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CNN based Optical Character Recognition and Applications

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***Abstract*—The procedure of translating images of handwritten, typewritten, or typed text into a format recognized by computers is called Optical Character Recognition (OCR). Editing, indexing, searching, and storage space reduction are the uses of Optical Character Recognition. This is done by scanning the picture of the text character-by-character first, then processing the scanned image and eventually converting the image of the character into character codes, such as ASCII. To translate text in an image into text format, the Optical Character Recognition system is used. There are three key aspects of OCR approach: pre-processing, character recognition, character segmentation and presentation of data. Convolutional Neural Network is a deep learning method which is used for character recognition. In this paper, CNN layers, architecture and implementation of CNN architecture are discussed. Here the CNN (VGG-16) model is trained over Telugu character data set which covers maximum of 1600 characters and its accuracy is measured.**

***Keywords*—Optical Character Recognition; Convolutional Neural Network; Segmentation; Feature Extraction; VGG-16.**

I. INTRODUCTION

Optical character recognition involves electronic or mechanical translation into machine-encoded text of images of typed, handwritten, whether from scanned paper, a subtitle text superimposed without an image. We have to compose text from some hard paper, such as magazine, journal, photos, several times. Optical Character Recognition device read images from typed and handwritten text and can also capture images using a webcam. With accuracy of around 90%, typed characters are read and handwritten characters are read with accuracy 40-50%. OCR is very useful method for translating scanned/photographed documents into text type, which read from a computer. Scanning to the next step is required. When the original data is on paper, it is an outstanding choice. OCR benefits from business cards, passport details, receipts, bank receipts, old papers and relevant documents. Good software opens up new possibilities and innovative choices will discover new way of approaching all document based knowledge with OCR apps.

OCRs are adjusting expansive measurements of reports, either typed letters in order or written manually into computer coded material, with no changes, clamour, evaluate varieties and multiple variables, in the sense of OCRs. Handwriting identification is usually defined as an off-line and on-line recognition. Handwritten character recognition is used to improve the recognition of character [10].Offline handwriting detection requires the automated translation of text to a picture of letter codes that can be used for device and text data analysis. Offline handwriting identification is tougher when there are various handwriting modes for different individuals. OCR areas of analysis in pattern recognition, artificial intelligence, machine vision, signal processing [16]. OCR methods widely refer to process of identification of the offline character that helps the machine to search and identify the current images of characters. It applies mechanical/electronic translation, with no difference, photographs of handwritten character or typed text. OCR consists of different phases like digitization, preprocessing, segmentation and feature extraction as shown in figure 1.

i. **Digitization:** The method of translating based handwritten text into an electronic format is digitization. Here, only one character consists of each text [14]. The electronic transfer performed by process which document is scanned and the original document is electronically displayed in an image file format. For digitization, different scanners, and next stage in the pre-processing phase was the digital image.

ii. **Pre-processing:** Sequence of operations conducted on scanned input image in pre-processing stage. This increases the image rendering so the gray level character image normalized into window size for segmentation [3]. After noise reduction, we created bitmap image. Afterwards, bitmap image was translated into diluted image.

iii. **Segmentation:** Segmentation achieved by removing an image from actual characters. It is more difficult to divide handwritten characters into various zones (upper, middle, and lower zones) and characters than refer for regular printed papers. This is largely because of paragraph variety, line words and word letters, skew, slant, scale and bent letters. It is often possible to cross or overlap elements of two adjacent characters and this condition causes difficulties in segmentation task. The issue of touching or overlapping also arises due to modified upper-zone

and lower zone characters. A significant stage is segmentation.

iv. **Feature Extraction:** This Point, individual character characteristics are extracted. Extracted attributes of the input character will make it possible to mark a character in particular way [3]. We used diagonal characteristics, crossover, open end points, transfer characteristics, zoning characteristics, directional features, parabolic curve-mounting features and power curve-based suits to define the characteristics.

