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Handwriting Recognition with Machine Learning algorithm

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Abstract - Machine learning makes an effort to extract information that is buried in data by using current data on a certain issue. Machine learning may be accomplished and output for unknown data can be predicted by using certain mathematical principles and functions to extract hidden data. One of the primary uses of machine learning is pattern recognition. The identification of patterns often requires significant visual data collection. One use of pattern recognition via image analysis is handwriting recognition. These ideas allow us to teach computers to understand any language's letters and numbers that are contained in a picture. Handwritten characters may be recognized using a variety of techniques. In this paper, some of the approaches will be discussed.

***Key Words*:** Handwriting Recognition, Machine Learning, CNN, Images.

1.INTRODUCTION

The most sought-after skill in machine learning is object identification. Face recognition, handwriting recognition, health detection, and other examples are a few instances of object recognition. A vast collection of picture data sets can cause all of these things to occur. There will be both good and negative facts in this picture data collection about that domain. This facilitates a more accurate classification of the unknown data by the algorithm. One new technology that will be helpful in the twenty-first century is hand writing recognition. It can serve as the foundational functionality when additional needs arise. For instance, until braille format is available, a blind guy cannot read newspapers. In this instance, the algorithm may be trained to identify characters in the news article, store them as text, and then translate the text into speech. Many blind persons will find their regular tasks made easier by this. Language translation might be the second use case for hand write recognition. When working with non-native languages in this situation, an individual only has to snap a picture of a document and transmit it to the hand write recognition algorithm. The characters in a picture may be identified by this method, which then turns them into text. The text may then be translated into the preferred language.

2. BODY OF THE PAPER

Handwriting recognition might also be used to handle vast sets of paper documents, such as scripts for answers. AI and hand-write recognition may be used to analyse the response scripts without the need for human intervention. Handwriting recognition is the baseline situation that needs to be addressed in each of the aforementioned cases. One kind of optical character recognition (OCR) is hand write recognition. Text identification, whether printed or handwritten, is known as OCR. With OCR, a document is photographed and then transformed into the required format, such as a PDF. The character recognition algorithm is then given the file. This can significantly lower the need for human intervention in some situations.

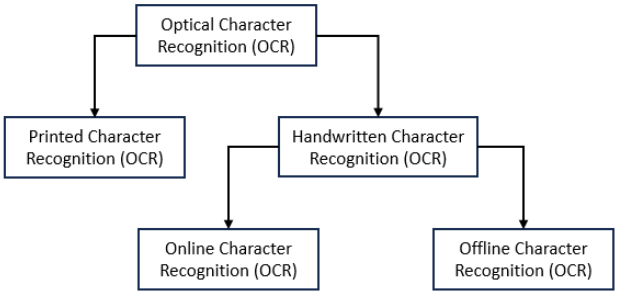

Fig -1: classification of OCR

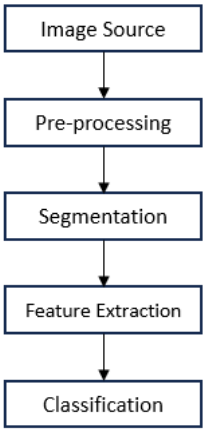

Fig -2: Phases of hand-write recognition

Handwritten character recognition and printed character recognition are OCR's two variants. As the name implies, printed character recognition is the process of identifying characters from a picture of a newspaper or other printed material. Characters written by humans or including human input are recognized using handwritten character recognition. Online and offline character recognition are the two categories into which it is separated. Compiling a picture of a document into a string of words and letters is known as offline character recognition. The procedure of online character recognition is a little challenging. It's a dynamic procedure. It entails identifying character data at the moment of writing. An electric pen and specific writing pad are required. The written character is identified based on pen movement. Figure 1 depicts the visual categorization of optical character recognition, whereas Figure 2 shows the phases of handwriting recognition.

***1. Image source*:** This stage involves the offline recognition of handwritten characters. Any digital tool can serve as the image source. The picture is captured by a scanner or camera and forwarded to the following stage.

