International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Recognizing Ancient Characters from Tamil Palm Leaf Manuscripts using Convolution Based Deep Learning

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Abstract*: Palm leaf manuscripts has been one of the ancient writing methods but the palm leaf manuscripts content requires to be inscribed in a new set of leaves. This study has provided a solution to save the contents in palm leaf manuscripts by recognizing the handwritten Tamil characters in manuscripts and storing them digitally. Character recognition is one of the most essential fields of pattern recognition and image processing. Generally Optical character recognition is the method of e-translation of typewritten text or handwritten images into machine editable text. The handwritten Tamil character recognition has been one of the challenging and active areas of research in the field of pattern recognition and image processing. In this study a trial was made to identify Tamil handwritten characters without extraction of feature using convolutional neural networks. This study uses convolutional neural networks for recognizing and classifying the Tamil palm leaf manuscripts of characters from separated character images. The convolutional neural network is a deep learning approach for which it does not need to retrieve features and also a rapid approach for character recognition. In the proposed system every character is expanded to needed pixels. The expanded characters have predetermined pixels and these pixels are considered as characteristics for neural network training. The trained network is employed for recognition and classification. Convolutional Network Model development contains convolution layer, Relu layer, pooling layer, fully connected layer. The ancient Tamil character dataset of 60 varying class has been created. The outputs reveal that the proposed approach generates better rates of recognition than that of schemes based on feature extraction for handwritten character recognition. The accuracy of the proposed approach has been identified as 97% which shows that the proposed approach is effective in terms of recognition of ancient characters.

***Keywords:** Palm Leaf Manuscript, Optical Character Recognition, Convolutional Neural Networks, Handwritten Tamil character, Ancient Tamil Character*

I. INTRODUCTION

Optical character recognition is the method of transforming images comprising typewritten, handwritten or printed characters into machine encoded format. Optical character recognition has leveraged their capabilities to decrease the tedious manual work of transforming images of handwritten or printed texts to digital form. Various approaches have been employed in optical character recognition such as Hidden Markov Model, Bayesian Theory, Neural Network and Template Matching. The handwritten characters recognition task is rather complicated and is a huge barrier to researchers as the solution must be capable to cope with the barriers in recognizing the characters from different styles of writing and slants of personal interest [4]. [17] have stated that the image recognition for handwriting is much challenging because every individual must have a varied form of handwriting. The detection of handwriting has many factors that will impact the successful identification of handwriting because a misinterpretation will be more handwriting than computer handwriting that is to have a fixed form relying on the type [2].

The OCR systems [3] have been developed efficiently for identifying several Indian Languages printed characters namely French, English, Chinese. Now huge efforts are made for the growth of effective systems for identifying the Indian languages particularly for Tamil - a South Indian language which is used widely in Puducherry, Tamilnadu, Srilanka and Singapore. The Tamil language specialty [14] is that every sound has a Tamil syllable. In Tamil language the characters economy to indicate a word is minimal. In Tamil script the smallest number is syllable. These syllabic Tamil script units have twelve vowels, eighteen consonants and a special character. The integration of consonants and vowels makes a total of 216 compound characters thus a total of 247 characters. There are five borrowed consonants from Sanskrit which when integrated with vowels would generate another 60 compound characters so as to make a total of 307 characters. The whole set of Tamil character can be indicated by an integration of 156 unique characters

[21] discussed that the identification of Tamil character is a challenging task in machine learning field due to Tamil characters complexity. To resolve this complexity a new method known as deep learning has occurred in machine learning field. Convolutional neural network is a special type of network that exists under deep learning which is employed to perform with images.

Manuscript published on 30 September 2019
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According to [25] convolutional neural network studies feature from pixels to classifier and it can learn a distinct feature set automatically in a hierarchical way unlike other vision learning methods where features are designed by hand. According to Yamashita [26] convolutional neural network is a deep learning methods class which has become familiar in different tasks of computer vision and is attracting interest across different domains involving radiology.

Convolutional neural network is comprised of numerous blocks of building such as pooling layers, convolution layers and fully connected layers and is designed to adapt and automatically learn spatial hierarchical features through a back-propagation algorithm.