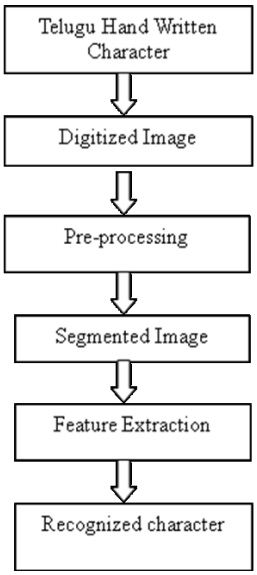


Fig. 1. Handwritten Telugu character recognition

II. LITERATURE REVIEW

In this section, we discussed about the convolution neural network, CNN layers and their architectures and also some of the techniques of the CNN are surveyed.

A. CONVOLUTIONAL NEURAL NETWORK

Deep learning recognizes the objects in an image using a Convolutional Neural Network. The Convolutional Neural Network is a feed forward network typically analyses visual representations by analyzing grid data such as topology [11]. CNN is also referred as "ConvNet. Each image in CNN is represented in form of pixel value arrays. Operation Convolution forms base of the Convolution Neural Network. The input layer can accept image pixels as an input in the form of arrays. By executing such calculations and manipulations, hidden layers carry out function extraction. Multiple hidden layers such as convolution layer, ReLU Layer, Pooling Layer and Fully Connected Layer as shown in figure 2. These hidden layers are performs feature extraction from the image [1]. Hidden layers use a matrix layer and perform convolution operation to detect patterns in an image.

1. Layers in CNN

A convolution layer has variety of filters performing process of convolution. In this layer, feature maps are extracted. Convolution Layer is set of filters which are applied a given input image. After removing function maps, next step is to transfer them to the ReLU sheet. The activation function ReLU (Rectified Linear Unit) is added to convolution layer to obtain the image's rectified feature chart [1]. A pooling layer now goes into the rectified function map. Pooling Layer is down-sampling process reduces function map's dimensionality. Pooling Layer uses different filter to detect points, corners, eyes, characteristics, etc. It reduces size of the feature maps and also shortens the size of an image. Average pooling and Max pooling is commonly used in Pooling Layer [14]. To preserve size of feature map, we use padded convolution. Finally Fully Connected Layer identifies object in image. Flattening is the procedure by which all resulting two-dimensional arrays are transformed from a pooled function map into a single continuous linear vector. To define an image, the flattened matrix from pooling layer is fed to Completely Connected Layer as entry.

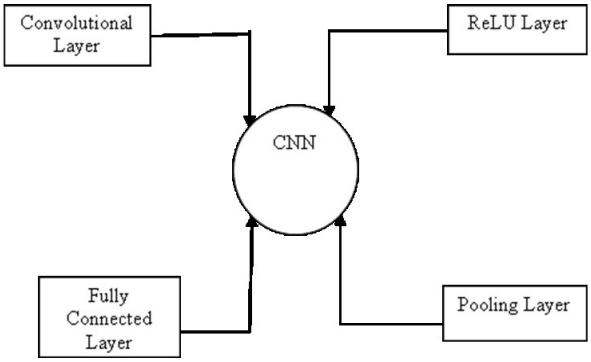


Fig. 2. Layers in CNN

The above figure explains about the character recognition using Convolutional Neural network. There are some of the architecture includes in CNN: they are LeNet, AlexNet and ZFNet.

a. LeNet

In 1988, the first convolution neural network named LeNet was developed by Yann LeCun. It has been used for character recognition practices such as decoding zip codes, numbers, etc. LeNet input of size is 32x32 grayscale image. This goes into convolutional Layer and the filter size is 5x5. Once the convolving goes successfully, the size the input sample reduced to 6@28x28. Now we deal with average pooling. Filter size is 2x2 and stride is 2. So the size is reduced by half 28x28 becomes 6 @ 14x14 after the applying the operation of average pooling [8]. Convolution happens again and 6@ 14x14 gets restricted as 16 @10x10 with having feature maps. This layer is again down sampling or subsampling layer. Filter size is 2x2 and stride is 2 [7]. So the reduction of the pixels should happen as expanded and 10x10 reduced to 16 @5x5. Then, with 120 attribute maps, the layer is a completely connected layer (FC). Both 400 nodes (5x5x16) are connected to each of the 120 units within the FC layer. A totally connected layer of 84 units is the next layer. The completely

connected softmax output layer varies from 0 to 9 with 10 potential values.

