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Review of Machine Learning Algorithms in Modern Image Processing Systems

Sukes Maiti[1] and Dr. Rajiv Dahiya[2]
[1]Research Scholar, Department of Electronics & Communication Engineering
[2]Research Guide, Department of Electronics & Communication Engineering
NIILM University, Kaithal, Haryana, India

Abstract: *The paper describes the anomaly and shows the mathematical approaches and algorithm needed to recognize it. Handwritten mathematical symbols and equations have garnered attention and consolidation in pattern recognition. With new and better handwritten character identification algorithms, more heterogeneous handwritten digit data sets develop. The issue is handwritten data sets' behavior. The disadvantage that handwritten digit data sets of diverse features can't calculate is addressed by a more complex handwritten digit representation model based on multiple instance learning (MIL) that contains digit data from different feature spaces in a bag. Different machine learning methods for offline pattern identification are presented in this research. Some machine learning methods include Multilayer Perception, SVMs, CNNs, and others. The goal is to find the best pattern recognition algorithm. variable classification methods have variable accuracy, the report demonstrates. Machine learning is used to identify symbols and numbers. A segment binary picture undergoes a "rough" categorization by the Bayesian Network or Neural Network for symbol initialization.*

Keywords: Feature extraction, Object recognition, Convolutional neural networks (CNNs), Real-time image enhancement

I. INTRODUCTION

Handwriting is one of the ways we've communicated for generations. Due to technological advances, computers and the Internet dominate communication, turning the world upside down and resolving into a small town. Developers are using machine learning and deep learning techniques to make computers more interactive and clever, just like humans practice a task until it masters it. Handwritten digit recognition remains a problem. It usually has three steps. The input strokes are divided into hypothetical symbols first.Then a symbol classifier recognizes hypothetical symbols. To find the most likely interpretation of an input OHME, structural relations among recognized symbols are discovered and the expression structure is evaluated by a parsing algorithm. It considers different neural tools for different tasks. Pattern reorganization uses digital image processing to develop useful applications and software. Over the years, researchers in machine learning and data mining have developed a coherent approach for approximating mathematical equation recognition. Individuals employ pattern restructuring for communication and information purposes today. However, every component has issues. Pattern reorganization has drawbacks in handwritten character set variation and form since various communities write differently. Handwritten datasets are indefinite because they may be sloppy, and proper reorganization removes duplication. SVM-based offline handwriting pattern reorganization is the developer's main method. The NIST SD19 data collection is used for SVM modeling.

Math equations use operators and symbols to indicate their relevance. The conversion of mathematical equations to testimonials and vice versa encourages developers to provide extraction and recognition technologies. The difficulty worsens when the computer receives the handwritten pattern. The image quality, font and symbol size, pattern, and writing style of the writer make mathematical equation recognition difficult. Recognizing mathematical equations is difficult since the authors' survey does not adequately express them. Digital equation construction is awkward and doesn't match written style. Today, pattern recognition can be done online or offline. These methods are suitable in

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different ways. Online mode is faster than offline mode because elements are recognized immediately when entered, while offline mode reorganizes after data entry.

Section 2 of our paper is a literature assessment of handwritten recognition studies from different eras.

Section 3 describes recognition system methods. Starting with the Hybrid Feature Extraction Technique, it preprocesses, segments, extracts, classifies, trains, and recognizes data. We also described CNN, the most common approach since its invention. CNN uses convolution, a mathematical procedure that creates output from two functions. Subsampling was employed in this procedure. Our next approach was kNN.The kNN approach is used for regression or huge data sets. Since calculations are divided till the completion of classification, this approach is called late learning classification algorithm.[15]. SVM is the final and most accurate approach. Classification and regression issues are added to supervised learning with SVM. Alternatives to NN approaches include SVM. This approach takes experimental data and structural behavior based on Structural Risk Minimization, which is its key benefit. This method is for nonlinear data.

After reviewing all the approaches, we concluded that the SVM method was approximately better in both the training and testing datasets in section 4.

II. LITERATURE REVIEW

This section of our study will showcase some of the below papers to show how different scholars used handwritten digit identification techniques.

