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Devanagari Character Recognition Using Deep Learning

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Abstract: *The Devanagari script is one of the broadly used scripts of India and is advanced from the Brahmi script. It includes forty-seven number one alphabets, 14 vowels, 33 consonants, and 10 digits. There isn't any capitalization of letters, like in the English language. The Devanagari script includes consonants and modifiers. Deep gaining knowledge of strategies is carried out to extract capabilities and apprehend the characters in an image. A Deep Convolutional Neural Network (DCNN) had been included to extract capabilities and classify the entered images. Consecutive convolutional layers are used in this manner which brings introduced gain withinside the manner of extracting higher-degree capabilities. The output of the CNN layers is fed to the completely related layers. The version has applied the use of Keras libraries on the pinnacle of a TensorFlow backend. Finally, the threat or possibility rating of every person is decided and the person with the very best possibility rating is proven because of the output. Handwritten Devanagari Character Recognition is extra tough in contrast to the popularity of the Roman characters.*

Keywords: Pre-processing, Segmentation, Classification, Image recognition, Convolutional Neural Network, Deep Learning, Devanagari Character Recognition.

I. INTRODUCTION

The Indic scripts have numerous consonants and vowels, which constitute different sounds. Based on the articulatory mechanism used to provide the corresponding sound, those consonants fall into distinctive organizations including velar, palatal, retroflex, dental, labial, and some others. The order of the unvoiced and voiced plosives observed with the aid of using the corresponding nasal sound is used to set up them as unaspirated and aspirated. Handwritten individual reputation is an area of studies in deep mastering, laptop imaginative and prescient, and sample reputation. Computer machines that's appearing handwriting reputation can gather and stumble on characters in paper files, pictures, etc. and convert them into digitalize form. This is wanted due to the fact we can not convey bodily files anywhere additionally it's far hard to control bodily documents. Nowadays such structures are carried out with the usage of distinctive deep mastering algorithms. Devanagari individual recognition consists of five stages which include image acquisition which means handwritten samples are collected and scanned, next is pre-processing which is used to enhance the image after segmentation is performed to sharpen the image. In the next step classification and recognition are performed and in post-processing, the output is stored in a text file. Deep learning is a branch of machine learning which uses neural networks inspired by human brain neural networks. A neural network consists of multiple layers. Deep networks have a hierarchical structure which makes them particularly well adapted to learn the hierarchies of knowledge. A single layer can compute a very complex function but to extract complex features deep learning is necessary.

As deep learning uses hierarchical structures, it can be used with image data efficiently so we have chosen deep learning for handwritten Devanagari character recognition. In deep learning, the algorithm is not provided with already extracted features as an input because the algorithm itself performs feature extraction and it will find all possible features which can be used to get the highest accuracy of the classification model. Thus the input to the algorithm is a preprocessed image.

There are various classification algorithms in deep learning such as Recurrent Neural Network (RNN), Back Propagation Neural Network (BPNN), Convolutional Neural Network (CNN), Deep Convolutional Neural Network (DCNN), Deep Belief Network (DBF), Deep Neural Network (DNN), etc. After several studies, it is observed that each algorithm has its pros and cons.[1] For example, DNN is widely used but it has a slow training process. RNN is best used for sequential

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data whereas the CNN algorithm is the best method for correlated data e.g. images. After studying the pros and cons of these neural networks we have decided to use Convolutional Neural Network (CNN) for handwritten Devanagari character recognition.

II. SYSTEM OVERVIEW

The complete flow diagram of dataset preparation and character classification is presented in Fig. 1. The dataset preparation phase can be divided into three subsystems; character extraction, preprocessing, and separation of Training and Testing set. Character extraction deals with scanning handwritten documents, cropping individual characters, and labeling them. Preprocessing subsystem deals with preprocessing on the character images and the last subsystem randomly splits the dataset into training and test set. A detailed description of preprocessing and dataset preparation is presented under the subheading "DHCD Preparation". The character classification phase includes training and testing on the dataset. CNN-trainer is run on the Training set and the accuracy of the trained model is tested using the Testing set of DHCD.

