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Kannada Character Recognition Using Convolutional Neural Network

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Abstract

Character recognition of reading handwritten alphabets in regional languages is a complex problem and needs machine learning for solving the problem effectively. There are multiple machine learning algorithms proposed to read the characters and deep learning approach, Convolutional Neural Network is one among them. In the work proposed we build a character recognition system for recognizing kannada alphabets. We have trained our model using our own dataset and trained model was tested with the test image. The model achieves 93% accuracy in recognizing kannada alphabets.

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1. Introduction

Character recognition is a fundamental and most challenging issue in the field of pattern recognition. It is a technique by which a device recognizes characters and other symbols. Handwritten recognition system is of two types, online and offline. The offline recognition system performed after the characters are scanned, digitized whereas online recognition system takes input at the runtime.

Optical Character Recognition (OCR) comes under classification domain. Most of the research work has been done for implementation of OCR in English and other foreign languages. Countable research work is done on implementation of OCR for South Indian languages and Kannada language is one among them. Kannada script is more complex than recognizing English scripts as it contain compound, overlapping and, subscript characters. In Kannada, alphabetsare classified into two main categories namely vowels and consonants. There are 16 vowels and 35 consonants.

In the field of OCR there are three methods: template matching, feature extraction and classification, and third one is the deep learning method. In the early stage of OCR, template matching and structural analysis were used[7]. Later, Artificial Neural Networks, Support Vector Machine (SVM) have been applied for pattern recognition problems. Neural network models became prominent in the implementation of classification related problems since 2012. This is because of their architecture, there is no need of manual feature extraction. In deep learning, the best way to implement character recognition is Convolutional Neural Network (CNN).

The architecture of CNN is analogous to the connectivity pattern of neurons in human brain and draws inspiration from visual cortex. CNN performance is better and powerful than traditional machine learning algorithms with appreciable results and computationally efficient. It is extremely successful in areas where large, unstructured data is involved. From the previous works, feature extraction based approach is suggested to classify characters. We have tried to classify kannada vowels using CNN due its efficiency.

The paper is structured as follows. Section 2 gives the review of literature work done in the related fields. Section 3 introduces CNN and Section 4 gives the methodology of the proposed solution, Section 5 discusses the results and Section 6 concludes.

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2. Literature Survey

[1]B.V.Dhandre et al. proposed a method to identify kannada vowels and English uppercase alphabets by density zone based feature extraction with KNN and SVM Classifiers.Average recognition accuracy was 95.77% and 97.03% for KNN and SVM classifier respectively.

[2]Saleem Pasha and M.C.Padma proposed a method for handwritten Kannada characters and achieved 87% accuracy. KNN classifier is used to classify characters using hybrid features. This hybrid feature extraction involves local and global feature extraction.

[3]Kavya.T.N et al. proposed a method to identify kannada handwritten characters that include vowels, consonants and numerals by hybrid zone based feature extraction algorithms and fused classifiers of K-Nearest Neighbour and Linear Discriminant Analysis. The recognition rate of fused classifier, provide best results than individual KNN and LDA classifiers. The algorithm have obtained 94.6%, 84% and 98% recognition rate for Kannada vowels, consonants and numerals respectively.

[4]Asha k et al. have proposed an approach to identify kannada handwritten document recognition using CNN model. They have used Chars 74k dataset for training and Kannada handwritten document for testing and achieved 96% and 98% accuracy respectively.

[5]Aravinda C.V et al. have proposed recognition of Kannada text from handwritten document based on correlation similarity as a measure and template matching for classifications of segmented charcters. It made use of printed and handwritten characters for template generation. It has achieved 65-95% accuracy.

[6]Jagan et al. have proposed an approach to identify handwritten telugu numeric characters using Deep Learning(CNN).Samples were trained and tested and recorded the overall accuracy of 94%.The experimental results shown that Convolutional Neural Networks performance better in recognition for Telugu numerals The recognition rate for few digits can be improved by new kernel filters.

3. Convolutional Neural Network

CNN is a deep learning classification algorithm, a specialized type of neural network model designed for working with image data. CNN model need to be constructed which is a series of network layers. It is a combination of two components: feature extraction part and the classification part. It consists of mainly 3 layers apart from input and output layer. The convolution and pooling layers perform feature extraction. Classification part is handled by fully connected layer (dense layer).

Input Layer: The input image of certain size which is an array of pixels is the input to this layer.

Convolution layer: Filter of certain size which is a set of weights convolves over the input image from the top left corner, element wise matrix multiplication is performed and product is summed up. Multiple convolutions are performed to get distinct feature map. Distinct feature maps are the final output of the first convolution layer. These feature maps are the input to its subsequent layers.Feature map at first layer detects low level features. Feature maps as the image pass through more convolution layers detects higher level features.

