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Odia Handwritten Character Recognition Based on Convolutional Neural Network

Rabinarayan Panda, Sachikanta Dash and Sasmita Padhy

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1st Rabinrayan Panda
Computer Science and Engineering
GIET University
Gunupur , Odisha
n.rabipanda2011@gmail.com

1st Sachikant Das
Computer Science and Engineering
GIET University
Gunupur , Odisha
dash.sachikanta@gmail.com

2nd Sasmita padhy
Computer Science and Engineering
VIET University
Bhopal , Odisha
pinki.padhy@gmail.com

Abstract— Odia is an eastern Indo-Aryan language spoken by 44 million people especially in Odisha, India .Some character are made up of more than one connected symbols. Handwritten Character Recognition (HCR) plays an important role in Optical Character Recognition (OCR) and Pattern Recognition (PR), as it has a good number of applications in various fields .HCR contributes extremely to the growth of automation and are applicable in the areas of bank cheque, medical prescriptions, tax returns etc. Handwritten characters are much more difficult to recognize than the printed characters due to different in writing styles for different people. We can use the character recognition technology that scans the different types of document that can be either handwritten or printed. This paper explores and analyzes the use of Deep learning techniques such as the Convolutional Neural Networks for the recognition of Odia characters. Inspired by the structure of the brain, CNNs classify characters by making use of neurons linked in various layers so as to achieve maximum efficiency. In this paper, 6 layers of neurons were used for the purpose of classifying Odia characters. An accuracy of 95.6% was achieved in this approach. Once recognized, the handwritten Odia characters can be easily translated into English or any other languages.

Keywords— Odia Script, Deep Learning, Image Processing, Convolutional Neural Networks

Introduction

Odisha is one of the state of India. Odia is a dominating language, where local speakers involve 80% of the populace and rest 20% originates from different parts of West Bengal, Jharkhand, Chhattisgarh, and Andhra Pradesh. It is an official language of Odisha state and is the second dialect of Jharkhand. Odia is the sixth Indian language to be recorded as a classical language in India, on the premise of having a long abstract history and not having acquired broad topic from different dialects. The Odia script represented in (Fig: 1) is created from the Kalinga script, one of the descendants of Brahmi script of antiquated India. The initial use of proses can be found at Puri, in the Madala Panji of the Jagannath Temple. Works like Rorakha Sahita, Shishu Veda, Amara Kosha, Saptanga, Gorakha Sahita and Kalasha Chautisha are written in Odia. The Vilanka Ramayana was written by Sarala Das. Around the Vaishnava leader Achyutananda, the 5 poets emerged towards the 16th century- Achyutananda Dasa, Ananta Das, Balaram Das, Jasobanta Dasa and Jagannatha Dasa. The Rahasya Manjari by Deba, Durlabha Dasa, Ushabhilasa by Sisu Sankara Das and the Rukmini Bibha by Kartika Dasa was written. There are three great poets and prose writers, Kabibar Radhanath Ray, Fakir Mohan Senapati and Madhusudan Rao made Odia their own and brought in a modern outlook and spirit into Odia literature. Odia writing system is unique in relation to some other territorial dialects in India. The present day Odia script comprises of 11 vowels, 36 consonants, and 10 numerals as well as anuswara, bisarga and chandrabindu. represented in (Fig: 4) . The structure of Odia characters are mostly round-formed like the Devanagari and Bengali characters, however the later dialects have a flat line on the top (called Sirorekha) which is truant in Odia. Odia language is not case touchy. The end of a sentence is stamped by a vertical line ('|') instead of a period ('.'). One of the significant attributes of Odia rudimentary characters is that most of their upper 33% is round shaped and a subset of them has a vertical straight line at their furthest right part. In free Form transcribed character identification; the characters are thought to be composed intelligibly permitting littler variety fit as a fiddle a character.

