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Handwritten Digit Recognition through Supervised Machine Learning

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Abstract: *Handwritten digit recognition system involves reception and interpretation of handwritten digit by supervised machine learning. Due to different in shape and orientation of handwritten digit. The applications of digit recognition includes in postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can 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 based on different machine learning technique. We are recognize the handwritten digit from 0-9. A dataset of 1000 sample were obtained from MNIST. In this paper the main objective of this paper is to ensure effective and reliable approaches for recognition of handwritten digit. Several machines learning algorithm namely, watershed algorithm, MNIST which is configured with KERAS model. In this paper our focus is on the improvement of the accuracy and efficiency of the handwritten digit recognition problem.*

Keywords: *Handwritten Digit recognition, machine learning, image recognition, MNIST, Machine learning Algorithm, Neural Network, Off-line handwritten recognition.*

I. Introduction

Handwriting recognition is the ability of a computer to retrieve and interpret handwriting input from sources such as paper documents, photographs, touch-screens and other devices. It is a classic machine learning problem, and the ideas have been applied to computer vision, speech, natural language processing, and other In this paper, we investigate the digit recognition problem using a machine learning approach that is implemented using a keras model to improve the efficiency. Handwritten digit recognition is already widely used in the automatic processing of bank cheques, postal addresses, etc. Some of the existing systems include computational intelligence techniques such as artificial neural networks. Handwritten digits recognition is a well-researched sub area within the field that is concerned with learning models to distinguish pre-segmented handwritten digits. It is one of the most important issues in data mining, machine learning, pattern recognition along with many other disciplines of artificial intelligence [4].The main application of machine learning methods over the last decade has determined efficacious in conforming decisive systems which are competing to human performance and which accomplish far improved than manually written classical artificial intelligence systems used in the beginnings of digit recognition technology. [5].

A great attempt of research worker in machine learning and data mining has been contrived to achieve efficient approaches for approximation of recognition from data. In twenty first Century handwritten digit communication has its own standard and most of the times in daily life are being used as means of conversation and recording the information to be shared with individuals. One of the challenges in handwritten digit recognition wholly lies in the variation and distortion of handwritten digit set because distinct community may use diverse style of handwriting, and control to draw the similar pattern of the digit of their recognized script with individuals. One of the challenges in handwritten characters recognition wholly lies in the variation and distortion of handwritten character set because distinct community may use diverse style of handwriting, and control to draw the similar pattern of the characters of their recognized script. There are many techniques that have been developed to recognize the handwriting. One of them is machine learning.

Problem with handwritten digits:

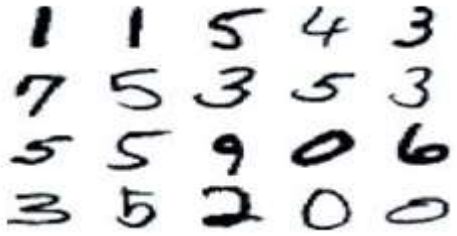
The handwritten digits are not always of the same size,domains[1][2] For example, digit recognition has been employed regularly by the post office for the purposes of classifying mailing addresses using machine learning[3]. Different people have very different writing style; even digits of a same person written in different time are not identical. How does artificial intelligence deal with the infinite possibility of different shapes of digits, given only an image.

width , orientation and justified to margins as they defer from writing of person to person, so the general problem would be will classifying the digits due to the similarity between digits such as 1 and 7,5 and 6, 3 and

8, 2 and 5, 2 and 7 etc. This problem is faced more when many people write a single digit with a variety of different handwritings. [6]

Various type of handwritten digit

Handwritten digit recognition plays a significant role in many user authentication applications in a modern world. The handwritten digit are not of the same size, thickness, style and orientation, therefore, these challenges are to be digit to resolve this problem. The handwritten digits are not always of the same size, width , orientation and justified to margins as they defer from writing of person to person, so the general problem would be will classifying the digits due to the similarity between digits [10]



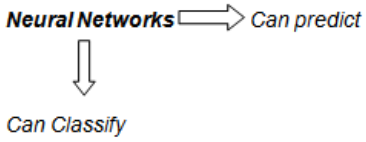
Why use machine learning: Machine Learning Vs Deep learning

Properties	**ML**	**DL**
Amount of data	Small	Big
Features	Need to be created manually	Learn automatically
Time	Short	Long
Accuracy	Good	The best
Debugging	Easy(know flow of information)	Very difficult(Black Box)
Expensive	Less	More

