Rajiv Gandhi University of Knowledge Technologies - Basar

Project Report - Handwritten Digit Recognition using KNN
(Machine Learning)
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1. Abstract

The task for handwritten digit recognition has been troublesome due to various variations in writing styles.The problem of handwritten digit recognition has long been an open problem in the field of pattern classification. It is a hard task for the machine because handwritten digits are not perfect as different people has different styles of writing. Machine learning solved these problems by finding the patterns in the data. The main objective of this project is to provide a technique for recognition of hand written digits by using K-Nearest Neighbor classifier.

2. Introduction

The problem of handwritten numerals recognition has been widely studied in recent years and the large quantity of preprocessing methods and classification algorithms have been developed. However, handwritten numerals recognition is still a challenge for us. The main difficulty of handwritten numerals recognition is the serious variance in size, translation, stroke thickness, rotation and deformation of the numeral image because of handwritten digits are written by different users and their writing style is different from one user to another user. Handwriting recognition is classified as offline handwriting recognition and online handwriting recognition. If handwriting is recognized while writing through touchpad using the stylus pen, it's called online handwriting recognition. In this case, handwriting is scanned and then understood by the computer, it is called offline handwriting recognition.

Hand written digit or character recognition helps us in many ways like sorting the postal cards, bank check processings,scanning the hand written documents which can convert directly into soft copies. This problem of handwritten digit recognition falls under the computer vision which is also a sub-field of machine learning. This project helps you develop to handwritten digit recognition model and study the K-NN classifier algorithm which is also used as a regressor from the scratch.

3. Theory (Machine Learning)

Machine learning is a sub-field of **Artificial Intelligence** that provides systems the ability to automatically learn and improve form experience like humans do without being explicitly programmed. Machine learning focuses on predicting the future values in various domains by digging insights from the past data.

Machine learning mainly classified into Supervised Learning, Unsupervised Learning, Semi-Supervised Learning, Reinforcement learning.

3.1 Supervised Learning

Supervised Learning is a type of machine learning in which the machine learns a prediction function that maps the input with the output. There are two types of Supervised Learning:

Classification - the target feature is discrete valued
Regression - the target feature is continuous valued

3.2 Unsupervised Learning

Unsupervised Learning is a type of machine learning in which patterns are learned from unlabeled data.
The following tasks comes under Unsupervised Learning.

Clustering - An ML task of grouping instances in the data in such a way that instances in the same group (called as cluster) are more similar than those to other groups (clusters)
Hierarchical Clustering - is a method in which a hierarchy of clusters is created by observing patterns in data
Association Rules - A method for discovering interesting relations between features in the unlabeled data

3.4 Semi-supervised Learning

Semi-supervised Learning makes use of large amount of unlabeled data along with a small amount of labeled data to achieve results which are better than using just labeled or unlabeled data.

3.5 Reinforcement Learning (RL)

RL is about learning to make a good sequence of decisions. The applications of RL are vast .For examples, it can be use to make the robots to learn.

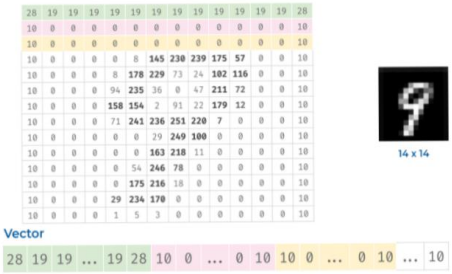
4. K- Nearest Neighbors (KNN) algorithm

KNN algorithm is supervised learning which is used for both regression and classification. In this projects as we want to recognise the hand written digits from 1- 9 . This is project belongs to classification problem and below follows the algorithm

4.1 Dataset

MNIST dataset released in 1999 . Contains Training examples - **60,000** and Test examples - **10,000**

In this project we used MNIST dataset which contains labeled grayscale images of size **28 *28** pixels.
In grayscale images each pixel is a shade of gray and can have values between **0** and **255**
A image is represented by the matrix of values(0 - 255) and stored in the computer and the matrix is converted into a vector and labeled with corresponding labels.



4.2 Algorithm

The K-Nearest-Neighbor is a type of Lazy Learners and one of the most commonly used nearest neighbor-based algorithms, works on learning by analogy, that is by comparing a given test example with training example that are similar to it.

I. When unkown sample is given ,calculate the distance between the sample in validation set and every sample in the training set.
II. Now sort the distances and pick the k- nearest distances . Here k is an integers 1,2,3,…
III. We predict the sample as the majority class in the k-classes that we have sorted.
IV. Also the class can be predicted based on majority based, weights of the distances.

4.3 Distance Measures

- How do we measure the distances between the two vectors(images) . As the images are represented in the form of vectors as shown in the above picture with the high dimensionality.
- Simply, we extend the concept of finding the distances in 2D plane to ND plane.

I. Euclidean distance -

$$\bar{a} = [a_1, a_2, \ldots, a_n]$$

$$\bar{b} = [b_1, b_2, \ldots, b_n]$$

$$\sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2 + \ldots + (a_n - b_n)^2}$$

II. Manhattan Distance - Manhattan distance might work better than euclidean distance in high dimensions

$$\bar{a} = [a_1, a_2, \ldots, a_n]$$

$$\bar{b} = [b_1, b_2, \ldots, b_n]$$

$$|a_1 - b_1| + |a_2 - b_2| + \ldots + |a_n - b_n|$$

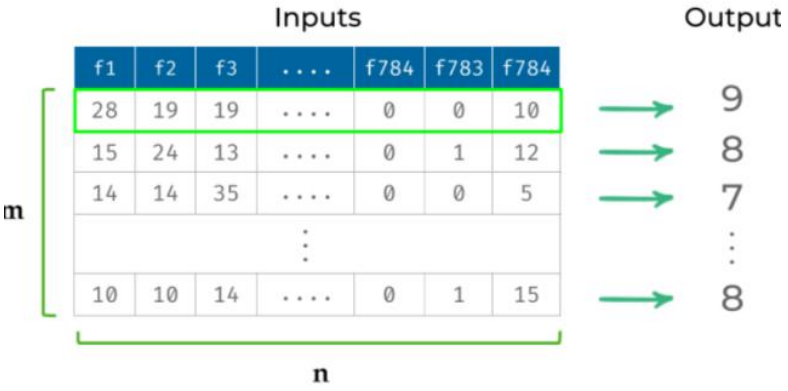
III. Minkowski Distance - Here n in the formula is hyperparameter we tune and fix the n value. In the project we took n = 2

$$L^n(a,b) = \sqrt[n]{\sum_{i=1}^{\#dim} |a_i - b_i|^n}$$

n = 1 ⇒ Manhattan Distance

n = 2 ⇒ Euclidean Distance

4.4 Data representation input and output



m represent the no.of samples
n represent the no of features

5. K-NN Implementation

Google drive link https://colab.research.google.com/drive/15FdXLgaWn56XJiyaKr7dHKCCLXGJFi5f?usp=sharing

6. Accuracy

The KNN model trained with 59,000 samples out of 60,000 and got the accuracy of 96.6% with **k = 20 and n = 2.**

7. Conclusion

Handwritten digit recognition is the first step to the vast field of Artificial Intelligence and Computer Vision.Handwritten digit recognition is the first step to the vast field of Artificial Intelligence and Computer Vision. Even though the project shows that it has given a accuracy of 96.6% with the simplest machine learning technique (K-NN). This project can also be done using many other machine learning technique like svm, decision tree, neural networks which the accuracy might increase but getting the 96.6% accuracy is good enough. This KNN algorithm can be used to solve many more problems.