Recognition of Handwritten Bangla Numerals using Adaptive Coefficient Matching Technique

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Abstract

This paper presents an approach to recognize handwritten bangla numerals from low pixel mobile camera based on correlation co-efficient. In this paper, an approach is identified to recognize such handwritten bangla numerals having different shape and scan through from any low pixel mobile device. It has also shown that while writing in continues sometimes two separated digit connected to each other, to distinguish such digit we used Line segmentation. High correlation coefficient will provide the successful results of recognition. A large dataset is used for training and testing purpose which gives overall 93.80% accuracy using mean of maximum correlation and 95.70% accuracy is shown when individually correlation found.

1. Introduction

Handwritten Numerical Recognition (HNR) system is aimed to identify a numeric value using computing device. HNR has always been a very challenging work in the field of pattern recognition. Using Optical Character Recognizer (OCR) we are able to edit a scan document image. Electronic translation of an image (like printed, handwritten or typewritten) into editable text is the main aim of OCR. Generally English is used in computing systems. But now days other languages are become a part of OCR. Bangla is one of the most popular languages in country like India and Bangladesh. The research of HNR is very popular for various practical applications for blind readability, bank cheque, and automatic pin code reading of postal system. Numerals in bangla are very curve in nature. Several researches are going on in the field of Bengali character recognition systems to improve its accuracy and efficiency. Still there are several challenges occur during the improvement. The writing pattern is different shape while we are talking about handwritten document. In begali number system there are ten digits, staring from 0 to 9, having different shape size and style. As hand writing is varied from person to person, to identify that particular content from the mobile captured images really a difficult work. OCR can be performed via online and offline. Offline handwritten recognition systems

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of finding numerals are present in digital image of handwritten document. In this paper, a template matching based recognition system is proposed. Scan document can be recognizing with the proposed method. Mobile captured images are also recognised using the described approach. The main challenge in mobile captured images is noise. Hence it should be kept on mind that noise should be eliminating properly for better result. The organization of this paper is as follows: In section 2, we discuss about the brief description of literature survey, in section 3, we describe the proposed methodology, in section 4, we describe about the experimental results and finally in section 5, conclusion is drawn.

2. Literature Survey

Bangla numeral recognition can be classified into two ways, offline and online systems. We mainly concentrate on off line HNR. The offline character recognition is presented in3 to describe HNR using template matching technique. In Mohammed Moshiul Hoque et al.2 proposed an OCR engine to recognize the Bangla numerals. The unique fuzzy base rule for applied to each numeral. The numerals features i.e. fuzzy features are mapped into some predefined linguistic variables. To recognition of a numeral, fuzzy rules are calculated, this fuzzy rule is compared with rule base and the character that contains highest percentage value is recognized character. The acceptance rate of the successful recognition is 82.099%. Vishweshwarayya C. Hallur and Ravinda S. Hegadi describe an approach based on template matching for handwritten numeral recognition of another Indian script4. OCR is used to text recognition. To recognize Indian handwritten script several algorithm has been proposed. K. Roy, C. Chaudhuri, U. Pal and M. Kundu describe an approach on the effect of varying training set sized on the recognition performance with handwritten bangla nurelas5. Amitava Choudhury and Joydeep Mukherjee also describe an approach to recognition of handwritten bangla numeral recognition using correlation coefficient method6. OCR can be recognizing the characters as well the numeric value also. In Ketan S. Machhale et al.7 proposed an adaptive template matching and feature extraction using curvelet transform for the recognition of handwritten Bangla numerals. The feature extracted from the numeral set based on the curvelet transform morphological method. To classify the characters a KNN classifier is used. Ujjawal Bhattacharya et al.8 proposed an efficient algorithm for recognition system of mixed numerals. A multistage cascaded recognition scheme using wavelet based multi resolution representations and multilayer perception of MLP classifier. The proposed method has been implemented for recognition of handwritten numerals in mixed script situation. In U. Pal, B. B. Chaudhuri9, an automatic recognition method for unconstrained off-line Bangla handwritten numerals was described. To obtain feature from each character, they provide a concept of water overflow from the reservoir as well as topological and statistical feature and numerals. The direction of water flow, height of water level when water overflows from the reservoir, position of the reservoir with respect to the character bonding box, shape of the reservoir etc, are used in the recognition scheme. Pulak purakait and Bhabatosh Chanda describe offline recognition of handwritten Bengali numerals10. They proposed some novel morphological feature and k-curvature feature extraction technique to recognize handwritten scripts. Multi-layer perceptron (MLP) classifier used to train the feature spaces and then fuse those classifiers used as modified native bayed combination to increase accuracy of recognition. An overview of segmentation of handwritten connected digit11 is described by R. V. Kulkarni and P. N. Vasambekar.

