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Handwritten Character Recognition using Deep Learning

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***Abstract:** In day to day human life, handwritten documents are a general purpose for communication and restoring their information. In the field of computer science, character recognition using Deep Learning has more attention. DL has a massive set of pattern recognition tools that can apply to speech recognition, image processing, natural language processing and has a remarkable capability to find out a solution for complex machine learning problems. DL can focus on the specific feature of an image to character recognition for enhancing efficiency and accuracy.*

In this paper, we have presented a methods for handwritten character recognition using deep learning.

***Keywords:** Deep Learning, segmentation, recognition*

I. INTRODUCTION

The fast development of smart devices; AI is more used to represent and develop the internet services, the transmission of information, sensors devices, decision making, etc. and they have used Deep Learning for the same. Deep learning may use object detection, object recognition, translation of speech-to-text, information retrieval from media and data analysis with multiple aspects. Deep learning has been widely used for handwriting character recognition over the last few years.

The convolutional neural network uses the integration of pooling layers, convolutional layers and fully connected layers. CNNs are the most used models of deep learning and it works with the classification of an image, recognition of an image, captioning of an image etc. CNN is one of the most vastly used methodologies for handwriting character recognition.

In recent years there has been a growing interest in digitizing the handwritten scripts. Handwriting recognition shows a key role in the process of digitization and has been avidly researched over the years

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II. REVIEW OF LITERATURE

Character recognition from an image depends on the composition of the image selection methods, preprocessing techniques, segmentation methods, and recognition models. The following are the papers that perform character recognition with different algorithms and they also used different deep learning for better accuracy and recognition.

Roy et. al., 2017 they developed Supervised Layer Wise training of a Deep Convolutional Neural Network (SL-DCNN) architecture. It had a set a new benchmark of 9.67% error rate on the rather difficult CMATERdb 3.1.3.3 handwritten *Bangla* isolated compound character dataset. The model represented a lowering of error rated by nearly 10% from the previously set benchmarks on the same and is an excellent result in the area of *Bangla* compound character recognition [1].

Savitha Attigeri, 2018 presented a neural network based offline character recognition from the handwritten script using offline mode without using feature extraction from the scanned image. They had used layers and got accuracy for 90.19/5 from 100 neurons [2].

Alom et. al., 2017 they have used a combination of dropout and many filters on a dataset CMATERdb 3.1.1 and evaluate the performance of CNN and DBN with the integration of Deep Learning. They perform many experiments and conclude that CNN with Gabor feature and dropout get better accuracy for BANGLA digit recognition to compare to another technique [3].

Roa et. al., 2018 they have used a nonlinear kernel residual network model for character recognition. They proposed three different network designs for the extended nonlinear kernel: (1) Intermediate convolution model with the preprocessed image. (2) A composite residue structure. (3) Dropout layer after parameter optimization. They compared previous models and conclude that the model used by them had good recognition results and data training time [4].

Pratikshaba, 2019 reviewed different types of segmentation, features, and classification; they concluded that the clustering approach is better for the segmentation. As from the feature extraction classification comparative, it can be said that if the use of deep learning in character recognition will give a better outcome for SANSKRIT scripts [5].

Aditi and Ahish, 2018 described that Hidden Markov Model (HMM) has a unique advantage to adjustment of pen-thickness and interpolation. With the benefit of this feature and using CNN can increase the accuracy rate by 1% to the previous character recognition accuracy. HMM also used for standardization of the sequence of stroke order so it will reduce the overhead of look-up table used for character recognition [6].

El-sawy et. al., 2017 they had used convolution neural network (CNN) handwritten character recognition for ARABIC character and show the results were promising with a 94.9% classification accuracy rate on testing image scripts [7].

Yu Weng & Chunel Xia, 2019 developed a convolution neural network to handwritten character recognition of SHUI. After performing the different experiments and they concluded that characters can be classified easily using CNN models. They also made a comparison with their developed model and another available model [8].

Chinagakham et. al., 2019 describe that the deep CNNs features descriptor can be more useful for developing a completer MEETEI MAYEK character recognition system [9].

Adnan et. al., 2018 had analyzed different deep convolution neural networks (DCNNs) and concluded that DenseNet can generate more fruitful results in BANGLA character recognition. They also mention that the accuracy could achieve up to 98% for digit, alphabet and special character recognition [10].