[27] have described that convolutional neural networks are the vastly used models of deep learning in managing image associated tasks like image classification, image recognition, captioning of image, etc. These networks are usually an integration of pooling layers, convolutional layers and fully connected layers. These three blocks are employed to build a convolutional neural network model by differentiating the block number or by deleting or adding a block. The CNN is one of the most vastly used approaches for handwriting recognition. Before entering into CNN the image must pass through pre-processing first and the steps used for pre-processing are: 1) first the input image is identified; 2) warping or cropping is performed and the image part that does not need to be identified is lost; and 3) image size is set and the size must be relevant. [13] have mentioned that the convolutional neural network comprises of a network comprising 2 convolutional layers followed by 2 FC (fully connected) layer and Max pooling layer followed by a layer of output. Every layer dimensionality is shown alongside of respective layers. Convolutional neural network performs well on tasks of image classification in spite of its computational and network complexity.

[1] has mentioned that the stages of convolutional neural networks for image identification are: 1) pre-processing; 2) datasets creation; 3) determination of final data; 4) classification; and 5) testing. In the stage of image processing the image is resized and if it is too big then the calculation will be greater or if it is too little it will be difficult to adjust to huge networks. Similarly, [12] has stated that if no open source set of data is feasible for handwritten characters to be predicted it must be constructed in a new set of data but if a dataset is feasible then an existing set of datasets can be employed. [6] have mentioned that the third stage is that a large set of data is needed to train convolutional neural network for the determination of final data. To accomplish this, images have been acquired are changed to acquire huge set of differences. The fourth stage is classification where the convolutional neural network end layer is SoftMax layer and this layer is employed to classify the input images. The last step is testing where the module of test is associated to test image and the test images were acquired by classifying the randomly sets of enlarged data [10].

[23] has stated that the convolutional neural networks have numerous convolutional layers to retrieve features automatically. The features are retrieved only once in several shallow models of learning but in models of deep learning numerous convolutional layers have been acquired to retrieve discriminating features several times. This is one of the reasons that models of deep learning are usually successful. [9] has mentioned that the time needed for long training due to convolutional neural network has better accuracy in CNN for handwriting recognition because much convolutional neural network training will outcome in much exact recognition of writing. Convolutional neural networks are regarded as an essential method which has greater accuracy than other handwritten recognition methods. Thus, it can be inferred that a convolutional neural network is capable of accomplishing outstanding results on Tamil datasets using supervised learning.

II. LITERATURE REVIEW

In the research of [24] a neural network-based classifier using OCR engine for Tamil language is suggested. The features derived at every sample point of pre-processed character are employed to build a subspace at the first level using OCR (optical character recognition) software. The test sample identification is carried out using a neural network-based classifier. Based on the examination of proposed approach it was recognized that the recognition of Tamil character was optimal and the implementation decreases the complexity of coding to a huge extent. The suggested method can be employed to identify any characters of language but in this research only Tamil Characters were verified for recognition. As a future speech processing enhancement implementation processing can be employed to recognize the categorized characters to impaired persons visually for ease. The similar technique can be employed to resolve confusion between quadruples and triplets of same characters. The similar recognition could be undertaken not only for separate characters but also for Tamil characters.

[8] has mentioned that courageous attempts were made towards handwritten optical character recognition for different scripts of India. The growth of HOCR systems was regarded as an active research area due to its structure and complexity of scripts of India. MODI script was an ancient Indian script as compared with other scripts of India. Huge set of historical documents occurs and they required to be discovered and conserved therefore special attention must be given to the script of MODI. This study is a trial towards an examination of present advances in handwritten optical character recognition system for the script of MODI.

[7] proposed a study on segmentation of handwritten Tamil character from palm script using histogram approach. Tamil palm script character is one of the difficult stages in machine identification. In India Tamil is the most familiar script and the palm script in Tamil comprises of consonants, different modifiers and vowels. Separate letter determines the character recognition technique accuracy hence appropriate segmentation is required. This study presents Tamil handwriting image segmentation from palm leaf manuscripts. The method involves three main steps namely the elimination of background to isolate text by the algorithm of Otsu, character segmentation and line segmentation.

An easy histogram-based method to segment the character of Tamil palm script is suggested in this study. Different barriers in Tamil script segmentation are also explained.

