International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Telugu Character Recognition using Adaptive Fuzzy Membership Functions With Adaptive Genetic Algorithm Based Techniques

V. V. Satyanarayana Tallapragada, V. Sireesha, G. V. Pradeep Kumar

Abstract*: *A novel Telugu character recognition technique is proposed in this paper where the given Telugu handwritten document is processed by normalizing the document and removing the noise. Then slant detection followed by correction process is conceded using the bilinear interpolation method to get more accurate result. Thus the de-skewed documents text lines and characters are separated by making use of Adaptive Histogram Equalization (AHE). In the next stage, the characteristics of the segmented characters are mined with the help of the zoning method. In zoning method, an adaptive fuzzy membership function will be developed by the Adaptive Genetic Algorithm (AGA). By using AGA in zoning method the characteristics are mined from the separated characters. The mined structures are applied to the Feed Forward Back Propagation Neural Network (FFBNN) for accomplishing the learning process. During testing, more number of handwritten segmented Telugu characters will be set to the FFBNN to verify whether the input character is recognized or not. Thus, the proposed method has given more accurate recognition results by using our proposed adaptive fuzzy membership function with AGA method. The proposed method performance is evaluated by getting more number of handwritten Telugu documents and compared with the GA-FFBNN and FFBNN.

***Keywords* : Adaptive Histogram Equalization, Feed-forward Back-propagation Neural Network, Adaptive Genetic Algorithm, Zoning, Bilinear Interpolation.**

I. INTRODUCTION

Pattern recognition is the process of recognizing an unknown pattern to be one of the patterns of the known database [1]. The performance of this recognition can be verified by statistics related to the number of correct and wrong recognitions [2]. Classification and description are the two tasks which are covered in Pattern recognition [3]. The pattern recognition system design includes three aspects:

- Data procurement and processing
- Data depiction
- Decision making

The crucial part of any pattern recognition task is to primarily classify and then recognize an object that belong to a specific group [4][5]. Methods of Pattern Recognition are Statistical Model, Structural Model, Neural Network Based Model [6], Fuzzy Based Model, and Hybrid Model [7][8]. Interpretation of input object as a systematic ordering of symbols which are pre-known is the main objective of character recognition. The task of character recognition may be applied on different kind of combinations of handwritten text, scanned documents and computer printouts. The handwritten text is most difficult to process as the text which is just a mixture of twenty six alphabets, ten numerals and few special characters, will have different fonts. These fonts are not exhaustive in many cases. The computer printouts will also have many fonts, but they are exhaustive [9]. All these, when printed on paper, the shadow of text written back side of the paper creates difficulty when they match with some of the known symbols [10].

Apurva A. Desai [11] carried an interesting task. He presented an optical character recognition scheme on Gujarati numbers. A successful character recognition scheme was presented for handwritten numbers in Gujarati language. Pirlo et al. [12] have proposed a set of fuzzy-membership functions for classification based on zoning. Jomy John et al. [13] have applied the concepts of wavelets for handwritten character recognition. Giuseppe Pirlo et al. [14] have proposed a new class of zone-based membership functions. These membership functions are introduced with adaptive capabilities and its effectiveness is shown. Soumya Soman et al. [15] have proposed a pattern analysis technique to develop a powerful and efficient system for handwritten character recognition.

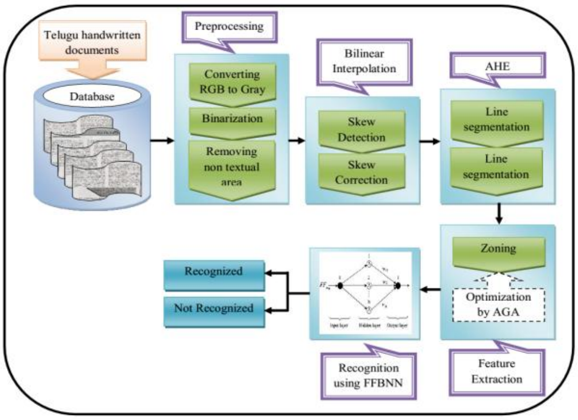
Amit Choudhary et al. [16] have presented a pattern classifier technique which is used to extract the features. Yunxue Shao et al. [17] have proposed a fast self-generation voting method for further improving the performance in handwritten Chinese character recognition. Toru Wakahara et al. [18] have proposed a GAT correlation method to reduce the computational cost of matching in k-NN classification. Dapeng Tao et al. [19] have proposed the kernel version of DLA, kernel DLA, and prudently show that learning KDLA is similar to leading kernel PCA followed by DLA.