b. AlexNet

Five convolutional layers, two fully interconnected layers and softmax layers make up this architecture. Each convolutional layer indicates convolutional filters and nonlinear activation function (ReLU) and three layers have a max pooling layer. This architecture consists of input of size 224x224x3. Input size needs to be fixed because of fully connected layer. This architecture was considered for recognizing characters.

c. ZFNet

ZFNet is a modification of AlexNet. ZFNet has input of size 7x7 filters whereas AlexNet has input 11x11 filters. In CONV1, AlexNet change 11x11 with stride 4 to 7x7 with stride 2. In CONV3, CONV4 and CONV5, instead of 384, 384, 256 filters it will use 512, 1024 and 512 filters in the ZFNet architecture.

B. Algorithm for Telugu Handwritten Character Recognition

- Begin searching the picture from the topmost left corner row by row horizontally.
- If any black pixel is located in a row, the row status is set to '0'.
- If no black pixel is identified in a row when tracing it, then the row status is labeled as'1'.
- It is possible to obtain the number and location of lines by counting and following the cumulative number of continuous '0' from the row status variable.
- Algorithm: Identification of character from the line
- Take into consideration a single section.
- Begin vertically scanning the picture from the topmost left corner column by column.
- If every black pixel is located in a panel, mark the state of the panel as '0'.
- If no black pixel is identified in a column when tracing it, the state of the column is marked as '1'.
- The number and direction of lines can be obtained by counting and following the cumulative number of continuous '0' from the column status variable.

Pre-production is the immediate stage following image acquisition. To remove noise from the picture, it will apply the noise removal method [13]. The image is primed for processing in the next step. The segmentation and feature extraction process is simple if pre-processing is carried out properly. Although scanning the noise on the images may be generated, pre-processing is needed for high quality images. Our Telugu handwritten composite character composite database includes colour characters. Colour images are translated using the rgb to gray command to binary images [6]. The threshold procedure is used to transform altered pixels above threshold to white and below threshold to black. Thresholding method is used in background to take the object away. In order to eliminate noise present in the file, filtering is carried out on a binarized image [12]. The separated character is used to rejoin it in the image dilation processing. For images approach to Blobs analysis, edge detection, image filling, only typical image processing operations were added. We also applied edge detection analysis to find discontinuities in the grey level.

Mayur Bhargab Bora et al [2]; proposed a typical CNN classifiers that are able to learn and classify important 2D features present in images; classification carried out utilising soft-max layers. CNN used function retrieval and ECOC used for sorting. A huge number of interacting neurons with learnable weights and prejudices make up CNN. The neurons in CNN's architecture are organized as layers. It consists of a layer of data, several secret layers, and a layer of output. If the network contains significant number of secret layers, deep neural networks commonly referred to the same. As in a fully linked network such as Multi Layered Perceptron (MLP) networks, instead of linking anything, neurons in CNN's hidden layers are bound to a limited region of input space generated from previous layer. Compared MLP, this method decreases the amount of relation weights (parameters) within CNN. As a result, it takes less time for CNN to practise on networks of comparable size. The standard CNN input is a two-dimensional (2D) data collection, such as images. CNN implements the training algorithm for back-propagation. In two passes, the preparation is carried out; forward and backward pass. The network weight and bias initialised in the forward pass with tiny random numbers and network performance is calculated using training input. Through contrasting network performance with the target training performance, the error is calculated. The error propagates backward in the backward pass, and all weights and bias balanced to mitigate error. If intended outcome achieved, procedure is replicated. It may be used to solve a problem until the network is trained with fitting dataset.