Machine Learning

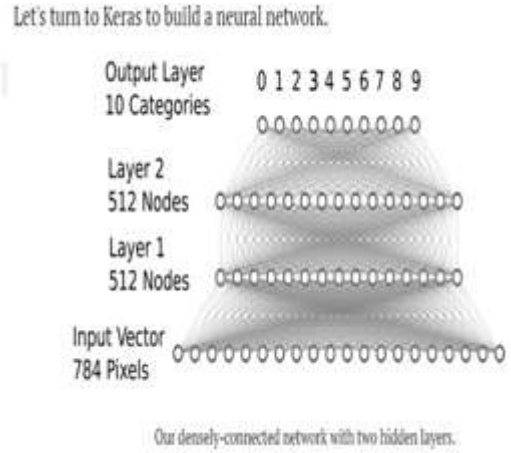
Machine learning is a branch of science that deals with programming the systems Machine learning is an artificial intelligence (AI) discipline geared toward the technological development of human knowledge. Machine Learning is a technique which works intelligently by using some complex algorithms and set of predefined rules. It uses the past data to read the patterns and then based on the analysis it generates the relevant data to performs the intended task abiding the defined rules and algorithm. Machine learning allows computers to handle new situations via analysis, self-training, observation and experience. Machine learning facilitates the continuous advancement of computing through exposure to new scenarios,

testing and adaptation, while employing pattern and trend detection for improved decisions in subsequent (though not identical) situations.[7]



What is machine and Architecture and parameters you are considering?
A final machine learning model is a model that you use to make predictions on new data.
That is, given new examples of input data, you want to use the model to predict the expected output. This may be a classification (assign a label) or a regression (a real value).

Building the Network



Our pixel vector serves as the input. Then, two hidden 512-node layers, with enough model complexity for recognizing digits. For the multi-class classification we add another densely-connected (or fully-connected) layer for the 10 different output classes. For this network architecture we can use the Keras Sequential Model. We can stack layers using the .add () method.

When adding the first layer in the Sequential Model we need to specify the input shape so Keras can create the appropriate matrices. For all remaining layers the shapeis inferred automatically.

In order to introduce nonlinearities into the network and elevate it beyond the capabilities of a simple perceptron we also add activation functions to the hidden layers. The differentiation for the training via back propagation is happening behind the scenes without having to implement the details.

We also add dropout as a way to prevent over fitting. Here we randomly keep some network weights fixed when we would normally update them so that the network doesn't rely too much on very few nodes.

The last layer consists of connections for our 10 classes and the softmax activation which is standard for multi-class targets.

Supervised Learning:

Supervised learning is the Data mining task of inferring a function from labelled training data. The training data consist of a set of training examples. In supervised learning, each example is pair consisting of an input object and a desired output value. A supervised learning algorithm analyzes the training data and produces an inferred function, which can used be for mapping new examples. An optimal scenario will allow for the algorithm to correctly determine the class labels for unseen instance. This requires the learning algorithm to generalize from the training data to unseen situation in a "reasonable" way. [8]

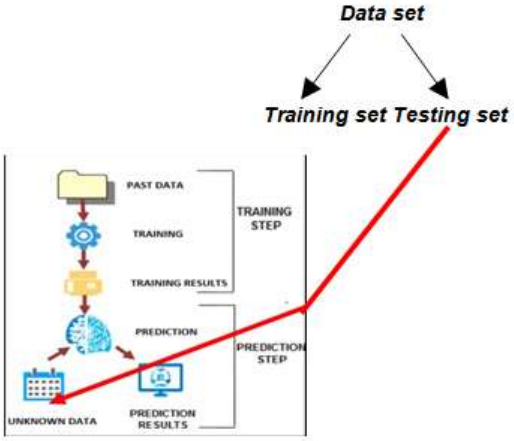


Fig: flow graph of machine learning

Supervised Methodologies:

How to Make Predictions with Keras:

Once you choose and fit a final deep learning model in Keras, you can use it to make predictions on new data instances.

1. Finalize Model
2. Classification Predictions
3. Regression Predictions

1. **Finalize Model**

Before you can make predictions, you must train a final model. You may have trained models using k-foldcross validation or train/test splits of your data. This was done in order to give you an estimate of the skill of the model on out of sample data, e.g. new data.

These models have served their purpose and can now be discarded.

Why do we use train and test sets?

Creating a train and test split of your dataset is one method to quickly evaluate the performance of an algorithm on your problem.

The training dataset is used to prepare a model, to train it.

We pretend the test dataset is new data where the output values are withheld from the algorithm. We gather predictions from the trained model on the inputs from the test dataset and compare them to the withheld output values of the test set.

omparing the predictions and withheld outputs on the test dataset allows us to compute a performance measure for the model on the test dataset. This is an estimate of the skill of the algorithm trained on the problem when making predictions on unseen data.

2. **Classification Predictions**

Classification problems are those where the model learns a mapping between input features and an output feature that is a label, such as "digits" and "not digits".

Class Predictions

A class prediction is given the finalized model and one or more data instances, predict the class for the data instances.

We do not know the outcome classes for the new data. That is why we need the model in the first place.

We can predict the class for new data instances using our finalized classification model in Keras using the predict classes () function. Note that this function is only available on Sequential models, not those models developed using the functional API.

Probability Predictions

Another type of prediction you may wish to make is the probability of the data instance belonging to each class.

This is called a probability prediction where, given a new instance, the model returns the probability for eachoutcome class as a value between 0 and 1.