Manuscript published on 30 September 2019
* Correspondence Author
V. V. Satyanarayana Tallapragada*, Associate Professor, Department of ECE, Sree Vidyanikethan Engineering College, Tirupati, India. satya.tvv@gmail.com.
V. Sireesha, Associate Professor, Geethanjali Institute of Science and Technology (GIST), Nellore, India. sireesha80.dhoorjati@gmail.com
G. V. Pradeep Kumar, Assistant Professor, Department of ECE, Chaitanya Bharathi Institute of Technology, Hyderabad, India. pradeepgv16@gmail.com

II. PROPOSED TELUGU CHARACTER RECOGNITION SYSTEM

In the proposed technology, first the text documents are obtained from the database and they are pre-processed to eliminate the noise which in turn helps to improve the accuracy of the recognition.

After that bilinear interpolation is applied on the preprocessed documents for skew detection and correction. Then, each character is segmented from the preprocessed documents by using AHE technique. Subsequently, features from the segmented characters are extracted by exploiting the voronoi based zoning approach. At the time of zoning, the adaptive fuzzy membership function is optimized with the utilization of Adaptive Genetic algorithm (AGA) and thus optimal structures are obtained from each character. The optimal features are then fed to FFBNN to attain the training process. At the testing time, more number of characters are utilized to analyze the performance of FFBNN. Architecture of the proposed Telugu character recognition system is given in Fig.



.

Fig. 1. Architecture of our proposed Telugu Character Recognition system

Figure 1, which is the proposed system, comprises of five stages namely,

- Preprocessing
- Detection and correction of Skew
- Segmentation
- Feature extraction
- Recognition

Let the database (D) contains many text documents and let $x_{i,j}$ be one of the document at location (i,j) taken from the database.

A. Preprocessing

Consider database (D) which contains document images (i) $\{i = 1,2,\cdots D\}$ where i is number of document images and each image has the size of $M \times N\{m = 1,2,\cdots M, n = 1,2,\cdots N\}$ that signifies the row and column of the image. The RGB document image is first converted into grayscale image and is represented as gD_i which is converted to binary in the next stage. The process of binarization is defined by equation (1),

$$BD_i = \begin{cases} 1; \ gD_i > \tau \\ 0; \ otherwise \end{cases}$$

(1)

Where τ is the threshold value and BD_i is the resultant binary image. The textual image TgD_i is mapped to the original image D_i and the output after preprocessing is denoted by:

$$PD_i \ \ where\, i = 1,2,..D : D \in M' \times N' \ where \ M' < M \ \& \ N' < N$$

(2)

The preprocessed image (PD_i) is then subjected to skew detection and correction process.

B. Bilinear Interpolation

Identification of skew in the image is an important task of any character recognition system. After finding skew angle, the document image can be corrected according to the detected skew angle. Here, bilinear interpolation (BI) is utilized to detect the skew angle (θ) of the document image and also for correcting the document image according to the skew angle (θ).

The stepwise procedure of the bilinear interpolation technique [29] is given below:

Step 1: Get the preprocessed image (PD_i) as the input image.

Step 2: Resize the row size ($M' \rightarrow H$) and the column size ($N' \rightarrow H$) of the image (PD_i) as equal and denote the resized image as RD_i .

Step 3: Enlarge the resized image (RD_i) from ($H \times H$) to ($H' \times H'$) and denote the enlarged image as ED_i .

Step 4: Imagine scaling the $H' \times H'$ grid to fit over $H \times H$.

Step 5: For each and every pixel in ED_i do:

Step 6: Take a pixel ($\hat{x}, \hat{y}$) in enlarged image (ED_i).

Step 7: Find the scaled coordinates of the grid point using equation below:

$$x = \hat{x}(H - 1)/(H' - 1) \quad (3)$$

$$y = \hat{y}(H - 1)/(H' - 1) \quad (4)$$

The range of scaled coordinates (x, y) are lies within the resized image (RD_i) size.