III. GENERALIZED APPROACH

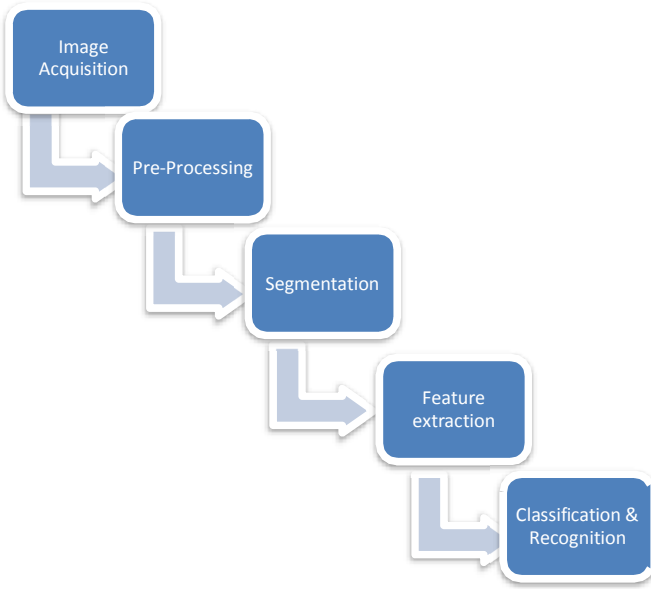

Fig (1) Generalized approach

1. Image Acquisition Handwritten Devanagari character samples are collected from different peoples and scanned with the help of a camera or scanner to convert them into picture format.
2. Pre-processing As the handwriting samples are collected from different peoples there may be different problems associated with it such as noise, the image may be a blur, etc. So the pre-processing techniques are applied to images to remove such noise and to enhance the image quality. Initially, the image is in RGB color format therefore there are some complexities while processing the image. So the RGB to grayscale conversion is required to reduce complexity from a 3D pixel value to a 1D value. Many tasks do not fare better with 3D pixels .[1]
3. Segmentation Pre-processed image is given as input to the segmentation process. Segmentation is carried out to separate the character from its background. In this case, the character will be represented in white or black color. Accordingly, the background may be black or white. This is one of the important steps in character recognition.
4. Feature Extraction Segmented image is given as an input to this module. This module will extract the features of the character from its image. Features can be Geometrical features such as area, perimeter, eccentricity, etc., low-level features such as color, the texture of an image, etc., and high level features such as vertical line,

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horizontal line, curve, etc.

5. Classification and recognition Classification is a process of identifying the character and assigning a correct class label to it. The output of the feature extraction module is given as an input to the classifier. The classifier will learn from extracted features and recognize the correct class label for the input image. For classification, there are different techniques available. One of the deep learning.[2] Deep learning uses different artificial neural networks such as CNN, ANN, RNN, etc. From all these neural networks CNN is the only neural network to which we don't need to provide already extracted features. CNN takes the image as an input and extracts maximum features as different layers. The main advantage of CNN is it reduces the human efforts of extracting the features. CNN works efficiently with a large amount of data such as images.

IV. WORKING OF CNN

A convolutional neural network (CNN) is a type of neural network which uses a special type of layer called a convolution layer. CNN consists of multiple layers such as convolution layer, non-linearity (ReLU) layer, pooling or sub-sampling layer, and fully-connected layer.

