International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Odia Characters and Numerals Recognition using Hopfield Neural Network Based on Zoning Feature

Om Prakash Jena, Sateesh Kumar Pradhan, Pradyut Kumar Biswal, Alok Ranjan Tripathy

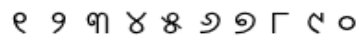
Abstract*: Odia character and digits recognition area are vital issues of these days in computer vision. In this paper a Hopfield neural network designe to solve the printed Odia character recognition has been discussed. Optical Character Recognition (OCR) is the principle of applying conversion of the pictures from handwritten, printed or typewritten to machine encoded text version. Artificial Neural Networks (ANNs) trained as a classifier and it had been trained, supported the rule of Hopfield Network by exploitation code designed within the MATLAB. Preprocessing of data (image acquisition, binarization, skeletonization, skew detection and correction, image cropping, resizing, implementation and digitalization) all these activities have been carried out using MATLAB. The OCR, designed a number of the thought accuses non-standard speech for different types of languages. Segmentation, feature extraction, classification tasks is the well-known techniques for reviewing of Odia characters and outlined with their weaknesses, relative strengths. It is expected that who are interested to figure within the field of recognition of Odia characters are described in this paper. Recognition of Odia printed characters, numerals, machine characters of research areas finds costly applications within the banks, industries, offices. In this proposed work we devolve an efficient and robust mechanism in which Odia characters are recognized by the Hopfield Neural Networks (HNN).

Keywords: Feature Extraction, Hopfield Neural Network, Segmentations, Zoning Features.

I. INTRODUCTION

The natural inclination to spot letters, numbers, voices, objects given by human beings is known as Pattern Recognition. It is a very complicated problem to do these types of task. In artificial intelligence, pattern recognition is a necessary component. Printed character and digit recognition could be terribly recent and vital in machine learning problem. The target is to acknowledge pictures of isolated printed digits (0 to 9) and printed Odia characters. Specifically, the matter is to seek out a model that takes images of printed digit as input and output the expected category label of the image. Automatic analysis printed or handwritten characters are the one in all the human necessities that are topic of rigorous analysis for the previous couple of decades and remain removed from the perfection. Analysis of printed characters that involves recognition uses pattern recognition strategies. Odia could be a regional language that comes from the Devanagari syllabic script ordinarily utilized in most of the North-East states of Asian countries. It is in the main used within the states of Odisha as well as some part of West Bengal. In Odisha, Odia is the Official language of counting for over forty million folks and it is also used in the state of Jharkhand known as the 2nd official language. Odia is especially used in the Odisha state. The script of Odia is originally comes from the script of Kalinga that could be a descendent of the script of Brahmi of Asian country. Primarily alphabets of Odia consist of 268 numbers of symbols out of which there are 11 numbers of vowels, 34 numbers of consonants, ten numerals and 210 numbers of conjuncts character.

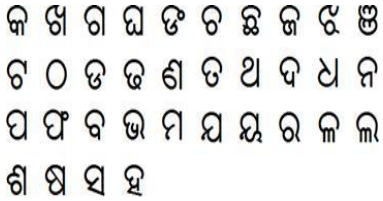
Odia Numerals:



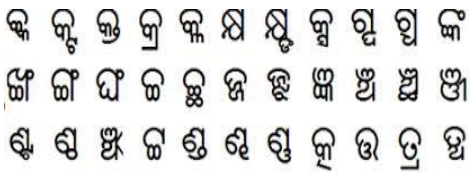
Odia characters:

Vowels:

Consonants:



Some Conjuncts character:



Revised Manuscript Received on 30 July 2019.

* Correspondence Author

Om Prakash Jena*, Department of Computer Science, Ravenshaw University, Cuttack, India.

Sateesh Kumar Pradhan, Department of Computer Science, Utkal University, Bhubaneswar, India.

Pradyut Kumar Biswal, Department of ECE, International Institute of Information Technology (IIIT) Bhubaneswar, India.

Alok Ranjan Tripathy*, Department of Computer Science, Ravenshaw University, Cuttack, India. Email: tripathyalok@gmail.com

II. RECENT WORKS

The author proposes a model for the reorganization of Oriya script using strokes and other features obtained 96.3% character level of accuracy [1].

Taking horizontal profiles with upper, middle and lower zoning and feature extraction used by support vector machine (SVM), author design a model to recognize the character with accuracy 99.8% [2]. Using neural networks of ANN recognize Oriya character by taking back propagation and implementing the feature using feed forward method [3]. Odia handwritten numbers are recognized taking bounding box features, blocks and chain code histogram feature of with 90.38% recognition accuracy [4]. The author proposes a model to recognize Odia printed documents accuracy of the word, character recognition by upper, middle, lower zone and upper mean, base, lower lines are used by the projection profile based and Hough transform techniques and thinning based approach. The line segmentation accuracy is overall 99.3% and word segmentation accuracy is overall 86.5% [5]. A model to recognize Odia character by globally and locally thresholding and line segmentation, word segmentation, character segmentation, based on Odia character [6]. To recognize Odia printed digit considering structural information as features and finite automaton using freeman chain coding method of overall accuracy is 96.08% [7]. The author designed a model to recognize isolated handwritten and printed Odia characters with feature scales symbol to size contains feature vector of Back propagation method with average recognition rate 93.95% [8]. The author developed a model to recognize the printed Oriya script using projection profiles and HOG feature extraction technique and SVM achieved 97.2% accuracy [9]. Oriya script was recognized using curvature feature, chain code based on SVM accuracy result is 94% [10].The author proposed a model to segment the Oriya handwritten character using water reservoir concept achieved 96.7% [11]. The author recognizes the handwritten character of Oriya numerals using Hopfield neural networks (HNN)of image cropping, resizing, digitalization of different data sets of this script recognition accuracy is 95.4% [12]. The author proposed a model to recognize the Java Character using Hopfield network algorithm achieved accuracy is 88% [13]. Recognition of handwritten Chinese character using Hopfield neural networks of stroke extraction and pre-processing feature set of stroke and row-column assignments character matching [14]. The author proposed a model to recognize the printed Gujrati script using Hopfield neural network of Otsu's histogram by zone separation (upper, middle, lower zone) recognition of accuracy is 93.25% [15]. A model was proposed by the author to recognize the character of Hindi using neural networks of extraction of different styles and font's accuracy approximately 95.97% was achieved and recognition accuracy was 98% [16]. In the Character recognition for printed Bangla script using zone detection of upper zoning, middle zoning, lower zoning and block detection overall accuracy is 95.50% in word level and 99.10% in character level [17]. The author proposed an efficient method with feature reduction mechanism using PCA and LDA to recognized Odia numerals with an accuracy 96.60% [18].