***2. Pre-processing**:* The series of steps known as pre-processing raises the image's accuracy by enhancing its quality. The pre-processing methods listed below are used for the handwritten character recognition process.

i. ***Noise-removal*:** It is the process of making an image noise-free. This also refers to minimizing undesired signals in the picture to smooth it out. Numerous methods are available for eliminating noise from images. Among these are the median filter, the Min-Max filtering method, and the Gaussian filtering method.

ii. ***Binarization:*** It is a method for transforming colorful or grayscale images into binary images. Images in binary code only have 0s and 1s. Images' pixels are divided into 0s and 1s according to a fixed value. The pixel value is replaced with 0 or 1, depending on whether it is smaller than the constant.

iii. ***Morphological operation:*** This is the procedure for enlarging or contracting a picture. The primary reason for doing this is that the algorithm would anticipate a consistent image size. An image's size can be increased by adding pixels to its border. Pixels from the image's border can be eliminated to reduce the size of the image.

3. Segmentation: A technique called segmentation is used to separate out individual characters from a picture. There are two different kinds of segmentation. Both explicit and implicit segmentation are what they are. Words are identified implicitly without going through the segmentation procedure. However, words in explicit segmentation are anticipated using character extraction.

4. Feature-Etraction: This is a crucial stage in the recognition process, and it is where the recognition algorithm begins. Every character has unique qualities. It has a set of rules, each of which describes a characteristic of a character. During this step, such traits are extracted.

5. Classification: At this point, the input data testing would have begun and the training would have concluded. All of the aforementioned processes would be passed by the testing data, and the matching rules are given different probabilities. The class-label associated with the rule with the highest probability is identified as a character.

Using Convolution Neural Network (CNN):

CNN stands for Convolution Neural Network in short. Convolution means wounded or twisted. The human brain is analogous to any neural network. The brain serves as an inspiration while designing neural networks. three main layers of CNN are:

1. Convolution Layer
2. Pooling Layer
3. Fully Connected Layer

***Convolution Layer*:** The concept of picture categorization stems from the convolution layer's capacity to recognize patterns. The picture matrix with the dimensions of width*height*depth is the input for this layer. The number of channels in the picture is indicated by the matrix's depth. In a grayscale image, there would be one channel, however in an RGB image, there would be three. The RGB image may be converted to a grayscale image so that CNN can be applied to it.

Table 1: Example for a filter

-1	**-1**	**-1**
1	**1**	**1**
0	**0**	**0**

A matrix known as a kernel or filter is used in the convolution layer. The desired pattern is indicated by this filter. The following filter is used in order to identify the upper horizontal edge, as shown in the table below. The character image's matrix representation is taken out. The picture is pre-processed to get rid of any noise and other undesirable data that could be there. As part of the pre-processing, we may additionally reduce the image's dimensionality. An identically sized sub-matrix in the picture is multiplied by the filter. The upper left corner is where the multiplication begins. Rather of the typical matrix multiplication, the multiplication is the dot product. The filter is transferred to the next sub-matrix and the dot product resultant is placed in the upper left corner.

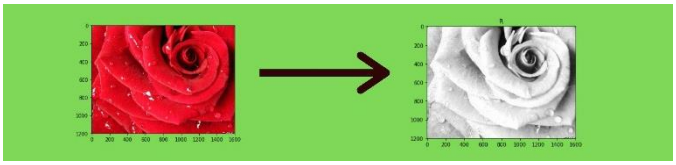

Fig -3: Images After processing and Convolution

Two photos are displayed in Figure 3. The picture on the left is the pre-processed version. The picture on the right has undergone convolution. Using the previously stated filter, the bright borders in the right image were achieved.

Pooling Layer: Both of the criteria are attempted to be addressed by the suggested method, both in terms of accuracy and time complexity. Both of the criteria are attempted to be addressed by the suggested method, both in terms of accuracy and time complexity. The primary purpose of layers is to reduce dimensionality. Convolution layer outputs up to 200 by 200 pixels in size. Since the following layer is fully linked, this cannot be used as an input for it. As a result, the matrix size must be decreased. Both dominant and submissive features in the image may be extracted by the pooling layer. These are referred to as average, min, and max pooling. Max pooling is employed in hand-write recognition. Move along the picture with a fixed m*n size of empty batch during pooling. The maximum, lowest, and average values of every pixel are obtained when a batch overlaps over a certain area of the twisted matrix. And the pooling values are filled to create the new matrix.

Fully connected layer: The primary goal of the fully connected layer is to categorize the picture into a label using the pooling layer's results. Matrix output is typically the result of pooling. An array that is only one dimension is created from this matrix.

We refer to this procedure as flattening. The vector's values indicate the likelihood of certain object characteristics.