Each convolution layer consists of a filter that is shared between multiple neurons within that layer. The size of these filters is smaller than the image size. The filters are used to extract the features from the input image. The subarea of the image from which the filter extracts the features are called as receptive field and the extracted feature is called a feature map i.e., the filter will perform dot product with the previous layer. The result of these dot products is stored in separate neurons of the convolution layer.[4]

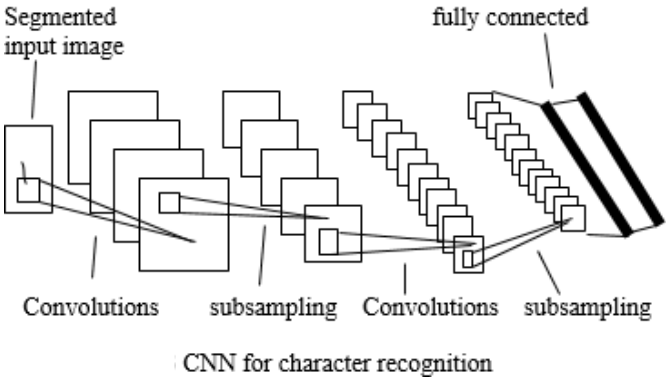

Fig (2) CNN Architecture

The next layer is the pooling layer which is also called the sub-sampling layer. Each neuron of the pooling layer works over the feature maps created in the previous convolution layer. The main aim of the pooling layer is to minimize the input. The pooling is done in two ways which are max pooling and average pooling. In max-pooling, the maximum value from the feature map is found and those pixels are replaced with the single pixel which has a maximum value. In the case of average pooling, the average value from the feature map is found and those pixels are replaced with the single-pixel which has an average value. At the end of this layer, we will get the minimized version of the previous image. Again, this minimized image is given as an input to the next convolution layer and the process will be repeated. The repetition of the process depends on the number of layers in the network. Several layers are not fixed which will vary as per requirement.[6]

The last layer is fully connected. This layer is also known as the output layer of the convolutional neural network. Task performed by this layer is classification. In a fully connected layer, every neuron is connected with every other neuron as shown in the figure.

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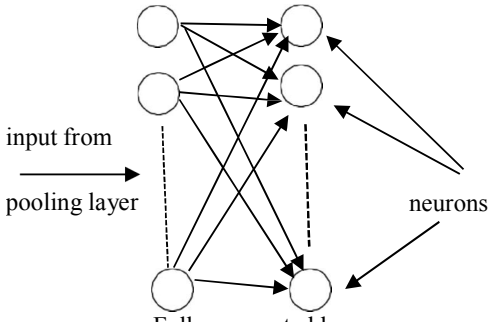

Fig (3) Neural Network

V. LITERATURE REVIEW

1. Shailesh Acharya, Ashok Kumar Pant, Prasanna Kumar Gyawali proposed a deep learning architecture for the recognition of Marathi's handwritten characters. They focus on the use of Dropout and dataset increment approaches to improve test accuracy. We have learned Deep Convolutional Neural networks from this paper.
2. A Comparative Study on Handwriting Digit Recognition Using Neural Networks In this paper, A Comparative Study on Handwriting Digit Recognition Using Neural Networks comparison is done on three Neural Network-based recognition algorithms to determine the best algorithm in terms of many factors such as accuracy and performance. Other criteria such as execution time have been also taken into consideration. Random and standard datasets of handwritten digits have been used to evaluate the algorithms.
3. Jinfeng Bai, Zhineng Chen, Bailan Feng, Bo Xu attempt to introduce the Shared Hidden Layer Convolutional Neural Network framework to image character recognition. It shows that the SHL-CNN can reduce recognition errors by 16-30% relatively compared with models strained by characters of only one language using conventional.
4. Miss. Minakshi Sanjay Bhandare, Miss. Anuradha Sopan Kakade has shown the result of pre-processing and segmentation of compound character. We are going to apply those techniques in our dataset for better results.
5. New Multimodal Fusion Method Based on Association Rules Mining for Image Retrieval The retrieving method proposed in this paper utilizes the fusion of the images' multimodal information (textual and visual) which is a recent trend in image retrieval research. It combines two different data mining techniques to retrieve semantically related images: clustering and association rules mining algorithm 6. Bishwajit Purkaystha, Tapos Datta, Md Saiful Islam used a deep convolutional neural network for recognizing handwritten Devanagari characters.
6. A Deep Learning Approach for Optical Character Recognition of Handwritten Devanagari Script. The paper proposes an approach for optical character recognition of handwritten Devanagari characters using Convolutional Neural Networks. Convolutional Neural Networks are considered to be efficient when it comes to image classification in comparison to SVMs and ANNs. Working with Devanagari characters is more complex because of their compound structures as compared to the roman characters