Zeeshan Khan, Sandeep Kumar, and Anurag Jain published a paper on Content-Based Image Classification using Machine Learning Approach, which compares KNN, DT, and SVM image classification methods. They found that SVM outperforms other methods but still has feature outlier and core problem issues.[1]

Gaurav, Bhatia P.K. This work covers handwritten recognition pre-processing approaches for photos ranging from a simple handwritten document to complicated backgrounds and image intensities [3]. Contrast stretching, noise reduction, normalization, segmentation, binarization, and morphological processing were used for pre-processing. They concluded that no preprocessing method can create a picture alone. All strategies work together. Even after applying all the strategies, the image is inaccurate.

According to España-Boquera et al. [4], the hybrid Hidden Markov Model (HMM) is employed to create unconstrained offline handwritten texts. ANN-based preprocessing and recognition are the main features of recognition systems. Preprocessing cleans photos and improves non-uniform tilt and slope correction. Recognition estimates emission probability.

P N V Sai Abhishikth Ayyadevara This paper compares two machine learning methods by Sai Ram Teja and Rajesh Kumar M [7]. The first was a new feature extraction method that combined three others. The second one compares three neural networks for geometric and gradient feature techniques. After surveying, they found that Levenberg-Marquardt algorithm makes convolutional neural networks more efficient.

KNN image classification using different wavelet is covered in this study by Dharmendra Patidar, Manoj R. Mishra, and Bhavin C. Shah [8]. Haar, Db4, and Demy wavelets are used in this paper to compare KNN classifier output efficiency. Demy wavelet-based KNN has the greatest classification efficiency, almost 100% with training data. Since Db4 has good classification efficiency, we can utilize it instead of demy, which takes longer.

Anuj Dutt, Aashi Dutt [13] use Deep Learning for Handwritten Character Recognition. RFC, CNN, and SVM are also in this paper. We compare three algorithms developed and tested on the same data set to demonstrate why Deep Learning is employed in critical scenarios. They found that CNN with Yens or Flow had 99.98% accuracy for taught images and 98.72% for tested images.

Related Work

This section of the report discusses developers' handwriting pattern expression recognition efforts. Focus is on popular mathematical pattern identification methods. Several academics have reported on handwritten numbers and English words. MNIST is a basic dataset for handwritten mathematical expression (HME) recognition, with 60,000 training and 10,000 testing sets. Usually a subset of NIST's bigger dataset.The MNIST dataset contains binary images of

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handwritten numbers from NIST's Special Database 3 and Special Database 1, and machine learning algorithms like KNN, CNN, SVM, etc. are used to test and reduce errors.

Hybrid Feature Extraction Technique:

R.Padmaprima and S. Karpagavalli[9] propose a mathematical expression recognition process that begins with data collection from various sources, then preprocessing, segmentation, feature extraction, symbol classification, and recognition.

Input Image Acquisition- The proposed system receives mathematical equation in the form of a^m.a^n=A^m+n, ax+by=c, y[n]=x[n]**h[n], law of gravity, and convolutional integral. Scanner images are captured offline. The data set includes integers, alphabetical characters, symbols, and special characters acquired from various sources and organized sequentially.

Preprocessing- Colour input photographs are transformed to black and white with a threshold of 0.5 using grey scale images. This change, or Unwanted spots are removed during image cleaning. Image components under 50 pixels are deleted. However, picture inversion and reshaping occur.

Segmentation- This phase involves structural and functional analysis. In segmentation, words, lines, and characters are separated, affecting script recognition. For training, input photos are divided into characters and shrunk to 5*7 pixels.

Feature Extraction- Extracting information from scanned input image is called extraction. Image attributes collected include area, border box, centroid, zoning density, and line segment. Centroids are extracted to determine component weights and center locations.

Classification- This part classifies using neural networks. Soft computing underpins neural networks. Multilayer preceptorn architecture is used to create neural networks. It has an input layer, one or more hidden nodes, and an outer node layer. Good feature extraction is needed for classification, hence this phase depends on the prior phases.

Training and recognition- All data set digits are learned and recognized in this phase for subsequent processing. The multilayer Perceptron Forwarding Handwritten mathematical symbol recognition using back propagation neural network.