3. Proposed Work

Writing style of Bengali numeral is different from English font and its shown that each number has a curve on its writing skill. As the handwriting is varies from person to person so recognize that using OCR is very challenging task. In this paper, an approach is identified to recognize such handwritten Bangla numerals having different shape and scan through from any low pixel mobile device. It has also shown that while writing in continues sometimes two separated digit connected to each other, to distinguish such digit we used Line segmentation. Input image has been resized into 32 × 32 pixel, which implies the each image size in the dataset. The correlation coefficient is computed between the input image and the image that are stored as training data in dataset. A high correlation coefficient will provide the successful results of recognition. The numeral digits 0 to 9 as represented in Bangla language is shown in Fig. 1.
The entire work is divided into the following steps:

i. Image input
ii. Pre processing
iii. Feature Extraction
iv. Template Matching
v. Classification

3.1 Image input

Input image is handwritten text written on paper and captured by a mobile phone camera. Figure 2 depicts a sample of the captured image.

3.2 Image preprocessing Binarization

Upon reducing the noise from gray scale image, an adaptive threshold is applied to get the binarized image because we assumed that some information may lose during the binarization process. Image binarization mainly done for two reasons one is to highlight the character and secondly to suppressing the background color. Figure 3 depicts the binarized image.

3.3 Segmentation

Segmentation is needed to separate each digit from the connected image of digit as shown in Fig. 2(b). Bounding box algorithm is to use to segment each number from the other number of the same image. The Area is the actual number of pixels in the region; the product of the widths is the number of pixels that are within the bounding box.

3.4 Feature Extraction

To extract feature we used the template matching technique. It is very effective to use character reorganization where templates don’t have such good features. From this technique we check whether the input image having similar feature with respect to stored template dataset or not. Different dataset consisting different bangla digits has been used.
to prepare trained dataset. Each segmented digits compared with trained features. Input images are matched with whole template dataset to find the absolute result using correlation method. If the input image is having same definition of the trained dataset then successful recognition is done. Input image is to be resized to a standard size of $32 \times 32$ pixels. Captured images are stored in white background and black font but while we use recognition we invert the image. Images are resized to $32 \times 32$ and stored in a matrix order of $10 \times 10$, this means that, first row consists of ten ones second row consists often twos and show on as described in Fig. 4.

3.5 Template matching

Template matching is the technique in which pixel definition of presorted patterns are sought in an image. The templates are describing relationship between the regions. The dataset containing different set of numeral in bangla character and store them in a matrix having order of $10 \times 10$. The process is following the following algorithm.

i. Convert the input image (Fig. 2(b)) into grayscale.
ii. Eliminate the noise present in the image using median filter.
iii. Convert the input image into grayscale and binarized image (Fig. 3(a) and (b)).
iv. Segment each number if more than one digit as Fig. 2(b).
v. Find the region of interest with the help of horizontal projection profile.
vi. Find the complement of the above image.
vii. Match the given image with the template image.
viii. If matching is found based on the feature from step v its shows the correct class.

