Abstract

Handwritten recognition has been one of the active and challenging research areas in the field of image processing. However, most of the current work in these areas is limited to English and a few oriental languages with single computer. Many systems and classification algorithms have been proposed in the past years on handwritten characters recognition in various languages like English, Persian, Arabian and Devanagari scripts also. Researchers had been worked on Handwritten Devanagari characters by applying different techniques on single PC but using client and server recognize the Marathi handwritten character based on cloud computing is challenging. Previously researchers had been worked on online Chinese characters based on cloud computing. So, this research work has been conducted on offline Marathi Handwritten character based on cloud computing and this system is very important because person can access any data from anywhere. There are various feature extraction techniques and classifiers for recognition of Marathi characters but Freeman chain code histogram and Gradient feature extraction techniques are better because freeman chain code approach is robustness to small variation and easy to implement and the gradient technique can be easily used to gray scale images and are robust against image noise and edge direction fluctuation. SVM classifier is better than KNN and ANN classifier because of its complexity of training, flexibility, classification accuracy and complexity which is given bellow.

Keywords
Devanagari Marathi Character Recognition, Off-line Handwriting Recognition, Pre-processor, Feature Extraction, Image Classification.

1. Introduction

Offline handwriting recognition is one of the challenging problems in pattern recognition. The main challenges are wide variety of handwriting styles, large varieties of pen-type, poor image quality and a lack of ordering information of strokes. In this work a cloud-based recognition architecture is presented. It has possible to be useful not only to end users, but also to researchers in the field. A cloud infrastructure can support the capture of recognition history[1]. Additionally, such a model has a number of other advantages: First, it allows the writer to train the model only once and then use the cloud with any device connected to the Internet. Secondly, it gives the user access to various default collections of training samples across different alphabets, languages, and domains. Thirdly, it provides a higher level of control over the classification results and correction history. Further, Cloud computing platform differentiate from the traditional client server model. Cloud computing offers the same super computer services over the Internet and dynamically allocates distributed computing resources. Cloud server can easily handle service requests of multiple users simultaneously; Cloud computing system supports cross-platform client terminals. Therefore, it would be more suitable and easier for recognition the offline Marathi handwritten character recognition[2].

2. Related Work

The first research work report on handwritten Devnagari characters was published in 1977[3]. For Indian languages most of research work is performed on firstly on Devnagari script and secondly on Bangla script. U. Pal and B.B. Chaudhury[4] presented a survey on Indian Script Character Recognition. This
This paper introduces recognition of many Indian language scripts including Devnagari, Bangla, Tamil, Oriya, Gurumukhi, Gujarati and Kannada. Bikash Shaw, Swapna Kr. Parui, Malayappan Shridhar[5] used a novel segmentation-based approach for recognition of offline handwritten Devnagari words. They also used Stroke based features for feature vectors. In this paper, Hidden Markov model is used for recognition at pseudocharacter level. Sandhya Arora et al.[6] used intersection, shadow features, chain code histogram and straight line fitting feature extraction and weighted majority voting technique for combining the classification decision obtained from different Multilayer Perceptron (MLP) based classifiers. They obtained 92.80% accuracy results for handwritten Devnagari recognition. Prachi Mukherji and Priti Rege[7] used shape features and fuzzy logic to recognize offline Devnagari character recognition. They segmented the character into strokes using structural features like endpoint, cross-point, junction points, and thinning. Using tree and fuzzy classifier they classified the segmented shapes or strokes as left curve, right curve, horizontal stroke, vertical stroke, slanted lines etc. They obtained average 86.4% accuracy. U. Pal, Wakahayashi and Kimura also presented comparative study of Devnagari handwritten character recognition using different features and classifiers[8]. They used four sets of features based on curvature and gradient feature extraction from binary as well as gray scale images and compared results using 12 different classifiers as concluded the best results 94.94% and 95.19% for features extracted from binary and gray image respectively obtained with Mirror Image Learning (MIL) classifier. They also accomplished curvature features to use for better results than gradient features in most of classifiers. Mallikarjun Hangarge[9] investigate a texture for determining the script of handwritten document image. Further, K nearest neighbour classifier is used to classify 300 text blocks as well as 400 text lines into one of the three major Indian scripts: English, Devnagari and Urdu. Using morphological filters 13 spatial spread features are extracted. K. Roy, S. Kundu Das, Sk Md Obaidullah[10] uses very simple and efficient feature at component level. In this paper fractal-based features, component based feature and Topological features, series of classifiers were used. Accuracy of the system is at present 89.48% on the test set without rejection. In this approach gradient features using Yan Gao, Lanwen Jin, Cong He, Guibin Zhou[2] are extracted and then these features are converted into 8 directional features. In chain code histogram to character contour there are basically two ways to determine the direction codes of contour pixels. In one way, the order of contour pixels is obtained by contour tracing, and then the chain codes are calculated. And secondly we use the gradient representation as the basis for extraction of features. These algorithms require a few simple arithmetic operations per image pixel which makes them suitable for real-time applications. Ved Prakash Agnihotri used Diagonal based feature extraction for the handwritten Devanagari script. After that these feature of each character image is converted into chromosome bit string of length 378. In recognition step using fitness function in which find the Chromosome difference between unknown character and Chromosome which are store in data base[11]. Pankaj Kumawat, Asha Khatri, Balaram Nagaria[12] used the Curve let transform and Invariant moments for character recognition problem. They compare the performance of HMM based technique with combined HMM- SVM based technique and found that for some combined HMM-SVM technique is better than HMM. Combined HMM-SVM classifier improve the problem of HMM classifier of multiple detection of Class.