Durjoy Sen Maitra et al [5]; proposed this method for using several common CNN classifiers researched to find right CNN for extracting characteristics conjunction with the ECOC classifier to correctly identify handwritten characters. Multilayer perceptron (MLP), RBF classifier, amended MQDF, SVM classifier etc. are typical classifiers. This can be found in a quantitative performance study on handwritten digital recognition of multiple classifiers. The chain code, gradient, and curvature features give state-of-the-art character recognition accuracy in hand-written activities. Also successfully implemented in a couple of character recognition tests are Gabor transforms and statistical or structural elements. A low resolution input character was refused transported into MLP corresponding to nearest higher resolution level, final attempt to accept the input character at its maximum resolution level. CNN-centered recognition approach profits effectively from lack of handcrafted vector. This architecture is able to learn from training character picture samples the vector function in an unattended manner in that no hand craftsmanship used to test function vector.

Khaled S. Younis et al [4]; proposed this method to explain about significant field in many applications like automated processing and identification of off-line

handwritten characters from images. These problems can be solved by using Deep Neural Networks. For the handwritten OCR query, we present a deep neural network. On data gathered at University of Jordan, UJ Face dataset, it presents findings of implementing a deep CNN. Tensorflow and Keras were the computing environments. One of the examples of these applications is modernization of method of text copying that was meant to be extended to ancient texts and the ambiguity and irregularity of the text due to the manual aspects of printing. Applying the new facial recognition technology to identify individuals using security camera mounted in malls, airports, hospitals, and businesses is very helpful. For deep learning, there are many applications. Tensorflow can run on various platforms. Therefore, it represents the findings of using TensorFlow and Keras to construct DNN and CNN to solve OCR problem and face recognition. The result of this analysis is: (i) Performance focus at new developments in Deep Learning, (ii) Operating on various multi-layer deep neural network architectures. (iii) The use of various techniques to boost model efficiency, such as optimization and generalization methods in normal and private databases, and (iv) the use of the functionalities provided in laboratory.

Comparison between CNN models with different algorithms or methods as shown in table 1.

Table I. Comparison between CNN models

Sl. No	Algorithm/Method	Model	Pros/cons
1	SVM Classifier[5]	CNN-ECOC	CNN with ECOC and AlexNet is most useful for character recognition.
2	KNN/NNC[18]	Deep Learning	This technique is used to improve the accuracy of character recognition.
3	AlexNet[19]	CNN	In this technique, Transfer Learning mechanism is used to train the samples easier.
4	User adaptive HWR[20]	CNN	This method is used for limited number of symbols and characters. This is suitable but less accuracy.
5	DAG-CNN[17]	CNN	DAG-CNN is used to extract all level of features for classification and more accuracy and efficiency.
6	Deep Residual Network[21]	CNN	Deep residual Network mainly used to improve the character recognition rate.

III. PROPOSED METHOD

In this section, we discussed about text to speech conversion and also the architecture of VGG-16 and their methodology for handwritten Telugu character recognition.

A. Architecture of Text to voice conversion

Character recognition for Telugu language uses different phases to get the recognized character using OCR.

