REVIEW ON HANDWRITTEN DIGIT RECOGNITION

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Abstract—Handwritten Digit Recognition System involves reception and interpretation of handwritten digits by a machine. Due to variation in shape and orientation of handwritten digits, it is difficult for a machine to interpret handwritten digits. Handwritten digit Recognition has a wide area of research due to its vast applications like automatic bank cheques processing, billing and automatic postal service. In this thesis, an Offline Handwritten Digit Recognition System is presented. The recognition system is broadly divided into 2 parts, first part is feature extraction from handwritten images and the second one is classification of feature vector into digits. We propose descriptors for handwritten digit recognition based on Histogram of Oriented Gradient (HOG) feature .It is one of the widely used feature vector for object detection in computer vision. For classification of features, linear Proximal Support Vector Machine Classifier is proposed. This is a binary class classifier which is further converted to a 10 class classifier by means of One against all algorithm. Due to small training time, PSVM classifier is preferable over standard Support Vector Machine (SVM) Classifier. The handwritten images both for training and testing are taken from MNIST database. The performance of the system is measured in terms of Sensitivity, Accuracy, Positive Predictively and Specificity.

IndexTerms— Handwritten Character Recognition, Histogram of Oriented Gradient, Neural network, support vector machine.

I. INTRODUCTION

Character recognition is a fundamental, but most challenging in the field of pattern recognition with large number of useful applications. It has been an intense field of research since the early days of computer science due to it being a natural way of interactions between computers and humans. More precisely Character recognition is the process of detecting and recognizing characters from the input image and converts it into ASCII or other equivalent machine editable form. The technique by which a computer system can recognize characters and other symbols written by hand in natural handwriting is called handwriting recognition system. Handwriting recognition is classified into offline handwriting recognition and online handwriting recognition [3]. If handwriting is scanned and then understood by the computer, it is called offline handwriting recognition. In this case, the handwriting is recognized while writing through touch pad using stylus pen, it's called online handwriting recognition. From the classifier perspective, character recognition systems are classified into two main categories i.e. segmentation free and segmentation based. The segmentation free also known as the holistic approach to recognize the character without segmenting it into subunits or characters. Each word is represented as a set of global features, e.g. ascender, loops, cusp, etc. Whereas segmentation based approach each word/ligature is segmented into subunits either uniform or non-uniform and subunits are considered independently. Handwritten character processing systems are domain and application specific, like it is not possible to design a generic system which can process all kinds of handwritten scripts and language.

II. DESCRIPTIONS

Writing styles differs in shape and orientation from person to person that makes handwriting digit recognition a challenging task. For the development of reliable handwritten digit recognition, two steps are important. The first step is extraction of discriminating feature from handwritten images and the second method is the classification of new digit images. The dimension of feature should be small[6]. The feature to be extracted should have minimum variance within a class and maximum variance between classes. The Classifier to be used should able to classify digit with high accuracy and should take less training time during classification. This thesis focuses on Offline Recognition System [11]. The handwritten images are taken from MNIST (Mixed National Institute of Standards and Technology) database. The handwritten digits from 0 to 9 are trained and then tested using supervised machine learning model. Histogram of Oriented Gradient (HOG) based features are extracted from handwritten digits. Proximal Support Vector Machine classifier is used . For classification of features of handwritten digits, classifiers like ANN, k-nearest neighbors (k-NN) and Support Vector Machine (SVM) are used. Out of these classifiers SVM is widely applicable. The main advantage of SVM classifier is high accuracy, but the classifier takes long training time. The computational time taken by Proximal SVM (PSVM) classifier is very less as compared to SVM. Considering reduced training delay during classification, PSVM classifier is used in this wok.

III. WORKING PRINCIPLE

Normally handwritten recognition is divided into six phases which are image acquisition, pre-processing, segmentation, feature extraction, classification and post processing. The block diagram of the basic character recognition is shown in below fig.
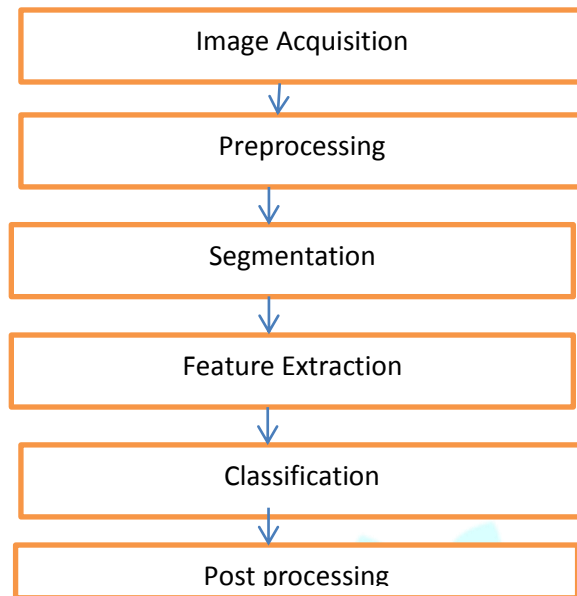
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│      Image Acquisition      │
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│        Preprocessing        │
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│        Classification       │
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│       Post processing       │
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Fig.1. character recognition steps.