Pooling Layer: This layer reduces the dimensionality of feature map. It shortens the training time and avoids overfitting. There are two types of pooling operations, average and max pooling. Average pooling and max pooling returns the average of all the pixel values from the portion of the image covered by filter. Max pooling is preferred because it takes out the dominant features and is also noise suppressant.

Fully Connected Layer: This layer takes the output of pooling layer and predicts the best label for the image by outputting an N dimensional vector where N is the number of classes. Numbers in the vector is the probability of the classes.

Output Layer: CNN uses softmax activation function as a classifier in the output layer. It computes the values between 0 and 1 and makes them add up to 1, outputs the 1-D array of size equal to number of classes. The Class with maximum value will be selected as the class for a particular image.

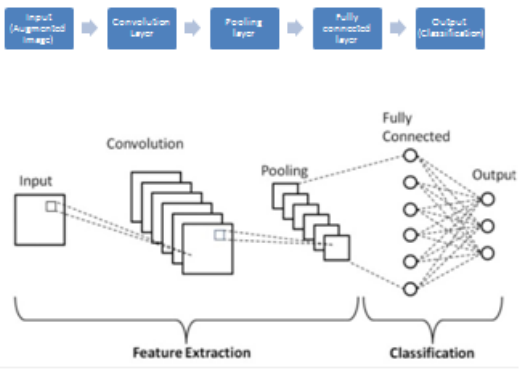

Figure 1.CNN Model

The image is flattened into a column vector fed to the feed forward neural network and backpropagation applied to every iteration of training to adjust its weights over a series of epochs. Activation function, Rectified Linear Unit (ReLu) introduce non-linearity applied after each convolutional layer increasing the non-linear properties to the model and over all network. Fully Connected layer learns the non-linear combinations of high level features.

Dropout layer is added to avoid the overfitting. The role of drop out is to dropout the random set of activations in that layer by setting them to zero.

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Hyper parameters used are filter size, number of filters, stride, padding. Filter size such as 3x3, 5x5 or7x7 used. Number of filters can be 16 or 32 filters at convolution layers, using more filters results in a more powerful model.And stride is parameter to be moved by filter on an array of input image. Same padding maintain the same dimensionality with surrounding the input with zeros and valid padding to reduces the dimensions of the input image.
Optimzers are used to adjust the learning rate, learning rate decides how fast the optimal weights are adjusted.

4. Methodology

There is no standard dataset for handwritten Kannada characters. Even though, Chars74K dataset is available, it cannot be efficiently used for our work. The result of CNN approach is mainly dependent on training the model, thereby requires the large amount of dataset. We have collected the handwritten kannada vowels from the people of the age group between 10-20 years. The individual characters are taken as a photograph and stored in the folder and given as input. Data augmentation was applied on the created dataset to increase the size of the dataset.

Our work has the following stages

Dataset Creation: Since no standard dataset is available, we created the dataset. Creating dataset is really tedious job as it is time consuming and requires lot of effort. 200 images are created for each character making up 3000images for all 15 kannada vowels. One of the character is excluded in dataset as this character is not mostly used. The kannada vowels and corresponding integer values used are shown in Fig 2. Fig 3 shows one of the image from dataset
Dataset augmentation: To train CNN, large dataset has to be used. Dataset is increased by augmentation technique. The technique involves horizontal flipping, slanting, zooming, rotation of images and rescaling of image.