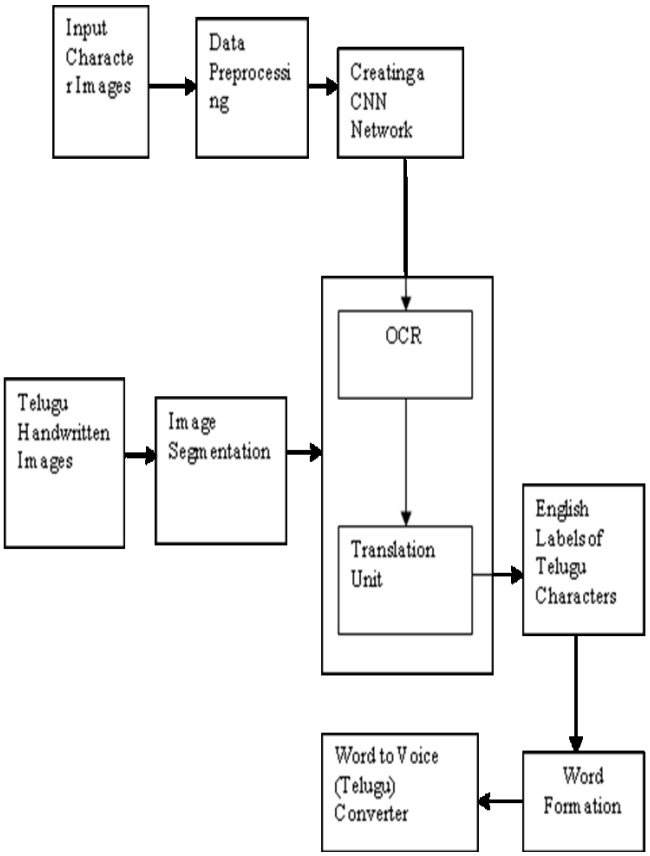


Fig. 3. Architecture of Proposed Native OCR to Voice Conversion

Firstly recognizing the image, then preprocessing phase and then segmentation is done for an image. Edge detection method is used in image segmentation. Lastly the recognized image is obtained and then the translation unit is applied called Google voice translator or voice converter as shown in figure 3. This voice translator is mainly useful for visually impaired people. Google voice translator is used to recognize telugu handwritten dataset.

B. VGG16 for Character classification

VGG-16 is the architecture or model of Convolution Neural Network and it is also used for character classification. The figure 4 indicates the architecture of VGG-16.

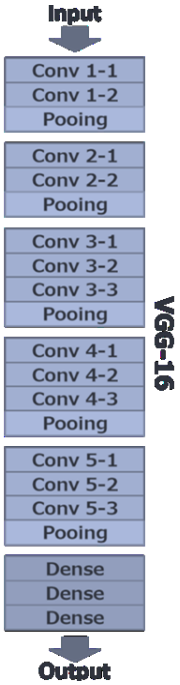


Fig. 4. Architecture of VGG-16

VGG-16 architecture consists of one input layer, one output layer and other six layers. Each layer consists of convolution layers and max pooling layer and also consists of dense layers. Let us assume input to the network with image of dimension (224, 224, 3). The primary two layers consist of 64 channels of (3, 3) filter size and identical padding. Next completion of a max pool layer of stride (2, 2), two layers which have convolution layers of 256 filter size and filter size (3, 3). This is accompanied by a max pooling layer of stride (2, 2) which is similar as earlier layer. Next it consists of two convolution layers of filter size (3, 3) and 256 filters. Later, it contains 2 pairs of three convolution layer and a max pool layer. Each have 512 filters of (3, 3) size with similar padding. This image is next moved to the mass of two convolution layers. We use the filters size 3*3 instead of 11*11 in AlexNet and 7*7 in ZF-Net in convolutional layer and max pooling layer. It also utilizes 1*1 pixels that are used to manage the amount of input channels. To suppress the spatial feature of the image, consists of 1-pixel padding is completed later individual convolution layer.

C. Properties of image and data set

Handwritten character recognition mainly used for classifying and recognizing the Telugu characters. To recognize the characters, firstly Telugu characters are written offline and scanned the images with optical character recognition. The main objective of handwritten character recognition is segmentation. The main property of handwritten character recognition is Image Acquisition.