A. Image Acquisition

Digitized/Digital Image is initially taken as input. The most common of these devices is the electronic tablet or digitizer. These devices use a pen that is digital in nature. Input images for handwritten characters can also be taken by using other methods such as scanners, photographs or by directly writing in the computer by using a stylus.

B. Preprocessing

Pre-processing is the basic phase of character recognition and it's crucial for good recognition rate. The main objective of pre-processing steps is to normalize strokes and remove variations that would otherwise complicate recognition and reduce the recognition rate. The variations or distortions include the irregular size of the text, missing points during pen movement collections, jitter present in text, left or right bend in handwriting and uneven distances of points from neighboring positions. Pre-processing includes five common steps, namely, size normalization and centering, interpolating missing points, smoothing, slant correction and resampling of points.

C. Segmentation

Segmentation is done by separation of the individual characters of an image. Generally document is processed in a hierarchical way. At first level lines are segmented using row histogram. From each row, words are extracted using column histogram and finally characters are extracted from words.

D. Feature Extraction

The main aim of feature extraction phase is to extract that pattern which is most pertinent for classification. Feature extraction techniques like Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA), Chain Code (CC), Scale Invariant Feature Extraction (SIFT), zoning, Gradient based features, Histogram might be applied to extract the features of individual characters. These features are used to train the system [9].

E. Classification

When input image is presented to HCR system, its features are extracted and given as an input to the trained classifier like artificial neural network or support vector machine [8]. Classifiers compare the input feature with stored pattern and find out the best matching class for input.

F. Post Processing

Post-processing refers to the procedure of correcting misclassified results by applying linguistic knowledge. Post processing is processing of the output from shape recognition. Language information can increase the accuracy obtained by pure shape recognition. For handwriting input, some shape recognizers yield a single string of characters, while others yield a number of alternatives for each character, often with a measure of confidence for each alternative.

IV. LITERATURE REVIEW

An early notable attempt in the area of character recognition research is by Grimsdale in 1959. The origin of a great deal of research work in the early sixties was based on an approach known as analysis-by-synthesis method suggested by Eden in 1968. The great importance of Eden's work was that he formally proved that all handwritten characters are formed by a finite number of schematic features, a point that was implicitly included in previous works. This notion was later used in all methods in syntactic (structural) approaches of character recognition.

K. Gaurav, Bhatia P. K. [5] Et al, this paper deals with the various pre-processing techniques involved in the character recognition with different kind of images ranges from a simple handwritten form based documents and documents containing colored and complex background and varied intensities. In this, different preprocessing techniques like skew detection and correction, image enhancement techniques of contrast stretching, binarization, noise removal techniques, normalization and segmentation, morphological processing techniques are discussed. It was concluded that using a single technique for preprocessing, we can't completely process the image. However, even after applying all the said techniques might not possible to achieve the full accuracy in a preprocessing system.

V. COMPARISION BETWEEN DIFFERENT TECHNIQUES

METHOD	ACCURACY	PURPOSE
Hand printed symbol recognition.	97%	Extract the geometrical, topological and local measurement
OCR for cursive Handwriting. [2]	88.8%	To implement segmentation and recognition algorithms for cursive handwriting
Recognition of handwritten numerals based upon fuzzy model.[6]	98.4%	The aim is to utilize the fuzzy technique to recognize handwritten
Combining decision of multiple connectionist classifiers for Devanagari numeral Recognition. [7]	89.6%	To use a reliable and an efficient technique for classifying Numerals.
Binarisation and normalization	88.8%	Multi-layer network
Optimization of feature selection for recognition of Arabic characters.[11]	88%	To apply a method of selecting the features in an Optimized way.

VI. CONCLUSION

The paper discusses in detail all advances in the area of handwritten character recognition. The most accurate solution provided in this area directly or indirectly depends upon the quality as well as the nature of the material to be read. Various techniques have been described in this paper for character recognition in handwriting recognition system. A sort comparison is shown between the different methods proposed so far in the above table. This thesis HOG-PSVM handwritten digit recognition system is presented. The images of handwritten digits are described in terms of 81 dimensions HOG feature descriptor.

VII. FUTURE WORK

The proposed recognition system is implemented on handwritten digits taken from MNIST database. Handwritten digit recognition system can be extended to a recognition system that can also able to recognize handwritten character and handwritten symbols. Future studies might consider on hardware implementation of recognition system.

VIII. ACKNOWLEDGEMENT

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