Writer Adaptation for Handwriting Recognition in Hindi Language – A Survey

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Abstract: *With the advancement in technology, there is an increased use of pen-based touch screen devices and PDAs. These devices come with an alternative for the traditional alphanumeric or QWERTY keyboard which is input in the form of user's handwriting. The handwriting is then converted into normal text form. However, these devices require prior training to be done by the user. There is a high demand for robust and accurate recognition systems in the practical applications of handwriting recognition. The real challenge lies with the selection of a classifier which gives accurate results in real-time, while making the system self-adaptive simultaneously. Thus, in this paper various classifiers have been studied so as to find the most appropriate classifier for anonline handwriting recognition system for handwriting in Hindi language that provides a way by which the touch screen device adapts itself to its user handwriting without prior training is studied.*

Keywords: Active-DTW, Markov Model, Self -adaptation, SVM, Writer adaptation

1. Introduction

Hindi is the fourth most spoken language in the world [16]. Being the national language of India, it has several million speakers across the country owing to its vast population. A majority of the population prefer to read and write in their native language which poses a new challenge to the penetration of Information Technology. Moreover, the keyboard for Hindi (Devanagari script) is two-layered shift keyboard. This makes it more difficult for people to get accustomed to it and type with ease. Thus, it is of utmost importance to facilitate human-computer interaction in easier ways like handwriting in the native language.

As compared to other scripts like Western, Korean, Chinese or Japanese, Devanagari script consists of a large number of characters, classes and strokes. The basic strokes are more often nonlinear and curved than straight as opposed to other scripts which consist of straight lines. Hence, more detailed features are required that contain all the information about the character. Moreover, the characters in a word may or may not be discrete; hence segmentation of the word may be necessary for recognition. As a result, the methods used for recognition of other scripts cannot be simply applied to Hindi language as well.

This paper explores different classifiers models and their use as a promising classifier for Hindi handwriting recognition.The classifiers which have been previously used or implemented for online handwriting recognition are dealt with in the next few sections. Section 2 deals with Hidden Markov Models. Support vector machines and Active DTW classifiers are discussed in sections 3 and 4 respectively. Conclusions are discussed in section 5 of this paper.

2. On-Line Handwriting Recognition Using Hidden Markov Models

Hidden Markov Models (HMMs) were initially developed at the IDA (Institute of Defense Analyses) in the 1960's by Baum and Eagon [3]. The success of these systems in speech recognition prompted the use of them for more complex pattern-recognition problems like handwriting recognition. HMMs could be described as extensions of the Markov process, which is a stochastic process. A process in which its future behavior depends only on the current state and not on the past states is called a stochastic process [3]. As a result, they can easily handle variations in handwriting as well as noise. HMMs can be successfully applied to western cursive handwriting along with Chinese, Japanese and Korean scripts. In the paper [4] published by Bharat A. *et al*, the same method is applied for Tamil language.

In the Hidden Markov model (HMM) approach the input character is modeled into a 7-state left to right HMM.Since the left to right HMM can effectively model the time dependent property in a signal, the on-line handwriting signal can be modeled by the left to right model.The number of states was experimentally taken to be 7 so as to maximize the recognition accuracy.States help to model variability in time [3].

Hindi language consists of a number of strokes and similar looking characters (refer to Fig 2) making it difficult to model the input character or word into 7-states.In HMM all the possible words are modeled for the recognition task. But to model each Hindi word explicitly is simply computationally impossible. As a result, this classifier in not best suited for online handwriting recognition of Hindi handwriting.