After describing cloud computing in Section 3 Handwritten character recognition techniques is discussed in Section 4, Segmentation is discussed in section 5, and Feature Extraction types discussed in section 6, Character Classification is discussed in Section 7. Proposed system of Cloud based Handwritten Character Recognition is discussed in Section 8. Finally, Discussion on review is discussed in Section 9.

3. Cloud Computing

Cloud computing is the junction of several concepts from resource pooling, virtualization, dynamic provisioning, and utility computing. Applications are easily deployed where the underlying technology components can expand and contract with the flow of the business cycle. Cloud computing is a new method to add capability to a computer without licensing new software, investing in new hardware or infrastructure or training new personnel. Applications are purchased and run over the network listed users’ desktop. A cloud server is a logical server that is built, hosted and delivered through a cloud computing platform over the Internet. Cloud servers possess and exhibit similar capabilities and functionality to a typical server but are accessed remotely from a cloud service provider. Most of the current clouds are built on top of modern data centers. It incorporates Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), and provides these services like utilities, so the end users are billed by how much they used[13]. IaaS provides service such as memory, CPU and storage. It reduces hardware cost. That means customer use a virtualized server and running software on it. Amazon EC2, is the best example of IaaS for storage and maintaining virtual servers.
4. Handwritten Character Recognition Techniques

The general steps of handwriting recognition include preprocessing, segmentation, feature extraction, classification and so on. The preprocessing technology consists of binarization, normalization, and smoothing and slant correction. The widely used feature extraction methods for handwritten Marathi character recognition include 8-directional feature extraction and Gradient feature extraction etc. In classification step, Support Vector Machine (SVM) classifier is mainly used.

5. Segmentation

Segmentation is the most important part of the pre-processing stage. It allows the recognizer to extract features from each individual character. In the more complicated case of handwritten text, the segmentation problem becomes much more difficult as quality have a tendency to be connected to each other, overlapped or unclear. Segmentation is done to break the single text line, single word and single character from the input document. For isolated characters or numerals, segmentation task is not that difficult. However, for joint and complex strings more advanced techniques required to be employed. There are two types of segmentations: 1. External segmentation isolates various writing units such as paragraphs, sentences or words. 2. Internal segmentation, which is isolation of letters. Character segmentation strategies are divided into three techniques: Explicit Segmentation-This approach is used to identify the smallest possible word segments that may be smaller than letters, but surely cannot be segmented further. It is done by the process of analysis. Implicit Segmentation- This is based on recognition. It searches the image for components that match predefined classes. Mixed Strategies- They combine explicit and implicit segmentation in a hybrid way[14].