III. PREPROCESSING

Pre-processing comprises sequential series of operation on input image. The OCR system consists of various steps.

- Input image
- Skeletonization and Binarization
- Removal of Noise
- Thinning
- Finding Skew and Correction of Skew
- Segmentation
- Feature Selection and Extraction
- Classification into classes

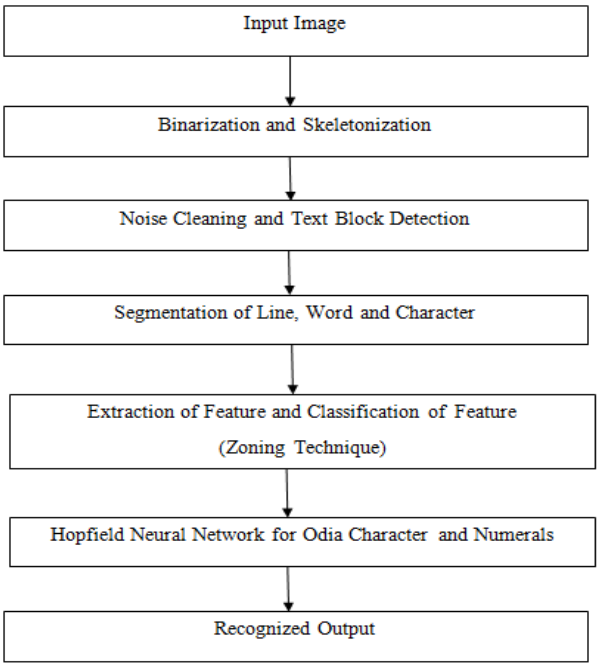
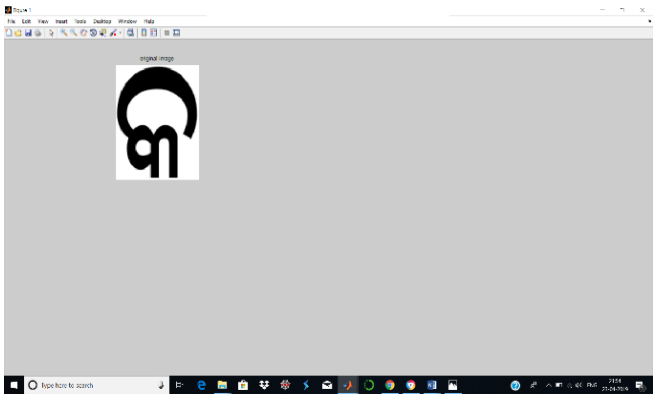


Fig 1: Overall Flow of the Process

A. *Input Image*

We take input image from the scanner, printer or camera image for pre-processing.



(a)

(b)

Fig 2: Input Image

B. *Binarization*

An image was produced by the printer from the Odia documents. In matrix form we stored the image in computer. Two possible values of binary image for every pixel point. In binary image of every pixel is keep as a one bit 0 or 1. Binary image is a grayscale distinction stretched image. That grayscale image under-goes digitization. Binarization converts grayscale image into binary image is also called digitization. Taking the input image from the high scanner, printer or from a camera, once this we have a tendency for binarization.

(a)

(b)

Fig 3: Binarized Image

C. *Normalization*

Basic techniques for Normalization embrace scaling, rotation and translation etc for avoiding the scaling and also for the rotational issues. Document images aren't forever within the equal size; however, the formula can think about will for a hard and fast size matrix image. Thus the input documents are square measure for normalization with regard to breadth, height or each. The documents to attain logical results should have the identical size, which suggest one to normalize.

D. *Thinning*

Eliminate the unwanted noise pixels from the image after that cutting is finished to slender edges within and in conjunction with. From binary pictures cutting could be a morphological operation that's wanted to take away hand-picked foreground pixels. Edge detection is that the method where the image brightness changes sharply of distinctive points of a digital image or a lot of formally has discontinuities.

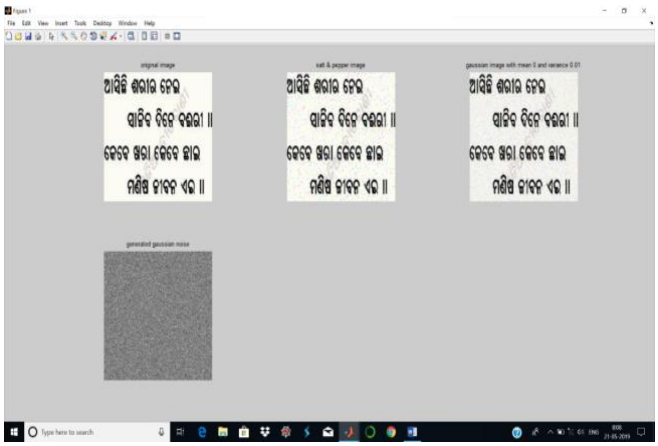
E. *Skew Correction and Detection*

To get a digital image, in a scanner once a document is set to it either automatically or also by somebody's operator, a number of skew of degrees is inescapable. The Skew is that the angle separated from its perceived position of steadies by that the pictures looks to be like that the skew of the pictures. Estimation of Skew and correction of skew square measure the vital steps of pre-processing. Correction of Skew may be achieved for any documents.