1. Image Acquisition

The dataset covers maximum of all Telugu characters within the literature approximately 1600 characters. It consists of training and testing sets with 70% and 30% and image is gray scale. The image size is (52, 52). In preprocessing stage image is resized into 224*224, 128*128, 64*64, 52*52 from the dimension (52, 52) is discussed in table II. Image is normalized and in image Acquisition; there are three phases to recognize characters: Data Collection, Data Analysis and Validation.

a. Data Collection

The dataset covers maximum of all Telugu characters within the literature approximately 1600 characters and 52 sets of handwritten characters with individual characters. There are different hand styles with different age groups. There are various advantages in offline handwritten characters. Firstly, segmentation is not necessary, no scanning is required and lastly feature extraction is not required for character recognition. Telugu Dataset collection is sown in figure 5.

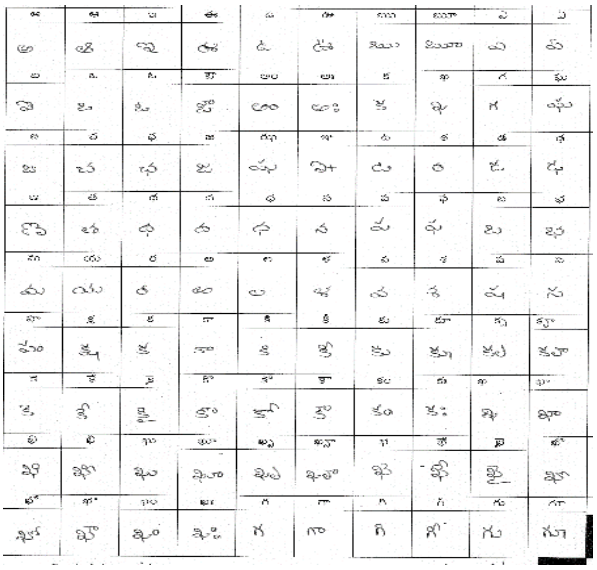


Fig. 5. Collection of Telugu Dataset

b. Data Analysis

We generated data set from data collection and data is collected from different people. We divided the data into training and testing dataset. We use the VGG-16 to train the dataset.

c. Validation

We verified the results from the test dataset.
Here, the two models are considered for Telugu handwritten characters recognition tasks. These are required for training and testing the collected data.

Table II. Models and Input Sizes

Model No.	Input sizes
Model 1	(224,224,3)
Model 2	(128,128,3)

D. Results

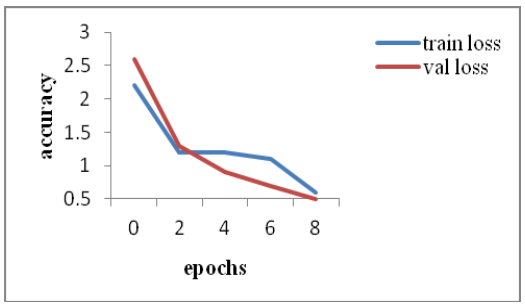
The dataset covers maximum of all Telugu characters within the literature approximately 1600 characters. Moreover, every

character image is multiplicities with 12 the usage of picture facts Argumentation (transferring, rotation, and sheering impact). The experimental analysis is evaluated using Google Colab. VGGNET-sixteen set of rules is applied to the Handwritten Telugu individual dataset. For quantitative analysis of the experimental effects, the subsequent performance metrics are considered, along with accuracy (AC). To try this we additionally use the variables proper advantageous (TP), authentic bad (TN), fake advantageous (FP), and false terrible (FN). The overall accuracy is calculated using an equation 1.

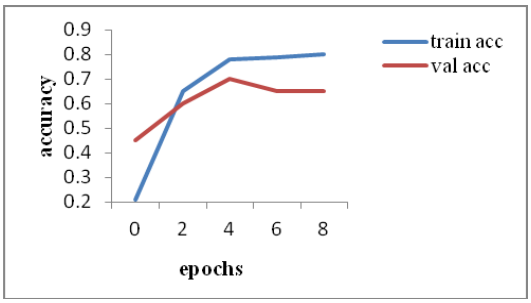
$$AC = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