[5] studies the process of character recognition of different scripts of Tamil using different classifier and the study proposed noise segmentation and image process for the separate image characters of letters from each other. An essential step of feature extraction is employed after the process to identify the ancient characters exactly with the combination of hypothesis. The feature explains the object features distinctly for the complexity image variability method. The process of noise reduction with filtering approach is one of the feature extractions which are the method of retrieving information from test data which is much similar for the purpose of classification that is similar to the error type with blur image of characters or letters. The technique retrieves the general Tamil character components and then it can be transformed into components for extract measures of recognition to blur image probability. Lastly a system of recognition process is suggested for Tamil script characters. The characters of data set are sampled from the script based on tools or automatically. The proposed hypothesis classifier is verified on several image samples of ancient Tamil image letters.

[11] has mentioned in their research that identification of ancient characters of Tamil is one of the challenging tasks for epigraphers as the language has developed with varied set of characters. If the inscriptions are on stone walls it adds much complexity in recognizing characters. This suggested work focuses mainly on identification of different characters of Tamil between ninth and twelfth centuries using NLP and OCR technologies. In this study the images of inscription gathered from Archaeological Department of TamilNadu are segmented and pre-processed. During the process of segmentation the color images are transformed to grey image and then it is transformed to binary image based on the value of threshold. From segmented, the features of image namely curves, number of lines, dots and loops have been retrieved using SIFT (scale invariant feature transform) algorithms for every letter to recognize the accurate characters. Characters will be categorized and built based on extracted vectors using SVM classifier and the character patterns will be matched with known characters and found using Trigram technique. Every recognized character will be allotted with its respective value of Unicode and it will be updated in the corpus of image for further recognition of character and to make the system in recognizing the characters much efficiently.

According to the study of [16] The ancient letters of Tamil and its handwritten characters seems in the inscriptions of template are hard. Beside the ancient letters of Tamil and its characters are varied from modern characters of Tamil by its character. This study concentrates on recognition of ancient characters of Tamil letters and recognized them with modern letters of Tamil by using computer classification and processing where a trial is made in this study by an approach for identifying ancient letters of Tamil and its characters from inscriptions of stone age by using the so known contour let transform approach is used which has been established presently. The former works of studies were performed by using computer wavelet transformation which is not rebuilding the curved images as it is. The new contour let transform approach provides a resolution to resolve this problem. The contour let transform approach is a new three-dimensional technology and it provides an exact outcome whereas the wavelet transform is a two-dimensional technology. The letters of Tamil and its characters from input image are identified through the mechanism of clustering. Moreover, the noise existing in image is eliminated by fuzzy median filters. Additionally, neural networks are implied to recognize the image and compare the data with modern usage of Tamil.

According to the study of [15] writer recognition is a challenging task for the reason that it needs structural and textural features. Textural features are like grey level co-occurrence matrix and Gabor filters can be retrieved from complete text block or page. The structural features namely skew and slant height of character, width of stroke, frequency of blobs or loops etc. also feature the style of handwriting. Before retrieving the level features of character, it is a prerequisite need to segment the image of document into characters. This study proposes a connected component-oriented method to segment handwritten Tamil document image into separate characters. The features retrieved from these characters can be employed for writer recognition.

[22] have mentioned that the information pertaining to history can be obtained through inscriptions that are predicted globally. The specific origin regional languages were employed in inscription writing. One of the ancient languages in the globe is Tamil with rich literature and heritage. The writings were encrypted using different materials namely metals, stones, conch shells, copper plate and palm leaf. These inscriptions are rich in data pertaining to history, astronomy, religious, and culture, ,and economic tax, educational and administrative conditions. This research uses Hough transform and Shape for extraction of feature and neural network to identify the ancient script of Tamil.

In the study of [19] Tamil is a beautiful and ancient language and owns the prestigious stand of classical language declared by UNESCO. Combining it with the technique is an attempt to develop its beauty. Combining language with technology has often proved to be a boon to learners. There have been several studies performed in combining the language of English teaching themselves. Being the 5th most spoken Indian language Tamil owns the official language status in Sri Lanka and Singapore apart from the identification as minority language in Malaysia, Mauritius and South Africa deserves to be simplified, explored and enhanced for their learners at the best. This catered authors concern towards combining the Tamil language and technology. The main aim of the study is to extend its scope to make it feasible offline as possible. The neural network algorithm can be employed to recognize and classify the language pattern which stands as a base to perform this study.

