

IMAGE PROCESSING USING MACHINE LEARNING

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Abstract: The paper basically describes the anomaly of demonstrating the mathematical methods and the algorithm required for their recognition. The use of handwritten mathematical symbols and equations has gained a lot of attention and consolidation in the field of pattern recognition. With the invention of new and advanced algorithm for the identification of the handwritten characters, now and more heterogeneous handwritten digits data set appears into sight. But the problem lies in the behavior of those handwritten data sets. For deciphering the drawback that handwritten digit data set of different feature can't compute, we design a more sophisticated handwritten digit representation model based on multiple instance learning (MIL), where a bag contains different digit data from different feature spaces. This paper consists of different approaches to an off-line pattern recognition using different machine learning techniques. Several machine learning algorithms like Multilayer Perception, Support Vector Machines, Convolutional Neural Networks, and many more. The main purpose or objective is to recognize the effective and efficient method for recognition of the pattern. The paper shows different classification algorithms have their different accuracy. The process of identification of the symbol and different numbers are generally based on the methods of machine learning. For the initial initialization of the symbols a segmented binary image passes a "rough" classification by the Bayesian Network Neural Network are also used for classification using contents.

Keywords: pattern recognition, handwritten recognition, digit recognition, machine learning, machine learning algorithms, neural network, classification algorithms.

1. INTRODUCTION

From centuries, there are various modes of communicating with others, handwriting is one of those means we have. But nowadays due to advancement in technology, computers and the Internet are the compelling way of latest communication, turning the world upside down and recompressing into a small town. To make machines more interactive and smart the developers are taking into account various machine learning, deep learning concepts, just like a human learns to perform a respective task by practicing it again and again so that it can master the task. However recognition of handwritten digit recognition is still a concern. It generally consists of three steps. First, a sequence of input strokes is segmented into hypothetical symbols (symbol segmentation). Then hypothetical symbols are recognized by a symbol classifier (symbol recognition). Finally, structural relations among the recognized symbols are determined and the structure of the expression is analyzed by a parsing algorithm in order to provide the most likely interpretation of an input OHME (structural analysis). It takes into account different neural used as a tool for different kind of problems. The basic behind the pattern reorganization is to develop useful application and software through the use of digital image processing, over the years, a great work by the researchers in the machine learning and data mining concepts have been elaborated to achieve a coherent approach for approximation of the mathematical equation recognition. Now a days, pattern reorganization is widely used as a tool for communication and information related purpose for the individual. But every aspect has some problem related to it. With respect to pattern reorganization, the drawbacks in the variation and form of handwritten character set because different community has different styles of writing. Handwritten dataset are generally indefinite in nature because they may not be sharp and perfect reorganization is to remove the redundancy from the data. The main approach that the developer have used is SVM based offline handwritten pattern reorganization system. The SVM model is being performed on NIST SD19 standard data set.

The mathematical equation consists of different number or operators and symbols representing their own importance. The conversion of those mathematical equation to the testimonial and vice versa urges the developers to endorse different technology features like extraction and recognition. The problem becomes more intense when the handwritten pattern is provided as input to the computer. The quality of image, font and size of symbols, pattern and writing style of the writer further arouse the problem in identification of the elements of the mathematical equation. One of the main problem with the recognition of the mathematical equation is that they are not fully conveyed the way they are found in the survey by the authors. The construction of equation in digital format is inconvenient and clumsy and does not go hand in hand with the actual writing style. In today's case, the pattern recognition can be carried out in two ways – one is offline mode and the other one is online mode. Both the method can be suitable in their own ways. Online mode is generally considered faster than offline mode, as, in the former one the element gets recognized as soon as it is entered while in the latter, the reorganization takes place after completing the data entry.

The section 2 of our paper deals with the literature survey which includes the brief information about the researched done by different research era in the field of handwritten recognition.