Step 8: Perform the floor and ceil operations on the obtained scaled coordinates (x, y) to get the four coordinates such as (x_1, y_1), (x_1, y_2), (x_2, y_1) and (x_2, y_2).

Step 9: Find the intensity values (Intsty) of the four neighbours in step 8.

Step 10: Construct the matrix as,

$$\begin{bmatrix} x_1 & y_1 & x_1y_1 & 1 \\ x_1 & y_2 & x_1y_2 & 1 \\ x_2 & y_1 & x_2y_1 & 1 \\ x_2 & y_2 & x_2y_2 & 1 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \\ D \end{bmatrix} = \begin{bmatrix} Insty(x_1y_1) \\ Insty(x_1y_2) \\ Insty(x_2y_1) \\ Insty(x_2y_2) \end{bmatrix}$$

(5)

Step 11: Find out the values of A, B, C, D by solving step 10 and substitute it in the below equation,

$$\mathrm{BI(x, y) = Ax + By + Cxy + D}$$

(6)

Step 12: Replace ($\hat{x}, \hat{y}$) by using the value $\mathrm{BI(x, y)}$ which is obtained from the above equation.

Finally, the skew corrected image ($SkD_i \;, D \in M' \times N'$) is obtained and it is passed to carry out the segmentation process.

C. Character Segmentation Using Adaptive Histogram Equalization

In order to recognize each character, the character should be segmented from the document image (SkD_i) and so AHE is used here to segment the character from the document image (SkD_i). AHE is an extension to traditional Histogram Equalization technique. AHE enhances contrast of the document x'. AHE is routine, locally adaptive and habitually produces superior document.

Consider a moving window w of size O x O and the pixel (i, j) having an intensity of I. Then, the modified pixel (i,j) is processed as:

$$Map(I) = p\,[q \times map_{-,-}(I) + (1-q)\, map_{+,-}(I)] + [1-p]\,[q \times map_{-,+}(I) + (1-p)\, map_{+,+}(I)] \quad (7)$$

Where, $map_{+,-}$ - mapping of right upper($i_+, _-$)

$map_{+,+}$ - mapping of right lower($i_+, _+$)

$map_{-,+}$ - mapping of left upper($i_-, _+$)

$map_{-,-}$ - mapping of left lower($i_-, _-$)

$$p = (j - j_-) / (j_+ - j_-) \quad (8)$$

$$q = (i - i_-) / (i_+ - i_-) \quad (9)$$

This modification is done for all the pixels in the entire document (SkD_i) and finally the segmented characters ($sc_i, i = 1,2,...,d \;\; where \;\; sc_i \in skD_i$) are obtained.

D. Optimal Feature Extraction with the help of Voronoi based Zoning

The segmented characters (sc) are then subjected to feature extraction process. To extract the features, the segmented characters (sc) are zoned by using voronoi based technique. In order to get the optimal features (ff_i), the membership function is optimized by using AGA. Zoning is nothing but dividing the given input image into number of sub images that can give information related to a particular part of the pattern. Zoning is of two types.

1. Static: Obtained by superimposing the regular m x n grids on a pattern image

2. Dynamic: The design of zoning is considered as an optimization problem

The steps followed to zone the image are :

1. Define the number of points $\{\mathrm{Z_j = Z_1, Z_2, ...Z_n}\}$ to be divide the image

2. Determine the size of the image ($sc_i : u \times v$)

3. Find the difference (d_i) between the number of points generated $\{\mathrm{Z_j}\}$and the size of the image (sc_i).

4. Get the minimum difference for each number of points generated $\{\mathrm{Z_j}\}$

5. Sort the points $\{\mathrm{Z_j}\}$ in descending order

By using these above steps, the image (sc_i) is partitioned into number of zones $\{\mathrm{Z_j = Z_1, Z_2, ...Z_n}\}$ based on the number of points generated already.

