Bangla Handwritten Character & Digit Recognition Using Convolutional Neural Network

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DECLARATION

I hereby declare that this thesis report has not been submitted elsewhere for the requirement of any kind of Degree, Diploma or Publication.

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ACCEPTANCE

This thesis report is submitted to the Department of Information & Communication Engineering, Noakhali Science & Technology University, Sonapur, Noakhali in partial fulfillment of the requirements for having the B.Sc. degree in ICE.

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ABSTRACT

Bangla handwriting recognition is an important and quite popular for the last few years. This paper proposes a Convolutional Neural Network(CNN) model to recognize the Bangla Handwritten Characters and Digits which contains 50 Character Classes and 10 Digit Classes. The most challenging part is to reduce the noise because of the different shapes of Banlga characters and digits. We propose to use a reliable and large dataset to get the best accuracy output with our proposed Convolutional Neural Network(CNN) model. We also compare the accuracy with the existing model. Finally, we hope we will make a model with less error and the best output result.

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INTRODUCTION

1.1 OVERVIEW

Bangla is the official and most widely spoken language in Bangladesh and the second most widely spoken among the languages of India. It is also the second-most spoken language in this Indian subcontinent. As it is the language of 228 million native speakers. Bangla is the fifth most-spoken native language and the sixth most spoken language by total number of speakers in the world. Bangla is a part of the Indo-European Language class, its primary roots originate from Sanskrit and this language has evolved over a thousand years since its existence. The current version of the language consists of 50 basic alphabets among which there are 11 vowels, 39 consonants, and 10 Bangla digits (Numerals).

In spite of being such a widely popular language, when we need to store information it needs in digital formats. Digital formats of information are reliable, easy to access or convert as well as less time-consuming. Furthermore, Bangla characters have a complex arrangement of curvatures which are more complicated than that of other languages such as English or German. One of the most challenging tasks in handwritten character classification is, dealing with the huge variety of handwritings by different people.

Handwriting recognition, also known as Handwritten Text Recognition, is the ability of a computer to receive and interpret intelligible handwritten input from sources such as paper documents, photographs, touch screens, and other devices.

The fundamental aim of this research is to recognize the Bangla handwriting character/alphabets and digits to open up the path for further development in Bangla handwriting recognition sector. To achieve the fundamental goal, we use Convolutional

Neural Network(CNN). First of all, we build a CNN model that can train on a large amount of data and classify new image samples in real-time. For the dataset, we use our dataset and observe the accuracy of recognition. Besides, we use an online dataset to observe and compare the accuracy of recognition.

1.2 LITERATURE REVIEW

In here different related works are described in short. All the required and related factors within this Bangla handwriting recognition process are noted here. The following are discussed, different types of existing research work.

A Bangla Handwritten Character Recognition using Convolutional Neural Network with Data Augmentation was developed by Chowdhury et al. [1] in 2019. The dataset used in this experiment is the BanglaLekha-Isolated dataset. Using Convolutional Neural Network, this model achieves 91.81% accuracy on the alphabets (50 character classes) on the base dataset, and after expanding the number of images to 200,000 using data augmentation, the accuracy achieved on the test set is 95.25%.

A BornoNet: Bangla Handwritten Characters Recognition Using Convolutional Neural Network was developed by Azad Rabby et al. [2] in 2018. A simple, lightweight CNN model has been proposed in this paper for classifying Bangla Handwriting Character, which contains 50 basic Bangla characters (11 vowels and 39 consonants). Experiments have been made on three datasets along with the BanglaLekha-Isolated, CMATERdb, and the ISI dataset. For character recognition, the proposed BornoNet model gets 98%, 96.81%, 95.71%, and 96.40% validation accuracy respectively for CMATERdb, ISI, BanglaLekha-Isolated dataset and mixed dataset.

A Bangla Handwritten Word Recognition System Using Convolutional Neural Network was developed by Hossain et al. [3] in 2021. This paper proposes a multi-zoned character segmentation, and a merging method is also proposed, which can produce the handwritten term. Utilizing Convolutional Neural Network (CNN) for preparing 84%

precision is accomplished for character level, and 82% precision is achieved in word level.