This study concerns with developing the composite letters accuracy and the main purpose of this study is that authors have worked on transforming the handwritten characters to a computerized format of text.

The main purpose of [20] is to develop the system that authorizes Tamil character recognition from inscription and palm leaf through seized images and stock them for upcoming use. Certain mechanisms of training have done with many methodologies but differentiating characters of Tamil stances challengeable need. The language of Tamil is regarded too complex compared to other language because of the occurrences of slope, curved, pits, twist and it will differ the style of writing from one individual to another individual. Much studies requires adapting ancient characters of Tamil to modern characters of Tamil to expand the purpose of creating computerized system for offering developed human knowledge understanding. This suggested work is used for classifying characters of Tamil and store it is an organized system folder for further image processing. The feature extraction of Grey Level Co-occurrence Matrix is employed to quantify the segmented characters statistical features. At this situation the classified characters of Tamil are differentiated with stone inscription, palm leaf manuscript, document characters and handwritten characters using features of Grey level co-occurrence matrix and the outputs are promising. The below Table I shows the reviews of character recognition of ancient Tamil characters using various techniques:

Table- I: Reviews of character recognition for ancient Tamil characters using different techniques

S.No.	Author	Year	Technique Used	Findings of the Research
1	Venkateshwaran and Kumar	2015	Neural network-based classifier	Reduce the complexity of coding to a huge extent
2	Kulkarni Sadanand et al	2015	Handwritten Optical character Recognition	Historical document are explored and preserved through special attention
3	Kiruba	2017	Histogram Approach	Improves the accuracy of recognition and offers solution to the character and overlapping line issue present in ancient manuscripts of Tamil
4	Kala and Thangaraj	2017	Filtering method and hypothesis classifier	Finds the error probability in super text image and risk free text from Tamil characters
5	Manigandan et al	2017	Optical Character Recognition and Natural Language Processing	Resolves the issue in reading the images of inscription
6	Rajan and Sridhar	2017	Contour let transform and Neural Network	Provides an exact recognition of ancient characters of Tamil from inscriptions of temple stone age of Tamil nation is acquired
7	Rajalakshmi and Jayanthi	2017	Connected component labelling	Offers robust outcomes and the characters retrieved successfully are sufficient for writer recognition
8	Suganya and Murugavalli	2017	Shape and hough transform	Extracts features to identify the ancient Tamil scripts
9	Shanmugam and Vanathi	2018	Neural Network Algorithm	Improve composite letters accuracy
10	Sornam and Poornima Devi	2018	Grey Level Clo-Occurrence Matrix	Quantify the segmented characters statistical features

III. PROPOSED SYSTEM

The proposed system is robust to varied types of text appearances involving the size of font, style of font, background and color. Integrating the respective strengths of various approaches and resolving their drawbacks the proposed approach employs effective detection of character and classifier training based on convolutional neural networks. A convolutional neural network is a specific kind of ANN that employs perceptron ML algorithm for supervised learning to examine the data. Convolutional neural network applies to natural language processing, image processing and other types of cognitive tasks. Convolutional neural networks employ little pre-processing compared to other algorithms of image classification. Other learning models or algorithms can be employed for classification of image. However convolutional neural network has developed as the model of option for several reasons. These involve several convolution operators' uses in processing of images. The convolutional neural networks integrate the advantages acquired by a standard training of neural network with the operation of convolution to classify images efficiently. Further being a neural network, the convolutional neural network is scalable for huge sets of data which is the case when images are to be classified.

Convolutional neural networks are used to accomplish greater accuracy in the reduced time of processing. The below figure shows the flow diagram of the proposed system:

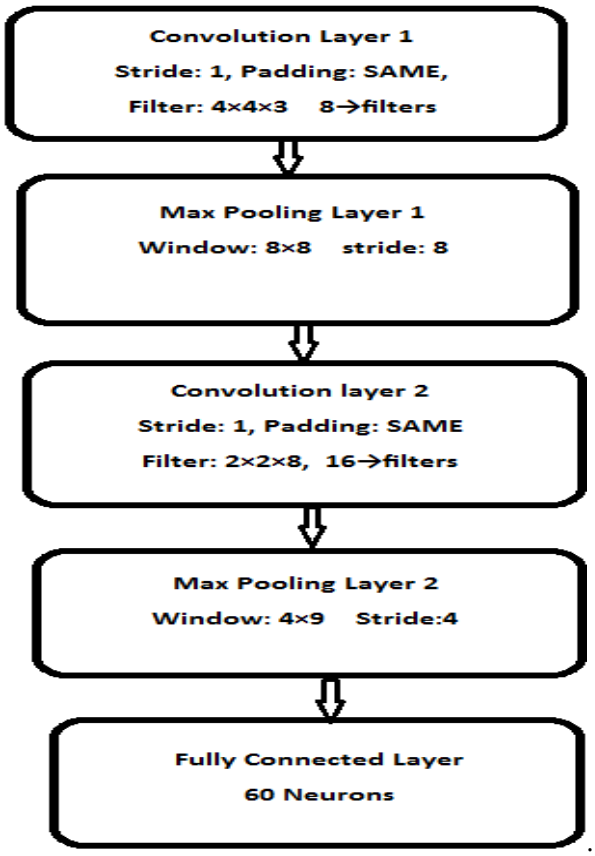


Figure 1: Proposed Flow Diagram

From the above fig.1, in the model there are 3 layers namely convolutional layer, max pooling layer and fully connected layer.

A. *Convolutional Layer*

The convolutional layer is the entire network building block because much of the work of computation is performed in this layer. The convolutional layer comprises of a collection of learnable filters which are known as parameters of this layer. Each filter is a square matrix of little height and width spatially but expands through the whole depth of input volume. For instance, a typical filter on network's first layer can have size of 5*5*3 because images have depth of 3 the channels of color. In this case filters have 1 size of depth. During the forward pass every filter is convolved or sided across the height and width of the input volume and evaluate dot products between filter entries and the input at any place. Intuitively the network will learn filters that activate when they view certain kind of visual characteristic such as an edge of horizontal gradients or orientation. In this way every filter is convolved over the complete image and the complete image and the generated output after convolution are known as activation maps. The number and size of filters relies on the experimental rules. There is no well-defined process to recognize the number and size of filters. Initially filters can comprise little random values as they are learnable parameters and their values will be updated with every network learning. The convolution layer approves the dimension input of width, depth and height and using two hyper-parameters that is stride and filter size produces input for another convolution layer. In the proposed study the number of strides chosen was 1 and padding was same for convolution layer 1. The number of filters chosen was 8 for the convolution layer 1 with size 4*4*3. Similarly, the convolution layer 2 is considered with same number of strides and padding as convolution layer 1. But the number of filters chosen was 16 for convolution layer 2 with size 2*2*8.

B. *Max Pooling Layer*

Pooling layers are located in between convolutional layers in architecture of convolution. Its performance is to reduce the representation spatial size progressively to decrease the number of computation and parameters in the network and hence to handle overfitting. The pooling layer performs independently on each input slice of depth and resizes it spatially. The commonly used operation is MAX. The most similar form is a pooling layer with 2*2 filter size applied with a stride of two down samples each depth slice in input by two along both height and width discarding 75 percent of activation. Each operation of MAX would choose a maximum value over four numbers. The dimension of depth remains unchanged. In this research for max pooling layer 1 the filter size is 8*8 and stride of 1 is used and for max pooling layer 2 the filter size is 4*9 with 4 strides.

C. *Fully Connected Layer*

In a fully connected layer neurons have complete connections to entire activations in previous layer as in regular neural networks. Their activation can be evaluated with a multiplication of matrix followed by bias offset. There can be numerous fully connected layers relying on the architecture of application. The last comprised neurons similar to number of classes in problem domain. In this study there are 60 neurons and the number of neurons in this layer is experimentally selected.

IV. RESULT AND DISCUSSION

The character set database has been created using scanned images of Tamil palm leaf manuscripts collected from Government Oriental Manuscript Library of archaeology department , Tamilnadu . The dataset consists of 60 class varieties and every class comprises of nearly 1000 different samples. The following Fig. 2(a) presents few sample character classes that were given as input to the neural network model. Likewise Fig 2(b) provides how numerous versions are generated for a single character.