The zones $\{\mathrm{Z_j}\}$ obtained in the above steps are utilized to calculate the features (ff_i) of the image (sc_i). After obtaining the zones $\{\mathrm{Z_j = Z_1, Z_2, ...Z_n}\}$, the center points of each zone are calculated and are represented as the voronoi points ($\{\mathrm{V_j = v_1, v_2, ...v_n}\}$). After the calculation of the voronoi points ($\{\mathrm{V_j = v_1, v_2, ...v_n}\}$), feature instances (fI_i) are find out with the help of the feature set (FS_i) from each zone ($\mathrm{Z_j}$). Then, the Euclidean distance (ED_{ij}) between the location of the feature instance (fI_i) and the voronoi points are calculated and based on that distance ranked index sequence (R) is created. The ranked index sequence (R) consists the zones $\{\mathrm{Z_j = Z_1, Z_2, ...Z_n}\}$ which are arranged based in the ascending order of the Euclidean distance (ED_{ij}) calculated. Finally, weight ($WE = \{\omega_1, \omega_2, ..., \omega_{ij}\}$) of each zone ($\mathrm{Z_j}$) is assigned by using the adaptive membership function (ω_{ij}) [14] where ω_{ij} is the weight of the zone ($\mathrm{Z_j}$) at the corresponding feature instance (fI_i).

The membership function used here is

$$\omega_{ij} = e^{-\gamma EDij} \quad (10)$$

Where, γ is a positive parameter which denotes the falling rate.

After the calculation the membership function, the range of the membership functions (ω_{ij}) are fuzzified between 0 and 1. Thus the adaptive membership function becomes adaptive fuzzy membership function. Finally, features (ff_i) of each character image (sc_i) is obtained as follows:

$$FF_{sc_i} = \begin{bmatrix} FF_{sc_i}(1,1) & FF_{sc_i}(1,2) & \ldots & FF_{sc_i}(1,n) \\ FF_{sc_i}(2,1) & FF_{sc_i}(2,2) & \ldots & FF_{sc_i}(2,n) \\ \ldots\ldots & \ldots\ldots & \ldots & \ldots\ldots \\ FF_{sc_i}(S,1) & FF_{sc_i}(S,2) & \ldots & FF_{sc_i}(S,n) \end{bmatrix} \quad (11)$$

In equation (11), FF_{sc_i} represents the feature matrix of each character (sc_i) and $FF_{sc_i}(2,1)$ denotes the weight obtained using the adaptive fuzzy membership function of s^{th} number of the feature in the feature set at n^{th} zone.

The falling rate (γ) in the adaptive fuzzy membership function is optimized using Adaptive Genetic Algorithm to get the optimal features. Here, the falling rate (γ) of the Adaptive Fuzzy membership function is optimized using AGA. The following figure shows the process involved in adaptive GA.

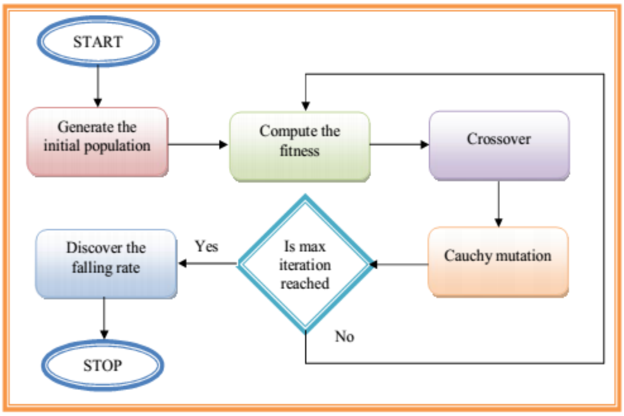


Fig. 2. Flowchart of the Adaptive Genetic Algorithm

Equation 12 shows the calculation of the fitness value for each of the parameter and the best chromosome is selected based on the highest value computed.

$$F(i,j) = \min(er) \quad (12)$$

where $er(i,j)$ is the error rate of t^{th} parameter.

Here, single point crossover is done at a rate of Cr which results in 'T/2' offspring. TCr genes are exchanged for each operation between the corresponding parents.

A change of characteristic in each and every individual will be achieved using a perturbation operation which will be applied probabilistically. The change of chromosome in mutation may result in addition of new features. The equation 13 can be used to mutate individual according to Cauchy mutation. The pre-determined probability is required to perform mutation. The distribution function associated with the Cauchy random variable is given below.

$$F(x) = \frac{1}{2} + \frac{1}{\pi}\arctan(x) \quad (13)$$

The process initiated and carried through the above steps will not be stopped until a condition is satisfied. This condition is referred to as termination condition. This is done by considering the optimal falling rate. The condition is obtained using AGA substituted in equation 11. This condition is chosen to obtain the optimal results by considering the time complexity and performance of recognition into consideration.

