Survey on Deep Learning Using CNN for Character Recognition

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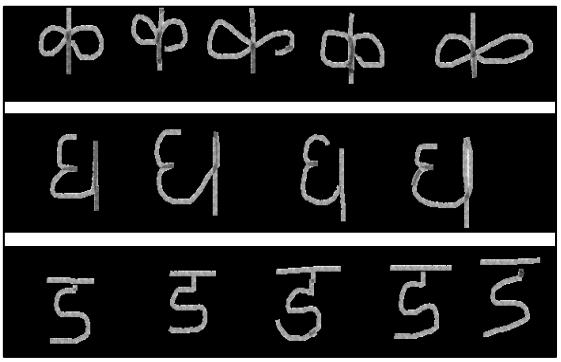
Abstract— Since past few years, deep neural networks are becoming highly popular because of their increasing performance. They are getting highly used in various machine learning tasks such as regression, segmentation, classification, detection and pattern recognition. Character recognition is currently gaining attention of most of the researchers because of its enormous applications in various sectors like human-robot interaction, data entry for business documents, etc. Recognition of characters is challenging task, but Deep learning techniques can be effectively used as a solution for various such problems. Person to person variations in writing style makes handwritten character recognition one of the most difficult tasks. There are hundreds of ways to write a single letter or a digit which automatically increases the size of the dataset to be used. The aim of this work is to incorporate machine learning techniques to improve the character recognition process.

Keywords: Deep Learning, Transfer Learning, Convolutional Neural Networks (CNN), image classification, image segmentation, Optical Character Recognition (OCR), Feature Extraction

I. INTRODUCTION

Out of several important applications of Machine Learning and deep Learning, image and pattern recognition enables identification of images and patterns for different use cases or applications. Image recognition technique focuses on extracting essential features from images to categorize images into different groups. Because of such variety of applications, Optical Character Recognition(OCR) has gained much importance as it recognizes text from any given image or document. It can also be used to identify characters from handwritten scripts. Obtaining high recognition accuracies on handwritten character datasets is a challenging problem because there can be different ways or styles to write the different characters. Due to this high variety, the direct use of pixel intensities is avoided because there is sometimes little overlap between two images displaying the same character. Figure below demonstrates the different ways or styles to write characters in Devanagari script.



Thus there are thousands of possibilities that differ from person to person to write characters in any language. For this purpose different datasets are to be developed which is challenging due to different writing styles, different ages, education, etc. In this paper we have studied different datasets and different character recognition techniques to yield better accuracy and expected outcomes.

Following outlines are some examples of architectures:

a) Inception model representations performs better in comparison to others regarding accurate results for dataset et al[1].

b)Vgg representations are also provides accurate results; however are computationally expensive in comparison to Inception et al[1].

c) DenseNet representations did not show better accurate results but can possibly show better accuracy over other datasets et al[1].

d) AlexNet is fastest and also provides reasonably good accuracy et al[1].

II. LITERATURE SURVEY

Sr.No	Published Year	Published By	Research Topic	Outcomes
1.	2015	Christian Szegedy, Vincent Vanhoucke, Sergey Ioffe, Jonathon Shlens	Rethinking the Inception Architecture for Computer Vision.	Factorizing convolutions and aggressive dimension reductions inside neural network can result in networks with relatively low computational cost while maintaining high quality.
2.	2018	Mahesh Jangid and Sumit Srivastava	Handwritten Devanagari Character Recognition Using Layer-Wise Training of Deep Convolutional Neural Networks and Adaptive Gradient Methods	We Experimentally developed a deep convolutional neural network (DCNN) and adaptive gradient methods to recognize the unconstrained handwritten Devanagari characters.
3	2015	Ashok Kumar Pant , Prashnna Kumar Gyawali,	Deep Learning Based Large Scale	The experimental results suggested that Deep CNNs with added Dropout layer