Mrugan & Mr.Ramani, 2019 used the feature extraction methods for character identification and also suggested that the back propagation network can achieve a good recognition accuracy near about 97% for ENGLISH character and number recognition [11].

Reddy & Babu, 2019 focused on HINDI character recognition. They had used different CNNs and Deep Forward Neural Network (DFFNN). After their experiment, they derived that DFFNN, CNN-Adam (Adaptive Moment) and CNN-RMSprop (Root Mean Square Propagation) produce the best accuracy for handwritten HINDI character compared to alternative techniques [12].

Gan et. al., 2019 used 1-D CNN for CHINESE character recognition with the implementation of the sequential structure of handwritten character and also derived that this model of CNN is very compact and runes faster than other architecture like 2-D CNN and RNN [13].

Subramani & Murugavalli, 2019 described in their research convolutional neural networks with the module of inception to verify the dataset. Using the Deep Learning methods the achieved the accuracy of 97% and they also show the growth in the inception and CNN training got good performance. They also make a suggestion to improve the CNNs with the use of glyphs and diacritics in handwritten character recognition from the TAMIL scripts [14].

Kavitha & Srimathi, 2019 have used CNNs for TAMIL handwritten character recognition. They achieved a testing accuracy of 97.7% using the HP Lab's dataset. They also proved that the CNNs are a more accurate paradigm for character recognition from the handwritten script [15].

Nuseir et. al., 2017 had compared different deep learning methods for the AREBIC character recognition system. They emphasize that deep learning is a more powerful and problem solving approach for handwritten character recognition [16].

Jangid et. al., 2018 have used deep convolution neural network (DCNN) and adaptive gradient methods for DEVENAGRI character recognition. They had also used Network Architecture – 6 and RAMSProp optimizer method. They achieved about 98% recognition accuracy using ISIDCHAR and V2DMCHAR dataset [17].

D.S. Joshi & Risodkar, 2018 focused on GUJARATI character recognition with the help of K-NN and Neural Network. They also used filtering, edge detection, morphological transformation for image processing and achieved 78.6% accuracy on a dataset [18].

Saha & Saha, 2018 introduced a deep convolution neural network with techniques like Divide and Merge Mapping and Optimal Path Finder for BANGLA handwritten character recognition. They achieved the results with the lowest complexity of the provided parameters on a small network as well as a large network of the dataset [19].

Das et. al., 2018 had presented a popular CNNs with kernel size, pooling methods and activation function for BANGLA handwritten character recognition. Results proved that CNNs architecture can improve the character recognition accuracy [20].

Bhatt & Patel, 2018 compare and analysis different classifier methods for character recognition like Support Vector Machine (SVM), Aartificial Neural Network (ANN), Hidden Markov Model (HMM), Convolution Neural Network (CNN), Deep Convolution Neural Network (DCNN), Binary Tree and K-NN. They had concluded that the Deep Learning Methods are very accurate for character recognition [21].

Ali et. al., 2019 have used K-NN, Decision tree, Multilayer perception and Random Forest(RF) classifier and achieved the accuracy like KNN(74%), Decision Tree(DT) (95%), Multi-Layer perception (MLP) (82%) and Random Forest(RF) (96%). They also analysis that RF and DT classifier has the highest accuracy rate to the recognition of SINDHI handwritten numerals [22].

Elleuch et. al., 2015 presented two different deep learning approaches like Deep Belief Network (DBN) and CNN for AREBIC character recognition. They concluded that DBN network architecture is to be able to deal with high-dimension data like words and integrate the hand-craft feature in order to increase the recognition rate [23].

Uki et. al., 2019 used CNN's depth and wavelet transformation on the image. They had used different approached like max-pooling, probabilistic voting, feature extraction, feature correction, etc. with the help of all these methods they found that the accuracy of the character recognition is increased more than 4% with the previous techniques [24].

There were many researchers who did work on character recognition from the scanned image from different languages. They got the success rate near about 75% to 98% from a specific domain. From the above mentioned literature, we may derive that for better character recognition with more accuracy new tasks may involve deep learning with a large amount of dataset for training as well as for testing.

III. COMPARATIVE STUDY

Table- I: Comparisons of approaches uses by different author for character recognition.