III. EXPERIMENTAL RESULTS

The proposed Telugu Character Recognition system is done with the help of FFBNN. In order to get the optimal features, the falling rate of the adaptive fuzzy membership function is optimized by using AGA. Then, the obtained features are given to the FFBNN to achieve the training process. The proposed Telugu Character Recognition system is evaluated by using a large number of handwritten document images and the proposed technique's performance is compared with the GA-FFBNN and FFBNN. Our proposed technique is implemented in Matlab Platform.

A. Performance Analysis

The parameters proposed in [20] are used to evaluate the performance of the proposed system. The database consists of 12 handwritten documents which are collected manually. The statistical measures TP, TN, FP and FN values of our suggested system are specified in Table 1. Fig. 3, 4, 5, 6, and 7 illustrate the sample of input handwritten document, preprocessed image, Skew corrected image, line segmented image and segmented characters respectively.

Fig. 3. Input handwritten document

Fig. 4. Preprocessed document

Fig. 5. Skew Corrected document

(i)

(ii)

(iii)

(iv)

(v)

Fig. 6. Line segmented Image

Fig. 7. Segmented Characters

Table 1: Performance measures

Measures	Proposed technique	GA-FFBNN	FFBNN
Accuracy	94.0828	89.3491	89.9408
Sensitivity	95.6522	92.5	85.7143
Specificity	93.4959	88.3721	91.6667
FAR	0.0650407	0.116279	0.0833333
FRR	0.0434783	0.075	0.142857

Accuracy, sensitivity, specificity, FAR (False Rejection Rate) and FRR (False Acceptance Ratio) measures are specified in Table1. At this point, performance of our suggested Telugu Character recognition scheme is related with the GA-FFBNN and FFBNN. The accuracy of the suggested method is 94.08%. While the other techniques such as GA-FFBNN and FFBNN offers 89.3491 and 89.9408 accuracy correspondingly. When compared to the existing systems, the suggested AGA-FFBNN provides higher rate of accuracy. It symbolizes the suggested method identify the character more precisely than the other methods. The suggested method has 95.6522% of sensitivity. It is about 2.5-10% higher than the other methods. High percentage of sensitivity points out the good presentation of the method. When observing the other performance measurements such as FAR and FRR also, our proposed technique yields our proposed method provides better performance results that is, the rate of FAR and FRR are less than the FAR and FRR rate of GA-FFBNN and FFBNN techniques. Thus by seeing the results, it is proved that the proposed technique recognize the Telugu characters efficiently.

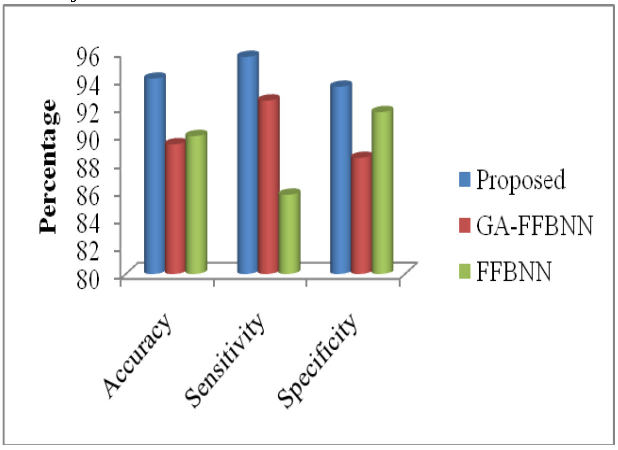


Fig. 8. Performance analysis

Accuracy and sensitivity measures of the suggested method are compared with the other methods in Fig. 8. From the graph, it is evident that the precision of the method is considerably higher than the precision with the other systems such as GA-FFBNN and FFBNN. Likewise, the sensitivity measure of the suggested AGA-FFBNN method is moreover particularly higher than the other methods. It points out the presentation and the precision of the suggested method is higher than the other methods. Similarly, the specificity of the proposed scheme is notably large than the specificity with other techniques. The suggested Telugu Character Recognition system based AGA-FFBNN has reached 94.08% of accuracy, 95.65% of sensitivity and 93.49% of specificity correspondingly. It points out that our suggested recognition system carried out better presentation when compared to the other techniques mentioned above.