		Shailesh Acharya	Handwritten Devanagari Character Recognition	and Dataset increment technique can result in very high test accuracy even for a diverse and challenging dataset like DCD which was used here**.**
4.	2017	Ms. Snehal Pachpande , Prof. Anagha Chaudhari	Implementation of Devanagri Character Recognition System Through Pattern Recognition Techniques .	Technique is suitable for handwritten devanagari script. The work deals with the designing of segmentation and feature extraction of devanagari handwritten words. For segmentation vertical and horizontal projection technique is used and for feature extraction convex hull technique is used.
5	2018	Md. Mahin Chowdhury Bipu , Shyla Afroge	A Feature Fusion Based Approach for Handwritten Bangla Character Recognition Using Extreme Learning Machine	The accomplishments of character segmentation and feature extraction mostly contribute to the accuracy of an OCR system. The improvement of these phases may ensure greater accuracy. Hopefully, in future, the work will be extended for compound characters and modifiers of Bangla script.
6.	2018	Sneha shitole, Savitri jadhav	Recognition of Handwritten Devanagari Characaters using Linear Discriminant Analysis.	From proposed system it is concluded that LDA has shown better results than PDA. For Direction features method the size of feature set reduces up to 42.59% using LDA while PCA reduces up to 70.58%.MLDA reduces the size of feature vectors up to 35.93% while PCA reduces up to 38.89% for chain code
7	2019	Mehdi Rizvi*, Hasnain Raza*, Shahab Tahzeeb, Shan Jaffry	Optical Character Recognition Based Intelligent Database Management System for Examination Process Control.	In this research, the workload of entering marks manually into system's database and generating results afterwards is being largely decreased. Through this work we have automized the entire process of entering and generating results manually after checking of papers till the very end of result display.
8.	2019	Shriansh Srivastava,J.Priyadarshini, Sachin Gopal, Sanchay Gupta, Har Shobhit Dayal.	Optical Character Recognition on Bank Cheques Using 2D Convolution Neural Network.	For processing cheques in the bank, image processing techniques such as segmentation and extraction are applied. A type of global thresholding i.e. Otsu thresholding is applied on the processed output. The processed and segmented image of each character is fed to the trained model and the results are obtained. The idea of combining CNN with image processing techniques on bank cheques is ingenious and can be used effectively in banking sectors.
9	2018	Prasad K. Sonawane, Sushama Shelke	Handwritten Devanagari Character Classification using Deep Learning.	The results show that the transfer learning is a better option for faster and better training with fewer training samples.
10.	2018	Adeline Granet, Emmanuel Morin, Harold Moucher, Solen Quiniou and Christian Viard-Gaudin	Transfer Learning for Handwriting Recognition on Historical Documents.	Experiments allows to conclude that HWR systems quickly specialize on learning data. We have found out that addition of one or more resources makes it possible to improve character recognition. These results will guide our future experiments.

III. LIVE SURVEY

A. Human-To-Machine Communication [2]

OCR is a great solution for converting human-to-human communication but falls short when converting more structured documents such as forms that need to be processed by machines[2]. Human-to-human communication is mostly in the form of free text which is considered as unstructured document. While, Such documents are hard for machines to understand. Myriad of forms is developed by governments and companies that structure text into easily recognizable labels[2]. While Machines cannot act on most of the texts because they are unable to understand its meaning.

Modern deep learning based data captures solutions and further process OCR output.

B. OCR System for Bharati Script [3]

At IIT-Madras a team of researchers developed a technique for reading documents in Bharati script using a multi-lingual Optical Character Recognition(OCR) system[3]. Bharati script is a unified script for nine Indian languages.

This includes Devanagari, Bengali, Gurmukhi, Gujarati, Oriya, Telugu, Kannada, Malayam and Tamil. In collaboration with TCS, Mumbai they created universal finger-spelling language for nine Indian languages using which a person with hearing disability can generate signatures or sign languages.

C. Modified Google Lens [4]

Google announced that it's in the process of introducing new features in its lens that will allow us to search our Google Photos Library for text that appears within photos and screenshots[4]. Then we can easily copy that text into another document. Optical Character Recognition(OCR) technique is used to extract the text found in the photos which can be a screenshot or photo of physically signed document. according to 9to5 Google this feature is available now on most of the android devices although it is not quite active on the IoS devices[4].

D. Multinational License Plate Recognition et al[5]

Automatic License Plate Recognition(ALPR) is a technique used to identify number plate of the vehicles. However most of the current works on ALPR are designed to work on LP of the vehicles of specific countries only[5]. The system works on the You Only Look Once(YOLO) networks[5]. Tiny YOLOv3 was used for the first step whereas the second step uses YOLOv3-SPP a version of YOLOv3 that consists of the Spatial Pyramid Pooling (SPP) block[5]. For character recognition, localized LP is put into the YOLOv3-Spp and the recognition network returns the bounding boxes of predicate characters and does not provide information about the sequence of the LP number[5].

E. Text Line Recognition In Camera Captured Images et al[6]

In this, an "on the device" text line recognition framework is introduced that is designed for mobile or embedded systems[6]. It is based on two separate artificial neural networks (ANN) and dynamic programming instead of employing image processing methods for the segmentation step or end-to-end ANN [6]. MIDV-500 and Census 1961 Project datasets are used for the text line recognition. This method considerably surpasses the algorithmic method implemented in Tesseract 3.05 and the LSTM method (Tesseract 4.00) [6].