VI. CHALLENGES

1. Deep learning needs to find and process massive datasets for training.
2. In deep learning overfitting occurs. Overfitting in neural networks occurs when the performance of the model on unseen data is lower than that on seen data.
3. Implement a deep learning algorithm, which requires high-performance hardware.
4. Lack of flexibility and multitasking because once the model is trained it can give efficient and accurate solutions for specific problems.

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VII. COMPARATIVE ANALYSIS

Here we have also created a hybrid model. This hybrid model is the combination of the CNN-Random Forest classifier, CNN-MLP (Multi-Layer Perceptron), and CNN-KNN (K-nearest Neighbor). These hybrid combinations help to improve the accuracy for the prediction.

```
Epoch 28/30
96/96 [==============================] - 3s 33ms/step - loss: 0.3591 - accuracy: 0.8778 - val_loss: 0.4187 - val_accuracy: 0.8608
Epoch 29/30
96/96 [==============================] - 3s 32ms/step - loss: 0.3544 - accuracy: 0.8796 - val_loss: 0.4069 - val_accuracy: 0.8667
Epoch 30/30
96/96 [==============================] - 3s 33ms/step - loss: 0.3482 - accuracy: 0.8827 - val_loss: 0.3973 - val_accuracy: 0.8718
Accuracy: 87.18%
Random Forest Classifier starting ...
Time taken for prediction = 13.350138 seconds
CNN-Random Forest Accuracy: 90.7%
Multi-Layer Perceptron Classifier starting ...
Time taken for prediction = 26.736907 seconds
CNN-Multi-Layer Perceptron Accuracy: 90.2%
KNN Classifier starting ...
Time taken for prediction = 1.466794 seconds
CNN-KNN Accuracy: 91.0%
```

Fig (4) Comparative Output

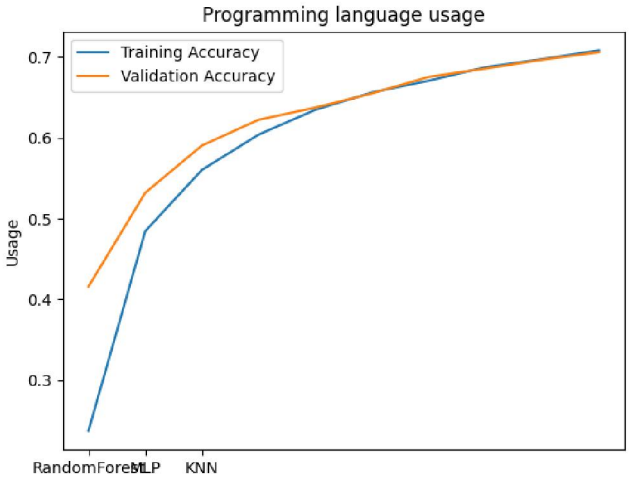

Fig (5) Comparative Graph

The accuracy that was achieved using the CNN model was 87.18% while CNN-Random Forest Classifier accuracy was 90.7%. In the same way, CNN-MLP accuracy was 90.2% and CNN-KNN accuracy was 91.0%.

VIII. EXPECTED OUTCOMES

The Character's image will be given as an input which will be processed and the output of the recognized character will be given in the form of text.

Fig (6) Expected Outcome

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IX. CONCLUSION

This paper provides information about the importance and applications of handwritten Devanagari character recognition. This paper also discusses the various techniques available to recognize the character. It discusses the approach that is being carried out for Devanagari character recognition. It also provides a summary about all the works done in this field till date. This paper has also discussed various challenges in character recognition, so this will affect the accuracy of the classifier. Handwritten character recognition can be used in various fields like in the banking sector for check processing, document processing, etc. The handwritten Devanagari recognition can explore more application areas.

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