A Thesis Mid Term Report

On

Compounded Devanagari Character Recognition using Convolutional Neural Networks and Transfer Learning

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Abstract

With the advent of the Convolutional Deep Neural Networks, it has been possible for humanity to convert handwritten text into digital form which makes the text more searchable and computational processing friendly. There has been many attempts to digitize Devanagari Scripts. However, due it's complexity of the structure, it is pretty much hard to digitalize full Devanagari Texts. The past researches has done the job of segmentation of the characters from words and even achieved high accuracy results for individual character. Compound characters, however, hasn't gotten much attention. This thesis is dedicated to fulfill that gap by achieving similar degree of accuracy for compounded characters there by using the method of transfer learning from the existing trained model for the basic characters.

Keywords: Machine Learning, Deep Learning, CNN, Transfer Learning

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List of Abbreviations

CNN	Convolutional Neural Network
RNN	Recurrent Neural Network
DCNN	Deep Convolutional Neural Network
SVM	Support Vector Machine
NA	Network Architecture
k-NN	k Nearest Neighbour
FANN	Fast Artificial Neural Network
NLP	Natural Language Processing
SGD	Stochastic Gradient Descent
MSGD	Minibatch Stochastic Gradient Descent
FFT	Fast Fourier Transform

Contents

1. Introduction

1.1 Background

For a very long time, so many computer scientists and researchers have worked tirelessly on digitization of Sanskrit language to unfold the vast knowledge embedded within the Ancient Sanskrit Scriptures [1]. Sanskrit Scriptures are basically the Devanagari Scripts only. The nature of the Devanagari script is such that it has basic characters and compound characters that is compounded by the vowel and consonant sounds which adds to the complexity in character recognition – unlike English and European scripts [2].

Figure 1 Depiction of compound characters

Recognition of Devanagari Handwritten text is very complex also because of the Shirorekha -- the line drawn above each character [3]. That is why, one of the steps in the whole process of digitization is word segmentation also. There have been researches and models been put forward where people worked for segmentation of Sanskrit scripts: separating one letter from another which in itself is great engineering feat [1].

In a survey entitled A Comparative study on Handwritten Devanagari Character Recognition, different nature of Feature Extractions and their corresponding classifiers and accuracy is tabulated. Upon extracting the best features from the raw data, different researchers have been able to gain accuracy, well over 98%. CNN has the highest accuracy followed by SVM [4].

The higher the size of the test data set, higher the accuracy it has. In the researches that have been carried out, albeit a small difference, the binarized image dataset showed better accuracy over grey scale image dataset. Some 10 years ago, even employing all available techniques, the accuracy of the conversion from handwritten to digitized form couldn't exceed 95.2% [2].

1.2 Statement of Problem

The researches have been done on recognizing individual Devanagari characters (basic characters) with astounding accuracy. The compound characters have also been worked upon by many researchers employing various techniques including CNN. The compound characters past researchers addressed have one half letters with another full letter which are seen together. The models generated for basic character and compounded characters can be used to push the frontier of Character Recognition. Such models could be used by transfer learning and hence the modifiers could be detected. This Thesis addresses that very problem. This is explained by Figure 2.

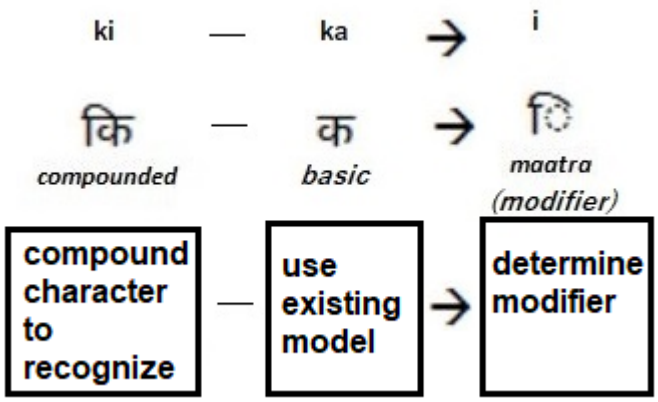

Figure 2 Statement of Problem; transfer learning to detect the modifier

1.3 Research Objectives

The main objectives of the research are:

- To Transfer the knowledge of existing CNN models to recognize the modifier within the compound character.