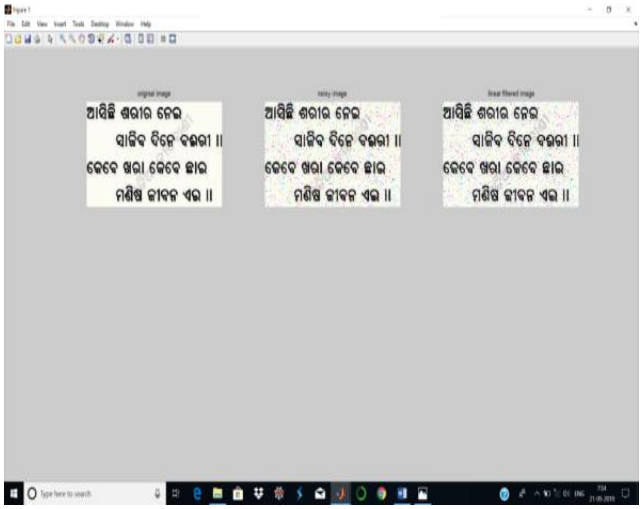
F. *Noise Removal*

In scanned pictures, noise is that the unwanted output comes with the element intensity price, wherever reduction of noise is that method of eliminating spurious points from noisy image. The digital image introduced from the scanning devices will have some noise. All non-word information should be removed to associate correct result. Reducing noise from the image, we have used two main approaches that are:

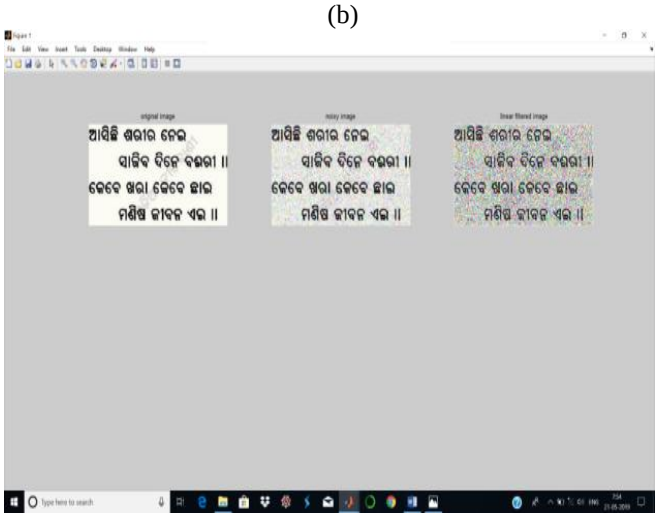
- Masking using filter.
- Morphological Operation.



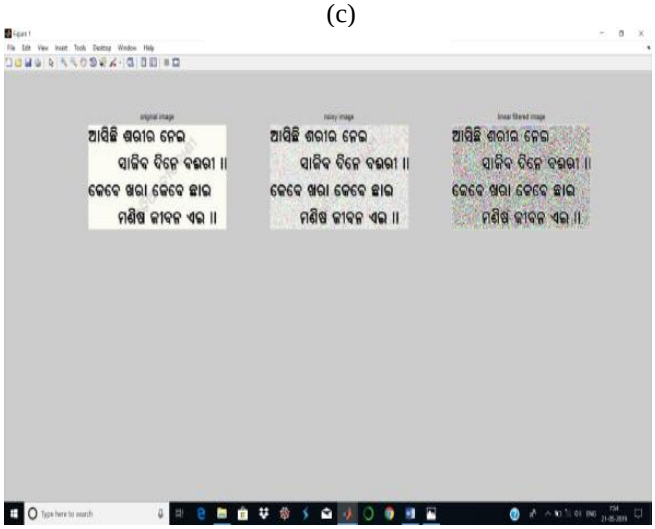
(a)



(b)



(c)



(d)

Fig. 4: Result of Different Noise Removal Methods

G. *Segmentation*

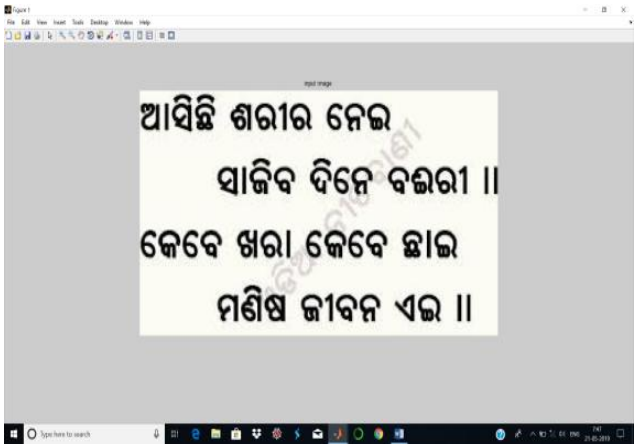
Segmentation is the procedure of separating the input image into smaller component. Extraction of each segment is done in order to help easily i.e. text document into line, line into words and words into character and then into segments. Segmentation is classified into three parts.

- Segmented Line
- Segmented Word
- Segmented Individual Character

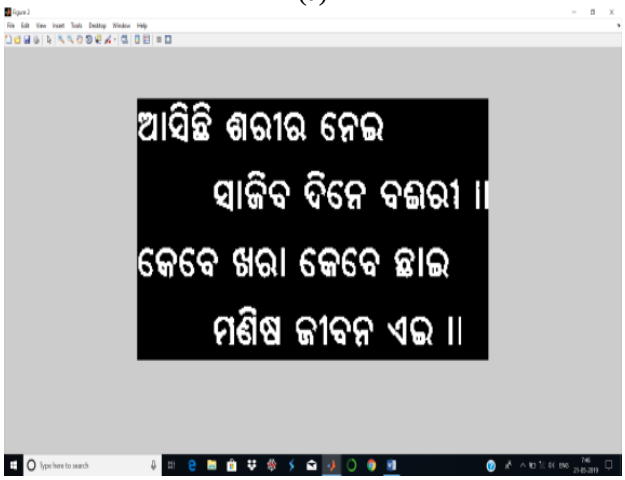
In segmentation techniques are Hough Transform, Horizontal projection, smearing etc. In word segmentation are based on vertical projection, connection component analysis. In character segmentation are based upon vertical projection, feature extraction.