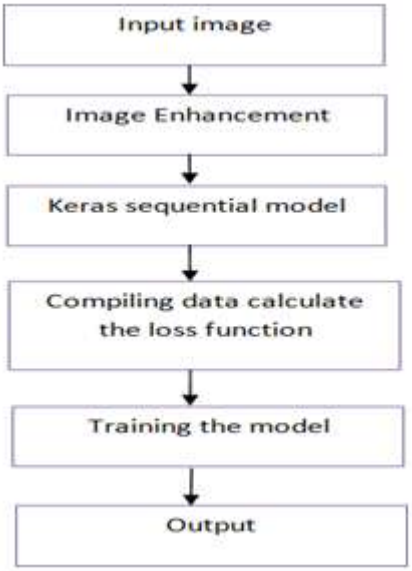
3. **Regression Predictions**

Regression is a supervised learning problem where given input examples, the model learns a mapping to suitable output quantities, such as "0.1" and "0.2", etc.

We can predict quantities with the finalized regression model by calling the predict () function on the finalized model.

The predict () function takes an array of one or more data instances.

Flow of project:



Input image:

Image Enhancement:-

Image enhancement is usually used as pre-processing steps in the fundamental step involved in digit image processing. Image enhancement is the process of adjusting digit image so that the results are more suitable for display or further image analysis

Keras sequential model:-

Neural network model in keras the focus of the keras library is the model .the simplest model is defined in the sequential class which is the linear stack of layers .sequential is the easiest way to build a model in keras it allows you to build a model layers by layer .each layer has weight that correspond to the layers.

Output:-

MNIST Dataset: In this paper we will demonstrate the use of tensor flow to recognize handwritten digit using neural network.

Fig: mnist dataset

Data is obtained from the MNIST dataset. National Institute of Standard Technology (NIST) has constructed and provided a from a number of scanned document images of digits were taken from a variety of scanned documents, normalized in size and centered. This makes it and excellent dataset for evaluating models, allowing the developer to focus on the machine learning with very little data cleaning or preparation required. In this dataset, each image is a 28 by28 pixels square (784 pixels total) .A standard split of the dataset is used to evaluate and compare models. It is the digit recognition task. As such there are 10 digits (0 to 9) or 10 classes to predict. The dataset was constructed from a number of scanned documents dataset available from the National Institute of Standard and Technology (NIST). This is where the name for the dataset comes from, as the Modified NIST or MNIST dataset. [9]
There are three types of data sets – Training and Test that are used at various stage of development.

Where and how you are training your data?
Before you can make predictions, you must train a final model.You may have trained models using k-fold cross validation or train/test splits of your data.

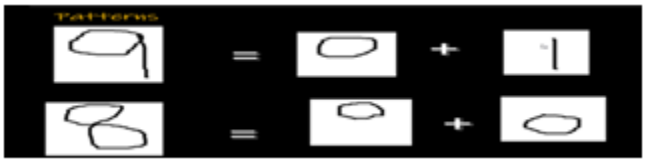
K-fold cross validation:
Cross-validation is another method to estimate the skill of a method on unseen data. Like using a train-test split.
Cross-validation systematically creates and evaluates multiple models on multiple subsets of the dataset.
With the finalized model, you can:

- Save the model for later or operational use.
- Make predictions on new data.

Training the model:
A machine learning model can be mathematically representation of a real world process the learning algorithm find pattern in training data such that input parameters correspond to the target. The

output of training process which you can use to make 0/prediction.

- **Training Data:** The part of data we use to train our model. This is the data which your model actually sees (both input and output) and learn from.



- **Testing Data:**

Once our model is completely trained, testing data provides the unbiased evaluation. When we feed in the inputs of testing data, our model will predict some values (without seeing actual output).

After prediction, we evaluate our model by comparing it with actual output present in the testing data. This is how we evaluate and see how much our model has learned from the experiences feed in as training data, set at the time of training

Watershed

In the study of image processing, a watershed is a transformation defined on a gray scale image. The name refers metaphorically to a geological watershed. Or drainage divide, which separates adjacent drainage basins. The watershed, transformation treats the image. it operates upon like a topographic map, with the brightness of each point representing its height, and finds the lines that run along the of ridges.

Fig: image enhancement process input

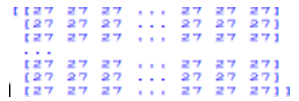


Fig b: image into array format

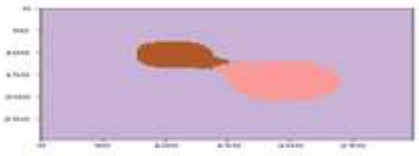


Fig c: image enhancement output

Future Scope:-

1. Can be integrated with other machine learning algorithms to get more accuracy.
2. Can be tested for more training dataset.
3. Detect joint numbers with more accuracy.
4. Can identify digits between characters.
5. Can be improved for real time digits recognition compatible with other devices.

II. Conclusion:

machine learning techniques are being widely used solve real word problems by storing manipulating extracting and retrieving data from larges sources. Supervised machine learning technique has been widely adapted how where this technique proves to be very expensive when the system demand implement over wide rang of data. This is due to the fact that significant amount of effort and cost is involved because of obtaining large labelled data sets. Classifications have to be done to gain numeral digits. Neural network seems to be better than other techniques used for reorganization.

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