1.3 Significance of Study

- Help save plethora of ancient scared scriptures knowledge in its pristine form from the possible decay, damage and larceny since it can be backed on multiple regional data centers [5].
- By digitalizing any hand written text, it becomes easily searchable and quickly learnable through internet; makes "Web-friendly" [6].
- Gives impetus to the research of recognition of characters in bulk and recognition of actual world images like hoarding boards, which can be used in internet services like Google maps and Apple maps [4] [7].

2. Literature Review

In a research, entitled Palm-Leaf Manuscript Character Recognition and Classification Using Convolutional Neural Networks, various machine learning approaches and their corresponding prediction rate and time were inferred for Tamil Language scripts. The SVM algorithm had a prediction rate of 86% with the prediction time of 1.06 seconds. The k-NN algorithm had a prediction rate of 77% with a prediction time of 1.04 seconds. The FFNN algorithm had a prediction rate of 89.21% with a prediction time of 0.95 seconds. And finally, the CNN algorithm had a prediction rate of 96.21% with a prediction time of 0.65 seconds. So the multiple researches have been suggesting that CNN has better performance both in terms of prediction rate and prediction time [8].

In an article entitled, Handwritten Devanagari Character Recognition Using Layer-Wise Training of Deep Convolutional Neural Networks and Adaptive Gradient Methods, DCNN is employed using variety of Networks: 6 different networks (NA-1, NA-2, ... NA-6) were made in which Input layer, Filter layer, Convolutional layer, are varied (RelU layer are also added in two consecutive networks) and their corresponding results are shown. With the increasing epoch, the accuracy almost tends to stabilize.

- For NA-1(64IN64-64C2-Relu-4P2-500FC-47OU), average recognition accuracy is 0.8436.
- For NA-2(64IN64-64C2-Relu-4P2-1000FC-47OU), average recognition accuracy is 0.8549.
- For NA-3(64IN64-32C2-Relu-4P2-32C2-Relu-4P2-1000FC-47OU), average recognition accuracy is 0.9000.
- For NA-4(64IN64-64C2-Relu-4P2-64C2-Relu-4P2-1000FC-47OU), average recognition accuracy is 0.9058.
- For NA-5(64IN64-32C2-Relu-4P2-32C2-Relu-4P2-32C2-Relu-4P2-1000FC-47OU), average recognition accuracy is 0.9190.
- For NA-(64IN64-64C2-Relu-4P2-64C2-Relu-4P2-64C2-Relu-4P2-1000FC-47OU), average recognition accuracy is 0.9427.

In a research entitled, On the Performance of Devanagari Handwritten Character Recognition, minibatch Stochastic Gradient Descent (MSGD) was used. The speed of recognition was accelerated for large dataset. They used pre-processing and feature extraction together which reduced their error rate by 1-3% [9].

In an Journal article entitled "A Novel approach towards Online Devanagari Handwritten word recognition based on robust feature extraction method and FFNN classifier", Saniya Ansari et. al achieved Devanagari character recognition accuracy of 84.70% for SVM, 82.30% for K-NN and

94.57% for FFNN. 7500 word samples were used to create 20 dataset out of which they used 70% samples for training, 20% for testing and 10% for validation [10].

In a Journal article entitled "Handwritten Devanagari (Marathi) Compound Character Recognition using Seventh Central Moment", P.E. Ajmire et. al worked on recognition of compound character using combination of 7 invariant moment (Rotational Moment) and 7th order Central Moment(Translation Moment). The performance of the system using SVM classifier was 93.87% [11].

In a Journal article entitled "Handwritten Marathi Compound Character Recognition using Structural and Statistical Features", Mrs.Snehal S. Golait et. al provide feature extraction for Handwritten Marathi Compound Character using structural and statistical methods (DFT and DWT) and multistage classification scheme. The character recognition accuracy was 90% [12].

In International Journal of scientific and technology research, an article entitled “Devanagari Handwritten Character Recognition Using Neural Network”, Anupama Thakur et. al published a hybrid technique: combining k-NN along with neural networks to recognize individual vowels and consonants of Devanagari scripts which resulted in 97.4% recognition rate [13].

