International Journal of Technology Engineering Arts Mathematics Science
Vol. 1, Iss. 2, July-December 2021, pp. 19~26
ISSN: **2583-1224**

Handwritten Character Recognition Using CNN, KNN and SVM

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Article Information

Article history:

Received December 2, 2021
Revised January 15, 2022
Accepted January 15, 2022

AISSMS IOIT RESEARCH

International Journal of TEAMS

ABSTRACT

Handwriting Recognition analyses a character's picture and recognizes the characters that are present. The capacity to detect, discriminate, and identify characters in an image is known as character recognition. Because each person has a unique writing style, recognizing handwritten pictures is difficult. Automatic Handwritten Character Recognition (HCR) is a difficult topic that necessitates a careful blend of numerous advanced Pattern Recognition techniques, such as Image Processing, but also Neural Network approaches and Language Modeling. Furthermore, HCR implementation is a difficult process due to the fact that handwritten letters can be imperfect and come in a variety of flavors. The suggested method focuses on identifying handwritten characters and using Convolutional Neural Networks to turn handwritten pages into editable documents (CNN). CNN's five modules are necessary for HCR:
(i) Pre-processing, which entails the introduction of an image representation enabling easy manipulation of huge page images, as well as image handling techniques based on the image representation; (ii) Text line detection and extracting images of text lines from a page image, as well as feature extraction and line separation; (iii) Min-max scalar and word segmentation, which is concerned with locating word gaps and isolating words from a line of text image obtained efficiently and intelligently; (iv) Image normalization and word recognition, which is concerned with handwritten word recognition algorithms; and (v) Classification and linguistic post-processing, which is concerned with using linguistic constraints to intelligently parse data. Also, to achieve accuracy to a greater extent, along with CNN, a Recurrent Neural Network (RNN) can be implemented. For ease of user, a spellchecker can also be integrated with model for achieving error free editable text files.

KEYWORDS: CNN; KNN; SVM; Handwritten Character Recognition (HCR).

1.INTRODUCTION

The human handwritten character recognition is the ability of computers to recognize handwritten characters. It is a hard task for the machine because handwritten characters are not perfect and can be made with many different flavors. The handwritten character recognition is the solution to this problem which uses the image of characters and recognizes the characters present in the image. Character recognition is a method of detection, segmentation and identification of characters (alphabets) from picture. Character recognition is a field that aims to improve the reading capabilities of computers so that the computers can work with text like humans**.**

2. LITERATURE SURVEY

Handwritten character recognition (HCR) is one of the critical machine learning problems. It has been used by researchers for years as an experiment on how to improve machine learning algorithms. In this section, we have discussed briefly some of existing research articles that are related with our work. Refer **Table I** for information about research papers. After analyzing the literature for handwritten character recognition using different algorithms, this work outlines basic working and principles of CNN, KNN and SVM. From the literature survey done, it can be concluded that, CNN has the best recognition rate as compared with KNN and SVM. The average accuracy observed from different sources of CNN, KNN and SVM is shown in below **Table II**.

Table I. Literature Survey

Sr. No.	Title	Methodology	Conclusion	Limitations
1.	Neural Network based Handwritten Character Recognition system [1]	The proposed system is a type of handwriting recognition that consists of various stages like pre-processing, segmentation, classification and post-processing stages.	This paper presents a novel neural network based off-line character recognition system.	Does not include feature extraction
2.	Handwriting Text Recognition Based on Faster R-CNN [2]	Region Proposal Networks (RPN) are a novel network structure that are used for HCR.	This system mainly focuses maintaining accuracy and also text recognition speed is also increased.	If two words are too near, it recognizes as one word.
3.	Exploration of CNN Features for Online Handwriting Recognition [3]	A CNN architecture capable of processing online handwriting without having to convert it to an image.	The proposed CNN characteristics are shown to be effective in character and large vocabulary word recognition challenges.	Limited for online text only
4.	A Proposed Framework for Recognition of Handwritten Cursive English Characters using DAG-CNN [4]	The fundamental CNN model has given a new architecture called DAG, which is a network divided into many routes.	The fundamental CNN model has given a new architecture called DAG, which is a network divided into many routes.	Takes more time.
5.	Beyond Human Recognition: A CNN-Based Framework for Handwritten Character Recognition [5]	The framework is divided into three sections: sample generation (random distortion), CNN models, and voting.	Despite the fact that CNN is extremely powerful for classification tasks, it still requires an appropriate framework to attain state-of-the-art performance.	Needs powerful system for training.
6.	Handwriting Comenia Script Recognition with Convolutional Neural Network [6]	Handwriting recognition (HWR) of the so-called Comenia script using artificial intelligence is the object of research.	Deep learning has proven that tasks involving images, such as pattern recognition and OCR, are acceptable and can be done more precisely.	Only works with the Comenia script.
7.	Offline Handwritten Mathematical Expression Recognition using Convolutional Neural Network [7]	The paper is scanned and the image is transmitted to the identification system in order to recognize the Handwritten Mathematical Expression (HME) that is written on it.	A system that can detect HME that is not connected to the internet. Latex will be made from the HME. Isolated symbols will benefit the most from this system.	Symbols that have been merged, connected, or joined are not recognized appropriately.
8.	Handwritten Character Recognition by Alternately Trained Relaxation Convolutional Neural Network [8]	To regularize the neural network, an approach of alternately training a subset of layers of a CNN is proposed.	On handwritten digit datasets from the MNIST and ICDAR'13, ATR-CNN achieves state-of-the-art performance.	No significant improvement in digit recognition.
9.	Data Augmentation for Recognition of Handwritten Words and Lines using a CNN-LSTM Network [9]	On both word and line images, a unique profile normalization technique was used, and existing text images were enhanced with random perturbations on a regular grid.	These techniques are independent of the network & might be used to improve the performance of different HWR networks & approaches.	It's possible that more time and resources may be required.