Table III. Accuracy and Loss

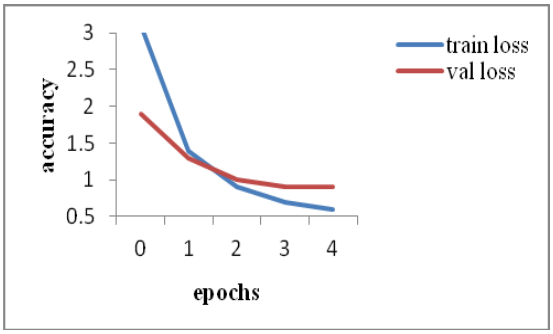
Model	Accuracy	Loss
Model 1	92%	80.60%
Model 2	80.50%	40%



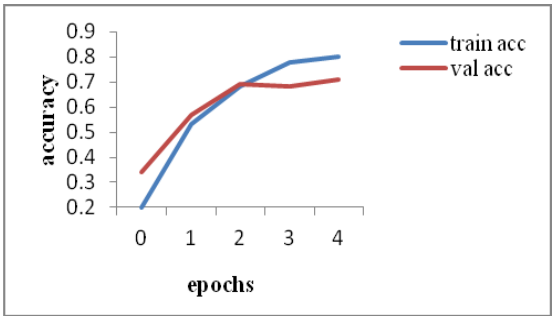
(a)



(b)



(c)



(d)

Fig. 6. (a,b) represents Model 1 and (c,d) represents Model 2

Here, Model 1 and Model 2 are indicates training loss, validation loss, training accuracy and validation accuracy. Accuracy and Loss are discussed in Table III and accuracy and loss of handwritten characters are represented by graphically in figure 5.

IV. Applications

A. Voice translation

Google voice translator is major application in the handwritten characters for Optical character recognition from text to speech. It is very easy to use to voice translation. Google Voice translator is also used to learn and recognize different languages. In Google voice translator, voice is recorded and saved offline.

B. Bank applications

Optical character recognition is defined as extracting text from different images and documents. The major application of OCR is banking industry. OCR is very useful in the Automatic Teller Machine (ATM). OCR has specified customers to scan and deposit checks from their cell phones with a machine perusing and preparing all aspects of the check. This incorporates things like the account number and the signature.

C. Library digitization

Digitization is a process to convert the images into digital images. Library Digitization is to improve the library materials by digitization for optical character recognition. Library digitization is mostly used to develop the modern libraries and to dispense the online services using optical character recognition.

V. Conclusion

The detailed information about Convolutional Neural Network (CNN) and its architecture for optical character recognition are discussed. CNN is a deep learning technique which is used for identification of character recognition. Several CNN techniques are discussed and their architectures are used for classification of handwritten character recognition are surveyed. In proposed method, VGG-16 architecture is discussed and trained with Telugu character dataset for handwritten recognition. The results represent the accuracy of training and testing of datasets.

REFERENCES

[1] Savita Ahlawat, Amit Choudhary, Anand Nayyar , Saurabh Singh and Byungun Yoon, "Improved Handwritten Digit Recognition Using Convolutional Neural Networks(CNN): Sensors", MDPI (2020).

[2] Mayur Bhargab Bora, Dinthisrang Daimary, Khwairakpam Amitab and Debdatta Kandar, "Handwritten Character Recognition from Images using CNN-ECOC", International Conference on Computational Intelligence and Data Science (ICCIDS)", Procedia Computer Science 167, pp. 2403-2409(2020).

[3] Neerugatti Varipally Vishwanath, K. Manjunathachari and K. Satyaprasad, "Handwritten Telugu Composite Character Recognition Using Morphological Analysis", International Journal of Pure and Applied Mathematics, Vol. 119, No. 18, pp. 667-676(2018).

[4] Khaled S. Younis, Abdullah A. Alkhateeb," A New Implementation of Deep Neural Networks for Optical Character Recognition and Face Recognition", Proceedings of the New Trends in Information Technology (NTIT), (2017).

