Problems and Technology Evolution in Handwritten Numeral Recognition of Marathi

A A Jinturkar, Research Student, Department of Computer Science, DSM College, Parbhani
Dr. P.B. Khanale, Professor, Department of Computer Science, DSM College, Parbhani, India

Abstract

With the increasing Computerization in every sector, there is growing demand for processing of handwritten documents by computer. Researchers are doing efforts to give efficient solution to this problem. Various Schemes have been used by researchers for Handwritten Numeral Recognition. Many of these systems have been developed for English, Arabic scripts. Indian languages especially Marathi needs attention. As India is Multi-lingual country the problem of handwriting recognition becomes a complex task. Some of benchmark work including development of database, efficient recognition systems have been done by researchers including U. Bhattacharya, et.al, N. Das, et. Al. In this study; the research done in field of Marathi Numeral recognition has been reviewed.

Keywords: Handwriting recognition, Marathi Numerals, Neural Network, Fuzzy Logic, Neuro-Fuzzy System

INTRODUCTION

Handwriting Recognition is an area of Pattern Recognition. Pattern Recognition is a broad term which deals with assigning input pattern to its respective class. It has drawn attention of researchers worldwide. Handwriting Recognition is the process of detecting, identifying and recognizing handwritten pattern from input image. It is a first step towards language processing by means of Computers. Handwriting Recognition has its significance in many areas such as Reading aid for blinds, Automated Text entry, Language Processing, Zip code recognition, sorting mails, Processing of bank slips, etc. Due to these applications, Handwriting recognition is popular among researchers worldwide.

Handwriting Recognition can be broadly classified in two areas: Offline & Online. Online recognition system recognizes numeral at the time of writing. An electronic pen is used to write on a touch-sensitive digitizer such as tablet, PDA or Smartphone. It uses movement of pen, stroke, and trace of symbol to recognise it. The offline recognition system digitizes existing handwritten document in the form of input.

Handwritten Marathi Numerals

Marathi is based on Devnagri Script. It is an official language of Maharashtra State, India. People use Marathi language for their daily working. Marathi Numerals are as shown in following figure:

![Figure 1: Marathi Numerals (0-9)](image)

Problems In Recognition

Handwritten Numerals get affected by people style of handwriting. They vary in size, thickness. Handwritten numerals are written differently by different age groups. These problems create Recognition System more complex.

In Real time; people used to write digits connected with each other as follows:

![Figure 3: Handwritten Mixed Marathi Numerals](image)

Such Numerals must be firstly separated from each other & then they can be recognized. A present system performs well for isolated numerals but they are unable to perform such complex task.

Since India is bilingual country; people sometimes used to write numerals from 2 languages mixed with each other. This problem also needs an attention.
Recognition Techniques

Broadly speaking, there are five steps in handwriting numeral recognition problem: Image pre-processing, Segmentation, Feature extraction, Training & Recognition, post processing.

Various methodologies have been used by researchers and implemented in area of handwriting recognition. Soft computing techniques like neural Network, Fuzzy Logic; Statistical techniques like PCA, LDA, HMM has been successfully applied to the various pattern recognition problems.

Across the world, many researchers are working on problem of handwriting numeral and character recognition. Some efficient techniques have been developed by the researchers which give efficient results for isolated numerals. Some databases have also created by the researchers in this area.

Database Development

In paper [1] Nonexistence of standard database is major problem in recognition of handwritten Indian scripts. Any work in the area of pattern recognition needs a benchmark database on which results can be tested. Ujjwal Bhattacharya et al. have developed two databases for two Indian scripts i.e. Devanagari and Bangla. These databases include 22,556 and 23,392 numerals of Devanagari and Bangla scripts respectively. Authors have discussed problems in recognition of Indian languages. Many times while writing information, people write some numerals in English and others in local language. For such mixed-script problem, multistage recognition scheme using Wavelet and MLP classifiers has been developed by the authors. This scheme is implemented on three scripts namely Devanagari, Bangla and English. Experimental results show that the multistage recognition scheme gives up to 99% results.

