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Handwritten Character Recognition from Image Using CNN

Partha Chakraborty, Shanta Roy, Sadia Nowshin Sumaiya, and Aditi Sarker

Abstract Handwritten character identification has always been an intriguing area of study in the realm of pattern recognition in image processing. Because of its numerous applications, the requirement for identifying handwritten characters is growing every day. Many scholars have defined their work in this field, and additional research is being carried out to obtain high precision. In compared to other major languages such as Bangla, there are numerous works in handwritten character recognition available for English. The goal is to present a comprehensive, effective, and efficient method for classifying and recognizing both Bangla and English letters. An extended convolution neural network (CNN) model has been suggested to recognize Bangla and English characters. Character recognition is achieved through segmentation, feature extraction, and classification. CNNs were recently discovered to be adept at English text detection. A CNN-based Bangla handwritten character recognition system is also being researched. A total of 23,040-character samples have been used, with 25% of the data having served as a test set and the remaining 75% having been used to train the recognition model.

Keywords Convolutional neural network · ReLU · Pooling · Extraction

1 Introduction

Character recognition is becoming increasingly important in our digital age. Handwritten character recognition is harder than printed character recognition. Handwritten letters, written by various people, are not similar and vary in size and shape. Approximately, 1.35 billion people speak English and 260 million people speak Bangla worldwide. The size, form, and stroke of both Bangla and English handwritten characters can be varied. As a result, a complex model such as CNN is

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required, which can automatically extract features from images without any explicit description [1].

The extraction of features from the character set is the first step in developing a handwritten character recognition system, followed by the use of learning tool(s) to classify individual characters [2]. After characters are extracted, a validation engine is utilized to distinguish the associated computer character. To train neural network classifier, a source images training set is used. The trained network then does the word identifications. In its own way, any neural network learns the properties that separate training images. The ability of a computer to detect and interpret meaningful handwriting input from photographs is referred to as handwritten character recognition. The primary goal of this research is to develop an expert system for handwriting character identification using a neural network technique [3].

The following are the primary goals of this article:

- Implement user friendly computer-assisted character representation.
- Develop a system to address the problem of accuracy in handwriting character recognition systems.
- To investigate and illustrate neural network technology's utility.

2 Related Work

Digit recognition for handwritten Bangla deep learning [4] techniques for recognizing Bangla digits using deep belief networks (DBN), convolutional neural networks (CNN), CNN with dropout, CNN with dropout and Gabor filters, and CNN with dropout and Gaussian filters are shown by Zahangir, Sidike, and Tarek. They tested the method's performance on the publicly available Bangla numeral image database CMATERdb 3.1.1.

Convolutional neural network for handwritten character recognition in Bangla [2], Mahbubar and Akhand developed an approach that uses CNN to categorize individual characters after first normalizing the written character images. 20,000 handwritten characters of complex styles and variants are employed.

A survey of handwritten character recognition techniques for various Indian languages [5], Dholakia and Krupa, this paper is primarily process character recognition and performance assessment for various Indian languages to recognize handwritten characters. Some other authors have worked on various techniques in these sectors [6–20]. The goal of this research is to convey a bundle of techniques for preprocessing, segmentation, feature extraction, and classification.

3 Structural Model

If we look at our system, we will find 5 major steps that are performed for all the characters. The structural model is Fig. 1.

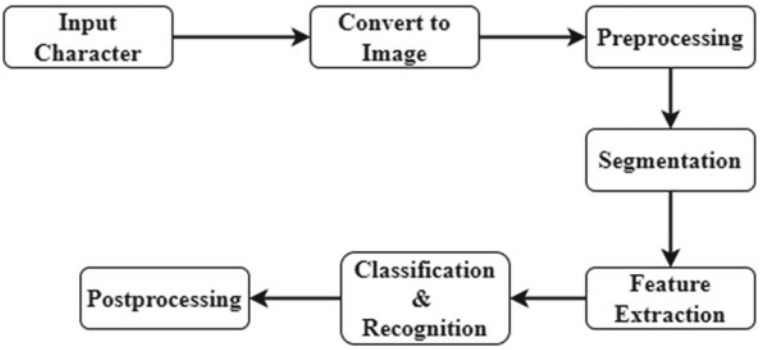

Fig. 1 Structural model of the system

4 Methodology

4.1 Preprocessing

First and foremost, the supplied image is transformed to grayscale. Binarization, size normalization, morphological procedures, noise removal employing filters, thresholding, skeletonization, thinning, cleaning approaches, and filtering mechanisms are all performed [5]. It streamlines the processing of the input image in order to improve the recognition system's overall efficiency.