Handwriting recognition using ML:

Numerous algorithms are available for handwriting recognition. Handwritten and paper documents may be recognized using a method called OCR (Optical Character Recognition). Paper documents are ones that need to be scanned, some of which include digital typing on them. Documents that are handwritten are ones that are written by hand. two types of recognition methods of different natural languages.

1. Offline Handwriting recognition
2. Online Handwriting recognition

Offline Handwriting recognition: In this case, the characters included in the papers are recognized using previously created and stored documents. The characters can be any kind of sign, including integers and alphabets. Mathematical expression recognition may be accomplished with this approach. This is a common feature of mobile apps. Students may use it to scan documents, and the mathematical expression recognizer will identify the equations and offer answers.

Online Handwriting recognition: Here, the data is entered using an electronic pen, and the characters are instantly recognized rather than being scanned from a page. In this case, character identification is based on strokes.

There are few more researches where they mentioned many methods similar to it:

1. Incremental Recognition
2. Line and Word segmentation
3. Part Based
4. Slope and Slant correction
5. Ensemble Method
6. Zoning Method

Incremental Recognition method: This method is generally used to determine the characters incrementally.

- The user first gives the stroke.
- The geometric feature has been modified.
- The symbol is identified.
- Refreshing the CYK table.

Line and Word segmentation: Segmentation is one of the key steps in character recognition. Accurate character or symbol recognition is challenging without segmentation. Thus, the following are the phases in the segmentation process

- identifying areas of interest through the use of crop imagery and scanned photos.
- A picture should be cleaned of noise using the subtraction approach. To eliminate, pre-processing is carried out the image's noise.
- After that, the image is turned into binary by extracting the backdrop and mining the text.
- The Hough transform is employed in skew detection and rectification.
- Horizontal projection is used for line segmentation.

Part Based Method: The object is identified using this technique. The following list of this method's properties:

- Several key points should be used to represent a single picture.
- A picture's similarity will rely on whether or not it contains a significant point.
- Occasionally Key points are gathered to represent each class.

The Part-Based Method has the following advantages:

- Character recognition is good, but normalization with preprocessing is challenging.
- It is not reliant on the global framework.
- It is applicable to script written in cursive.

Slope and Slant correction method: Here, by employing this technique the baseline's slope can be used to determine the text's slope. Ascenders' input is absent, and descenders in the original formation are eliminated as much as feasible.

Ensemble Method: It is a brand-new classifier that machine learning has introduced. Using this technique, several classifiers are automatically created from a single base class. The following is the explanation:

- Feature Search Ensemble method.
- Feature selection algorithm is used to identify features.
- Feature Selection Ensemble method.

Zoning method: In the zoning scheme. After the processed picture has been separated into zones, the sign or letters are extracted using features.

It has two methods:

1. Static Zone
2. Dynamic Zone

1. ***Static Zone:*** This picture is separated into homogeneous areas. When full recognition is achieved, the zones remain fixed. This is carried performed in the absence of any previous knowledge of feature distribution or extraction. Static zoning is carried out using knowledge of experimental data or the developer's years of expertise.
2. ***Dynamic Zone:*** The processed picture is separated into irregular zones. This picture is split up into several zones that have dynamic resizing capabilities. Furthermore, it is dynamic. The zone size is adjusted based on the neighboring zones. Additionally, by employing this technique, zones may be expanded by resizing them if some are identified and others require more room. Herein lies the crucial benefit. Based on optimization process outcomes, these dynamic zones are created. We must modify the locations of each zone in order to extract features from the processed image based on local information patterns. Moving dynamic zones in close proximity to the pattern body allows for this modification, and the offset needed to do so is determined by maximizing the pixel density.

3. CONCLUSIONS

There are several methods for recognizing handwriting. Convolutional neural networks (CNNs), incremental segmentation, zoning, semi-incremental segmentation, and slope and slant correction are a few of them. Of these techniques, the Convolutional Neural Network (CNN) yields the best accuracy, while the Slope and Slant Correction approach yields the lowest accuracy. One effective technique for handwriting recognition is CNN image training, which yields good results in terms of accuracy. The major drawback to this approach is the large number of picture samples used in the model's training, which takes too long. When using the zoning approach, accuracy will drop if there are fewer zones that are obtained after splitting the input picture. The primary drawback of this approach is that it is too simplistic for handwriting recognition, which will cause developers to struggle greatly during the segmentation process. This approach is straightforward because it simply looks at the Lat and. Because every person has a unique handwriting style, handwriting recognition is extremely difficult to achieve and gets much more difficult to detect when compared to machine generated handwriting.

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