6. Feature Extraction Techniques

After the segmentation procedure the feature set is extracted. Extracted features from the character images are used to train the Support vector Machine. In this stage, the features of the characters that are used for classifying them at recognition stage are extracted. This is an important stage as its efficient performance improves the recognition rate and reduces the misclassification. A good feature set should represent characteristic of a class that help distinguish it from other classes. The widely used feature extraction methods are Template matching, Deformable templates, Unitary Image transforms, Graph description, Projection Histograms, Contour profiles, Zoning, Geometric moment invariants, Zernike Moments, Spline curve approximation, Fourier descriptors, Gabor feature. Due to the nature of handwriting with its high degree of inconsistency and ambiguity extracting these features, is a difficult task. Chain code Histogram of Character contour and gradient feature extraction techniques are used in this paper[15].

6.1 Chain Code Histogram of Character Contour

Given a scaled binary image, first find the contour points of the character image. Consider a 3 × 3 window surrounded by the object points of the image. If any of the 4-connected neighbor points is a background point then the object point (P), as shown in Figure 1 is considered as contour point.

![Figure 1. Contour point detection](image)

The contour following procedure uses a contour representation called “chain coding” that is used for contour shown in Figure 1.4. Each pixel of the contour is assigned a different code that indicates the direction of the next pixel that belongs to the contour in some given direction. Chain code provides the points in relative position to one another, independent of the coordinate system. In this methodology of using a chain coding of connecting neighboring contour pixels, the points and the outline coding are captured. Contour following procedure may proceed in clockwise or in counter clockwise direction. Here, we have chosen to proceed in a clockwise direction [16].

![Figure 2. Chain Coding](image)

6.2 Gradient Feature Extraction

The gradient measures the magnitude and direction of the greatest change in intensity in a small
neighborhood of each pixel. (In what follows, "gradient" refers to both the gradient magnitude and direction). Gradients are computed by means of the Sobel operator. The Sobel templates used to compute the horizontal (X) & vertical (Y) components of the gradient are shown in Figure 3. The arc tangent of the gradient and Gaussian filter. A modified quadratic classifier is applied on the features of handwritten characters for recognition. Elastic matching (EM) technique based on an Eigen deformation (ED) for recognition of handwritten Devnagari characters is proposed in [17].

After this, gradient vector of each pixel is decomposed into components along these standard direction planes. If a gradient direction lies between two standard directions, it is decomposed into two components in the two standard directions.

7. Classifiers

The decision making part of a recognition system is the classification stage and it uses the features extracted from the previous stage. There are various methods for classification. K Nearest Neighbor (KNN), Artificial Neural Network(ANN) and Support Vector Machine (SVM) In this paper, we discuss the characteristics of the some classification methods that have been successfully applied to Offline Devnagari Marathi character recognition and results of SVM classification is better than other classification methods, applied on Handwritten Devnagari characters.

7.1 Support Vector Machine Classifier

Support Vector Machine is relatively new classification technique producing efficient recognition results. SVM is a new type of hyperplane classifier developed based on statistical learning theory given by Vapnik. Basically SVM is a binary (two class) linear classifier in kernel induced feature space and is formulated as a weighted combination of kernel functions on training examples. The kernel function represents the inner product of two vectors in a high dimensional space, which can be used for classification, regression or other tasks. Support Vector Machine is supervised learning tool which is used for classification and regression. The basic SVM takes a set of input data and predicts, for each given input. A set of training examples given each marked as belonging to one of two categories, a SVM training algorithm builds a model that assigns new examples into one category or the other. A support vector machine constructs a hyper plane or set of hyper planes in a high dimensional space, which can be used for classification, regression or other tasks. Naturally, a good separation is achieved by the hyper plane that has the largest distance to the nearest training data point of any class (so-called functional margin), since in general the larger the margin the lower the generalization error of the classifier[18].

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>-1</td>
<td>-2</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Figure 3. Contour point detection**

**Figure 5. Feature transformation using SVM**
There are two types of SVM: 1) Linear SVM & 2) Non Linear SVM. Linear SVM is the newest extremely fast machine learning (data mining) algorithm for solving multiclass classification problems from ultra large data sets that implements an original proprietary version of a cutting plane algorithm for designing a linear support vector machine. Linear SVM is a linearly scalable routine meaning that it creates an SVM model in a CPU time which scales linearly with the size of the training data set. SVM models clearly show its superior performance when high accuracy is required.