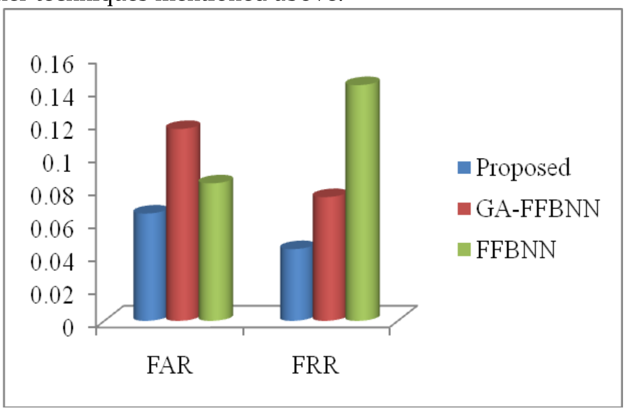


Fig. 9. Comparison of the performance

FAR and FRR measures of the suggested method are compared with the other methods in Fig. 9. FAR is obtained by subtracting the specificity value from 1. When looking the FAR value of our proposed technique (0.0650407). But the GA-FFBNN and FFBNN yields the FAR rate 0.116279 and 0.0833333 respectively. And the FRR rate is attained by subtracting the sensitivity value from 1. On looking at the FRR value also, the proposed technique offers less rate of FRR than the other techniques. Thus it indicates our proposed Telugu Character recognition technique performs efficiently with less error rate.

IV. CONCLUSIONS

A Telugu character recognition scheme based on FFBNN was presented. The experimental analysis show that the accuracy of this scheme is about 94.08%, sensitivity is 95.65%, specificity is 93.49%, FAR is 0.0650407 and FRR is 0.0434783. These values are arrived after an extensive performance analysis on test images. The test images include the handwritten script, printout of a computer and scanned document. The parameters considered in the proposed FFBNN compensated the complexities that arise from the back through effects from scanned document as well as the printout from a computer.