Odia Script

Fig 1

Printed Odia Numbers

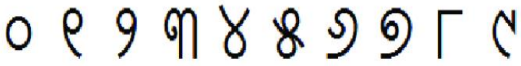

Fig 2

Odia Handwritten Character

The following handwritten script is represented in Fig 3

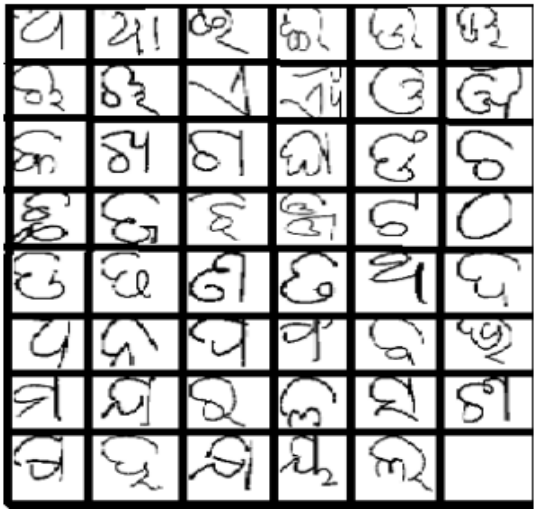

Fig 3

Printed Odia character

Fig 4

Overview of Dataset

A framework to recognize Odia characters has been proposed and evaluated on the OHCSV 1.0 database. Here we propose an efficient framework to recognize the Odia scripts data set where the proposed model comprises of data acquisition and essential strides of preprocessing steps like image binarization, skew angle detection and correction, text line segmentation followed by character segmentation. At long last, each secluded character is standardized and put away into the repository. Our database of isolated Odia handwritten character samples are collected from 150 distinct people. These writers are selected from various age, gender, and educational background groups. The samples are collected by asking the informants to write on a formatted sheet containing the Odia character set. Along these lines, a person gives an aggregate of 57 test images. We chose an input page layout that makes the segmentation simple, to stay away from the perplexing issue of document segmentation in characters. We composed a structure containing the printed dis-engaged Odia characters and empty space just below for each isolated printed character which has to be filled by a writer.

LITERATURE REVIEW

Even though Odia handwritten numeral recognition got substantial interest by the researchers, very few works have been reported for Odia handwritten character recognition yet. Those few works are listed here:

J.Mariyathas[1]represented Sinhala handwritten Character Recognition using Convolutional Neural Network by experimenting around 110,000 image data. CNN's performance was evaluated by training and testing the dataset by increasing the number of character classes. When it reaches 100 character classes it shows reasonable accuracy of 90.27%. The model was trained by 5 sets of different 100 character classes. Finally, the overall accuracy of 82.33% is achieved for 434 characters.

R. V. Kumar Reddy, B. Srinivasa Rao and K. P. Raju[2] describes "Handwritten Hindi Digits Recognition Using Convolutional Neural Network with RMSprop Optimization .They explained Convolutional Neural Networks as a powerful feature extraction do not use the predefined kernels, but instead they learn data from specific kernels. The structural design of the network consists of convolutional (Conv2D) layer, pooling (MaxPool2D) layer, Flatten layer and two fully-connected layers. Where a sliding window function is applied to a matrix of a numerical image. they evaluated the scheme on 20,000 handwritten samples of Hindi numerals from kaggle dataset and from their experiment they achieved 99.85% recognition rate by the proposed method and concluded Convolutional Neural Network with RMSprop (Root Mean Square Propagation) Optimization which is very promising results

Vishal A Naik et al[3] presented about Support Vector Machine for the Gujarati language to recognize the online handwritten characters. They have used SVM with polynomials, linear and Rbf kernel, k-Nearest Neighbor and multi-layer perceptron (MLP) to classify the strokes by using hybrid features set. 3000 samples of data sets are used to train the system and 100 different writers tested it and achieved 91.63% which was the highest accuracy SVM-RBF kernel and 86.72% was the lowest accuracy with MLP. In this process, the minimum and maximum average processing time was achieved were 0.056 seconds per stroke with SVM linear kernel and 1.062 seconds per stroke with MLP respectively.