Statistical Techniques

In paper [2] Hidden Markov Model is statistical model. It is found to be very useful in pattern recognition area. Albert Hung-Ren Ko et al. have discussed the problem of unexpected noise that occurs in training set or testing set. Noise in training observation will create problems in trained model while noise in testing data set will make pattern unrecognizable. To deal with this problem authors proposed Leave-One-Out-Training and Leave-One-Out-Testing strategy for Hidden Markov Model. System gives 98.88% accuracy

In paper [3] Unconstrained handwriting is one of major problem in recognition process. People used to write adjacent digits connected. These digits need to be separated before recognition process. In this paper, an idea of multi-agents has been proposed by the authors. One agent detects deepest top valley & finds centre of valley as candidate cut-point; and another agent does same process for highest bottom hill. Then these two agents negotiate on common cut-point and the digits are separated along that point.

In paper [4] pattern recognition problems such as character recognition, high classification accuracy and resistance to non-characters are requirements from classifier. Many statistical techniques and neural networks are used for the task of pattern recognition. In this paper, authors have proposed discriminative learning quadratic discriminant function (DLQDF) function. DLQDF is mainly designed for segmentation based classification. This classifier gives similar results as that of neural classifier MLP for numeral string recognition. Recognition accuracy of the system is 96%.

In paper [5] Linear Discriminant Analysis (LDA) is a very popular method used in the area of pattern recognition for extracting the features. Authors have proposed a generalized version of classical LDA method. This method possesses all properties of LDA and gives optimal solution. GerDA also gives efficient results up to 99% for problems such as handwritten digit recognition, face detection.

Comparative Study of some benchmark algorithms using fuzzy logic is shown in following Table:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Author</th>
<th>Methodology</th>
<th>Result (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Albert Hung-Ren Ko, et.al.</td>
<td>HMM</td>
<td>98.88</td>
</tr>
<tr>
<td>2</td>
<td>Reda Alhajj, et.al.</td>
<td>Multiagents</td>
<td>97.8</td>
</tr>
<tr>
<td>3</td>
<td>Cheng-Lin Liu, et.al.</td>
<td>DLQDF</td>
<td>96</td>
</tr>
<tr>
<td>4</td>
<td>André Stuhlsatz, et. Al.</td>
<td>GerDA</td>
<td>99</td>
</tr>
</tbody>
</table>
Neural Networks

In paper [6] 100 samples of handwritten devnagri numerals 0-9 have been collected from 10 different persons. After pre-processing these samples undergoes morphological processing, and then database is created. There were three steps used for feature extraction of these numerals: measurement of extreme coordinates, grid computation and then digitization of numerals. This feature vector then trained with multilayer neural network.Proposed system gives 100% result for some numerals but it requires 500 epoch hence time consuming.

In paper [7] numeral string recognition system has been proposed by the authors. Recognition of numeral strings requires segmentation of string into isolated patterns of numerals which in turn are recognized separately. Classification scores are assigned to candidate patterns using classifier. The developed system tests scores using three neural classifiers, two discriminative density models, and two support vector classifiers.

In paper [8] kernel Fisher discriminant analysis has been studied in detail and two-phase KFD framework has been proposed. An algorithm based on this framework has been developed known as complete kernel fisher discriminant analysis (CKFD). It is then tested on FERET face database & CENPARMI handwritten numeral database. It gives better results but developing more optimal & efficient algorithm is still open problem.

In paper [9] a new ANN model has been discussed – Quantum Neural Network (QNN) which has advantages of both Neural network with fuzzy features. Experiment done on QNN proves that it has great potential as Handwritten classifier and it can be used in expert systems.

In paper [10] Multilayer perceptron classifier has been used to classify Marathi numerals 0-9. MLP networks have proven to be very useful in the area of handwriting recognition because of its simplicity & elegance in recognition process. Present experiment uses MLP with one hidden layer. It uses tan sigmoid function for both layers. When evaluated on training data set, MLP gives reasonable result with average error rate of 1.43%. There is still scope for modification in the network configuration as well as dimensions of data.

In paper [11] handwritten numeral recognition system based on Support Vector Machine (SVM) has been developed. 2000 samples from 20 different people has been collected and given to SVM for recognition. SVM uses binary classification techniques and given almost 99% recognition rate for data. This research work can be extended by increasing data set as well as using different function in SVM.