Figure 2(a): Input ancient characters from Tamil Palm leaf manuscript

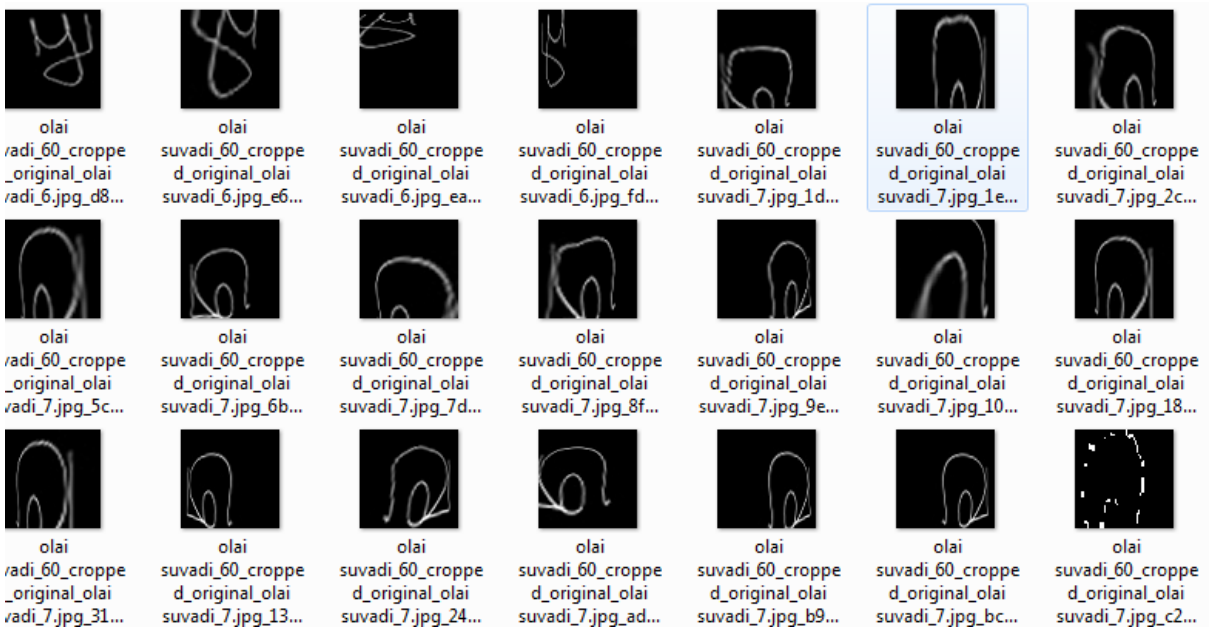


Figure 2(b): Numerous versions of a single character

The usage of convolutional neural network classifier is found to provide around 90 percent accuracy when it comes to character recognition. The rate of prediction is predicted to be greater due to huge number of characteristics retrieved for every layer of convolutional neural network. The results of [25] study mentioned that a convolutional neural network is capable of accomplishing outstanding results of the research on Tamil dataset using supervised learning. It is mentioned that their network performance degrades if an individual convolutional layer is removed and does not develop much with addition of another pooling + convolutional layer set. This research augments the JS library of Convolutional Network for learning characteristics by using probabilistic weighted pooling, local contrast normalization and stochastic pooling to set up a new state of art of 95% accuracy. Similarly, in the study of [18] the proposed convolutional neural network architecture performance for palm leaf manuscript character recognition has been compared with other machine learning method namely Fast artificial neural network, support vector machine and k-NN. The results for the convolutional neural network architecture show that 0.64s is the prediction time for single character and the prediction rate is 96% and mis-prediction rate is 3.8%. It was found that the obtained results are better comparatively to other approaches of machine learning. Comparatively in the study of [3] of the several neural network architectures used for categorizing characters the one with 2 hidden layers each having 100 neurons has been predicted to generate greater accuracy of recognition of 90.19%.