3.6 Classification

When an image is tested as input image, the system first loads the template. Resize the input image as same size of the template that is $32 \times 32$. Compute the numbers in the template file and count the connected components. Compute correlation between the template and the input image. A perfect matching gives a correlation coefficient of 1.0. Then only the input image can be identified by matching numeral from the database. For two images $A$ and $B$ each of size $m \times n$ the correlation between them is given by the following, where $A'$ denotes the mean value of the pixels of image $A$. A correlation is a single number that describes the degree of relationship between two variables. The quantity $r$, called the linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables which is described as

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \bar{A})^2\right) \left(\sum_m \sum_n (B_{mn} - \bar{B})^2\right)}}$$

4. Experimental Results

Experimentations are performed on a dataset of Bengali numeral images downloaded. The dataset consists of 300 images divided into 100 training images and 200 test images on randomly basis. 10 different numbers 0 to 9 are used each having 10 training instances and 20 test instances. Figure 4 shows the training template.

During classification, each test image is compared to all the 100 training images using correlation and the maximum value is considered to indicate the class. For the first test character ‘1’ the following shows the plots of its correlation value with the 100 training samples.

The mean correlation values over all instances of the 10 characters are: $0.3435 \ (1), 0.0167 \ (2), 0.1388 \ (3), 0.0170 \ (4), 0.0556 \ (5), 0.1849 \ (6), -0.0444 \ (7), 0.0101 \ (8), 0.1196 \ (9), 0.1069 \ (0)$.

The following figures show the plots of mean correlation values of each of the 20 instances of test characters with the training set samples 0–9.
Fig. 5. Correlation Value of First Test Sample (1) with 10 Instances of Each Character of the Training Set.

Fig. 6. Mean Correlation Plots: Character 1.

Fig. 7. Mean Correlation Plots: Character 2.

Fig. 8. Mean Correlation Plots: Character 3.

Fig. 9. Mean Correlation Plots: Character 4.
Fig. 10. Mean Correlation Plots: Character 5.

Fig. 11. Mean Correlation Plots: Character 6.

Fig. 12. Mean Correlation Plots: Character 7.

Fig. 13. Mean Correlation Plots: Character 8.

Fig. 14. Mean Correlation Plots: Character 9.

Fig. 15. Mean Correlation Plots: Character 0.
Table 1. Percentage Recognition Accuracies using Proposed Method and Compared Method.

<table>
<thead>
<tr>
<th>Characters</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognition Accuracy by paper 4 and 6</td>
<td>95</td>
<td>80</td>
<td>98</td>
<td>94</td>
<td>95</td>
<td>75</td>
<td>95</td>
<td>90</td>
<td>95</td>
<td>85</td>
</tr>
<tr>
<td>Recognition accuracy by proposed method</td>
<td>99</td>
<td>98</td>
<td>100</td>
<td>95</td>
<td>97</td>
<td>92</td>
<td>95</td>
<td>90</td>
<td>95</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1 has shown the accuracy of the numeral testing, proposed by our method. Overall accuracy is 95.70%. This data is compared with results described on\textsuperscript{4,6}.

4.1 Analysis

Our proposed method gives more accuracy even if noisily image also as compared with paper\textsuperscript{4} and\textsuperscript{6}. It is very difficult to get 100% accuracy as the style of writing is different from person to person. For hand written bangla digit 2 the accuracy reached 98% and for 0 it is 100%. The accuracy of the proposed algorithm is increased if each test class sample compared with the all trained sample i.e. 100 sample for each class and the maximum correlation is treated as correct recognition. By the proposed approach accuracy increased to 95.70%.

5. Conclusions

This paper presents a correlation based template matching algorithm to recognize banglal numeric numbers from the scanned or mobile captured images. Writing pattern Bangla numerals are very difficult as such numerals are found to be very curve in nature. We tested the input images both for the connected digits or single number. Noise is also eliminated from the input image to compute high accuracy. More than 300 data sample is used in testing part. As correlation coefficient factor is the main feature, hence we used a large the training dataset. The classification of handwritten data is shown. It is obvious that other different integrated approaches will improve the performance of the whole recognition system. In future our aim is to improve the system accuracy by use of other classifier, various feature extraction algorithm.

References