A Sahu and S.N Mishra[4] described Odia handwritten character recognition with noise using machine learning technique like Naïve Bays, Decisions tree, and WIKA and developed a methods for data processing and classification for offline handwritten characters with and without noise and concluded that noise data decision table is 24% and Naïve bays it is 49%

M.Das and M.Panda[5] represented an ensemble methods of feature selection and classification of Odia charter and described the pattern recognition filler and wrapper methods for selecting top k important features and their accuracy is analyzed .Their accuracy and execution time to build the tree before feature selection and after selection is compared and got 92.2 % accuracy to reduce feature set

P.Sarma,C.K.Chourasiaand,MBarman[6]described Handwritten Assamese character recognition described about offline handwritten Assamese alphabets as input using modern input devices like camera or scanner and tried to convert it to

digital form to recognize the alphabets. They used template Matching technique and anticipated for recognizing hand written characters, including the schemes of Grayscale, Binary, Dilation, Erosion conversion or transformation of image, detection of ROI and comparing with dataset. The efficiency or the accuracy is calculated for every character with a number of testing cases and have been able to get accuracy more than 80% for maximum Assamese handwritten alphabets.

Mayank Jain ,Gagandeep kaur[7] represented handwritten digit recognition using CNN by exhibition of Convolutional Neural Network (CCN) and demonstrate that CNN classifier beat over Neural Network with critical improved computational effectiveness without relinquishing execution. Handwritten digit recognition can be performed using the Convolutional neural network from Machine Learning. Using the MNIST (Modified National Institute of Standards and Technologies) database. They basically perform the model by using some libraries such as NumPy, `Pandas', tensor Flow, Keras.

Ramesh Kumar Mohapatra, Tusar Kanti Mishra [8] experimented a complete database of handwritten atomic Odia characters. The first version of the database has been modeled and named OHCSv1.0 (Odia handwritten character set). The database comprises of 17,100 transcribed characters, each collected twice from 150 unique people at different point of time. Each character has 300 numbers of occurrences. The character images are standardized to a size of 64 × 64 pixels. The character images are gathered into various groups in view of their shape components utilizing an incremental spectral clustering algorithm.

Indugu Rushiraj, Souvik Kundu[9] published hand written character recognition of Odia script by classifying 36 basic Odia consonants. They extracted 48 geometric features which includes shadow features, centroid features and distance based features. They used Weighted Euclidean Distance method classifies the characters. The overall accuracy of their method is 87.6%.

Akansha Gaur , Sunita Yadav[10] presented handwritten Hindi character recognition using K-Means cluster and SVM for classification. They used hyper-plane decision surface with maximum margin and closest data point. Support vector machine uses a different kernel functions which defines the way of classification.

Ayush Kumar Agrwal ,A.K shrives[11] in A Robert model for handwritten digit recognition using machine and deep learning they used a datasets named as MNIST, which is collection of 70000 images. Many of machine learning and deep learning techniques have been already used by the researches for handwritten digit recognition like Support Vector Machine (SVM), RFC, K-nearest Neighbor (K-NN), Multilayer Perceptron (MLP), Convolutional Neural Network (CNN) etc. They compared the performance of CNN with SVM and KNN. The proposed CNN based on keras model used to classify handwritten digit images with

RMSprop optimizer for optimizing the model. The main contribution of their research work is to increase the convolutional layer with pooling and dropout and also tuned the model using filter, kernel size and number of neurons. The proposed CNN model achieves 99.06% of training accuracy and 98.80% of testing accuracy with epoch 10.

Dibyasundar Das, Ratnakar Dash[12] published a paper about Optimization based feature generation for handwritten Odia numeral recognition, they focused on developing a non – handcraft features extraction method using convolution, multiplication, and weight filler .the weight mask are optimized and a classifier can be used to classify the character images to its corresponding class.

P.Pujari and B.Majhi[13] published a survey of Odia character recognition and used a techniques employed for segmentation , feature extraction and classification task of Odia character and their strength and weakness are outlined .