3. Design and Methodology

3.1 Background

The proposed model is shown in the Figure 3. The Tensorflow library with Keras will be used to apply the proposed algorithm with the datasets.

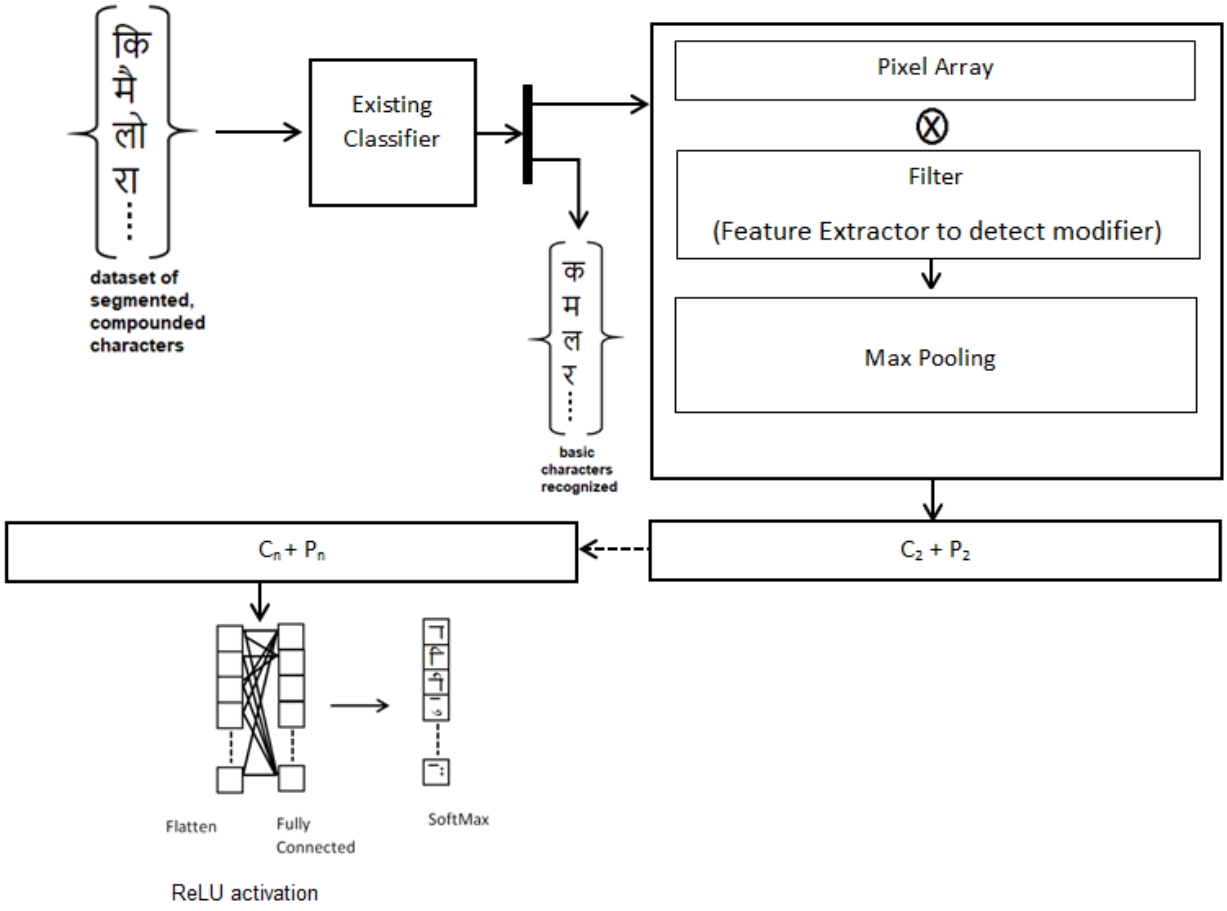

Figure 3 Flowchart of Proposed model and work flow

Transfer Learning is using the classifier from an existing model and employing some portion of it or all of it to a different sector of CNN. It is all about repurposing an existing model [14]. Since models have already been developed for basic characters, such models will be used to detect the basic characters. The image will be further fed to the Convolutional Neural Networks to detect the further features – modifiers in this case.