Compared to the above proposed researches this study identifies the characters from ancient palm leaf manuscripts of Tamil characters using convolutional neural networks method which provides 97.8% accuracy. The below Table II shows the method and accuracy of the following researches compared to the proposed research:

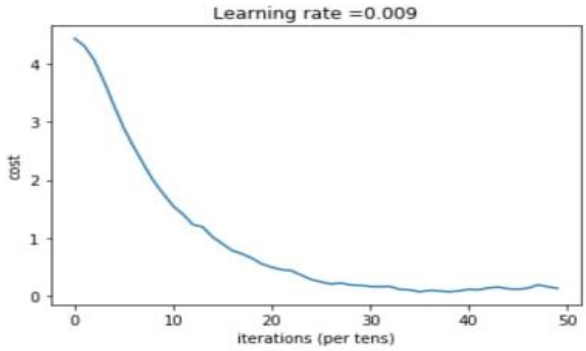
Table II: Method and Accuracy comparison based on proposed research

Author	Year	Method used	Accuracy Obtained
VijayaRaghavan and Sra	2015	Convolutional Neural network	95%
Sabeenian et al	2019	Convolutional Neural Network	96%
Deepa et al	2019	Convolutional Neural Network	90.19%

The training accuracy is identified to be 97.8% and the testing accuracy of the proposed model is identified to be 40%. In Fig 3 the cost is predicted for every 10 iteration . The graph is plotted and presented in Fig 4 showing the accuracy prediction .

```
Cost after epoch 0: 4.434523
Cost after epoch 5: 2.887781
Cost after epoch 10: 1.550784
Cost after epoch 15: 0.900653
Cost after epoch 20: 0.498557
Cost after epoch 25: 0.246698
Cost after epoch 30: 0.166962
Cost after epoch 35: 0.074268
Cost after epoch 40: 0.120227
Cost after epoch 45: 0.118979
```

Figure 3 Cost of the Model




```
Tensor("Mean_1:0", shape=(), d
type=float32)
Train Accuracy: 0.97875
Test Accuracy: 0.385
```

Figure 4 Accuracy of the Model

In every ten iterations the accuracy of training is acquired using the tensor parameters namely mean, shape and data type. Fig. 5 illustrates the screenshot of the tensor flow.

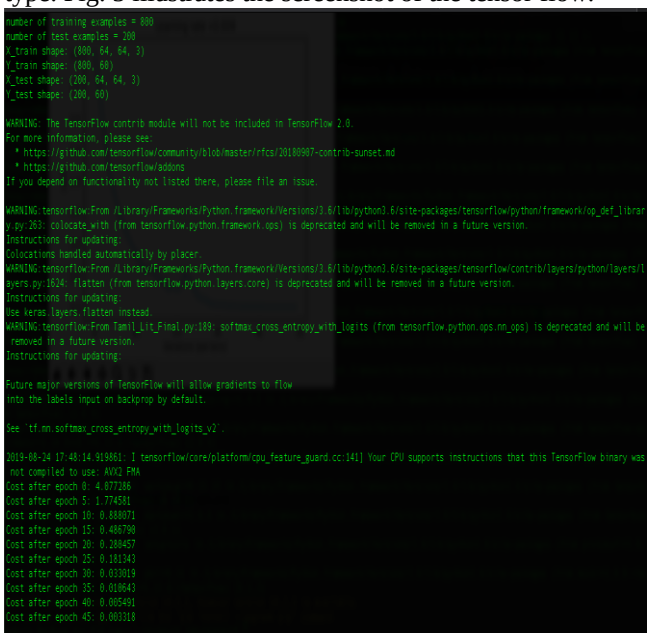


Figure 5: Screenshots of the Tensorflow output

V. CONCLUSION

The character recognition of ancient Tamil manuscripts is a field where many real time researches are being done. These researches concentrate on identifying the ancient characters of Tamil so that much data can be studied Particularly ancient system of medicine namely Siddha can be viewed in the ancient scripts of Tamil through the palm leaves medium. There are several Tamil palm manuscripts that are yet to be digitalized. A huge set of dataset is verified by convolutional neural networks with module of inception. Using inception convolution good accuracy has been accomplished. The suggested approach is revealed competitive performance with the existing approaches on the basis of accuracy test set for the set of data. Thus, it can be concluded that the accuracy obtained from the proposed system is 97% and based on the output it represents that there might be certain growth in inception and convolutional neural network training to acquire good performance. In future the convolutional neural network must be improved with all the diacritics and glyphs in the ancient Tamil scripts written by different authors. Thus creating dictionary for all diacritics which helps to find the centaury of the scripts and mapping of old centaury diacritics to current centaury diacritics from a ancient Tamil scripts.

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