A Bangla Continuous Handwriting Character and Digit Recognition Using CNN was developed by Hasan et al. [4] in 2020. In this present study, here they used Ekushnet dataset model which includes 50 basic characters, 10-character modifiers, 52-frequently used conjunct characters, and 10 digits. By using the CNN algorithm, they are able to segment 95% of words from the text and 90% of characters from the words.

A Segmentation-Free Bangla Offline Handwriting Recognition using Sequential Detection of Characters and Diacritics with a Faster R-CNN was developed by Majid et al. [5] in 2019. This paper presents an offline handwriting recognition system for Bangla script using sequential detection of characters and diacritics with a Faster R-CNN. This is an entirely segmentation-free approach where the characters and associated diacritics are detected separately with different networks named C-Net and D-Net. Both of these networks were prepared with transfer learning from VGG-16. The essay scripts from the Boise State Bangla Handwriting Dataset along with standard data augmentation techniques were used for training and testing. The F1 scores for the C-Net and D-Net networks are 89.6% and 93.2% respectively.

Another Bangla Handwritten Character Recognition using Convolutional Neural Network model was developed by Rahman et al. [6] in 2015. The proposed method normalizes the written character images and then employs CNN to classify individual characters. It does not employ any feature extraction method like other related works. 20000 handwritten characters with different shapes and variations are used in this study. The proposed BHCR-CNN misclassified 351 cases out of 2500 test cases and achieved an accuracy of 85.96%.

An End-to-End System for Bangla Online Handwriting Recognition was developed by Bhattacharya et al. [7] in 2016. It first segments the input texts into individual lines, each line into its constituent words and each word into sub-strokes. In the present study, 152 different symbols which include basic characters, character modifiers, frequently used conjunct characters, a few special characters and numerals have been considered. The

entire set of sub-strokes obtained from the training sample set has been exhaustively studied by 3 experts and 76 different shapes of sub-strokes have been identified based on consensus among these experts. The proposed system provided 94.3% character level accuracy on a test set consisting of 33,453-word samples written by 31 writers.

A Bangla Handwritten Digit Recognition Using an Improved Deep ConvolutionalNeural Network Architecture was developed by C. Saha et al. [8] in 2019. This paper proposes a Deep Convolutional Neural Network (DCNN) based Bangla handwritten digits recognition scheme. The proposed method applies a seven-layered D-CNN containing three convolution layers, three average pool layers and one fully connected layer for recognizing Bangla handwritten digits. Rigorous experimentation on a relatively large Bangla digit dataset namely, CMATERdb 3.1.1. A seven-layered D-CNN model is proposed in this paper for Bangla handwritten isolated digits, which provides up to 97.6% accuracy on test data.

A Bengali Handwritten Character Recognition Using Deep Convolutional Neural Network was developed by Purkaystha et al. [9] in 2018. In this paper, we propose a convolutional deep model to recognize Bengali handwritten characters. We first learned a useful set of features by using kernels and local receptive fields, and then we have employed densely connected layers for the discrimination task. Our system has been tested on BanglaLekha-Isolated dataset. It achieves 98.66% accuracy on numerals (10 character classes), 94.99% accuracy on vowels (11 character classes), 91.60% accuracy on compound letters (20 character classes), 91.23% accuracy on alphabets (50 character classes), and 89.93% accuracy on almost all Bengali characters (80 character classes).

Title	Author	Year	Source of data	Implemented Method	Result/Accuracy
Bangla Handwritten Character Recognition using Convolutional Neural Network with Data Augmentation	1.Rumman Rashid Chowdhury 2.Mohammad Shahadat Hossain 3.Raihan Ul Islam 4.Karl Andersson 5.Sazzad Hossain	2019	BanglaLekha-Isolated dataset	Used Convolutional Neural Network and Data Augmentation Process.	Achieves 91.81% accuracy.After use of augmented the accuracy achieved on the test, set is 95.25%.
BornoNet: Bangla Handwritten Characters Recognition Using Convolutional Neural Network	1.AKM Shahariar Azad Rabbya 2.Sadeka Haquea 3.Md. Sanzidul Islama 4.Sheikh Abujara 5.Syed Akhter Hossaina	2018	1.BanglaLekha-Isolated 2.CMATERdb 3.The ISI dataset	A simple, lightweight CNN model has been proposed in this paper for classifying Bangla Handwriting Character	Gets 98%, 96.81%, 95.71%, and 96.40% validation accuracy respectively for CMATERdb, ISI, BanglaLekha-Isolated dataset and mixed dataset.
Bangla Handwritten Word Recognition System Using Convolutional Neural Network	1.Md. Tanvir Hossain 2.Md. Wahid Hasan 3.Amit Kumar Das	2021	BanglaLekha-Isolated data set	This paper proposes a multi-zoned character segmentation, and a merging method is also proposed	The output: 84% precision is accomplished for character level, and 82% precision is achieved in word