Similarly section 3 highlight the different methods that are used in the recognition system. Starting with the Hybrid Feature Extraction Technique, it performs different operation like Preprocessing, Segmenting, and Feature Extraction, classifying the data and then training and finally its recognition. Additionally we explained the most popular and used method upon its invention, i.e.,

CNN method. The CNN method used a convolution which is a mathematical operation that produces output function from two different function. In this method we used a process what we called as Sub sampling method. The next method that we used is the kNN method. The kNN method is used for regression problems or when the amount of data is very large. In this method, the computations are divide till the end most stage of classification hence it is also known as late learning classification algorithm.[15]. The last and most accurate of all the above mentioned method is the SVM method. SVM method is supervised learning method with an additional bonus of classification and regression problems. The SVM method is used as an alternative to various NN methods. The main advantage of this method is that it takes both the experimental data and the structural behavior based on the principle of Structural Risk Minimization (SRM). This method is used for nonlinear datasets.

In section 4, the paper deals with the overall conclusion that was made after going through all the different methods, we found out that the SVM method was approximately better in both the training and testing datasets.

II.LITRATURE REVIEW

In this section of our paper, we will highlight some of the below mentioned paper which is used as a reference to depict what different techniques were used by different researchers in the field of handwritten digit recognition.

Zeeshan Khan, Sandeep Kumar and Anurag Jain put forward a paper based on Content Based Image Classification using Machine Learning Approach, in which they mentioned different techniques like KNN, DT and SVM which are used for image classification and present a detailed comparative analysis of the above techniques. They came to a conclusion that SVM performs better results as compared to the other techniques but finds out SVM still faces some problem related to feature outlier and core problem.[1]

K.Gaurav, Bhatia P. K. [3], this paper deals with assorted pre-processing techniques used for handwritten recognition which consists of different images starting from a simple handwritten document and extending its radius to complex background and diverse image intensities. The pre-processing techniques that were included are contrast stretching, noise removal techniques, normalization and segmentation, binarization, morphological processing techniques. They came to the conclusion that no technique for preprocessing can single handedly can be used to produce an image. All the techniques goes hand in hand. Even though after applying all the said techniques, the accuracy of the image in not upto the mark.

Salvador España-Boquera, Maria J. C. B., Jorge G. M. and Francisco Z. M. [4], this paper outlines the hybrid Hidden Markov Model (HMM) is used to conceive the unconstrained offline handwritten texts. The main characteristics of the recognition systems is to produce a new way in the form of preprocessing and recognition which are both based on ANNs. The preprocessing is used to clean the images and to enhance the non-uniform slant and slope correction. Whereas the recognition is used to estimate the emission probabilities.

Sai Abhishikth Ayyadevara, P N V Sai Ram Teja, Rajesh Kumar M [7],this paper deals with two different proposals of machine learning technique. The first one was a new feature extraction technique, includes the feature of three different existing feature extraction techniques. While the second one includes the analysis of the performance of three different neural network for two different feature technique- geometric and gradient. After doing all the survey, they concluded that Convolutional neural network is most efficient observed through Levenberg-Marquardt algorithm.

Dharmendra Patidar, Manoj R. Mishra, Bhavin C. Shah [8],this paper content with the KNN method used for image classification with different wavelet. The wavelets which are included in this paper include-Haar,Db4 and Demy and to compare the output result through KNN classifier in terms of the classification efficiency. They cam to conclusion that demy wavelet based KNN provides the highest classification efficient which is almost approx to 100% with the training data. demy takes more classification time than Hear and Db4 that's why we can use Db4 as it also has good classification efficiency.

Anuj Dutt, Aashi Dutt [13], this paper implements the Handwritten Character Recognition using Deep Learning. This paper also includes some of the machine learning algorithms like RFC, CNN and SVM. These three algorithms were trained and tested on the same data set and a comparison is drawn between the three and to see why Deep Learning is used in these critical situations. They revealed that the accuracy of CNN method with Yens or Flow is 99.98% for trained images and 98.72% for tested images.