Sr. No.	Author(s)	Year Of Publication	Approach	Dataset	Pre-processing	Result / Accuracy
1	Roy et. al.	2017	Supervised layer wise training of a deep convolution neural network (SL-DCNN)	CMATERdb 3.1.3.3	The available dataset used, they resized the image to 30 pixels of height and width.	CNN model provides an error rate of 9.67% compared to 15.96% for the DCNN.
2	Savitha Attigeri	2018	Artificial Neural Network (ANN)	Own dataset of 49 characters and 4840 samples.	Each individual character is uniformly resized to 30 X 20 pixels.	The character recognition accuracy of 90.19% they have achieved.
3	Alom et. al.	2017	Deep Belief Network (DBN), CNN with dropout, CNN with dropout and Gaussian filters, CNN with dropout and Gabor Filters.	CMATERdb 3.1.1	Raw images used as input and passed to the next phase (Normalization).	DBN produced 97.20 % CNN + GABOR + DROPOUT achieved an accuracy of 98.78%
4	Sawy et. al.	2017	Convolution Neural Network (CNN)	16800 images 13340 images for Training and 3360 images for testing.	The input to a convolution layer is the M X M X C; where M is the height and width of the image and C is a number of channels per pixel.	They achieved an accuracy of 94.9%.
5	Yu Weng & Cnulei Xia	2019	Deep Neural Network (DNNs)	400 types of pictures used as a dataset. 37500 data are used as a training and 12500 data used as test data.	Shui character image normalized to 52 * 52 pixels. The class label is added to the clustering results.	The final test accuracy is around 93.3% achieved.
6	Adnan et. al.	2018	Deep Belief Network (DBN), Stacked Auto encoder (AE), CNN, DenseNet	CMATERdb 3.11	Each digit has 600 images that are rescaled to 32 X 32 pixels.	Digit-10 --- 99.13%. Alphabet -50 --- 98.31%. Special Character --- 98.18% accuracy.
7	Gan et. al.	2019	1-D CNN	Databases ICDAR-2013 IAHCC-UC AS2016	Chainese character images rescaled into 60 X 60 pixel size.	98.11 % on ICDAR-2013 and 97.14% on IAHCC-UCA2016 dataset.

8	Kavitha & Srimathi	2019	CNN model total of nine layers; five convolution layers, two max pooling layers, and two fully connected layers.	HPL-taiml-iso-char 156 characters 500 samples for each class 82,928 total samples.	Convert into a grayscale image from the original image.	Testing accuracy of 97.7%.
9	Jangid et. al.	2018	Deep Convolution neural network (DCNN)	ISIDCHAR and V2DMDCHAR database.	A normalization process has to follow for converting the image h X w X c size to m m X m X c size where m represents the height and width of an image.	Using a DCNN layer-wise training model, they obtained 98% recognition accuracy.
10	D.S.Joshi & Risodkar	2018	K-NN classifier and Neural Network	Own database with 30 samples	RGB to gray conversion, skew correction, filtering, morphological operation	Got accuracy nearby 78.6%
11	Saha & Saha	2019	Divide and Merge Mapping (DAMM)	Own database with 1,66,105 images	Resize all images to 128 X 128 pixels.	Achieved a training accuracy of 99.13% along with a validation accuracy of 98.87%
12	Das et. al.	2018	Convolutional Neural Network (CNN) architecture	Own database with 200 samples from 100 different persons.	Resized all images to 28 X 28 pixels.	They have achieved an accuracy of 99.40% for character recognition.
13	Ukil et. al.	2019	Convolutional Neural Networks (CNNs)	PHD_Indic_11 dataset	RGB to grayscale conversion and resized image to 28 X 28 pixels.	CNNprob performed the best with an accuracy of 95.45%, precision of 95.36%, recall of 95.32% and f-measure of 95.33%

For character recognition, the researchers had used different methods and algorithms that can get better character recognition speed with more accuracy. We had compared many deep learning approaches and methods as discussed above. From the above comparisons, we may conclude that for finding fruitful results we have to use CNN with deep learning.

IV. CONCLUSION

Greatest work carried out for that character recognition using deep learning. Deep learning is a methodology to handle the task related to handwritten character recognition from the scanned image. This has special importance to transmit the written gujarati information to the electronic form. From this paper, we may conclude that it is a necessity to develop such a method that can directly convert the hand written character into digital form. For this cause, we may use a deep learning methods and it helps to deal with image processing very smoothly.

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