4.2 Segmentation

Only during the testing stage is segmentation done. It compares all points to the average distance between segmentation points in the incomplete image to look for any improperly included points. The method creates "super pixels," which are numerous picture segments. The purpose of segmentation is to make an image's representation simpler so that it can be analyzed more simply.

4.3 Feature Extraction

The procedure of converting input data into a set of features that can accurately signify the input data is known as feature extraction. Elimination of aspect and feature extraction is linked [21]. When the input data is too big to handle, it can be reduced to a smaller set of features.

4.4 Classification and Recognition

To classify the handwritten characters from the input image, a convolutional neural network is utilized as a classifier. An input and output layer, as well as several hidden layers, makes up a CNN [21]. Classification stage is where the recognition system makes its decisions. The quality of the extracted features determines a classifier's performance.

4.5 Post-processing

Post-processing is the last phase of the character recognition system. It generates structured text with the relevant recognized characters.

4.6 Dataset

For 96 Bangla and English characters, we generated a relatively big handwritten dataset. Our produced dataset is 23,040 bytes in size, with 240 samples per character. Because of the various writing styles, the dataset comprises a wide range of distinct characters. Some of these character pictures have intricate shapes and are related to one another [1]. The character classes that we chose for honor are listed below (Tables 1, 2 and 3)

Table 1 Set of Bangla alphabets

অ	আ	ই	ঈ	উ	ঊ	ঋ	এ	ঐ	ও
ঔ	ক	খ	গ	ঘ	ঙ	চ	ছ	জ	ঝ
ঞ	ট	ঠ	ড	ঢ	ণ	ত	থ	দ	ধ
ন	প	ফ	ব	ভ	ম	জ	য	র	ল
শ	ষ	স	হ	ড়	ঢ়	য়	ৎ	ং	ঃ
ঁ									

Table 2 Set of English alphabets

A	B	C	D	E	F	G	H	I	J
K	L	M	N	O	P	Q	R	S	T
U	V	W	X	Y	Z				

Table 3 Set of Bangla and English digits

০	১	২	৩	৪	৫	৬	৭	৮	৯
0	1	2	3	4	5	6	7	8	9

4.7 System Architecture

The image input layer accepts handwritten character images in Bangla and English with a dimension of 80 * 80 * 1.

Preprocessing the inputs is required for every model to provide the images a consistent form before feeding to any classifier [1]. All of the images were transformed to 32 * 32 pixels.

In the first convolutional layer, the input pictures are padded by zero padding of size 1. After that, eight 3 * 3 * 1 kernels were used to extract eight different characteristics. The convolution operation formula is if the kernel has m rows and n columns (Fig. 2).

$$Z\,(x,\ y)\ =\ \sum\sum(i,)ni = 1mj = 1\,I\,(x-i)(y-j)$$

We get a 32 * 32 * 8 feature map by stacking the activation maps. The ReLU layer is then applied to our feature map. We used the ReLU activation function to ensure positive values as,

$$f(x)\ =\begin{cases} x, x \geq 0 \\ 0, x \leq 0 \end{cases}$$

System then uses a max-pooling layer with a kernel size of 2 * 2. If the kernel size is $P * P$, it will cover an area A of the feature map with dimension $P * P$.

The 1st layer's features are then supplied to the 2nd convolutional layer, which is subsequently fed to the 3rd convolutional layer. The flattened feature map is now given to the fully connected layer. The soft-max layer determines the probability of each of the predefined character classes.

Eventually, a classification layer follows the soft-max layer. A single epoch of the training process is now complete.