10.	Transfer Learning using CNN for Handwritten Devanagari Character Recognition [10]	For feature extraction, picture representation, and dimensionality reduction, DCNN incorporates convolutional layers, fully connected layers, and pooling layers.	With 99 percent accuracy, Inception outperformed the dataset.	The most precise inception takes the most time.
11.	Comparisons on KNN, SVM, BP and the CNN for Handwritten Digit Recognition [11]	The KNN approach is based on geometric measurement, and it is used to calculate the distance between distinct feature values in the model for regression and classification.	When comparing the outcomes of the simulation experiments, it is clear that the CNN algorithm outperforms the KNN method in terms of recognition rate.	The KNN method is a sluggish algorithm that does a lot of calculations and uses a lot of memory during classification.
12.	Handwritten Digit and Letter Recognition Using Hybrid DWT-DCT with KNN and SVM classifier [12]	For classification, the K-Nearest Neighbor and Support Vector Machine algorithms are used. On the MNIST dataset, these two classifiers were tested.	KNN classifier achieves the maximum accuracy of 97.33 percent for digit recognition, while SVM achieves the highest accuracy of 97.74 percent. KNN has an 88.56 percent recognition rate for letter recognition, while SVM has an 89.51 percent recognition rate.	Due to similarities and unclear writing, the algorithm is unable to recognize and classify some of the numerals and letters.
13.	Handwritten Digit Recognition Using K-Nearest Neighbor Classifier [13]	The type of features employed in the digit recognition system is crucial. To discover minimum distances, a Euclidean minimum distance criterion is utilized, and the digits are classified using a k-nearest neighbor classifier.	The recognition method has an average accuracy of 96.94 percent.	The time it takes to classify or estimate something is slow, especially when the training set is huge.
14.	Optical Character Recognition using KNN on Custom Image Dataset [14]	The KNN algorithm has a number of advantages, one of which is that it works well with multi-modal2 classes due to the fact that its conclusion is based on a small neighborhood of comparable targets.	Regardless of whether the target class is multi-modal, the technique can lead to high precision in any instance.	Because we need to compute distance for each query instance of all training samples, the computation cost is rather large.
15.	Analogizing Time Complexity of KNN and CNN in Recognizing Handwritten Digits [15]	The K-Nearest Neighbor Algorithm is a classifier that calculates the Euclidean distance between data set input photos. To avoid long wait times, CNN is employed.	On this dataset, KNN and CNN perform similarly with their respective algorithms, with CNN producing higher accuracy than KNN and thus being picked as the best strategy.	We must presume that a data point should be categorized in the same way as nearby data points.

Table II. Recognition rate of CNN, KNN and SVM

Algorithm	CNN	KNN	SVM
Recognition Rate	97.7%	94.6%	94.1%

3. ALGORITHMS

After reviewing literature, we found that for handwritten character recognition (HCR), mainly three algorithms were used. In this section, we are discussing those algorithms.

a. CNN (CONVOLUTIONAL NEURAL NETWORK)

In machine learning, a CNN algorithm is a class of deep neural network, most commonly used to analyze images. Basic architecture of CNN is shown in Fig. 1.

3.1.1. Pre-processing

Before the input image is processed, it is usually converted to a gray scale. The resulting image then has a single monochrome channel to minimize noise. The input image will have various sizes which can lead the loss of accurate prediction. For instance, if the image is compared to a trained convolutional neural system, the former will be resized to a blank image.