IV. ACCURACY AND EFFICIENCY SURVEY

Various character recognition techniques have been developed since last decade, but still their performance is not satisfactory because of variations in the inputs. Various factors like writing styles, pixel orientation, image clarity affects the efficiency of the system. Even by increasing the number of epochs, increase in accuracy is not much. Most of the character recognition techniques gives 98% to 99% of accuracy at the maximum level, which is acceptable but not 100% accurate. To increase the accuracy of recognition various techniques like feature extraction, image segmentation, image reduction and clarification, proper datasets have been used so far. Here are some accuracies for different datasets, techniques and architectures.

Sr. No	Published Year	Published By	Research Topic	Efficiency
1.	2015	Christian Szegedy, Vincent Vanhoucke, Sergey Ioffe, Jonathon Shlens	Rethinking the Inception Architecture for Computer Vision.	The highest quality version of Inception-v3 reaches 21.2%, top-1 and 5.6% top-5 error for single crop evaluation on the ILSVR 2012 classification, setting a new state of the art.
2.	2018	Mahesh Jangid and Sumit Srivastava	Handwritten Devanagari Character Recognition Using Layer-Wise Training of Deep Convolutional Neural Networks and Adaptive Gradient Methods	The highest recognition accuracy 96.02% was obtained using NA-6 network architecture. The database obtained 98% recognition accuracy using DCNN training model, which is the highest recognition accuracy of the database.
3	2015	Ashok Kumar Pant ,Prashnna Kumar Gyawali,Pulchowk, Shailesh Acharya	Deep Learning Based Large Scale Handwritten Devanagari Character Recognition	Dataset is tested with different architectures by varying depth, width and number of parameters of network. The results of two of those experiments are presented. The highest testing accuracy obtained for

				Model A is 0.98471 and that for model B is 0.982681**.**
4.	2017	Ms. Snehal Pachpande , Prof. Anagha Chaudhari	Implementation of Devanagri Character Recognition System Through Pattern Recognition Techniques .	Histogram technique is the best method for segmentation which gives 98.1% accuracy for word segmentation**.**
5	2018	Md. Mahin Chowdhury Bipu , Shyla Afroge	A Feature Fusion Based Approach for Handwritten Bangla Character Recognition Using Extreme Learning Machine	The fusion of feature vectors has brought out a benchmark recognition result (96.1%) where individual feature extraction method gives comparatively lower accuracy (90.5% for HOG, 91.2% for Gabor filter).
6.	2018	Sneha shitole, Savitri jadhav	Recognition of Handwritten Devanagari Characaters using Linear Discriminant Analysis.	For direction features 94.2% accuracy is obtained using SVM and 89.3% accuracy using KNN. For chain coding 86.6% accuracy is obtained using SVM and 75.8% accuracy using KNN.
7	2019	Mehdi Rizvi*, Hasnain Raza*, Shahab Tahzeeb, Shan Jaffry	Optical Character Recognition Based Intelligent Database Management System for Examination Process Control.	This deep learning model recognizes the handwritten digits using Keras library and provides approximately 99% of accuracy which is excellent.
8.	2019	Shriansh Srivastava,J.Priyadarshini, Sachin Gopal, Sanchay Gupta, Har Shobhit Dayal.	Optical Character Recognition on Bank Cheques Using 2D Convolution Neural Network.	The machine learning model used in this paper is 2D Convolution Neural Network which provided a training accuracy of 98% for digits and 97% for letters. An accuracy of 95.71% was achieved from a pool of sample cheques that were used for testing.
9	2018	Prasad K. Sonawane, Sushama Shelke	Handwritten Devanagari Character Classification using Deep Learning.	This paper presents fine-tuning of CNN with the help of transfer learning. The CNN achieved 94.49% validation accuracy and 95.46% test accuracy. In the training curves, the training accuracy went above 90% in 3 epochs only.
10.	2018	Adeline Granet, Emmanuel Morin, Harold Moucher, Solen Quiniou and Christian Viard-Gaudin	Transfer Learning for Handwriting Recognition on Historical Documents.	GW dataset achieves a CRR of 56.8% without the out-of-vocabulary words. For RMW , the character recognition rate increases by 6.6%. Then, the saved weights are used to perform fine-tuning on CIL. This specialization of network on the target data increase d recognition rate the of the characters by 15%.

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