HANDWRITTEN BENGALI CHARACTER RECOGNITION A STUDY OF WORKS DURING CURRENT DECADE

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Abstract

Recognition of Handwritten Bengali Character in the field of pattern recognition is still an interesting and complex task. The huge application area of the language made the work much important. Bengali script is widely used in the states, like West Bengal, Tripura, and Assam in India. Also an entire country, Bangladesh also used them. But unfortunately there is not much success in the field. There is no such system which is efficiently and successfully automated the complete documentation work, or a part of it. Here the work is a study of achievements in the field of Bengali handwritten character recognition throughout the last decade.

1. Introduction

Bengali, is not only a major language in two states West Bengal, and Tripura of India, but it is the main language of an Entire country Bangladesh. Bengali scripts are widely used is some other languages also, like Assamese. So no doubt it is an important language for a large number of populations in the world. With the evolution of automation, machine learning, and tending technological development [25-28] it is also high time to make a complete product which can easily and efficiently recognize Bengali handwritten characters.

It is a huge number of research work is going on in different places of the world in this field. Research in the field of handwritten character recognition for any language itself a though task [19-24]. But the inherent complexity of Bengali script, large variety of compound character, etc. made the task of recognizing them much more difficult. Research in this is getting popular day

to day, and there are the obvious reasons. Application area of such Bengali handwritten character recognition system is undoubtedly very high, but unfortunately, there is not such success in the research, which can produce a complete operational system which can be commercialize or practically implemented in day to day life.

Here, the work is a study of achievements in the field of Bengali handwritten character recognition throughout the last decade. The content is distributed as Introduction, about HCR, Study of the works during the last decade, conclusion

2. Handwritten Character Recognition

Here is the general form of Handwritten Character recognition system. The system takes the hardcopy characters as input and produces softcopy characters in the basis of the recognition, to word editors like notepad, Ms Word, etc.
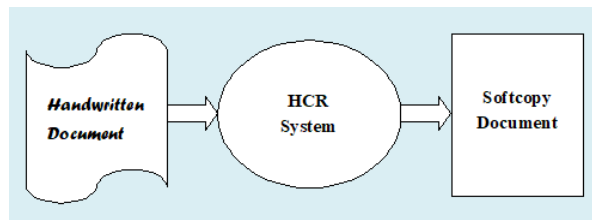
Figure 1. Handwritten Character recognition system.
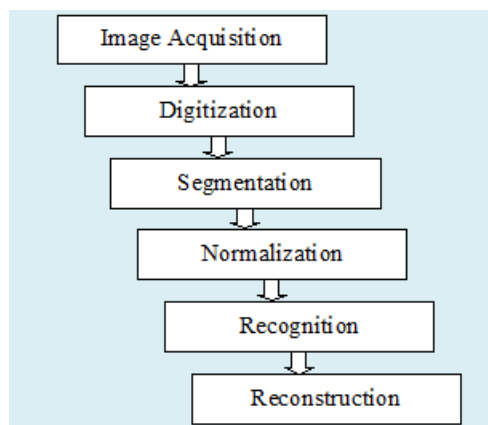
Figure 2. Tasks in Handwritten Character Recognition.

The system performs several tasks before and after it employs the said neural network to recognize it. The input characters for training or testing are written on a paper, and are converted into digital format by scanner, camera or some other image acquisition hardware. Those images are converted into a matrix of binary value and kept into a vector to feed them into the neural network. When the network gives recognized character, the system puts the identified character in a text file separately, so that the file can be edited afterwards by any word processor like Ms Word, etc. The conceptual block diagram of the system is shown in Figure 2.

3. Study of Works during Current Decade

Bengali characters contains 160 complex characters along with 50 basic characters classes, which creates a big challenge for the researchers in the field of handwritten character recognition. Such huge variety of complex shaped characters not only associated uncertainty and imprecision, but they make the problem more complex by close resemblance of some character classes. Here is a good approach find out compound character classes depending on the frequency of occurrence and train a classifier with incrementally increasing number of learned classes of compound character more frequency of occurrence to less [1].

Benchmark result for Bengali handwritten character is presented in [2] by testing an online freely available database of handwritten characters for

Bengali, Devanagari, Tamil and Telegu language. The database is tested by applying two existing feature extraction method named point- float and direction code histogram and three existing classifier, nearest neighbour (NN), Multilayer perceptron (MLP), and hidden markov model (HMM).

A claimed, one of the first online cursive Bengali character recognition system is presented in [3]. Different approaches are investigated for defining model structure for a highly compositional Bengali script. The methods include sub stroke level feature extraction and model based hidden Markov model.

An important feature extraction through skeletal convexity of characters strokes are depicted in the work [4]. Different skeletal convexity covers the shape of a character irrespective of the viewing direction of a character in 2D plane. This allows the method deal with vast variety of shapes of the handwritten character by different individual. For recognition, common matching technique is applied. Preliminary results claimed efficient when tested with a benchmark dataset of Bengali character images.

Another technique based on skeletal feature is depicted in [5]. Here the strategy is to break down a compound character into skeletal segments and then extracting the convex shape, which are finally used for matching purpose. Segmenting character skeleton into stroke segment and grouping them for meaning shape extraction is main challenge approached in this work. The technique claimed applicable for both printed and handwritten characters with an effective performance.