III.RELATED WORK

This section of the paper deals with the efforts carried out by various developers towards the chore of recognizing handwritten pattern expressions. The centre of attention is on different techniques that is widely used for identifying the mathematical patterns. Much of the work has been published till date by different researchers on acknowledging the handwritten digits and English words. For Recognition of Handwritten Mathematical Expression (HME), MNIST data set is considered to be as a basic set, this dataset generally consist of 60,000 training set and 10,000 testing set which are very helpful in pattern recognition. This dataset is generally a subset of larger version of NIST dataset. The MNIST dataset has been set up from NIST's Special Database 3 and Special Database 1 in which binary images of handwritten digits are accommodated and different machine learning algorithms like KNN, CNN, SVM etc. are used to test this dataset and minimize the error rate.

a. Hybrid Feature Extraction Technique:

R.Padmaprima and S. Karpagavalli[9] conceive the mathematical expression recognition arrangement carried out in different stages which include collection of data from different sources, followed by the major processes including preprocessing, segmentation, feature extraction and finally symbol classification and mathematical expression recognition are performed.

Input Image Acquisition- The image of mathematical equation via $a^m \cdot a^n = A^{m+n}$, $ax+by=c$, $y[n]=x[n]**h[n]$, law of gravity, Convolutional integral has gather as an input and provided to the proposed system. The offline approach is used to capture the image from the scanner. Various data from the data set such as numbers, alphabetical characters, symbols and special characters has been collected from different sources as a database and putted into sequential form.

Preprocessing- Input images which are in color format are converted into black and white form with a threshold of 0.5 through a grey scale images. This transformation or what we can say Image cleaning takes place to remove unwanted spots from image. The component whose size is less than 50 pixels is removed from the image. However, image inversion and reshaping takes place.

Segmentation-In this phase, structural and functional analysis is used. In segmentation, separation of words, lines, characters which consequently affects the recognition rate of script. Input images are broken into individual characters and then each character is resized into $5*7$ pixels towards training methods.

Feature Extraction- The process of extracting certain type of information from scanned input image is known as extraction. The features viz. area, boundary box, centroid, zoning density and line segment are extracted from the image. Centroid extracted to find out the weights of the component and it locates the centre of component.

Classification- In this part, neural networks are used as classifier. Neural Network are generally based on soft computing techniques. The architecture used in designing neural network is arranged in layers known as multilayer perceptron. It consist of three different layers including input layer, one or more layer of hidden nodes and a layer of outer nodes. This phase is dependent on the previous phases as the classification performance depends on good feature extraction.

Training and recognition- In this phase, all the digit collected from the data set are trained and the recognized for performing the further processes. Multilayer Perceptron Feed forward Back propagation neural network is used for recognition of handwritten mathematical symbols and recognition.

In simple terms, different phases plays a vital role in recognition of mathematical equation. Preprocessing [9] process involves various four different operation that includes:

- * Binarization-This process converts the grey letter image into binary letter image.
- * Noise Reduction-This operation, marks the image, or the finer details of the image, if they were concealed by the noise, and hence become even less visible after noise reduction.
- * Size-normalization –This process changes the range of pixel intensity values.
- * Skew detection and Correction-The skew detection identifies the divergence of the text lines from the horizontal or vertical axis.

A well-known connected component analysis technique is used in the segmentation process. The features extraction set also consists of different operations including

- * Zoning-In this step, the image is divided into different window frames of equal dimension and feature extraction is used.
- * Skeletonisation-This method is directly connected to binary pixel image.
- * Directional Features-This step is used to refine any characters boundary line and also line segments in the image.
- * Determining Directions- There are different boundary parts that could be obvious in each individual image is also consists of 4 parts,

:- Vertical Type

:- Horizontal Type

:- Right Diagonal

:- Left Diagonal.

Support Vector Machine(SVM) and Multilayer Perceptron(MLP) classifiers are used in the recognition process. The recognition rate is different for both the classifiers. For MLP, the recognition rate is 92% and for SVM classification it is 85%.[9]

b. Convolutional Neural Network

Upon its invention, CNN method was considered to be the best for the identification of mathematical pattern or English word. Different papers report various ways of achievements better results when training and evaluating CNNs.