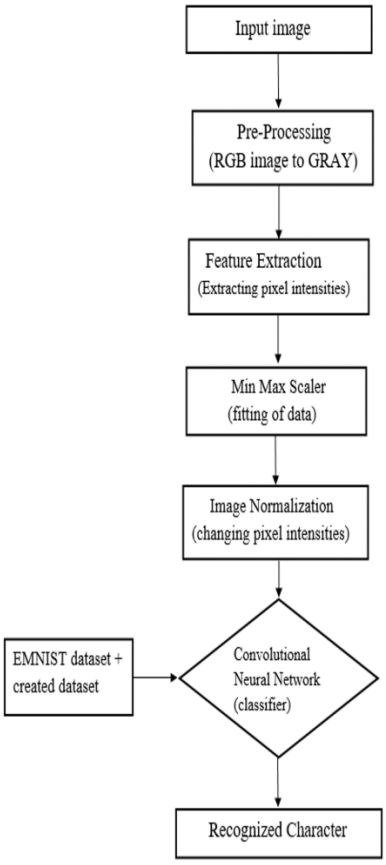

Fig. 1. System architecture of CNN

3.1.2. Feature Extraction

Feature extraction is a process that involves converting input data to a set of features that can be used to represent them. The element selection function selects the first few elements of the image. It sends the necessary details to the editor in order to enable the work to be done using the reduced caption. For CNN model refer Fig. 2.

3.1.3. The Min-Max Scalar

The standard min-max scalar form shows the mean and standard deviations of data in the range between a given size and the indicated value. This rating scale is used to determine the unit variability of a feature. It can also be used to reduce the width as it moves between zero and 1, which is the same as -1 to 1.

3.1.4. Image Normalization

Normalization is often used to alter the pixel density of an image. It is done by removing the background pixels and providing a character found in the image. This method will give the background pixel a value that's less than the character's shadows. This method matches the image to the EMNIST database. The pixel values are computed as they appear in the region where the letter "A" is written. Refer Fig. 3.

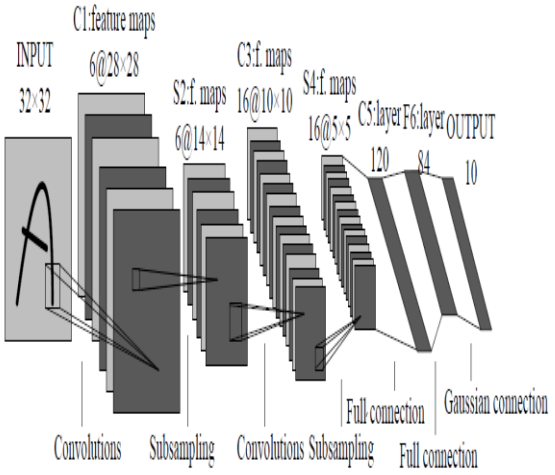

Fig. 2. CNN Model

Fig. 3. Letter 'A'

3.1.5. Classification

Convolutional neural networks are used to classify a handwritten character into two separate images. Convolutional neural network is a type of algorithm that can separate a character from an image. It uses its hidden layers to make the separation easier. CNN has various hidden layers. These layers are typically composed of various convolutional and cohesive layers. CNN is a series of three main elements. It consists of the convolutional layer, compound layer, and the extraction layer. In CNN, Rectified Linear Unit (ReLU) is the most common activation unit used in CNN.

b. KNN (K-NEAREST NEIGHBOR)

K-nearest neighbor is a supervised ML algorithm used for classifying an unknown item. It does so by looking at the value k of its already classified neighbor item. System architecture of KNN is shown in Fig. 4.

3.2.1. Pre-Processing

Preliminary processing is a process that involves removing unwanted parts from an image. It can also improve the image's quality and reduce noise. The output picture is RGB, hidden gray. It has been processed through a central filter to reduce the noise.

3.2.2. Segmentation

KNN is a type of image recognition system that breaks down an image into sub-images of its individual character. It can also identify special characters. This method can be used to separate the characters of various oral languages. It can also defeat NNs in solving problems related to sequence of stages. NN is a type of network that learns and remembers a given pattern. It can also control if the input contains a certain number of digits. ANN partitioning specialists are trained to create sets and classify input models. They can easily get rid of cluttered sets.