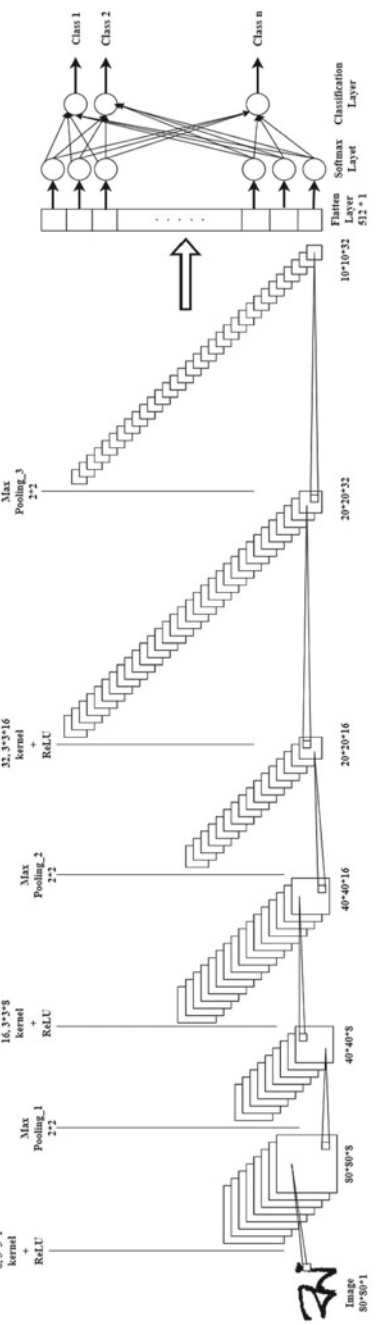

Fig. 2 Architecture of convolutional neural network

4.8 Working Sequence of the System

In the system, the author works with both Bangla and English characters. But compared to English, Bangla is very much more versatile. The recognition process is relatively difficult due to their diversity in shape and size. But using CNN, every image is classified into layers and the system easily predicts the letter or digit (Fig. 3).

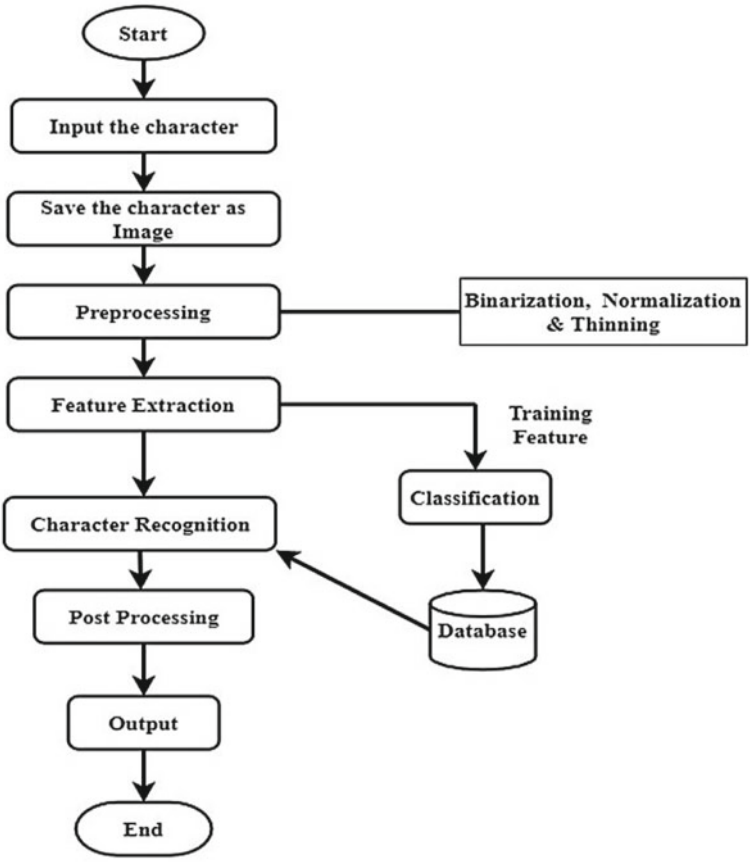

Fig. 3 Flowchart of the system

5 Result and Discussion

5.1 Analysis and Comparison

Python 3 is used to implement the recommended approach. The input can be an alphabet, a number, or a Bangla character. The data is preprocessed, scaled, and standardized before being fed into the CNN classifier. Because the CNN classifier is trained on the dataset, it can predict the input character.

The following table gives the comparison between some previous work. From this table, we found that our system combined Bangla and English character (Table 4).

We used 75% of the data from each class to create the training set, and 25% of the samples from each class to conduct the testing. We achieved a loss of 0.5579 when we used the CNN model on handwritten characters. After ten epochs, we had an accuracy of 85.96 percent. The accuracy percentages suggest that our model was properly trained with the training set (Fig. 4).

After analyzing the results, the author got some misclassified characters from our validation set. The model performed well for classifying characters. But several mistakes can also be made by humans. Majority of the erroneous classifications are driven by errors in labeling. Owing to the vast deviation in writing patterns, such character images are challenging to classify, even by humans.