Recognition handwritten characters inside machine printed form is approached here in the work [6]. The image of the forms are scanned and converted to gray scale and then segmented in two steps, form segmentation, where machine printed words and line are omitted from the image, and character segmentation. Three major feature extraction is done here, gradient computation, wavelet transform, and feature combination

A novel multi stage approach for recognizing Bengali compound character based on two pass Genetic algorithm and Support Vector Machine is depicted in the work [7]. Second pass classifier deals with discriminating regions within each group of pattern classes identified in first pass.

A combination of online and offline information is applied for segmentation of Bengali characters and then recognizing them is a good work done in [8]. The whole character or part of a character is represented through conversion of cursive written words to strokes. A large variety of Bengali handwritten characters by group of people are analyzed to form some important rules of joining patterns of cursive handwritten characters from Bengali language. Efficient segmentation of 97.89% is achieved on the dataset. 97.68% of recognition is achieved with directional feature and Support Vector machine (SVM).

Emerging deep machine learning technique is investigated for bangle handwritten character recognition in the work [9]. The main work is done through a two step learning process, where first an unsupervised technique is applied for learning and then a supervised technique is applied to further modification of network parameters. The network is said Deep Belief Network (DBN), which is a probabilistic generative model, where samples can be generated from the model suitable for both supervised and semi supervised learning settings. This allows the model to replace a manual pre-processing of character features such as strike, loop, etc.

In view of script dependency of the OCR algorithms for different languages here is another approach to construct a multi-lingual and multi-script recognition system [10]. The algorithm first identifies the type of script and then input is placed in suitable OCR scheme for processing. Vertical and diagonal edge based directional features are applied in proposed method.

Here is one significant work for recognition of handwritten bangle character and a efficient methodology for reading handwritten filled in forms in Bengali has been presented in [11]. A two pass approach is considered here, where first pass deals with classifying unknown samples from group of patterns with an algorithmic fashion. Further the patterns are again refined by soft computing methodology of optimal selection, to determine its proper group in second pass. A standard database is made with handwritten Bengali characters and tested with the methodology.

One important feature extraction method is proposed in the work [12]. Feature vector are extracted using local gradient feature descriptors from isolated handwritten images. They call the technique as scale invariant

feature transform key point descriptor. Along with two other languages, Bengali handwritten digit dataset images are tested and found outstanding result. The feature extraction directly uses the pixel intensities from the image. For classification purpose, *k*-nearest neighbour and the Support Vector Machine (SVM) is used, and SVM proved efficient with the proposed method of feature extraction.

Giving emphasize on local regions of a handwritten character image, a multi-objective feature extraction based approached is applied on the work [13]. Separately, two popular multi-objective optimization Algorithm (1) a Non-Dominated Sorting Harmony-Search Algorithm (NSHA) and (2) a Non-Dominated Sorting Genetic Algorithm-II (NSGA-II,) are applied for sampling the regions. Further, the framework of Axiomatic Fuzzy Set (AFS) theory is applied to find out the most informative region of the character.

A new benchmark of recognition for Bengali isolated compound character based on CMATERdb 3.1.3.3 data set is presented in the work [14]. Claimed recognition accuracy of 90.33% makes the work interesting. A deep Deep Convolutional Neural Networks (DCNN) in supervised learning is applied on layer wise training process of samples. Making the process to converge faster the RMSProp algorithm is applied also. The results, as compared with support Vector Machine (SVM) and simple Deep Convolutional Neural Network are found very good, thus setting up a new benchmark.

Pixel level distribution is produces as an important and effective feature for classifying character images of handwritten numerals in [15]. Four direction distributions are considered in the work, However, there are scope of improvisation with more features. The work proved that the proposed feature can give better result compared to simple histogram based approaches.

A fast, decision tree based approach, which works without any training samples, to recognize individual Bengali handwritten character is presented in the paper [16]. The decision tree analyzes the feature set from scanned handwritten images. Use of mathematical morphology to categorize the characters based on their anatomical feature plays important role in this work. Some feature extraction based on curvature scale space is also done in the work.

Recognizing online Bengali isolated characters based on structural and topological features shows promising output [17]. Two feature extraction based approach along with support vector machine as classifier is applied on 15000 of isolated Bengali online characters. In feature extraction, one is applied to describe the transition from background to foreground pixel, and vice versa. Another feature extraction combines different topological features and centre-of-gravity- (CG) based circular features to extract local, global and Circular Quadrant Mass Distribution information.

Identification of city names written in Bengali script is approached in the work [18]. As the context is limited and predefined, the shape of whole word image is considered instead of segmenting the characters from the words. From each word image a 64 dimensional feature vector is estimated. A database of 150 samples of 50 most popular cities of west Bengal, a state of India is evaluated.

4. Conclusion

During last few years the works on handwritten Bengali character recognition is gained much popularity. A number of research works are done by vast number of researchers. The areas included, feature extraction, segmentation, classification, recognition. Some complete work like handwritten Bengali filled in form reading is also approached. Though the approaches direct to have a promising prospect, but, there is lots of scope for work to reach to a system, which is completely capable of recognizing Bengali handwritten texts for practical use.

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