Line Segmentation

In line segmentation method where the lines are nearly of equal height, during constant font size additionally script is written so the script is consisting by a machine typing. Compare between the two texts lines in line segmentation, row level line generated with no picture element or only some pixels. Thus by checking and storing of break-points through them are going to be helpful valleys for detecting it, bands of text line will be retrieved.



(a)



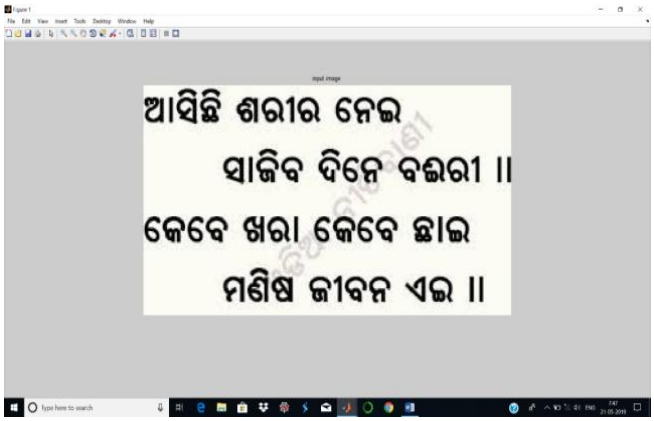
(b)

Fig.5: Output of Line Segmented Image

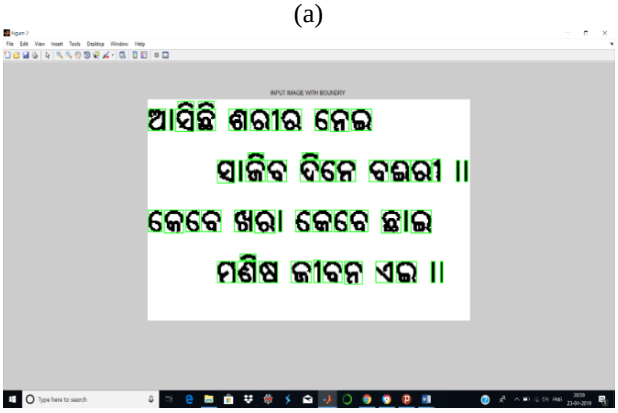
Word Segmentation

In segmentation of word a text by using a projection profile in vertical direction the line is scanned vertically. Words and characters of a text line square measure segmental by computing the valleys for vertical projection profile obtained by investigating the point in which black point pixels present in every column. If there exists a minimum value within the profile of k_1 (threshold value), consecutive 0's then that is thought of as a word boundary. We have a tendency to take into the centre zone of the word, to phase every word into individual characters.

Once again, this zone for the vertical projection profile is taken into account. The boundary between two characters doesn't contain black picture element marks of a column. The vertical projection profile in two characters can have peaks at text positions.



(a)

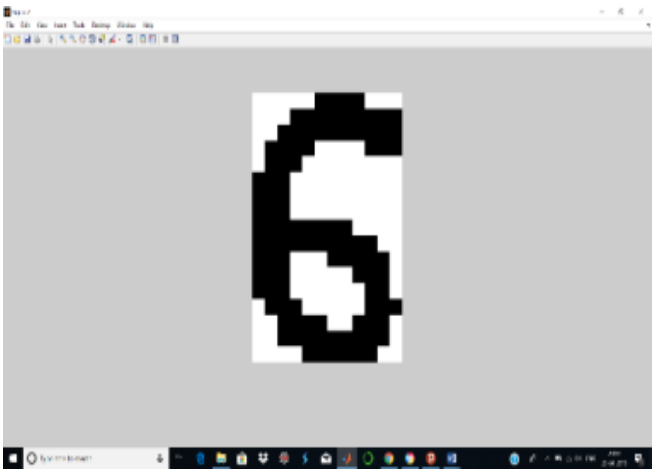


(b)

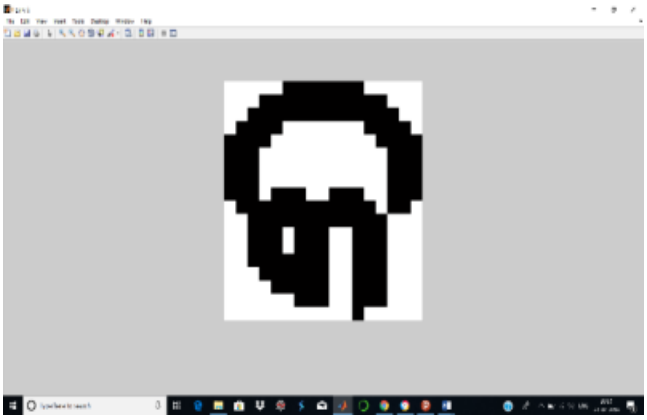
Fig. 6: Word and Character Segmented Image

Character Segmentation

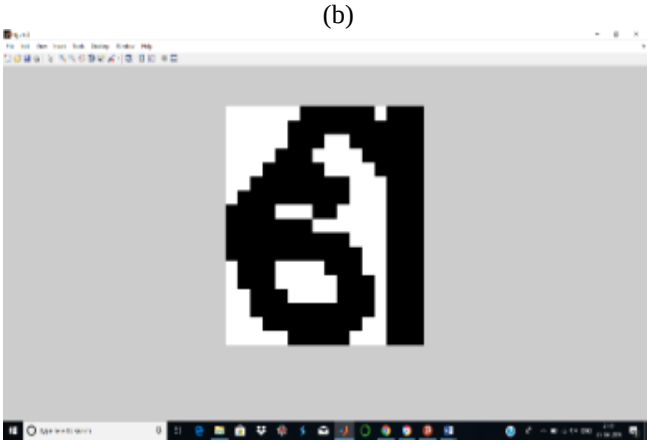
In character segmentation before browsing the method each and every of the line is segmental. For any operation its characters are individually separated, and every line is segmental.