Different phases are crucial to mathematical equation recognition. Preprocessing [9] involves four operations:

Binarization- The grey letter picture is converted to binary.

Noise Reduction- This process marks the image or finer details if they were hidden by noise and become even less obvious after noise reduction.

Size-normalization – This alters pixel intensity range.

Skew detection and Correction- Skew detects text line deviation from the horizontal or vertical axis.

A popular linked component analysis method is utilized for segmentation. Other processes in the features extraction set include

Zoning- This stage divides the image into equal-sized window frames and extracts features.

Skeletonisation- Binary pixel picture is directly related to this technology.

Directional Features- This stage refines character boundary lines and image line segments.

Determining Directions- In each image, the boundary has four pieces.

Vertical Type
Horizontal Type
Right Diagonal
Left Diagonal.

Recognition uses SVM and MLP classifiers. Two classifiers have varying recognition rates. The recognition rate for MLP is 92% and SVM classification is 85%.[9]

Convolutional Neural Network

CNN was once the best method for identifying mathematical patterns and English words. Various publications report approaches to improve CNN training and evaluation.

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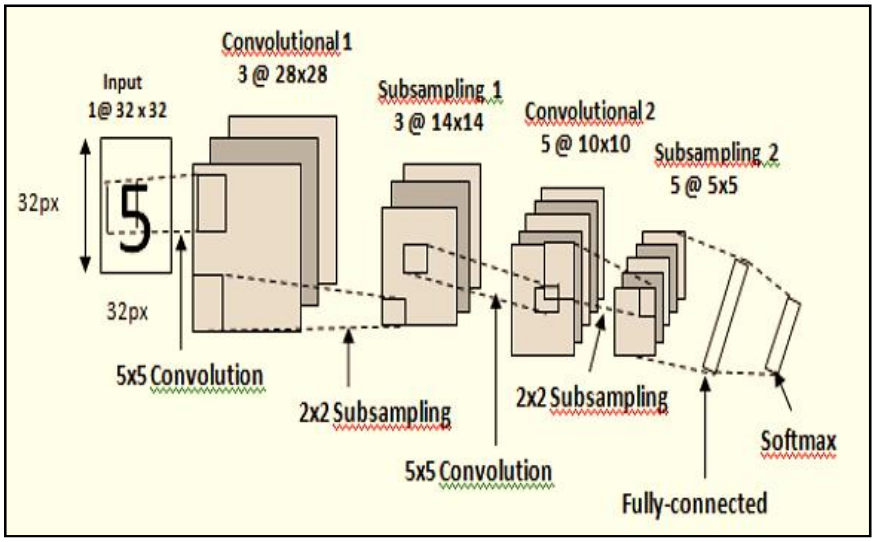

Figure 1. Architecture of CNN

Convolutional Neural Networks (CNN) are modified Multilayer Perceptrons (MLPs). CNN has convolutional and subsampling layers, unlike MLP. CNN approves three machine learning concepts: 1. Low Interaction 2. Sharing Parameters 3. Equivariant Representation. Sparse Interaction detects edges by making the kernel smaller than the input. Sparse connection or weight are other names for it. As the name implies, parameter sharing reduces the number of parameters by sharing weights amongst feature maps. Parameter sharing gives the layer equivariance and translation. Filters link each layer.

Convolution

Convolution is a mathematical process on two functions that creates a third function that shows how one changes shape. This image processing procedure modifies an input image to highlight specific features, such as edge detection, sharpening, and blurring. Curling around the image and matrix, termed filters or kernels, changes the input image.