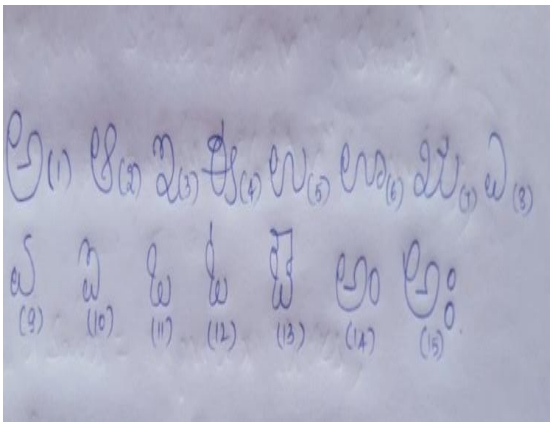

Figure 2: Characters with its corresponding integers

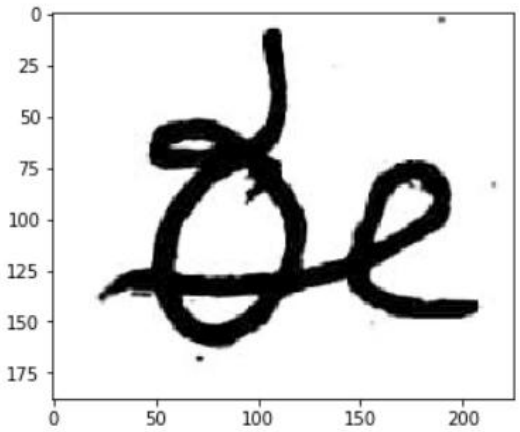

Figure 3: A sample character from the Dataset

5. Implementation

Convolution Layer: The input images are resized to 28*28 size and input convolutional layer. Convolutional layers are made of filters of size 3*3 and the stride to convolve is fixed at 1, with no padding and ReLu activation function.
Max Pooling layer: This layer uses a pooling window of size 2*2. Series of convolution layer and Maxpooling layer are arranged alternately. In the last layer of these feature extraction layers, dropout layer is added. The feature map are flattened to pass through fully connected layer.
Fully Connected Layer: Fully connected layer and softmax function with 15 outputs is used to get the label of the class.
Optimizer used is Root Mean Square prop (RMSprop).CNN model is subjected to batch normalisation.
Training and testing: The model is trained and validated. The images are randomly selected and scaled to 28*28 from the test dataset is given as the test image to the trained CNN model to predict the label. This integer value is associated with the character (Fig 1). Softmax function is used to classify the character and the accuracy is measured. Eqn 1 is the formula to calculate the test accuracy.

Test Accuracy = (correctly predicted labels/ test images)*100 (Eqn 1)

Loss = (wrongly classified labels/total no of images) *100 (Eqn 2)

6. Results

After training the CNN model, the performance was evaluated using accuracy and loss. The training accuracy was in the range 93%. And the validation accuracy was 95%. The training loss is 15 % and the validation loss was fluctuating between 20% to 5%. Due to unavailability of resources we trained only for 50 epochs. If the training is increased to more epochs, there will be an improvement in accuracy. Fig 4 shows training and testing accuracy and training and

testing for 50 epochs. Also it shows the minimizing of loss as epochs increase while calculating the weights through the network. The testing accuracy was nearly 90%

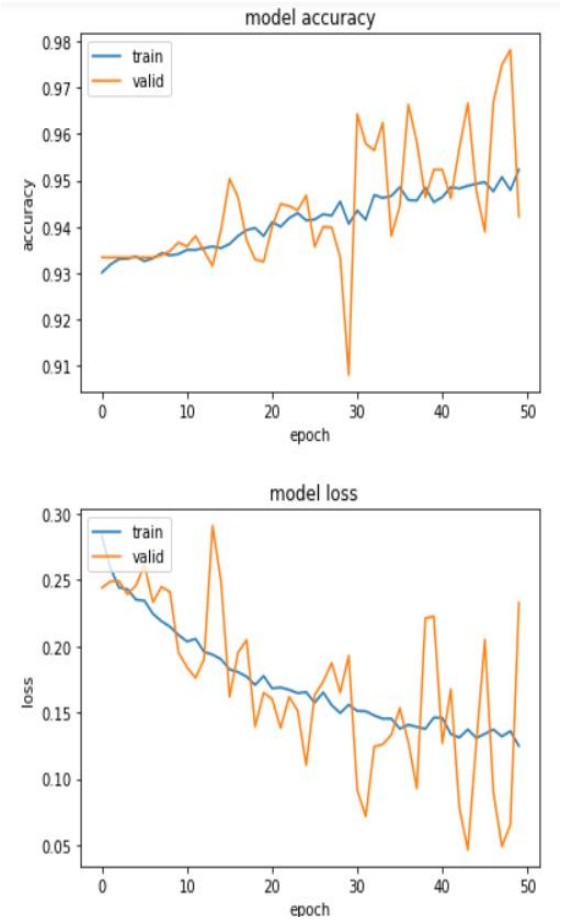

Figure 4: Training and test accuracy and loss

7. Conclusion

Every script of its respective language have its own challenges. Few language characters are less challenging as characters are well separated and the features are less complicated. South Indian languages like kannada, telugu, tamil, Malayalam are very complicated due to number of alphabets present and also complexity in the shapes and also presence of subscripts. And scripts where characters are attached with one another and chances of overlapping are high, so recognition is challenging. We have tried to classify kannada vowels and plan to extend it to all kannada alphabets. The attempt is fruitful with over 90% accuracy on both training and testing data. This work can be extended to recognize the consonants, kagunitha, words from handwritten and printed documents.

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