Om Praksh Jena,Sateesh Kumar Pradhan[14] Implemented a linear discriminant analysis for Odia number recognition The process of converting input text images into machine understandable code or text is known as optical character recognition they devolved an efficient OCR for recognition of Odia Numerals using Linear Discriminant Analysis and compare the result with principal component analysis. And conclude that LDA has a better recognition accuracy over PCA due to dimensionality reduction.

N.Joshi ,G.Sita[15] represented about Machine recognition of online handwritten Devangari characters. They used a system for the automatic recognition of isolated handwritten Devanagari characters. Owing to the large number of characters and resulting demands on data acquisition, they used structural recognition techniques to reduce some characters to others. These residual characters are then classified using the subspace method. Finally the results of structural recognition and feature-based matching are mapped to give final output. The proposed system is evaluated for the writer dependent scenario.

S. Ansari and U. Sutar, [16] "Optimized and efficient feature extraction method for devanagari handwritten character recognition.

Vivek kumar Verma and Pradeep Kumar Tiwari[17] represented an Obstacles in Devanagari Script for Efficient Optical Character Recognition. They proposed a methodology that suitable for handling script styles information.

Abhishek Das, Mihir Narayan Mohanty [18] represented about Design of encoder in CNN for effective recognition of Odia numerals .They designed an encoder that generates the feature vectors by applying Convolutional layers activated by Leaky-ReLU followed by max pooling. They generated images are quite similar to original data that validate the proposed AE is well reconstructive.

PHASES OF OCR

The recognition process of an OCR follows several phases like collecting Input Image followed by required preprocessing steps followed by suitable feature extraction step followed by a Classification technique represented in this fig 5

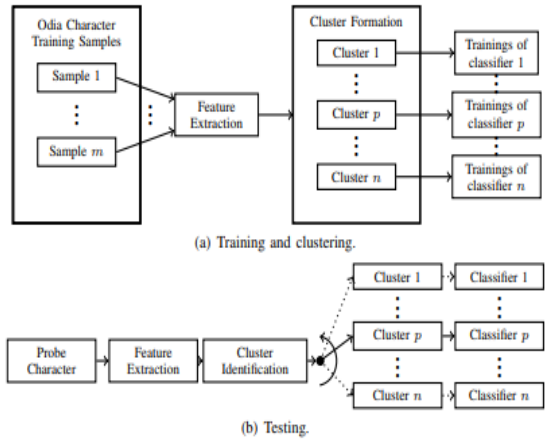

Fig 5

The proposed recognition frame work is compared with other competent recognition schemes. These schemes have foreground and background Pixel frequency and count represented in fig 6

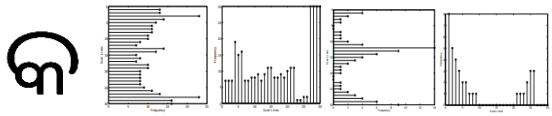

Fig 6

To organize and search the manuscripts written on papers is not that much efficient as compared to the digital copy of the manuscripts. We can only be able to search a huge database of handwritten texts when transformed into a digital copy; consequently, we can not only save time and money but also preserve our precious manuscripts. Handwritten Character Recognition schemes. are responsible for the automatic conversion of handwritten text into computerized text.

Steps to recognition of Character

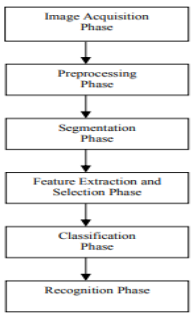

Fig 7

METHODOLOGY

Feature Extraction Using Shadow Feature

For extracting shadow features, each image has been divided into 4 equal sized squares i.e. into 8 octants as shown in the fig8 Then the length of projection of character image on both x-axis and y-axis of each octant are computed [8] Hence total 16 shadow features are extracted. For this projection, a light source is assumed in the opposite side. The shadow feature has been illustrated in the figure fig 8.

Illustration of Shadow Image

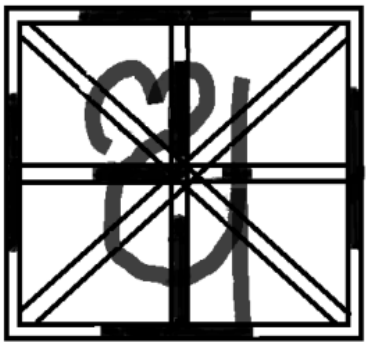

Fig 8

Feature extraction using Zoning based method For zoning based features, the image has been divided into 4x4 grids. Hence total 16 numbers of blocks or zones are generated.