(a)



(b)



(c)

Fig. 7: Individual Character Segmentation

IV. HOPFIELD MODEL

To recognize Odia Characters, we used Hopfield network. A Hopfield network may be a type of repeated artificial neural networks with Anderson 1977, Kohonen 1977 however given by John Hopfield in 1982, however delineated earlier by very little in 1974. Once a feedback is coming into its network, stability of it can't be bonded. The Hopfield network additionally has the advantage, as compared with different models, using electronic or optical devices for an easy technical implementation, Hopfield networks model some of the properties are investigated since 1982 mistreatment the theoretical tools of statistical mechanics.

At the same time, Synchronous networks need the computing parts to gauge the inputs and cipher as the outputs; asynchronous networks to cipher excitation choose a unit randomly. To Enhance the auto association a method is used (which means that the input and output should be same) to make one layer with step-functions a repeated network of neurons shown. However the structure may be a single layer as a feedback model though Hopfield network may build it behave sort of a multilayer.

A. *Discrete Hopfield Network*

Using discrete Hopfield neural network, we can represent every neuron with binary value state as; $V_m = \{1,0\}$. Represent the network state containing N number of neurons by its vector form as,

$$V = [V_1, V_2, \ldots V_m \ldots V_N]^T \quad (1)$$

In the network each and every neuron interconnected with all other neurons to form fully-connected network. The weight between neuron m and neuron n denoted by W_{mn} and its weight matrix can be given by

$$W = \{w_{mn}\} \tag{2}$$

Due to presence of cycles, the computation is dynamic in nature and it is associated with discrete variable. Let at time step t_1 each neuron updates its own state after receiving inputs from other neurons. The next state of neuron m can be represented by a function which depends upon current state only. For updation we have to use the equation as

$$V_m(t_1+1) = \sigma\left(\sum_{n=1}^{N} w_{mn} V_n(t_1)\right) \tag{3}$$

Where σ denote the sign function. By using energy function, we can converge the desired output as:

$$E = -1/2\left(\sum_{m=1}^{N}\sum_{n=1}^{N} w_{mn} V_m V_n\right) \tag{4}$$

The energy function E is bounded because state V is bounded. Now to update V_m, we have to calculate the change in energy function E. Take the part of energy function E which contains V_m as:

$$\begin{aligned}\Delta E &= -\Delta V_m\left(\sum_{n\neq i}^{N} w_{mn} V_n\right)\\ &= 2V_m\left(\sum_{n=1}^{N} w_{mn} V_n\right)\\ &= 2V_m\left(\sum_{n=1}^{N} w_{mn} V_n\right) - 2w_{mn}\end{aligned} \tag{5}$$

B. *Hebbian Learning Rule*

For storing the state S as $\{S_m\}$ in the network, we have to minimise the energy function E as:

$$E = -1/2N\left(\sum_{m} S_m V_m\right)^2 \tag{6}$$

The energy function E is minimum at state $S = V$. By standardizing the above equation, we get

$$\begin{aligned}E &= -1/2N\left(\sum_{m} S_m V_m\right)\left(\sum_{n} S_n V_n\right)\\ &= -1/2\sum_{mn}\left(\frac{1}{N} S_m S_n\right) V_m V_n\end{aligned} \tag{7}$$

So, for storing the S we need the weight matrix as:

$$W = 1/N(S_m S_n) \tag{8}$$

To store multiple patterns, S^p the rule can be given by

$$w_{mn} = (1/N)\sum_{P} S_m^p S_n^p \tag{9}$$

C. *Continuous Hopfield Network*

For discrete Hopfield model the equation is

$$V(t_1+1) \leftarrow V(t_1) \tag{10}$$

For continuous Hopfield model the equation is

$$dV/dt_1 = f(V) \tag{12}$$

$$\frac{du_m}{dt_1} = -u_m + \sum_{n=1}^{N} w_{mn} V_n + I_m \tag{13}$$

$V_m = g(\lambda u_m) = \tan\ h(\lambda u_m)$.

Lyapunov or "Energy" Function:

$$E = -\frac{1}{2}\sum_{m=1}^{N}\sum_{n=1}^{N} w_{mn} V_m V_n + \sum_{m=1}^{N}\int_0^V g^{-1}(V)\, dv - \sum_{m=1}^{N} I_m V_m \tag{14}$$

Consider,

$$\begin{aligned}\frac{dE}{dt_1} &= -\sum_{m=1}^{N}\left(\sum_{n=1}^{N} w_{mn} V_n - u_m + I_m\right)\frac{dV_m}{dt_1}\\ &= -\sum_{m=1}^{N}\frac{du_m}{dt_1}\frac{dV_m}{dt_1} = -\sum_{m=1}^{N} g'(u_m)\left(\frac{du_m}{dt_1}\right)^2 \le 0\end{aligned} \tag{15}$$

Hence the value of energy function E is monotonousness with time t_1. There are two different type of continuous Hopfield model.

System with Single Neuron:

Dynamics of a single neuron in the continuous Hopfield network may be given as:

$$\frac{du}{dt_1} = -u + wg(\lambda u) \tag{16}$$

By taking $I_m = 0$ the convergence value:

$$\frac{du}{dt_1} = 0 \text{ or } u = w\tanh(\lambda u) \tag{17}$$

Then the solution exists at the intersection of points $y = V$ and $y = w\tanh(\lambda u)$. Using the value of λ we can get the number of intersection. If $\lambda > 1$ then we get multiple point of intersection where as if $\lambda < 0$ then only one intersection point can be found.

For $\lambda > 1$: we can get three intersection points called them $V_{POS}, V_{NEG}, V_{ORIGIN}$. Any stationary point can be consider as stable, if

$$\frac{d^2u}{dt_1} < 0;\ \frac{d^2u}{dt_1} = -1 + w\lambda g'(\lambda u) \tag{18}$$

Therefore, $\frac{d^2u}{dt_1} < 0$, When the slope of the sigmoid function is less than 1, which is true for both $V+$, $V-$ but not true at the origin. Therefore, V_{POS}, V_{NEG} are stable but the origin V_{ORIGIN} is unstable.