					level
Segmentation -Free Bangla Offline Handwriting Recognition using Sequential Detection of Characters and Diacritics with a Faster R-CNN	1.Nishatul Majid 2.Elisa H. Barney Smith	2019	The Boise State Bangla Handwriting Dataset	Offline handwriting recognition system for Bangla script using sequential detection of characters and diacritics with a Faster R-CNN	The F1 scores for the C-Net and D-Net networks are 89.6% and 93.2% respectively
An End-to-End System for Bangla Online Handwriting Recognition	1. Soumik Bhattacharya 2. Durjoy Sen Maitra 3. Ujjwal Bhattacharya 4. Swapan K. Parui		Oun Dataset: 33,453-word samples written by 31 writers	It first segments all the input texts into sub-strokes. Then apply the model.	The proposed system provided 94.3% character level accuracy on a test set consisting of 33,453-word samples written by 31 writers.

Table of Literature Review

1.3 STATEMENT OF PROBLEM

According to the literature review, we found that different types of methods and strategies are used separately to recognize Bangla Handwriting Character as well as Digits. Bangla Handwriting Character and Digits Recognition is a complex and challenging task. In order to handle these complex recognition tasks, several advanced strategies are required. The current challenge is to increase the accuracy level of recognizing Bangla Handwriting Character and Digits. We will use both Characters and Digits datasets combined to increase the accuracy result.

1.4 HYPOTHESIS

To overcome the complexities that we face in Bangla Handwriting Character and Digits Recognition System mainly different types of handwriting in our dataset. We want make a system that gives handwriting recognition best accuracy. The motto of this work is to remove the noise of data to increase the accuracy for improving the overall efficiency.

1.5 OBJECTIVE

The main objective of this research is to improve the accuracy, accessibility, and reliability of the Bangla handwriting character and digits recognition system. Also works with the problems or faults of the Bangla handwriting character and digits recognition system. It will make an improvement in Bangla handwriting character and digits recognition system that everyone can use it easily. It will be also beneficial for advanced work in Bangla handwriting character and digits recognition system. In handwriting recognition, there is a lot to research and we are really curious and interested in this topic. The specific objectives are:

i. To study the Bangla handwriting character and digits recognition system
ii. To improve the accuracy of the Bangla handwriting character and digits recognition system
iii. To make a fast and accurate Bangla handwriting character and digits recognition system
iv. To make a comparison with the existed system

Chapter 2

METHODOLOGY

2.1 PROPOSED METHOD

The main goal of this research is to build a CNN model that can be used to recognize Bangla handwritten characters and digits. That's why we need to collect data and train that data in our CNN model. Finally, test that dataset and by the analysis of outcome, we provide our accuracy result. The proposed model is given in below:

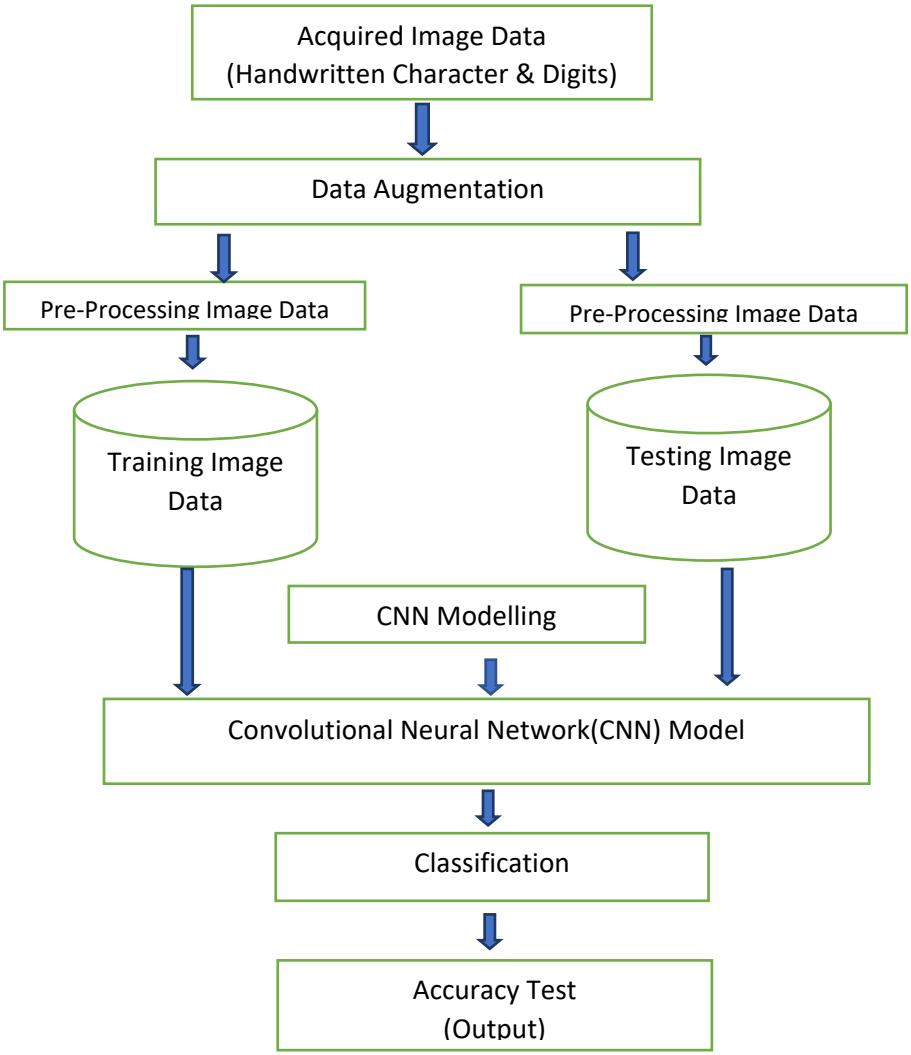

Figure 2.1: Proposed model of Bangla Handwriting Recognition System

2.2 DATA COLLECTION

To achieve our goal we need to use a unique dataset that contains a large number of image data. These datasets consist of Bangla characters in 50 classes, Bangla numeral digits in 10 classes. The image data need to be noise-free. Different age people have different styles of handwritten. We need to collect different types of handwritten Bangla characters and numeral digits. Besides we use online available datasets to compare our accuracy results.

2.3 Data PREPROCESSING

The handwriting raw data and images are often incomplete, inconsistent, and lacking in certain behaviors or trends. They are also likely to contain many noise and errors. So, once collected, they are pre-processed into a format that can be easily used for our model. To achieve the highest accuracy results we need to use noise-free and same pixel data, which should be done in the data pre-processing phase. It includes several tasks employed in the process to make the data more relevant.

2.4 CNN ARCHITECTURE

A Convolutional Neural Network(CNN) is a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data [10].

CNN is a particular type of feed-forward neural network in AI. CNN represents the input data in the form of multidimensional arrays. It works well for a large number of labeled data. CNN extracts each and every portion of an input image, which is known as the receptive field. It assigns weights for each neuron based on the significant role of the receptive field. So that it can discriminate the importance of neurons from one another [11]. The architecture of CNN consists of three types of layer: (1) convolution layer, (2)

pooling layer, and (3) fully connected layer [11]. The architecture of CNN is shown in Fig. 2.2