Convolutional Neural Networks

The term Convolutional Neural Networks is inspired by one of the most important operators in the network that is convolution and the human brain itself. The hidden layers/feature extraction part and the Classification part are the two common components of any Convolutional Neural Network .The algorithm of the Convolutional Neural Networks is as shown as in Fig: 9. The network performs a series of convolutions and pooling operations in the feature extraction step during which the particular features are detected. This is very essential to the classification step as the important features of the image are already separated out during this step. This is achieved by performing convolution with kernel filters represented here. The convolution is performed on the input data with the use of a filter or a kernel to produce a feature map. The input image is nothing but a representation of pixels in a matrix format. Convolution is executed by sliding the filter over the input image matrix. At each and every location, pixel values at corresponding locations of the input image and the kernel are multiplied and the products are added and the final value after addition is assigned to the central pixel. It is represented in fig 10

Flow chart of Convolutional Neural Networks

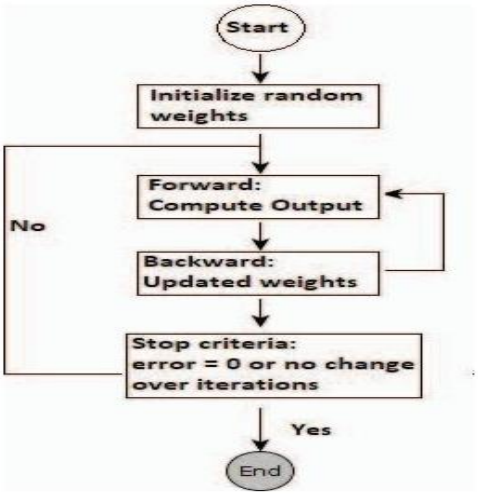

Fig 9

The input image is nothing but a representation of pixels in a matrix format. Convolution is executed by sliding the filter over the input image matrix. At each and every location, pixel values at corresponding locations of the input image and the kernel are multiplied and the products are added and the final value after addition is assigned to the central pixel. It is represented in fig 10

Convolutional Kernel

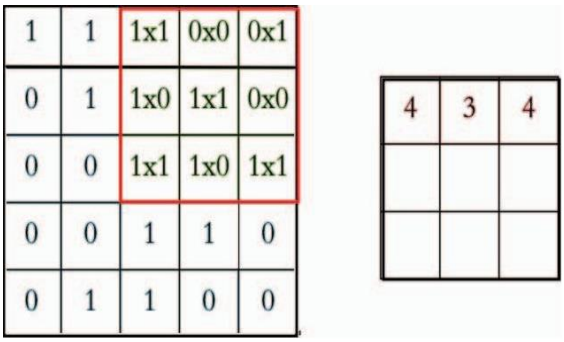

Fig 10

Pooling operation is performed to reduce the spatial size of the representation. The respective values of the kernel filters are automatically learned by the neural network through the training process, and the filter kernels which result in the most efficient features for the particular classification or detection are also automatically learned .In the Classification layer, the fully connected layers will serve as a classifier on top of these extracted features. They will assign a priority for the object based on the neurons in the network. Each neuron has an activation function that changes with step in the training phase. The ultimate aim with the activation functions is to reach a phase where there is an optimal solution for the entire training set data. This is done by minimizing the error at each step and changing the activation functions accordingly. The methodology comprises two steps: the training and the testing step.

Training Step

Training a Convolutional Neural Network works in the same way as a regular neural network i.e. by using a methods such as back propagation or gradient descent. For the purpose of training the neural networks, 3001 images were used which had around 1500 images per consonant and 1000 images per vowel. Initially, OHCSV1.0 database was taken but when the character data increases then we have to implements data augmentation technique. The layered architecture of our convolutional neural network is shown fig 11 .In the Keras library with Tensor Flow backend it has used in order to implement the Convolutional Neural Networks. Once the CNN was trained, an .h5 file was generated. An .h5 file stores and organizes the humongous amount of data in a Hierarchical Data Format. The .h5 file consists of model parameters including weights between the layers of the neural network.