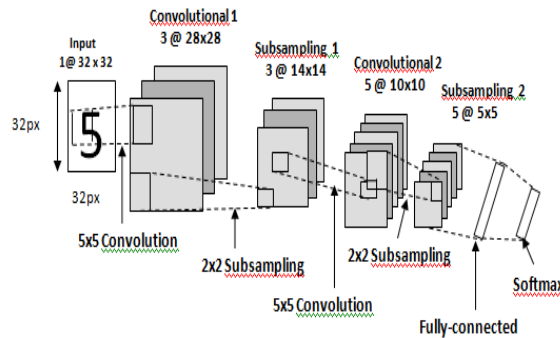


Figure1. Architecture of CNN

Convolutional Neural Networks(CNN) are the modified version of the Multilayer Perceptron(MLP) which is one of the architecture of Artificial Neural Network. Unlike MLP, CNN consist of a Convolutional layer and sub sampling layer . CNN authorizes three different concept related to machine learning system that are- 1. Sparse Interaction 2. Parameter Sharing 3. Equivariant Representation. Sparse Interaction is used to detect small and meaningful features such as edges by making the kernel smaller than the input . We can also refer to it as the sparse connectivity or sparse weight. Parameter Sharing, as the name suggests, means that each feature map is sharing the same weights, hence the number of parameters is reduced. The parameter sharing causes the layer to have the property known as equivariance and translation. Every layer is connected to the previous layer by a filter.

Convolution

Generally, a convolution is a mathematical operation on two functions that produces a third function expressing how the shape of one is modified by the other. It is an image processing operation that transforms an input image in order to show specific feature, e.g. edge detection, image sharpening, and image blurring. The input image can be altered by curling around the image and the matrix, called as filters or kernels.

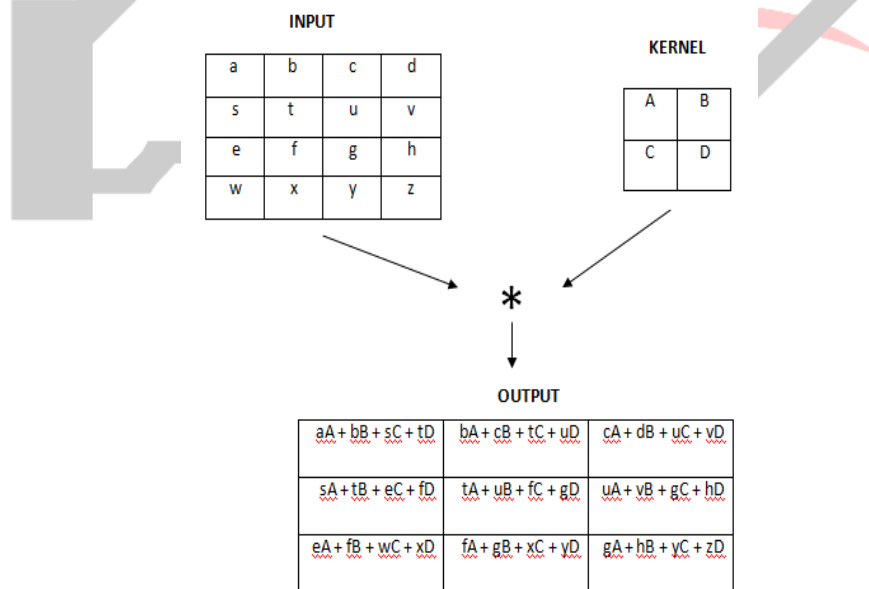


Figure2. Sub sampling

Sub sampling

It is a process of converting an input feature to become another feature based on its statistical representation. It is also known as pooling method. Another benefit of using pooling is to reduce sensitivity to invariance, such as translation, rotation, and distortion of the input. This functionality is performed in non overlapping neighborhoods. It also reduces the size of the input image. Researchers found out that there are different types of pooling but the most accurate are the max pooling and an average pooling.