[5] Durjoy Sen Maitra, Ujjwal Bhattacharya, Swapan K. Parui, "CNN based common approach to handwritten character recognition of multiple scripts", 13th International Conference on Document Analysis and Recognition (ICDAR), IEEE (2015).

[6] Md. Mahbubar Rahman, ,M. A. H. Akhand, Shahidul Islam, Pintu Chandra Shill, M. M. Hafizur Rahman, "Bangla handwritten character recognition using convolutional neural network", International Journal of Image, Graphics and Signal Processing, Vol. 8, pp.52-59(2015).

[7] Aiquan Yuan, Gang Bai, Lijing Jiao and Yajie Liu, "Offline handwritten English character recognition based on convolutional neural network",10th IAPR International Workshop on Document Analysis Systems, IEEE (2012).

[8] Huiqun Deng and George Stathopoulos and Ching Y. Suen, "Error-correcting output coding for the convolutional neural network for optical character recognition", 10th International Conference on Document Analysis and Recognition, IEEE (2009).

[9] Ujjwal Bhattacharya and B. B. Chaudhuri, "Handwritten Numeral Databases of Indian Scripts and Multistage Recognition of Mixed Numerals", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 31, Issue 3, pp. 444- 457 (2009).

[10] Hailong Liu and Xiaoqung Ding, "Handwritten Character Recognition using Gradient Feature and Quadratic Classifier with Multiple Discrimination Schemes", Eighth International Conference on Document Analysis and Recognition, IEEE (2005).

[11] P. Y. Simard, D. Steinkraus, and J. C. Platt,"Best Practices for Convolutional Neural Networks Applied to Visual Document Analysis", Seventh International Conference on Document Analysis and Recognition, IEEE (2003).

[12] R. Plamondon and S. N. Srihari, "On-Line and Off-Line Handwriting Recognition: A Comprehensive Survey", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.22, Issue 1, pp.63-84, (2000).

[13] L.Heutte, T. Paquet, J. V. Moreau, Y. Lecourtier, and C. Olivier, "A Structural/Statistical Feature Based Vector for Handwritten Character Recognition", Pattern Recognition Letters, vol. 19, Issue 7, pp. 629-64 (1998).

[14] Muni Sekhar Velpuru, NageswaraRao Sirisala, M. Ravi Kumar, G. Tejasree "A Deep Learning Aided Handwritten Digits Recognition", International conference on computational intelligence and informatics (2020).

[15] Naragudem Sarika and Nageswararao Sirisala, "Deep Learning Techniques for Optical Character Recognition", Lecture Notes on Data Engineering and Communication Technologies, Sustainable Communications Networks and Application, Vol. 55 (2021).

[16] Muni Sekhar Velpuru, Priyadarshini Chatterjee, G Tejasree, M Ravi Kumar, S Nageswara Rao, "Comprehensive study of Deep learning-based Telugu OCR", IEEE,ICSSIT (2020).

[17] Bhagyasree P V, Ajay James and Chandran Saravanan, "1st International Conference on Innovations in Information and Communication Technology (ICIICT), IEEE (2019).

[18] Dhara s. Joshi and Yogesh R. Risodkar, "Deep Learning Based Gujarati Handwritten Character Recognition", International Conference on Advances Communication and Computing Technology, IEEE (2018).

[19] Prasad K. Sonawane and Sushama Shelke, "Handwritten Devanagari Character Classification using Deep Learning", International Conference on Information, Communication, Engineering and Technology(ICICET), IEEE (2018).

[20] Huijie Zhang, Qiyu Wang, Xin Luo, Yufang Yin, Yingsong Chen, Zhouping Cui and Quan Zhou, "1st International Conference on Knowledge Innovation and Invention, IEEE (2018).

[21] Samatha P Salim, Ajay James and Chandran Saravanan, "1st International Conference on Innovations in Information and Communication Technology (ICIICT), IEEE (2019).

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