System with Two Neurons:

Let us assume a system with two neurons along with its weight matrix as: $W = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$, By taking the external input I_m as zero, we get

$$\begin{aligned}\frac{du_1}{dt_1} &= -u_1 + w_{11}V_1 + w_{12}V_2\\ \frac{du_2}{dt_1} &= -u_2 + w_{21}V_1 + w_{22}V_2\end{aligned} \tag{19}$$

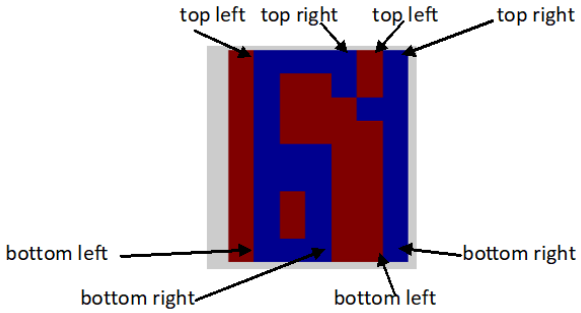
$V_1 = \tanh\ (\lambda u_1)$ and $V_2 = \tanh\ (\lambda u_2)$, $\lambda = 2$

V. FEATURE EXTRACTION

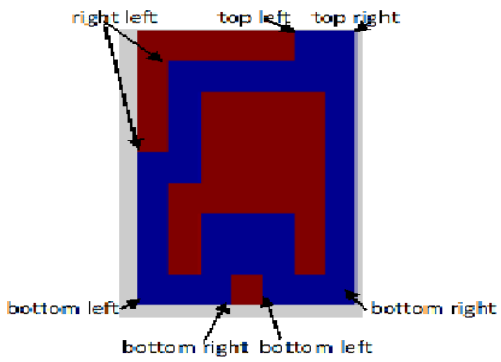
After character segmentation, options from every character are extracted that is within the sort of matrix zone based mostly and region based options embody the quantity and position of vertical and horizontal lines. The options used embody existence of holes and their variety, with open and close parts reference to the character bounding box of the numerals, quantitative relation number of holes to the height of character. To identify Odia character based on structural are terribly complicated. There are number of characters having similar shaped. So along with structural features we also consider moment based feature vectors for recognition. There are two steps in building a classifier: training and testing. Zone primarily based options are of various sorts i.e. upper part zone, middle part zone and lower part zone.

VI. ZONING

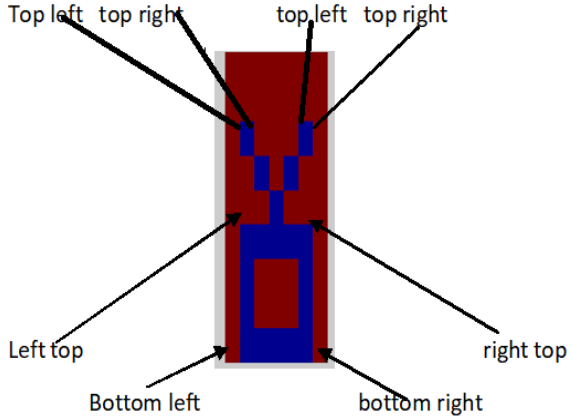
In Segmentation every line the zones are square measure known by detection the bottom and base lines. We tend to contemplate a group of lines in vertical and horizontal direction passing around the topmost and bottommost points of the interconnected parts of a line containing text.



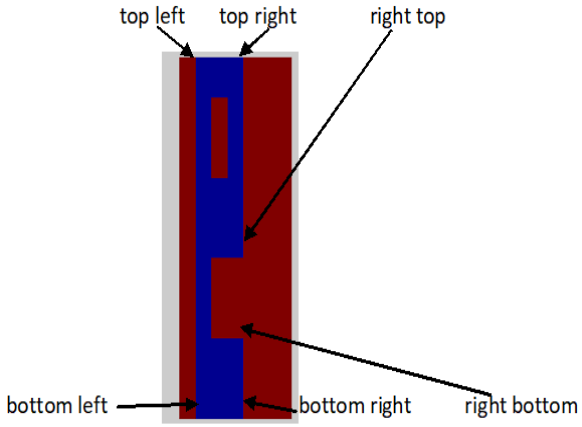
(a)



(b)



(c)



(d)

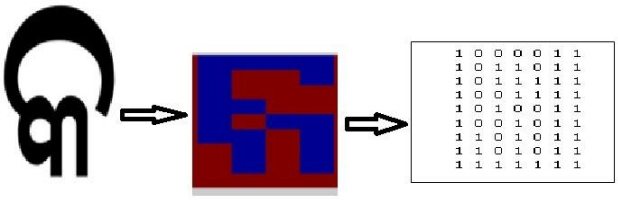
Fig.9: Different Zoning Features

Feature extraction includes the number of holes, vertical and horizontal lines and open and close components.

Table 1: Implementation for Feature Extraction

Input Image	No. Of Holes	Vertical	Horizontal	Open	Close
Ka	1	0	0	1	
Kha	1	1	0	1	
Ga	1	1	0	1	
Gha	0	1	0		0
Eka	1	0	0		0
Dui	1	0	0		0
Thin	1	2	0	1	
Chari	1	0	0		0
Atha	0	1	1	1	
Na	1	0	0		0

The matrix form for different character and numerals are given as



(a)