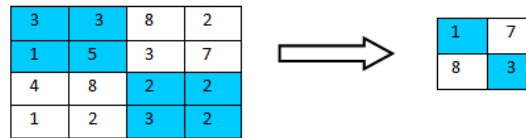


Figure 3.CNN

There are five different layers in Convolutional Neural Network. They are

1. Input- In this layer, raw pixels are provided as input.
2. Convolutional Layer- In this, the input layer changes the result of the neuron layer. The filter that are going to be used should be defined beforehand.
3. Rectified Input unit [ReLU] layer-During back propagation , this function prevents the values of pixels from changing. It also provides activation function on the image.
4. Pooling layer- It performs a down sampling operation along the height and width of the image.
5. Fully connected layer-In this layer, focus is on score class and who has the maximum score of the input digit is found.

c. K NEAREST NEIGHNORS (KNN)

KNN is a non parametric, lazy learning algorithm .KNN method classification is based on the nearest distance of neighbor classes. It only selects the k-nearest neighbor depending upon the distance. Then we calculate the majority weight to calculate the best for the point. The word distance plays a key or vital role in this algorithm.KNN image classifier provide good image classification when the suspicious images is similar to one of the stereotyped images in the class. Moreover the NN method is considered to be the most competitive among all the other method based on the domains of other algorithms, where the number of labeled database images is very high relative to the class complexity. However the NN method classifier cannot deduce much beyond the labeled classified image. In real time evaluation, total number of trials are very small relation to its class complexity. There is very large discrepancy in object shape and appearance when there are only images that are identified from a class, due to which bad classification is obtained. Nowadays this method is widely used for regression and classification of multiclass images. Classification is completely based on the distance from its neighbors. If $k = 1$, the algorithm can be considered as the nearest neighbor algorithm and the object is classified to the class of its nearest neighbor. Euclidean formula is most commonly used to calculate the distance between the neighbors. Euclidean squared, city-block, Hamming, Chebyshev are some distance measuring methods used in k-nearest-neighbor.

$$d(r, s) = \sqrt{(r_1 - s_1)^2 + (r_2 - s_2)^2 + \dots + (r_n - s_n)^2}$$

$$= \sqrt{\sum_{i=1}^n (r_i - s_i)^2}$$

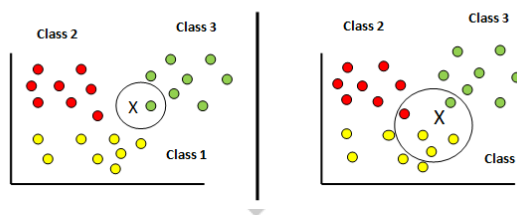


Figure 4.a.

Figure 4.b.

KNN method classifier is generally consists of different steps[15]. These include

1. First step include providing the input image to the classifier picked from the given database. Size of the image is not defined , hence we can pick any pixel sized image.
2. In this step resizing of the images is done as the image selected from the database may be very large, and hence large size images increases the complexity of the classifier.
3. The third step is based on RGB color band. For success extraction we have to find the RGB color band of the image. The RGB color band of each resized image is determined and then each band is degrade into six decomposition level by using discrete wavelet transform.
4. In this step we find the color moment of first order from each decomposed color band and then normalized each color band. Normalization changes the pixel information of each decomposed image.
5. Image features of each band is obtained. Image feature contains all the important information about the classification and used as input for algorithm.