REFERENCES

1. Jayanta Kumar Basu, Debnath Bhattacharyya and Tai-Hoon Kim, “Use of Artificial Neural Network in Pattern Recognition”, International Journal of Software Engineering and Its Applications, vol. 4, no. 2, pp. 23-34, 2010.
2. Majida Ali Abed, Ahmad Nasser Ismail and Zubadi Matiz Hazi, “Pattern Recognition Using Genetic Algorithm”, International Journal of Computer and Electrical Engineering, vol. 2, no. 3, pp. 583- 588, 2010 .
3. Navdeep Kaur and UsvirKaur, “Survey of Pattern Recognition Methods”, International Journal of Advanced Research in Computer Science and Software Engineering, vol. 3, no. 2, pp. 317-319, 2013.
4. Jie Liu, Jigui Sun and Shengsheng Wang, “Pattern Recognition: An Overview”, International Journal of Computer Science and Network Security, vol. 6, no. 6, pp. 57 -61, 2009.
5. Hui-Ping Cheng and Chuen-Sheng Cheng, “Control Chart Pattern Recognition Using Wavelet Analysis and Neural Networks”, Journal of Quality, vol. 16, no. 5, pp. 311 -321, 2009.
6. Jaya Krishna Sunkara, L. Ramasubba Reddy, L. Rajyalakshmi, K. Anitha, K. Santhipriya and M. Prathapreddy, “Object Detection with Improved Shape Context Features”, CiiT International Journal of Digital Image Processing, vol. 4, no. 5, March 2012.
7. Vasantha Lakshmi, Ritu Jain, and Patvardhan, “OCR of Printed Telugu Text with High Recognition Accuracies”, Journal of Emerging Trends in Computing and Information Sciences, vol. 3, no. 1, pp. 786-795, 2006.
8. Jaya Krishna Sunkara, M Santhosh, Suresh Babu Cherukuri and L. Gopi Krishna, “Object Tracking Techniques and Performance Measures – A Conceptual Survey”, IEEE International Conference on Power, Control, Signals and Instrumentation Engineering, pp. 333-341, Sep 2017, Chennai.
9. Thilagavathy and Indra Gandhi, “Recognition of Distorted Character Using Edge Detection Algorithm”, International Journal of Innovative Research in Computer and Communication Engineering, vol. 1, no. 4, pp. 1056-1061, 2013.
10. Panyam Narahari Sastry, Ramakrishnan Krishnan and Bhagavatula Venkata Sanker Ram, “Classification and Identification of Telugu Handwritten Characters Extracted From Palm Leaves Using Decision Tree Approach”, ARPN Journal of Engineering and Applied Sciences, vol. 5, no. 3, pp. 22- 32, 2010.
11. Apurva Desai, “Gujarati handwritten numeral optical character reorganization through neural network”, Pattern Recognition, vol. 43, no. 7, pp. 2582–2589, 2010.
12. Pirlo and Impedovo, “Fuzzy-Zoning-Based Classification for Handwritten Characters”, IEEE Transactions on Fuzzy Systems, vol. 19, no. 4, pp. 780-785, 2011.
13. Jomy Johna, Pramod and Kannan Balakrishnan, “Unconstrained Handwritten Malayalam Character Recognition using Wavelet Transform and Support vector Machine Classifier”, International Conference on Communication Technology and System Design, pp. 598-605, 2012.
14. Giuseppe Pirlo and Donato Impedovo, “Adaptive Membership Functions for Handwritten character Recognition by Voronoi-Based Image Zoning”, IEEE Transactions on Image Processing, vol. 21, no. 9, pp. 3827- 3837, 2012.
15. Soumya Soman, Ashakranthi Nandigam and Srinivasa Chakravarthy, “An Efficient Multi classifier System Based on Convolution Neural Network for Offline Handwritten Telugu Character Recognition”, National conference on communications, pp. 1-5, 2013.
16. Amit Choudharya, Rahul Rishib and Savita Ahlawat, “Off-Line Handwritten Character Recognition using Features Extracted from Binarization Technique”, AASRI Conference on Intelligent Systems and Control, pp. 306-312, 2013.
17. Yunxue Shao, Chunheng Wang and Baihua Xiao, “Fast self-generation voting for handwritten Chinese character recognition”, International Journal on Document Analysis and Recognition, vol. 16, no. 4, pp. 413-424, 2013.
18. Toru Wakahara and Yukihiko Yamashita, "k -NN classification of handwritten characters via accelerated GAT correlation", Pattern Recognition, vol. 47, pp. 994-1001, 2014.
19. Dapeng Tao, Lingyu Liang, Lianwen Jin and Yan Gao, “Similar handwritten Chinese character recognition by kernel discriminative locality alignment”, Pattern Recognition Letters, vol. 35, pp. 186–194, 2014.
20. https://en.wikipedia.org/wiki/Sensitivity_and_specificity

AUTHORS PROFILE

Dr. V. V. Satyanarayana Tallapragada is currently working as Associate Professor in the Department of ECE, Sree Vidyanikethan Engineering College, Tirupati. He obtained Ph.D in ECE from JNTU - Hyderabad in 2015. He completed his graduation and post graduation in Communications and Radar Systems from Acharya Nagarjuna University in 2002 and 2007 respectively. He is having 12 years of teaching experience and 7 years of research experience. His research interests include Signal and Image Processing, Embedded systems, Internet of Things.

Dr. V.Sireesha is presently working in Computer Science and Engineering Department as Associate Professor in **Geethanjali Institute of Science and Technology (GIST), Nellore. She** obtained his Bachelor’s degree in Computer Science from Osmania University. Then she obtained her Master’s degree in computer science from Satybhama University and Ph.D from Sri Padmavati Mahila Visvavidyalayam (SPMVV), Tirupati. She is having 14 years of teaching experience and published 12 papers in reputed journals. Her thrust areas of research are Pattern Recognition, Big Data Analytics, Machine learning. She served the college in various positions such as NAAC Coordinator and IQAC Convenor.

G.V. Pradeep Kumar received his B.Tech in Electronics and Communication Engineering from Kamala Institute of Technology & Science, JNTU in 2003 and M.E in Communication Engineering from CBIT, Osmania University, Hyderabad, India in 2007. He has more than 11 years of teaching experience. Presently he is working as an Assistant Professor in the Department of Electronics and Communication Engineering, Chaitanya Bharathi Institute of Technology. His areas of interest are Computer Networking and Security, Wireless communications.