3. Online Character Recognition based on Support Vector Machines

Support Vector Machines classifies an input data into one of the two classes separated by a decision plane. SVM is based on statistical learning theory. Its performance is dependent on the principle of Structural Risk Minimization. Structural Risk Minimization maximizes the margin of class classification. Every SVM is associated with a kernel function.
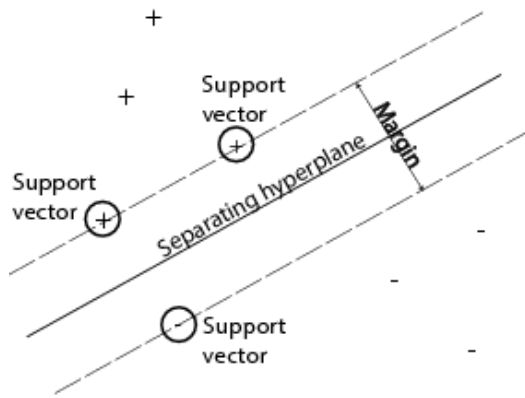
Figure 1: + indicates data points of type1 and – indicates data points of type2 separated by a hyper-plane.

The work proposed in [5] describes the use of SVM classifier with Gaussian kernel for online recognition of Telugu handwritten characters. The paper presents a systematic approach of how a Telugu character is represented and classified. A Telugu character is first divided in three tiers; upper stroke, main stroke and lower stroke. Except for the main stroke all the other strokes differ for each character. These pre-classified strokes are then classified by SVM classifier.After the classification of these pre-classified strokes they are combined to identify the character using two schemas;

1) Ternary Search Tree
2) SVM

Comparative study in [5] proved SVM to be a better classifier with an accuracy that was as high as 99.55%. However, for online recognition of Hindi handwriting, the character database of Hindi language is large and also there are a lot of similar looking characters as shown in Fig 2.
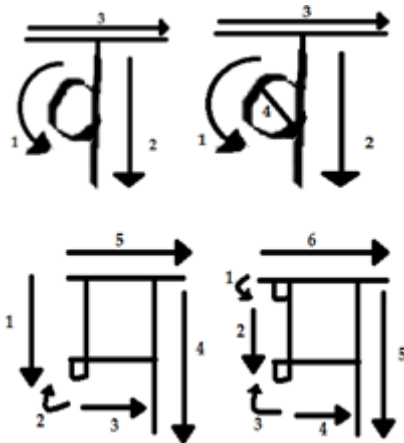

Figure 2: Strokes for two pairs of similar looking Hindi characters

SVM being a discriminative classifier classifies the input into either of the two classes. Ambiguity between the similar looking characters will lead to incorrect classification. This makes the recognition task difficult using SVM classifier for Hindi handwriting.

3.1 Multiple Kernel Learning Framework

The problem of formulation becomes complex and uncoordinated in the feature space due to generation of samples of a single character class from multiple sources. The in-depth study of this paper [8] shows that Multiple Kernel Learning (MKL) Framework shows a great potential in handling this problem in a better way. MKL methods are coupled with maximal marginal learning algorithms so as to formulate the mentioned problem in this framework for better recognition accuracy.

English is the language used and experiments have been carried out with the sample size of 16000 alphabets (10000 from the IRONOFF dataset augmented with another 6000 alphabets) collected from miscellaneous sources (approximately 470 sources) using a digitizing tablet.

Even though generative classifier approaches are popular for online handwriting due to its sequential nature, discriminative classifiers like Support Vector Machines have been demonstrated to perform better to resolve similar looking characters. The problem of overfitting was handled in a principled way due to the use of SVMs while learning from a set of trained samples of data.The kernel affects the SVM classifier to a great extent as it affects the nature and complexity of its decision boundary.
The kernel to be employed is chosen after analyzing the problem at hand.Furthermore the choice of the kernel optimizes the performance of the SVM classifier.

Multiple kernel learning allows us to define a kernel as a weighted combination of multiple basic kernels, and learn the weights during the training phase, effectively selecting the most appropriate kernels and their relative importance [8]. Each input is first normalized to a fixed size and smoothened by a Gaussian Filer. Normalized x and y coordinates, curvature, and sine and cosine of the tangent direction are the feature vectors extracted from the input data. The character is then mapped into a 300 dimensional space so as to carry out the training and adaptation processes. Adaptation involves re-modeling of the support vectors to better prototype the decision boundary of a specific writer, and adjustment of the parameters of the kernel combination to suit a specific writer's distribution. However poor adaptation takes place in the event of incorrectly written or labeled data and hence, it is not a viable alternative for character recognition of Hindi handwriting.