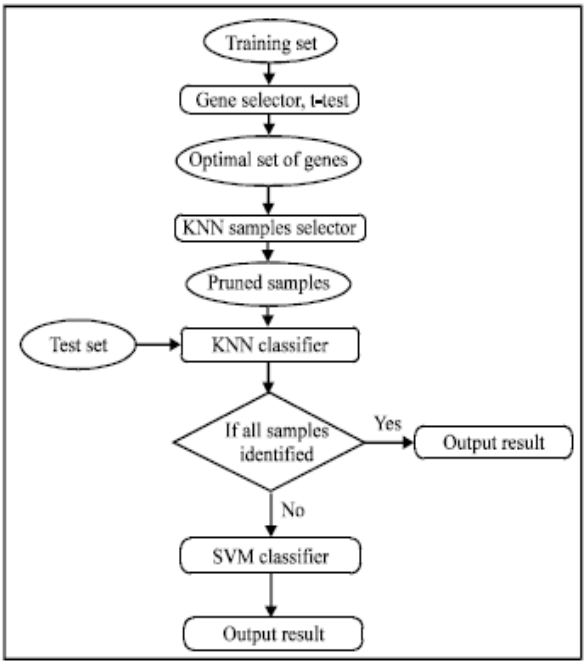

Fig. 4. KNN System Architecture

3.2.3. Feature Extraction

Feature extraction is a process that involves identifying the various aspects of input that are necessary for a KNN algorithm to operate. This step can improve the recognition rate of HCR. It can also decrease the misclassification. This stage is mainly focused on extracting a set of features, which can increase the recognition rate. Fig.5 feature extraction process in KNN.

3.3 SVM (SUPPORT VECTOR MACHINE)

SVM is a support vector machine that automatically classifies new input according to its hyperplane. It uses a training module to generate its output.

3.3.1. Pre-Processing

In order to get rid of noise from the database, all the images in the database have to be cleaned. This step is done by taking into account the sizes of the images in the database.

3.3.2. Implementation

A support vector machine is a machine that takes data points and outputs a hyperplane. It does so by separating the tags from the data. The decision boundary is the line that decides which animal falls to which side of it. It's the one that decides which animal falls to which side. This line is the decision boundary: anything that falls to one side of it we will classify as rabbits, and anything that falls to the other as tigers (Refer Fig. 6).

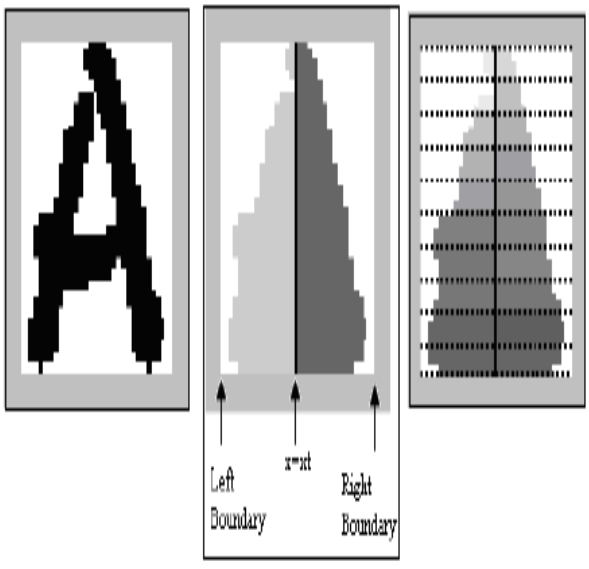

Fig. 5. Feature Extraction

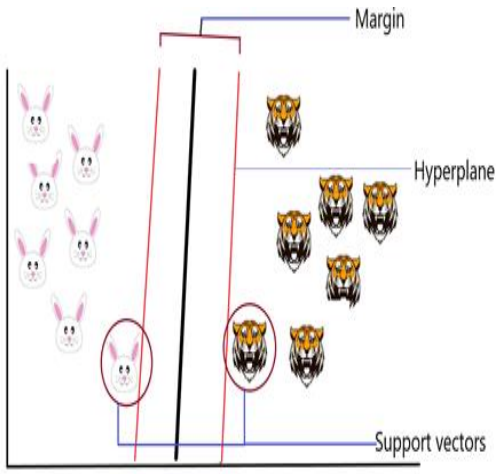

Fig. 6. Margin Hyperplane and Support Vector

3.3.3. Feature Extraction

Feature extraction is an approach to classify an object by its measurements relative to other objects in the same category. Support vector machines are machines that can extract features from a web page. They are mainly used for training. The SVM is a feature extractor that shows the training data of different class classes that are projected onto the vector.

3.3.4. Kernel Selection

SVM algorithms are known to use a set of mathematical functions known as the kernel. The function of the kernel is to transform data into a required form. Different SVM algorithms introduce different types of kernel functions, such as linear, nonlinear, radial basis function, and sigmoid. Most common kernel function used is radial basis function.

4. CONCLUSION

Handwritten Character Recognition is an important part of computing moving forward. It can be used to automate many things such as bank receipts which may take up a lot of time, so it is crucial to have handwritten character recognition. From the literature survey, it is clear that out of three algorithms CNN is using less time and giving more accuracy, so it is beneficial to use CNN for moving forward. CNN has been already very accurate; however, it still needs to have a proper framework to achieve state-of-the-art results. For that we can use some cleaning algorithms on input images to make it more accurate and add a spellchecker at the output so we can reach maximum efficiency. Besides, we will also keep looking for areas where proposed system can be used to automate things.

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