Features:
1. Efficiency in dealing with extra large data sets (say, several millions training data pairs),
2. Solution of multiclass classification problems with any number of classes,
3. Working with high dimensional data (thousands of features, attributes) in both sparse and dense format,
4. No need for expensive computing resources (personal computer is a standard platform),
5. Ideal for contemporary applications in digital advertisement, e-commerce, web page categorization, text classification, bioinformatics, proteomics, banking services and many other areas.

Linear functions can control the complexity of a learning machine. To avoided the problem of dealing with too complex functions at the value of being able to solve only linearly separable problems. Following diagram will show how to extend the linear SVM for constructing a very rich set of non-linear decision functions while at the same time controlling their complexity.

7.2 Kernels of SVM Classifiers

In addition to basic linear kernel, many other kernels are also proposed by researchers. Following are the four basic kernels used in SVM classifications:

Linear: \( K(x_i, x_j) = x_i^T x_j \)

Polynomial: \( K(x_i, x_j) = (\gamma x_i^T x_j + r)^d, \gamma > 0. \)

Radial Basis Function(RBF):

\( K(x_i, x_j) = \exp\left(-\gamma ||x_i - x_j||^2\right), \gamma > 0. \)

Sigmoid: \( K(x_i, x_j) = \tanh(\gamma x_i^T x_j + r). \)

Here and are kernel parameters. Among these kernels RBF kernel is mostly used [19].

8. Proposed System

8.1 Challenges solution of System

1) How to identify variability for same character?

The main challenges in offline handwritten character for Indian languages is to build a system that is able to distinguish between variation in writing the same stroke and minor variation in similar characters in the script. The recognition system should be able to distinguish between structural or shape variations across similar characters and the natural variability that exist when the same character is written by different persons or same character written at different times. The feature extraction and stroke classification address this issue to identify an
appropriate representation and method of classification.

2) Which dataset can be used for handwritten recognition?
The standard database for Indian script is neither available freely nor commercially, hence we have collected the samples Devnagari handwritten characters data from different professional belonging to schools, colleges, nor commercial sectors are collected and created the data set. Generation of database from the scanned datasheets.

3) Which techniques are used to extract the features for recognition of characters?
Feature extraction is extracting information from raw data which is most relevant for classification purpose and that minimizes the variations within a class and maximizes the variations between classes. Different feature extraction methods are designed for different representations of the characters, such as solid binary characters, character contours, skeletons or gray level sub images of each individual character. In above discussion we have studied that there are so many features extraction techniques. In that we have used chain code histogram to character contour and gradient features for recognition of Marathi characters.

4) Which classifiers are used?
SVM is better than other classifier because of its complexity of training, flexibility, classification accuracy and complexity which is given bellow.

8.2 Cloud Based Recognition System

The architecture of the proposed Cloud-based handwriting recognition system is shown in Figure 8. The client terminal is Computer device or laptop with different operating systems, such as Windows XP, Windows 7 Embedded Linux so on. There is a scanned image of the handwritten character through which we take the strokes of input character. The server is virtual Cloud combining many physical server machines and personal computers. When finishing writing, strokes are sent to the server by socket protocol through WiFi, GPRS, EDGE or the 3G networks. The handwriting recognition are run on the Cloud server Relative to the bandwidths of the networks, the data of the strokes and candidates is small, so it costs very little transmission time and users have no sense about the delay. It feels like that the recognition is done locally In theory, the memory and computing capacity of Cloud server are infinite. So, we can implement any state-of-the art recognition algorithm to get very high accuracy in real time[2].