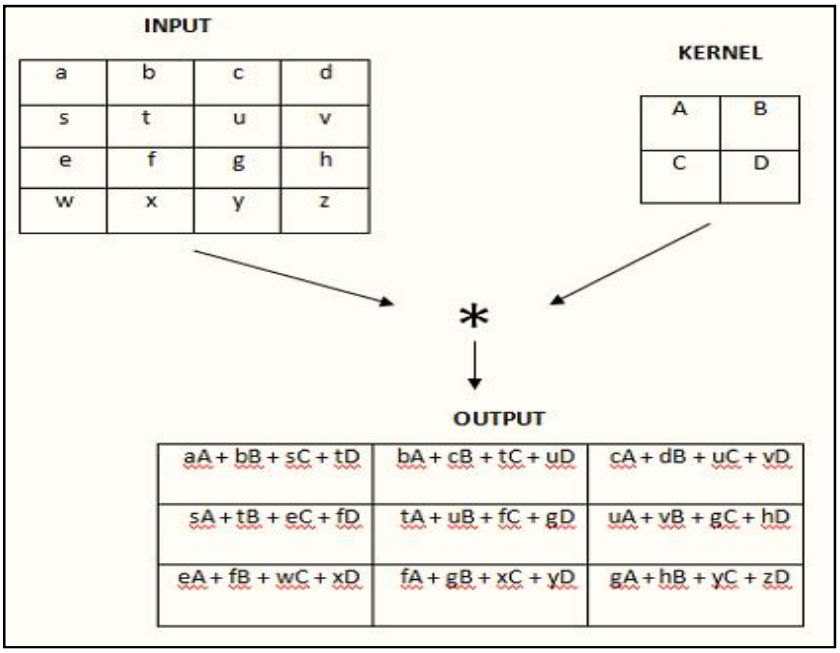

Figure2. Sub sampling

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Sub sampling

The statistical representation of an input feature is used to create a new feature. Also called pooling method. Pooling reduces sensitivity to input invariance such translation, rotation, and distortion. This function is done in non-overlapping neighborhoods. It also shrinks the supplied image. Max and average pooling are the most accurate, according to researchers.

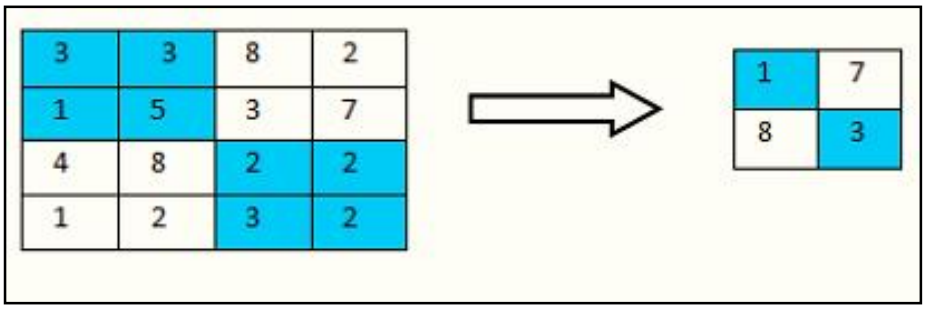

Figure 3.CNN There are five different layers in Convolutional Neural Network.

Input- This layer accepts raw pixels.

Convolutional Layer- The input layer alters the neuron layer's result. The filter should be chosen beforehand. This function keeps pixel values constant during back propagation. Image activation is also available.

Pooling layer—It downsamples image height and breadth.

Fully connected layer—This layer finds the input digit's highest score class.

K Nearest Neighbors (Knn)

A sluggish, non-parametric learning algorithm is KNN.The KNN approach classifies neighbor classes by nearest distance. Only the k-nearest neighbor based on distance is chosen. Then we calculate the point's best using majority weight. Distance is crucial to this method. KNN image classifiers classify suspicious images well when they resemble stereotyped images.

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

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

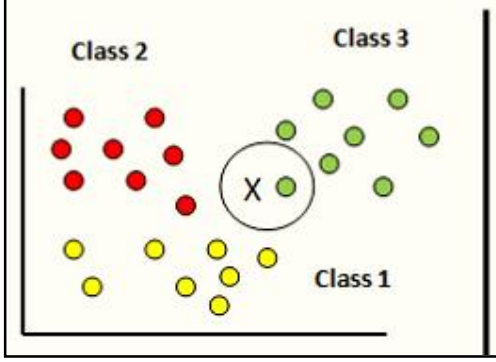

Figure 4.a.

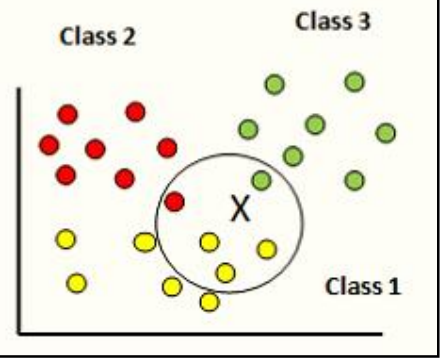

Figure 4.b.