4. Active-DTW Classifier for Online Handwritten Character Recognition

DTW or dynamic time warping can be defined as an algorithm for measuring similarity between two sequences which may vary in time or speed [16]. It is a well-known technique to find an optimal alignment between two given (time-dependent) sequences under certain restrictions. It was originally developed for speech recognition. In the DTW technique, one-to-one matching of linear sequences is done (refer to Fig 3). However, in the Active-DTW method proposed by Sridhar et al [10], one-to-many matching is done between the linear sequences. As a result, it results in better recognition accuracy and a robust system
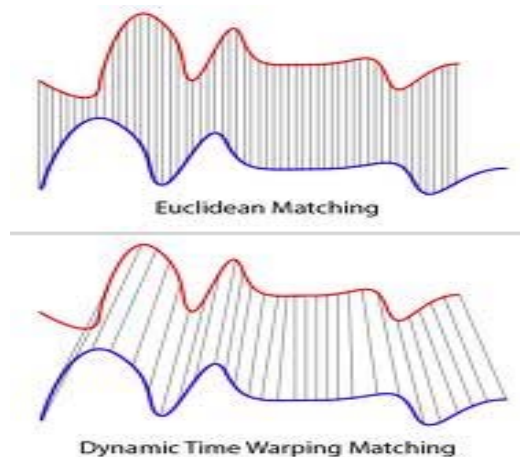
Figure 3: One to many matching pattern in case of Active-DTW

A thorough study of the papers [9] and [10] reveals that Active-DTW classifier shows substantial promise as a generative classifier in combination with discriminative classifiers. Hybrid Classifiers address many issues faced in the development of Online Character Recognition for particular scripts (for example Hindi) viz. characters contain subtle differences and are similar at the first instant, every minute detail for different writing styles cannot be captured effectively and presence of unclear samples.

The database for handwriting recognition consists of a pre-defined character data set. For each character class in this set, a specified number of clusters (say N) are generated and an average deformation is calculated [11]. The main aim of Active DTW is to calculate variations of the test sample with these deformation measures. Principal Component Analysis is used in order to determine the variations in a low dimensional subspace. Whenever the user writes a character on any touch screen device, the DTW distance is calculated against the optimal deformation measure of each of the N classes. The class with the lowest DTW distance is chosen as the recognized character class. This new character is added to the cluster of that class and the deformation measure for that particular cluster is calculated again [13] and [14]. In this way the device gets accustomed to the user's handwriting. Asaresult, thesystemisself-adaptive. In case a character does not belong to any class of any character, it forms a free sample. After a threshold value i.e. the minimum cluster size is reached, a new cluster is created for that character.

The performance of Active-DTW using the proposed adaptation framework is evaluated using the HP Labs Isolated Handwritten Tamil Character Dataset [12]. The dataset consists of approximately 500 isolated samples each of 156 Tamil characters written by native Tamil writers. This classifier displayed better accuracies as compared to other existing classifiers.

5. Conclusion

- In this paper a survey conducted on various classifiers such as Hidden Markov Models, Support Vector Machines, Active DTW implemented for handwriting recognition is presented.

- From the survey conducted the Active DTW classifier is found to be the best classifier available online character recognition for Hindi Handwriting.
- Experimental results have shown that Active DTW is a generative classifier that combines Active Shape models with Elastic matching. It also possesses a unique property which makes it possible to form free samples for input that does not belong to any character class.
- Unlike other classifiers such as SVM and HMM, Active DTW classifier combines the advantages of both discriminative as well as generative classifiers.
- On the basis of the survey conducted it is proposed to build a better adaptation system which would consist of two modules.
- The emphasis in both the modules will be on the ability of the proposed system to classify the input lexemes on the basis of their features and modify the existing database.
- The main intention is to design a new strategy that meets both the instantly incremental learning mechanism and the ability of using a complex and powerful classifier structure.

6. Acknowledgement

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