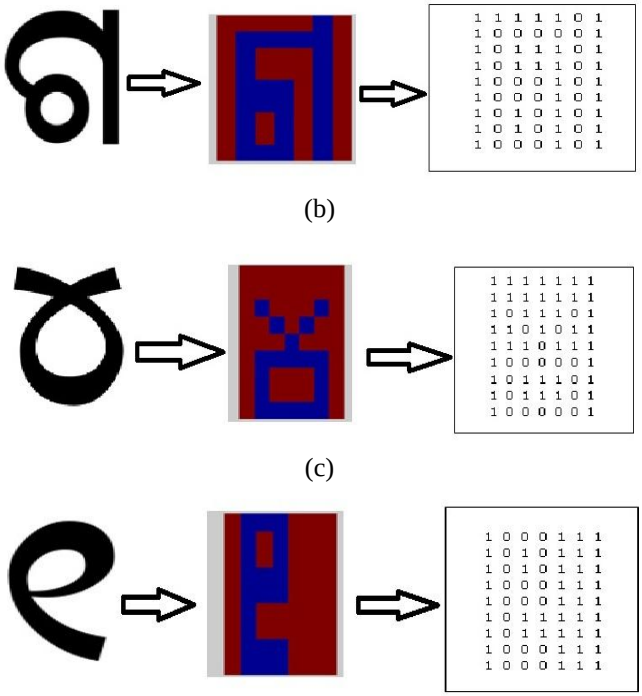


Fig. 10 Equivalent Characters and its matrix form

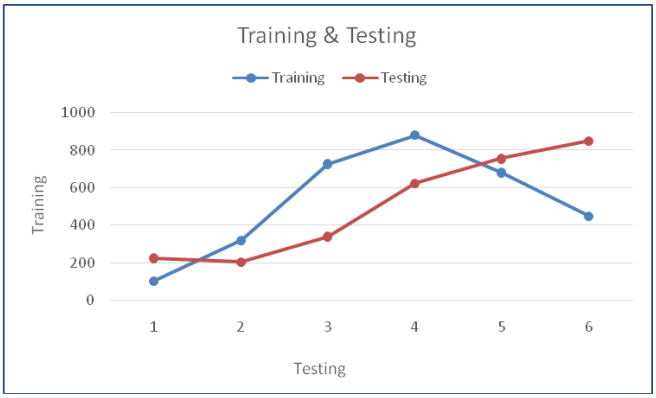
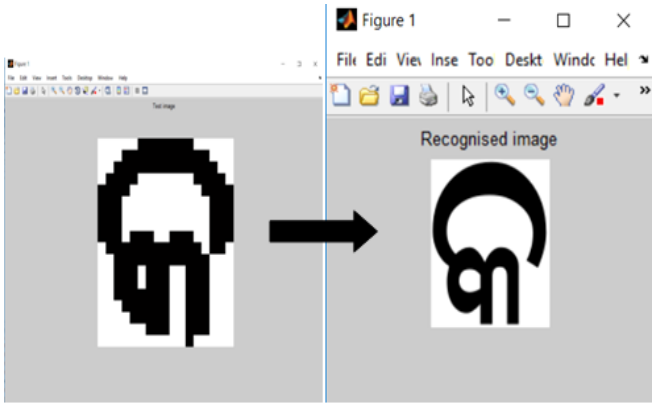
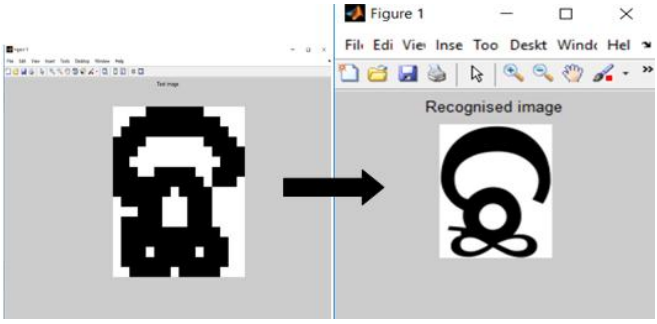


Fig 11: Implementation of Training and Testing for Different Iinput Parameters.

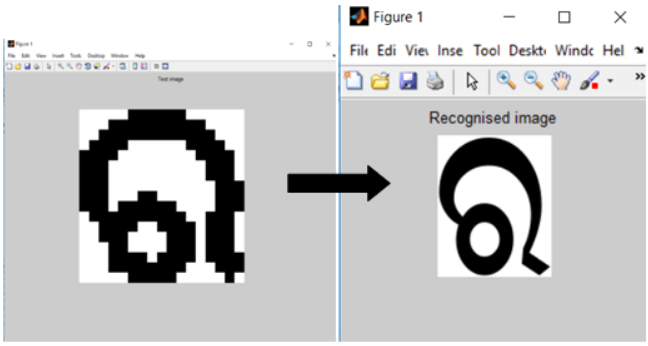
In this Hopfield neural network two classification for characters & numerals using the test image as input and recognised the same image shown below in the figures.



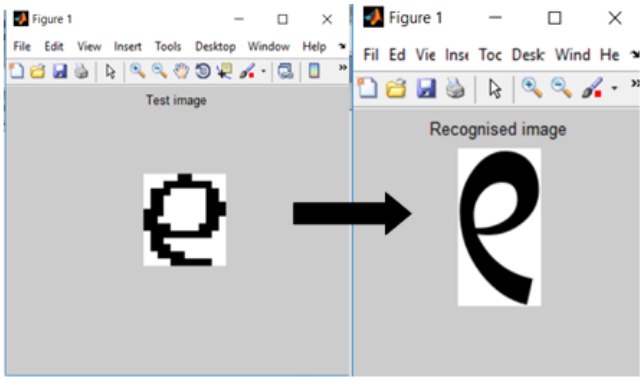
(a)



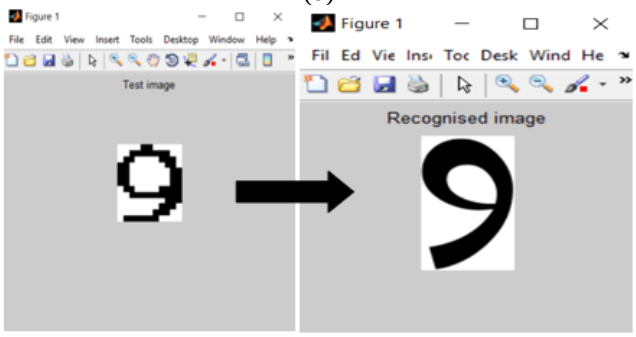
(b)



(c)



(d)



(e)

Fig. 12: Recognised Characters and Numerals

VII. RESULTS AND DISCUSSION

In this research work we focused on recognizing Odia characters and numerals using Hopfield neural network. We have implemented 10000 data sets with each input 200 times on MATLAB 2014a on image processing toolbox. The experimental result to measure the performance for recognizing Odia characters and numerals are given in table-3 and table-4.