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According to other algorithms, the NN approach is the most competitive since it has a high number of labeled database images relative to class complexity. The NN classifier cannot derive much beyond the annotated image. The number of trials in real-time evaluation is tiny compared to class complexity. When only photos are identified from a class, object shape and appearance differ greatly, resulting in poor classification. This regression and classification method is popular today for multiclass pictures. Classification is entirely based on neighbor distance. The nearest neighbor algorithm classifies the object if k = 1. Euclidean formula is most typically used to compute neighbor distance. Euclidean squared, city-block, Hamming, and Chebyshev measure distance in k-nearest-neighbor.

KNN classifiers tend to have multiple steps[15]. Include these

First, provide the database-selected classifier the input image. Since the image size is undefined, we can choose any pixel size.

In this stage, photos are resized because the database image may be huge and complicate the classifier.

Third step uses RGB color band. Finding the image's RGB band is essential for extraction. Using discrete wavelet transform, each enlarged image's RGB color band is decomposed into six levels.

The first-order color moment of each decomposed color band is found and normalized in this stage. Normalization alters deconstructed image pixels.

Image features of each band are retrieved. Image feature provides all categorization information and is input for algorithm.

This stage uses KNN classifiers. The classifier uses step 5's result as important data.

Support Vector Machine (SVM)

SVM is used for classification and regression in Vapnik's supervised learning method, like KNN. The ideal hyper plane drawn using SVM classifies into categories[15].SVM is a linear binary hyper plane classifier that indirectly maps a non-linear input to a linear feature space using the maximum margin decision function. SVM groups data points by exaggerating class gaps in high-dimensional space. Risk minimization helps SVM generalize machine learning as much as feasible. Recently, SVM has been employed in digit recognition, pattern recognition, regression analysis, and feature extraction. The only elements that affect SVM model performance are kernel function parameters and penalty coefficient.

SVM is used in a massive voice recognition vocabulary (Ganapathiraju, 2002, 2004). As SVM uses a static classifier and HMM handles dynamic data, they complement each other. SVM classifiers are the most valuable because they have good generalization, low risk, absolute convergence, and stronger discrimination power. The SVNM model solves many conventional and novel problems better, which is advantageous for researchers.Usually, SVM outperforms nonlinear classifiers like KNN. This classifier was initially used for handwritten digit recognition. With its development over the years, this model is now used in e-learning, handwritten character recognition, image clustering, speaker verification, land cover classification, forecasting, fraud prediction, intrusion detection, cancer prognosis, and many other fields.

The most prevalent optimization criteria for classifier estimation in NN is empirical risk minimization. This strategy isn't unique. In contrast, SVM minimizes structural risk. To find a classifier with the lowest predicted risk on the test set, SVM uses SRM.IRONOFF, UNIPEN, and the mixture IRONOFF-UNIPEN datasets were utilized to compare SVM early results with Poisson NN results [10].Basic SVM classifies only two classes. Different SVM model techniques have been developed over time to increase approximation accuracy, memory need, and training time. Initial investigations examined SVM's role in character recognition. This was done using the database set above. IRONOFF contains IRCCyN's Nantes, France, online and offline handwriting data. It has 4096 lonely digits, 10685 lower case, 10679 upper case, 410 EURO signs, and 31346 solitary sentences. UNIPEN online database has 16000 isolated digits, 28000 lower case characters, and 61000 upper case characters. Higher than lower case because handwritten lower case characters vary greatly amongst people, according to IRONOFF-UNIPEN databases.

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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.

	MLP		SVM	
Data Set	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.

III. CONCLUSION

Using CNN, KNN, and SVM with diverse frameworks and applications We noticed accuracy and timing differences among classifiers while scaling vectors. Accuracy depends on data training and testing, and increasing data set size can enhance model accuracy. Each algorithm's accuracy and time are different. Different algorithms can work better with less time and better results if CPU power is switched to GPU. How well the classifier identifies a condition, the proportion of accurate findings, the number of false positives, and its capacity to exclude can be measured.

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