Convolution is mixing of two multi-dimensional arrays: the pixel n × n is convolved with the kernel of m × m [15]. In this particular case, 28 × 28 input matrix will be convolved with the kernel of 3×3 which will slide across the image with the stride of 1. Various cases like changing the kernel size or the size of stride may happen as the understanding about the subject matter gets better.

The resultant image after the convolution is called feature map [15]. The result from convolutional layer is fed into the pooling layer. In pooling layer, the model will be tested by max-pooling and average pooling. Usually, for this kind of applications, max-pooling has been proven to be better since it performs as noise suppressant. This pooling layer reduces the computational complexity [16]. However, both of them will go for test and then whichever gives better result will be in this research's findings.

The further step is flattening and feeding forward to regular multi-layer neural network for series of epochs. Flattening of the layer is converting the pixel format into to 1 × n dimensional vector [16]. Back propagation will be employed to update weights in order to reduce error [17]. The dominating features will be extracted after series of epoch which will be distinguished by the activation function called SoftMax at outermost layer [16].

As it starts getting clearer on how much time and resources each method takes, test will be done with different CNN like LeNet, AlexNet, VGGNet, GoogLeNet etcetera.

This paper is thus an step further for natural language processing (NLP) using transfer learning and CNN. The very use of transfer learning increases the efficacy of the learning [14].

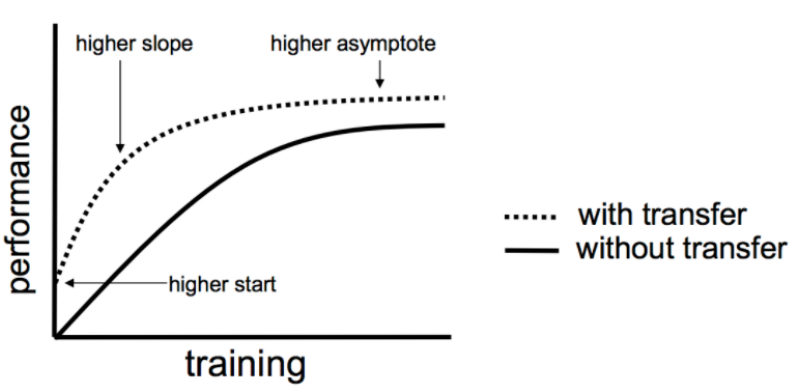

Figure 4 Higher performance comes with Transfer learning

3.1.1 Data Collection

The dataset images of the compounded characters will be collected from various sources like Kaggle, and Open Data Journals. If not found, data may be manually extracted from Ancient Sanskrit Scriptures as the dataset need not be very large. In that case, the extracted dataset will be open sourced for others to make use of it.

3.1.2 Model Building

As the data is received into the software via some library methods of Keras, the imape input layer is prepared. The Convolutional Layer, RelU layer, Pooling Layer is constructed. This is Deep Convolutional Neural Network architecture. This layer of hidden layer can be repeated n-times as per the requirement of accuracy. It also depends on the computational capacity. Thus the model (classifier) is prepared.

3.1.3 Classification

The input image dataset is passed to train the model. As the model is trained, now as the image-dataset is passed, the output will come as labeled output at the output layer. Finally, the accuracy is tested.

4. Expected Outputs

The research expects:

- The model would efficiently predict the modifiers (maatraa) of compounded Devanagari Scripts with acceptable degree of accuracy.

5. Model Validation

Different Evaluation Metric like Precision, Recall, Accuracy and f-measure will be employed thereby using the confusion matrix for the validation of model.

Evaluation Metric	**Formula**
Precision	TP/ (TP + FP)
Recall	TP/ (TP + FN)
Accuracy	(TP + TN)/N
F Measure	2 * Recall * Precision (Recall + Precision)

Table 1 Model Validation

6. Activity plan

Task	December, 2020	January, 2021	February 2021	March, 2021	April, 2021
Literature Review					
Prepare Proposal					
Design, Develop and Implementation					
Mid Term Report					
Final Report					
Documentation					

Table 2 Gantt Chart

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