In paper [12], a review of Offline recognition methodologies for different languages has been done. An approach for developing local database has been proposed. Prewitt operator and SVM classifiers are used for recognition. Proposed system gives an aggregate 94.25% recognition rate.

In paper [13], Novel method has been proposed to recognize similar shaped Marathi characters. It uses combination of Feature extraction & adaptive smoothing technique which gives better results. Experimental result shows approximately 98% accuracy.

Table 2: Performance comparison of ANN Techniques

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Author</th>
<th>Methodology</th>
<th>Result (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cheng-Lin Liu, et. Al.</td>
<td>Neural Classifier</td>
<td>99</td>
</tr>
<tr>
<td>2</td>
<td>Jian Yang, et. Al.</td>
<td>KFD classifier</td>
<td>84</td>
</tr>
<tr>
<td>3</td>
<td>Jie Zhou, et. Al.</td>
<td>Quantum NN</td>
<td>99.10</td>
</tr>
<tr>
<td>4</td>
<td>S.K. Shrivastava, et. Al.</td>
<td>SVM</td>
<td>99.48</td>
</tr>
<tr>
<td>5</td>
<td>S. Patwardhan, et. Al.</td>
<td>SVM</td>
<td>94.25</td>
</tr>
<tr>
<td>6</td>
<td>A.P. Jane, et.al.</td>
<td>ANN</td>
<td>87</td>
</tr>
</tbody>
</table>

Results are shown are very promising but most of these techniques have been implemented on other scripts & they work well for isolated numerals. Their performance decreases for mixed multi digit numerals.

Fuzzy Logic

In paper [14], Problem of Offline signature verification has been addressed using fuzzy modelling approach. Proposed model uses Takagi-sugeno type Fuzzy model which has been proved to be good in this area. Each Feature corresponds to Fuzzy set which is fuzzified using exponential membership function. Parameters of fuzzy sets take into account variation in style of handwriting.

In paper [15], Fuzzy Logic has been used in design of online recognition system which recognizes multi-stroke
sketches of symbols. The proposed system performs well with acceptable recognition rate up to 93%.

In paper [16], Fuzzy approach is used to recognize characters. Characters are firstly segmented and then recognized using fuzzy based algorithm. Fuzzy sets & logic are used for representation of characters & their recognition. The system gives high recognition accuracy for most characters.

In paper [17], problem of handwritten character detection has been discussed. Two algorithms are proposed which uses fuzzy logic. They are Active Character detection & Contour algorithms.

In paper [18], Feature extraction technique based on Axiomatic Fuzzy Set Theory has been proposed. It uses rules to combine features from Fuzzy feature set. System has been implemented on Indian scripts such as Bangla, Devnagri, Roman, Telugu and Arabic. SVM based classifier is used to recognize patterns. System gives higher recognition rate up to 96%.

**Neuro-Fuzzy System**

In paper [19], A neuro-fuzzy system ANFIS has been used for recognition of handwritten digits. The system uses seven feature extraction techniques have been used in recognition system. As a classifier, System uses Adaptive Neuro Fuzzy Inference System which have been used firstly in this area. System was evaluated on MNIST Handwritten numeral database. Proposed system reported high recognition accuracy up to 99.52%.

In paper [20], Neuro Fuzzy model system has been developed for recognition of handwritten hindi modifiers. The system works using fuzzy information having layered architecture. Proposed system gives recognition rate of 97.6%.

**Conclusion**

Over the years; Researchers have made an attempt to find solution for Handwriting recognition problem. Many techniques have been developed by researchers. They give good results for isolated numerals but they find it difficult in recognizing mixed or multi-digit numerals. There is a scope to develop more efficient techniques for mixed multi-digit numerals. In case of Marathi, there are some techniques available for recognition but efficient solution is still to come. Especially, Neuro-fuzzy approach is used by very few researchers. So there is a scope for to develop recognition system using neuro-fuzzy approach.

**References**


[8] Jian Yang, Alejandro F. Frangi, Jing-yu Yang, David Zhang, Senior Member, IEEE, and ZhongJin “KPCA
Plus LDA: A Complete Kernel Fisher Discriminant Framework for Feature Extraction and Recognition”
IEEE Transactions On Pattern Analysis And Machine Intelligence, VOL. 27, NO. 2 FEBRUARY 2005