9. Discussion on Review

9.1 Preprocessing

Pre-processing aims to produce data that are easy for the character recognition systems to operate accurately. The main objectives of pre-processing are:
1) Binarization: If the illumination over the document is not uniform, for instance in the case of scanned book pages or camera-captured documents, global binarization methods tend to produce marginal noise along the page borders. To overcome these complexities, local thresholding techniques have been proposed for document binarization[21].
2) Normalization: Normalization is used to reduce the variation of shapes of the character. Size normalization depends on how user moves the pen on writing pad. Centering is required when pen is moved along the border of writing pad. Normalization is for reducing variability in character size and pen velocity
3) Smoothing: Smoothing operations are used to blur the image and reduce the noise. Smoothing and noise removal can be done by filtering.
4) Interpolation: Input handwritten characters could have missing points when handwriting speed is fast. It is used to find missing points in characters. Bresenham’s line algorithms can be used to estimate the missing intermediate points.
5) Slant Correction: Slant correction and normalizing slant is required to correct the shape of input handwritten character which is bending in left or right directions. For this slant correction DESLANT algorithm is used. Slant correction method uses the vertical projection histogram. The idea is that the histogram of a word that is written straight up will have larger and more distinct peaks. Therefore, look
at the histogram of the word at different shear angles and take the one with the highest peaks. For angles between −45 and 45 degrees, which is the most common range of slant angles in normal writing[22].

9.2 Segmentation

In complicated case of handwritten text, the segmentation problem becomes difficult when letters tend to be connected to each other, overlapped or distorted. Segmentation is break the single text line, single word and single character from the input document. For isolated characters or numerals, segmentation task is not that difficult. However, for joint and complex strings more advanced techniques required to be employed. Average Longest path algorithm is used in different handwriting styles large variation of neighboring characters within words are usually connected for that time need to segment the word into individual character for accurate character recognition[23].

9.3 Feature Extraction Techniques

There are various feature extraction techniques but freeman chain code and gradient feature extraction techniques are better. The freeman chain code approach is robustness to small variation and easy to implement and which provides good recognition rate. The gradient feature extraction technique can be easily used to gray scale images and are robust against image noise and edge direction variation.

9.4 Classifier

Neural classifiers, K Nearest Neighbor and SVMs show different properties in the following respects[24][25].

Complexity of training: The parameters of neural classifiers are generally adjusted by gradient descent. By feeding the training samples a fixed number of sweeps, the training time is linear with the number of samples. K-NN classifiers are generally adjusted by distance measure. By feeding the training samples a fixed number of sweeps, the training time is linear with the number of samples. SVMs are trained by quadratic programming (QP), and the training time is generally proportional to the square of number of samples. Some fast SVM training algorithms with nearly linear complexity are available, however.

Flexibility of training: The parameters of neural classifiers can be adjusted in string-level or layout-level training by gradient descent with the aim of optimizing the global performance. In this case, the neural classifier is embedded in the string or layout recognizer for character recognition. The parameters of K-NN classifiers can be adjusted in Feature weighting improve classification accuracy for global performance and also easy to add a new class to an existing classifier. On the other hand, SVMs can only be trained at the level of holistic patterns.

Classification accuracy: SVMs have been demonstrated superior classification accuracies to neural classifiers in many experiments. The parameters of K-NN classifiers can be adjusted in Feature weighting improve classification accuracy for global performance and also easy to add a new class to an existing classifier.

Storage and execution complexity: SVM learning by QP often results in a large number of SVs, which should be stored and computed in classification. Neural classifiers have much less parameters, and the number of parameters is easy to control. In a word, neural classifiers consume less storage and computation than SVMs. K-NN classifiers have much less parameters, and are easy to control. In a word, K-NN classifiers consume less storage and computation than SVMs.

In above discussion SVM is better than KNN and ANN classifier because of its complexity of training, flexibility, classification accuracy and complexity. The SVM is a machine learning algorithm which

- Solves classification problems
- Uses a flexible representation of the class boundaries
- Implements automatic complexity control to reduce over fitting
- Has a single global minimum which can be found in polynomial time.

SVM is popular because

- It can be easy to use
- It often has good generalization performance
- The same algorithm solves a variety of problems with little tuning.

Conclusion

The idea of regarding handwritten character recognition as a service based on Cloud computing, it can be more convenient. These clouds can evolve as new data is received by the server, improving recognition. These clouds also provide a simple but effective method for handwriting recognition. Among all the methods it is found that chain code histogram of a character contour and gradient feature extraction techniques are the best performing with SVM classifier.

References

[2] Yan Gao, Lanwen Jin+, Cong He, Guibin Zhou,” Handwriting Character Recognition as a Service: A