Table 4 Comparison between different system

Index	Work	Accuracy (%)
1	Convolutional neural network used for Bangla handwritten character recognition	85.36
2	Use extended CNN method for recognized Bangla character	92.25
3	Artificial intelligence neural network and image processing used for handwriting recognition	83.40
4	BornoNet: Bangla handwritten characters recognition 95.71% using convolutional neural network	95.71
5	Handwritten character recognition from image using CNN	85.96

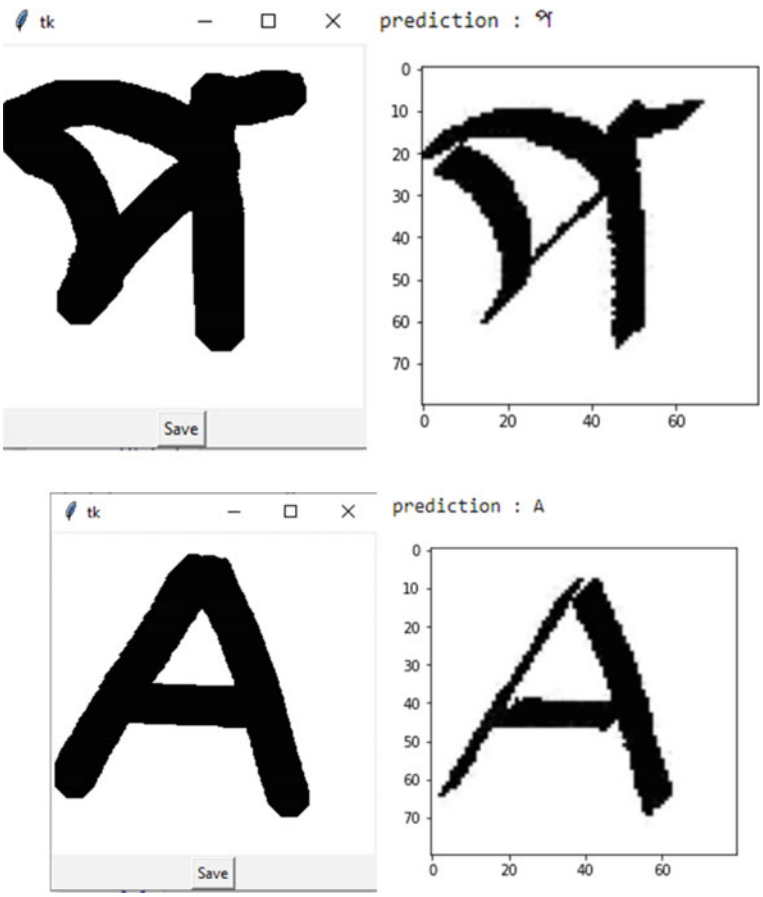

Fig. 4 Input and output

6 Summary

Many regional languages around the world have distinct writing styles that HCR systems may identify with the right algorithm and methodology. According to this paper, the existence of unusual characters or similar shapes for many characters makes handwritten character identification difficult. A cleaned image is created by preprocessing the scanned image. Normalization and filtration are performed, utilizing preprocessing techniques to provide a noise-free and clean output. Managing our evolution algorithm with correct training, evaluation, and other step-by-step processes will result in a successful system output with improved efficiency.

6.1 Future Scope

In this research, the author combined both Bangla and English characters, for which we had to work with a huge dataset. The versatility of the shapes of each character made the model more complex. But we tackle the problem smoothly. The model became confused when attempting to understand overwritten characters, and the system failed to recognize the character. In the future work, it should be done to fix the dataset and overcome the limitation of overwriting characters. Creating a baseline model for handwritten characters, including numerals, basic characters, modifiers, and compound letters, is trying to set audio for each character.

7 Conclusion

The primary goal of this study was to develop a system that would help in the classification and recognition of handwriting characters and numbers. In digital world, the ability to recognize characters and numbers is crucial. Convolutional neural networks (CNNs) can recognize visual patterns directly from pixel images with little preparation. As a result, in this study, a CNN structure is studied without any feature selection for Bangla and English handwritten pattern classification. The approach was evaluated on a huge handwritten character dataset, and the results were compared to other popular Bangla or English methods. On a standard dataset, we tested the performance of CNN with a dropout and several filters.

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