Convolutional layers in our algorithm

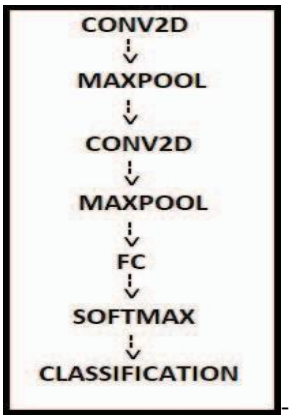

Fig. 11

Testing Step

In the testing step, the .h5 file was imported into the main code for recognition. Two different applications for recording inputs from the user were made by tkinter and OpenCV.

Fig 12

The tkinter approach involves making a python-based GUI where the person can draw into the screen using the cursor as shown in Fig 12. The image is then used for the purpose of recognition. For this purpose, an application for drawing the letters in tkinter GUI was made. Another approach made use of OpenCV, for the user to draw the letter in mid-air and having the computer track the position of the user in order to determine the character to be tested. For this, an application was built which tracked the movements of the stylus which the user was holding. This was implemented by simply attaching a blue colored piece of paper on top of a cardboard and having the computer track the position of any object with the color blue. Once the user input was taken using either of these two methods, it was classified by using this model. The input was classified as which character it was based on its similarities with the training images.

RESULTS

In the training phase, the Convolutional Neural Network was successfully trained with 2500 images. The neural network was optimized at 3 epochs after which the considerable margin. The training dataset accuracy was 96.8%. The accuracy vs epochs plot was observed to optimize the model. The graph stating the accuracy as the epochs in fig 13.

Accuracy vs No. of Epochs

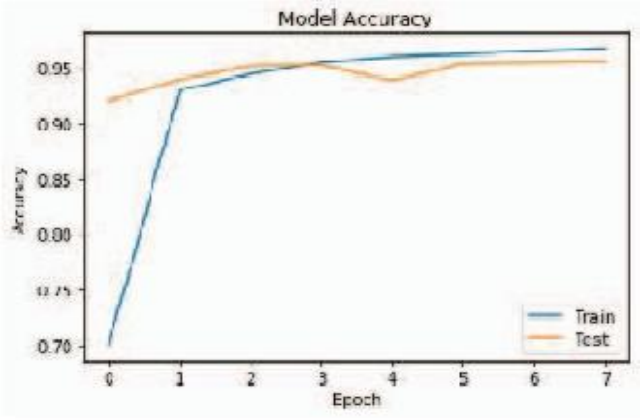

Fig 13

FUTURE SCOPE

Future study can be extended to be implementing to classify the huge amount datas using matras of the hand written characters .Research can be done by implementing smartphone or desktop application .It can be used by school going children for understanding the alphabets better. They can search the internet by drawing in their native language. Such an application can impact people across the globe, including people who are learning new dialects and furthermore children who are just beginning their education. This concept can be extrapolated to all other languages beyond Odia Script languages as well. An user interface can be built to extend its usage to mobile, tablet and other gadgets. A real time application can also be built which would directly recognize the characters, as they are drawn on the screen, without explicitly telling the computer to recognize the character.

CONCLUSION

Technology has transformed the lives of billions of individuals for the better. But, in order to reach the people who are not connected to the technology grid today, it is imperative that the applications be built specifically for those people. Also, the intended applications be built in a medium which they can not only understand, but also feel a sense of belonging with. For contributing towards that goal, this paper proposes an Odia Character recognition system using Convolutional Neural Networks. After being trained through several images of characters, the classification was done with an accuracy of 95.6%. CNN is hence a reliable technique for the classification of handwritten characters and can be implemented for applications including home schooling and automated answer checking. Odia Character Recognition is not only a major application in itself, but is also a significant step in the implementation of other applications.

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