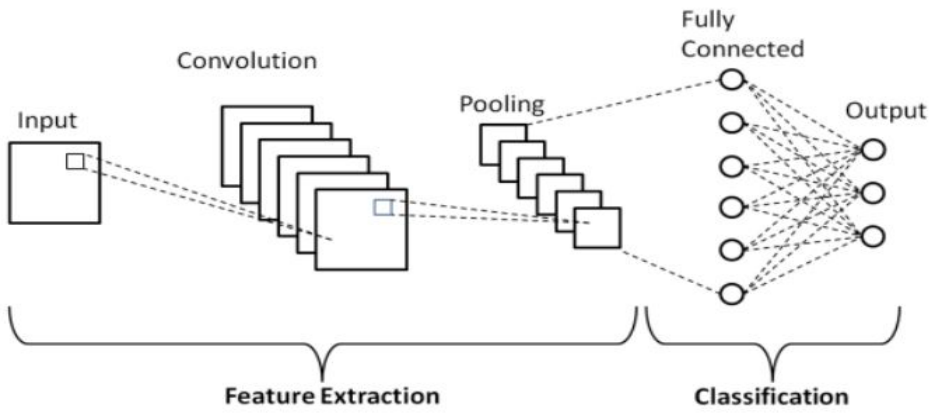

Figure 2.2 The architecture of CNN.[12]

Convolution layer: Convolution is an orderly procedure where two sources of information are intertwined; it's an operation that changes a function into something else. Convolutions have been used for a long time typically in image processing to blur and sharpen images, but also to perform other operations. The most common type of convolution that is used is the 2D convolution layer and is usually abbreviated as conv2D. A filter or a kernel in a conv2D layer "slides" over the 2D input data, performing an elementwise multiplication. As a result, it will be summing up the results into a single output pixel. The kernel will perform the same operation for every location it slides over, transforming a 2D matrix of features into a different 2D matrix of features [13]. The 2D figure of convolution layer fig 2.3 :

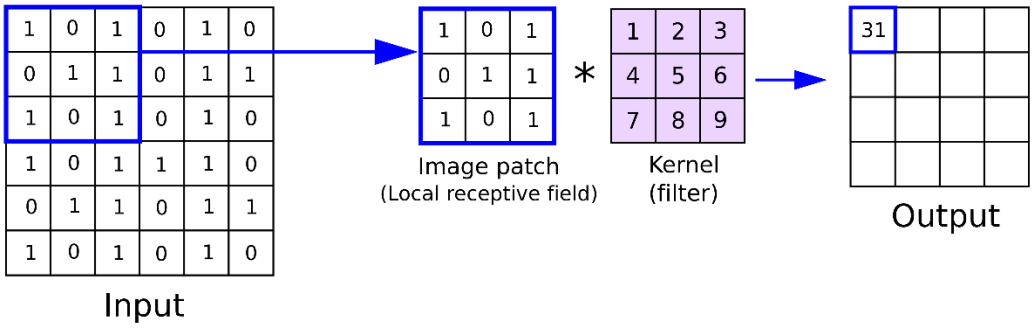

Figure 2.3: Convolution Layer (Conv2D) [14]

Pooling Layer: It is common to periodically insert a Pooling layer in-between successive Conv layers in a ConvNet architecture. Its function is to progressively reduce the spatial size of the representation to reduce the number of parameters and computation in the network, and hence to also control overfitting. The Pooling Layer operates independently on every depth slice of the input and resizes it spatially, using the MAX operation. The most common form is a pooling layer with filters of size 2x2 applied with a stride of 2 downsamples every depth slice in the input by 2 along both width and height, discarding 75% of the activations [15]. The figure of pooling layer in fig 2.4

