Type 2 error. The predicted value was falsely predicted.The actual value was positive but the model predicted a negative value.

Accuracy is the most intuitive performance measure and it is simply a ratio of correctly predicted observation to the total observations. Other performance metrics include Precision, Recall etc. Precision tells us how many of the correctly predicted cases actually turned out to be positive. Recall tells us how many of the actual positive cases we were able to predict correctly with our model.

In machine learning, we use the term parameters to refer to something that can be learned by the algorithm during training and hyperparameters to refer to something that is passed to the algorithm.For tuning of hyperparameters, GridSearchCV from scikitlearn library is used to find out the optimum value of 'k'.GridSearchCV() determines the parameters like n neighbors and weights etc and the best set of hyperparameters to use for this data is evaluated and the score is compared.

7.FUTURE SCOPE AND CONCLUSION

This paper gives an idea about the machine learning classifier — the k-Nearest Neighbor classifier, or simply k-NN for short. The k-NN algorithm classifies unknown data point by comparing the unknown data point to the total data points in the training set. This comparison is done using a distance function. Then, from the k most similar examples in the training set, we accumulate the number of votes for each label. The category with the highest number of votes wins and is chosen as the overall classification and that is the label of the new data point. While simple and intuitive, the overall accuracy of 97.9% is achieved in the recognition process.The work is carried out as an attempt, and the aim of the paper is to facilitate for pattern recognition. It is our future endeavour to modify this algorithm and design a still robust handwritten digit recognition for high recognition rate and also recognition of offline handwritten digit recognition.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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