Performance Evaluation of Fuzzy c-means and Adaptive Neuro-fuzzy Inference System for Handwritten Numeral recognition

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Abstract— **The Handwritten mixed multi digit recognition for Marathi Language is also area of thrust for many researchers. This study is useful to recognize the correct numerals for handwritten bank withdrawal form. Many systems have been developed using soft computing paradigms such as Artificial Neural Networks, Fuzzy logic-based methods. Hybrid soft computing techniques have been also implemented to solve multi digit numeral recognition. In this paper, the problem of handwritten Marathi numeral recognition using different soft computing techniques have been implemented that are Fuzzy C-means and ANFIS. For feature extraction; chain code has been used. Proposed system is implemented on primary database containing 250 samples of Marathi handwritten numerals.**

Index Terms— **C-means, Chain code, Fuzzy C-Means, ANFIS.**

I. INTRODUCTION

Knowledge is recorded in the form handwritten notes, forms, books, etc. worldwide for purpose of communicating. For purpose of recording this knowledge we use natural languages such as English, Hindi, Marathi and many others [3]. In order to process these documents; we digitize them and store in the form of digital images. Recognition of these documents written in natural languages by computers is an important area of research for past many years. Many technologies have been developed to address this problem. As a part of research study; problem of recognizing handwritten Marathi numerals has been addressed.

Marathi language is derived from Devanagari script which is taken from Brahmi script. It was originally developed for Sanskrit; later on, many languages like Bhojpuri, Maithili have also been derived [7].

II. METHODOLOGY

In this research work, we have used chain code for feature extraction while Fuzzy C-means and ANFIS classifiers have been used for purpose of recognition.

A. Chain Code

Feature extraction technique has profound impact on recognition results. Feature extraction techniques are categorized as Shape based and Contour based methods. In case of shape-based methods extracts more information on boundary of object under consideration while contour-based methods focus on curves and lines of object [4]. Chain code means consecutive or successive two pixels that may be go in one of four or eight directions as shown in fig.1.
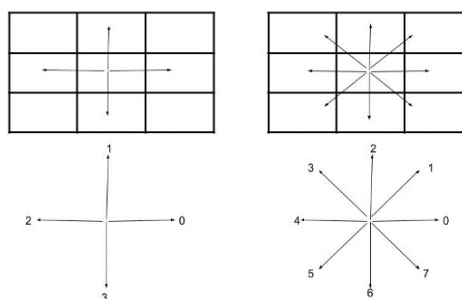

Fig.1: Chain Code (4 or 8 directional)

In case of 4-directional chain code; we get 4 features of a numeral and each numeral divided into four quadrants hence we get 4(chain code) x 4(quadrants) =16 chain code features.

B. Fuzzy C-Means

Fuzzy C-means is one of the widely used algorithm for solving problem of pattern recognition. FCM algorithm does job of recognition by partitioning number of elements into a total c no. of clusters. Let

us consider we have finite collection X of elements as in equation

$$X = \{x_1, x_2, \dots x_n\} \qquad \text{Eq.1}$$

C. Adaptive Neuro-fuzzy Inference System

ANFIS is hybrid neuro-fuzzy paradigm which implements Takagi-sugeno type of fuzzy system. It implements backpropagation training of ANN to optimize fuzzy system. Common architecture of ANFIS is as shown in fig 2.
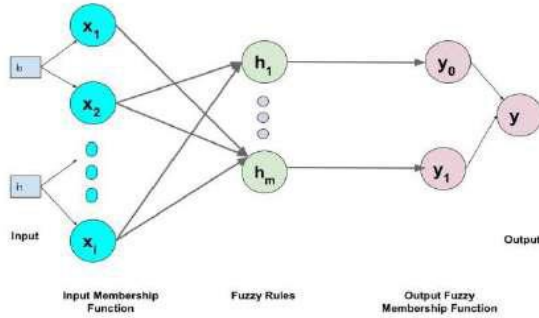

Fig. 2: Architecture of ANFIS

From fig.2 it is observed that the ANFIS works in five stages. Firstly, inputs are mapped to their respective fuzzy membership functions. Followed by framing of fuzzy rules and their firing strength. ANN training part normalizes the fuzzy rule base. Output layer calculates the overall output.

III. EXPERIMENT

The Proposed system which uses Fuzzy C-means and ANFIS classifiers was implemented on primary database developed. Chain code of every sample from database was computed and feature vector was defined for training.

In case of fuzzy c-means; algorithm counts distance of test image from database image and distance for which distance is minimum is considered as matching image. ANFIS classifier takes chain code feature vector of training samples and fine tunes the system. After training gets completed, the system is presented to test data for validating the system.

IV. RESULT AND CONCLUSION

The recognition system has been developed and successfully implemented o primary database of Marathi handwritten numerals. The system uses chain code as a feature vector. Two soft computing paradigms namely Fuzzy C-means and ANFIS have been used for recognition.

The proposed algorithm has been tested on primary database of handwritten Marathi numerals. Database contains 25 samples of each digit from 0 to 9. To measure accuracy of the system; two classification measures have been used i.e. Precision and Recall. Formulas for determining precision and recall rate are given in equation 2 and 3 respectively.

$$Precision = \frac{No.of\ Correctly\ Classified\ Patterns}{Total\ no.of\ Classified\ Patterns} * 100$$

$$\text{Eq. 2}$$

$$Recall = \frac{No.of\ Correctly\ Classified\ Patterns}{Total\ no.of\ Patterns} * 100$$

$$\text{Eq. 3}$$

Table I shows result of fuzzy c-means classifier. It can be observed that for digits 1, 6 and 0 it gives 100% precision while for other numerals results drops up to 95%.

Table I: Performance of FCM on primary database

Sr. No.	Digit	Total Number of Samples (A)	No. Of Correctly Classified samples (B)	Total number of Classified patterns (C)	PRECISION (B/C)	RECALL (C/A)
1		25	24	24	100	96
2		25	22	24	91.67	88
3		25	22	25	88	88
4		25	24	25	96	96
5		25	24	25	96	96
6		25	25	25	100	100
7		25	23	24	95.83	92
8		25	24	25	96	96
9		25	23	24	95.83	92
10		25	24	24	100	96
					95.93	94

Table II: Performance of ANFIS on primary database

Sr. No.	Digit	Total Number of Samples (A)	No. Of Correctly Classified samples (B)	Total number of Classified patterns (C)	PRECISION (B/C)	RECALL (C/A)
1		25	25	25	100	100
2		25	25	25	100	100
3		25	23	25	92	92
4		25	25	25	100	100
5		25	25	25	100	100
6		25	25	25	100	100
7		25	24	25	96	96
8		25	25	25	100	100
9		25	24	24	100	96
10		25	25	25	100	100
					98.8	98.4

The ANFIS classifier on same samples of database has been tested. The Results of ANFIS is as shown in table II. Table shows that for most of the digits ANFIS gives 100% result. Average result of ANFIS classifier is more than 98%. Comparing results from both tables; we can say that ANFIS classifier outperforms fuzzy c-means classifier.

V.CONCLUSION

The result obtained using fuzzy c-means and adaptive neuro-fuzzy system on primary dataset shows that the hybrid system gives better results than using fuzzy paradigm alone. It has been also observed that when fuzzy systems get support of learning capabilities of ANN then they give efficient results.

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