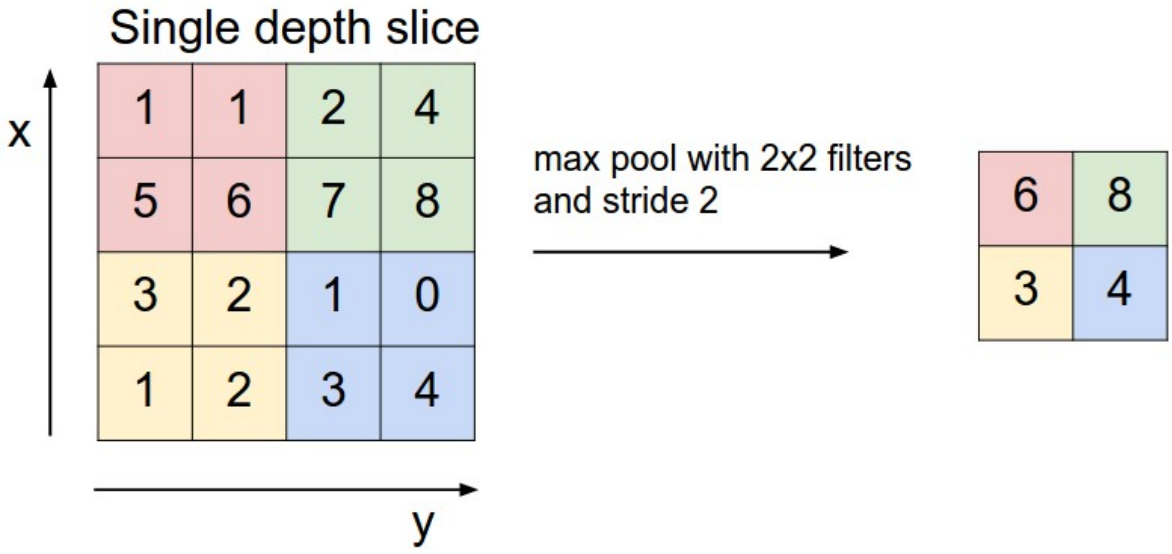

Figure 2.4: Pooling Layer [16]

Fully Connected Layer: Fully connected layers are the normal flat feed-forward neural network layer. These layers may have a non-linear activation function or a softmax activation in order to output probabilities of class predictions. Fully connected layers are used at the end of the network after feature extraction and consolidation have been performed by the convolutional and pooling layers. They are used to create final non-linear combinations of features and for making predictions by the network [17]. The figure of fully connected layer in fig 2.5

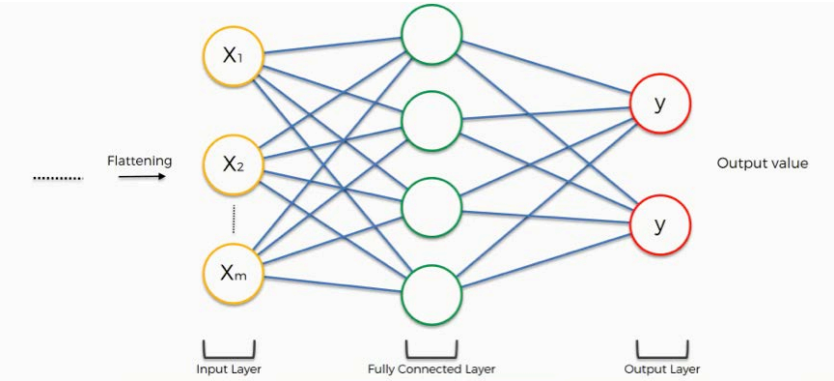

Figure 2.5: The fully connected layer [18].

By the processing of three layers we get the final output result.

2.5 REQUIREMENT

Hardware Requirement: Computer Core i3,

Software Requirement: Jupyter Notebook, Anaconda,

Programming Languages: Python

Algorithms: Machine Learning Algorithm, CNN

Chapter 3

EXPECTED OUTCOMES

The primary goal of this method is to recognize Bangla Handwriting Character and Digit. Apply the Convolutional Neural Network (CNN) model we expect the best accuracy result compare to the others model which already has been used in previous work. Also, we expect we will use a large number of image data, to get our best accuracy result. We also expect:

- Improve and increase the accuracy of Bangla handwriting recognition system.
- More faster performance
- Make a system available and one can easily use this system
- Our proposed system will consume less time and energy when compared to other models.

Chapter 4

Conclusion

A Convolutional Neural Network is really effective for recognizing Bangla Handwriting Characters and Digits. This research will prove that the CNN model is more efficient compared to other machine learning approaches. This research explores the opportunities that are required to classify Bangla handwritten Characters and Digits. This research also creates future scope to apply for advanced work in Bangla handwriting recognition sector.

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