- 6. This step consist of KNN classifiers. The result obtained in the step 5 is provided as the input to the classifier and used as an important information.

d. SUPPORT VECTOR MACHINE (SVM)

Like KNN, Support Vector Machine (SVM) is used for the classification as well as the regression problem and this method is used for supervised learning proposed by Vapnik. In this method, SVM draws an optimal hyper plane which classifies into different categories[15].In simple terms , SVM is a linear binary hyper plane classifier and it gives as output the linear feature space from a non-linear input by indirect mapping, where the maximum margin decision function is calculated . SVM aims to group the data points by exaggerating the gap among classes in high dimensional space. Based on the risk minimization, SVM can improve its generalization ability of the machine learning as much as possible. In recent years, SVM is used in digit recognition, pattern recognition, and regression analysis and feature extraction. The only factors that can affect the performance of the SVM model are kernel function parameters and penalty coefficient.

(Ganapathiraju, 2002) and (Ganapathiraju, 2004) describes application of SVM in a immense glossary of speech recognition. The HMM and SVM complements each other as the SVM model is adhere to a static classifier and HMM has the capability to handle dynamic data set. The SVM model is considered to be the most valuable among other classifier because it has good generalization, minimal risk, absolute convergence properties and stronger discrimination power. Researchers are very fortunate as the SVM model has a greater response towards many problems, whether it is traditional or newly developed .Typically, SVM routinely enact superior than various nonlinear classifiers like KNN. Initially, this classifier was used for only few purposes including recognition of handwritten digit. But with the development over these years . now this model is used in a widespread categories in a never-ending list which include – e-learning, handwritten character recognition, image clustering, speaker verification, land cover classification, forecasting, fraud prediction, intrusion detection, cancer prognosis and many more.

Generally empirical risk minimization are used in NN and is the most common common optimization criteria used to estimate classifiers. But this method is not unique. On the other hand, SVM method is based on structural risk minimization. We use SRM in SVM because there is a need to identify a classifier which has the least expected risk on the test set.The following database set like - : IRONOFF, UNIPEN and the mixture IRONOFF-UNIPEN databases has been used to compare the preliminary results obtained during the SVM process with those with the result using NN reported by Poisson [10].Also , SVM in its basic form handles only a two class classification. Over the years, different new approaches of the SVM model have been developed to improve on approximation accuracy, memory requirement and training time. Initial experiments were done to look over the usage and importance of SVM in character recognition. The above mention database set have been used for these purpose. Starting with IRONOFF, which contain both the collection of online and offline handwritten information collected by IRCCyN in Nantes, France. It contain 4096 lonely digits, 10685 lower case characters, 10679 upper case characters and 410 EURO signs and a total of 31346 isolated words. While in UNIPEN online database, there are 16000 isolated digits, 28000 lower case character and 61000 upper case character. After testing of IRONOFF-UNIPEN databases shows that higher than lower case since handwritten lower case characters differs significantly from person to person.

Detail Recognition performance of SVM on IRONOFF- UNIPEN datasets.

Data Set	Training Set	Test Set	Test Set (%)	nSV	Training Time(s)
Digit	13450	6270	98.60	3014	497
Lowecase	42775	20170	93.70	15690	5897
Uppercase	25660	11620	95.10	10030	2805

Fig 5. Detailed Recognition performance of SVM on IRONOFF-UNIPEN datasets.

Data Set	MLP		SVM	
	Free par.	Rec Rate	nSV	Rec Rate
Digit	3610	98.00	3014	98.60
Lowercase	37720	91.30	15690	93.70
Uppercase	37720	93.00	10030	95.10

Fig 6. Recognition rates and parameters using MLP and SVM on IRONOFF-UNIPEN datasets.

IV. CONCLUSION

Using different machine learning algorithm CNN, KNN and SVM along with different framework and applications Scaling vectors, we found different variation among the classifiers in terms of their accuracy and timing. Accuracy can be reformed as it depends on the training and tested of data and there is always a chance to improve the accuracy of these models if the size of data set is increases. Every algorithm as its own accuracy and time consumption. If the power of CPU changes to GPU different algorithm can perform with better accuracy and less time and better result can be obtained. The performance of the classifier can be measured in terms of ability to identify a condition properly, the proportion of true results, number of positive results from the procedure of classification as false positives and ability to exclude.

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