200 characters were randomly taken from our dataset which are implemented on Hopfield neural network. We convert each character into its matrix form based on its structural feature and moment-based feature parameter. We have taken different extreme points like top of the left, top of the right, bottom of the left, bottom of the right etc and we convert all those feature to vector form. The characters are divided into different class for easier recognition. For the testing purpose a sample of each letters and numbers are collected from scanned image by high resolution camera and other scanning devices. There are some similar shaped characters which caused misclassification is given in table-2.

Table-2: Collection of Similar Types of Odia Characters

No. of Characters	Characters	Similar Characters
1	ଉ	ଉ
2	କ	ଜ
3	ଖ	ଗ
4	ତ	ଢ, ଡ
5	ପ	ଫ, ଯ, ୟ
6	ଚ	ଛ,ର , ଟ
7	ଦ	ବ ,ହ
8	ଳ	ଲ

Table-3: Individual Character not Recognised from Some Inputs

Words	Individual Characters	Not Recognised
କଟକ	କ,ଟ,କ	0
ବରଗଛ	ବ,ର,ଗ,ଛ	0
ଶିକ୍ଷାନୁଷ୍ଠାନ	ଶି,କ୍ଷା,ନୁ,ଷ,ନ	2
ଟଗର	ଟ,ଗ,ର	0
ଭୁବନଶ୍ୱର	ଭୁ,ବ,ନ,ଶ,ର	1
ଚାଟଶାଳି	ଚା,ଟ,ଶା,ଳି	0
ଭାରତବାସୀ	ଭା,ର,ତ,ବା,ସୀ	0
ବାରବାଟୀ	ବା,ର,ବା,ଟୀ	0
ବୃହସ୍ପତି	ବ,ହ,ସ,ତି	2
ଧର୍ମପଦ	ଧ,ମ,ପ,ଦ	1

Table-4: Implementing Result of Correctly Recognised and Misclassified Characters and Numerals

Input Characters /Numerals	No. of Samples	Correctly Recognised	Misclassified	Recognised Rate (%)	Misclassified Rate (%)
ଉ	200	194	6	97%	3%
ଖ	200	192	8	96%	4%
ଗ	200	196	4	98%	2%
ଘ	200	192	8	96%	4%
ଙ	200	185	15	92%	7%
ଚ	200	197	3	98%	1%
ଛ	200	195	5	97%	2%
ଜ	200	196	4	98%	2%
ଝ	200	194	6	97%	3%
ଞ	200	186	14	93%	7%
୧	200	195	5	97%	2%
୨	200	194	6	97%	3%
୩	200	192	8	96%	4%
୪	200	196	4	98%	2%
୫	200	193	7	96.7%	3.3%
				Overall Rate-96%	Overall Rate-3%

VIII. CONCLUSION AND FUTURE DIRECTION

In the proposed research work an optimistic OCR is developed to recognize Odia characters and numbers taking the help of Hopfield neural network with different structural and moment based feature. The overall recognition accuracy for our model is 96.7%. It will be little bit higher if we properly recognize similar shaped character, better noise removal procedure and avoiding miscalculation of feature. In future work we extend our work on different fonts, size and script of Odia character. We also have aim to work on developing a complete OCR system for Odia language and implementing it on natural language processing system.

REFERENCES

1. B.B. Chaudhuri, U. Pal, M. Mitra "Automatic Recognition of Printed Oriya Script", *Proceedings of Sixth International Conference on Document Analysis and Recognition*, IEEE, 2001, pp. 795-799.
2. H. N. Bebartta S. Mohanty, "A novel approach for Bilingual script Identification and Recognition in a printed Document", International Journal og Image Processing, *(IJIP)*, Vol.4, Issue 2, pp.175-190.
3. S. Mishra, D. Nanda , S. Mohanty, "Oriya Character Recognition using Neural Networks ", *International Journal of Computer & Communication Technology*, vol2, Issue 2, pp.88-92.
4. K. Roy, T. Pal, U. Pal , F. Kimura, "Oriya handwritten numeral recognition system," *Eighth International Conference on Document Analysis and Recognition (ICDAR'05)*, Seoul, South Korea, 2005, pp. 770-774 Vol. 2
5. D. Senapati, S. Rout ,M. Nayak, "A Novel Approach to Text Line and word Segmentation on Odia Printed Documents" *Proceedings of IEEE Third International Conference on Computing Communication and Networking Technologies 2012*, 6th - 28th July 2012, pp.1- 6.
6. D. Basa , S. Meher "Handwritten Odia Character Recognition" *National Conference on Recent Advances in Microwave Tubes, Devices and Communication Systems*, March 4-5, 2011.
7. RK Mohapatra, B. Majhi, S. K. Jena "Printed odia digit recognition using finite automaton" *3rd International Conference on Advanced Computing, Networking and Informatics, Springer*, 2016 vol.1.

8. M. Nayak, A.K. Nayak, "Odia Conjuct Character Recognition using Evolutionary Algorithm" *Asian Journal of Applied Sciences (ISSN:2321-0893,)* Volume 03 Issue 04,August 2015, pp. 789-798.
9. S. Choudhury, T. Patnaik, S.Singh "An efficient algorithm for characters recognition of printed oriya script" *Advances in Computer Science and Information Technology*, ISSN:2393-9915, volume2, number7, April-June 2015 pages:77-80.
10. S. Chanda, K. Franke and U. Pal, "Text Independent Writer Identification for Oriya Script," *10th IAPR International Workshop on Document Analysis Systems*, Gold Cost, QLD, 2012, pp. 369-373.
11. N. Tripathy and U. Pal, "Handwriting segmentation of unconstrained Oriya text," *Ninth International Workshop on Frontiers in Handwriting Recognition*, Kokubunji, Tokyo, Japan, 2004, pp. 306-311
12. P. K. Sarangi, A.K. Sahoo, P. Ahmed, "Recognition of Isolated Handwritten Oriya Numerals using Hopfield Neural Network," *International Journal of Computer Applications* , 40(8) ,February2012, pp 37-42.
13. W. Widodo, R. A. Priambodo, B. P. Adhi "Java character recognition using Hopfield network". *IOP Conference Series: Materials Science and Engineering*, Volume 434, Number 1.
14. H.Y. Liao, J. Huang, S. Huang "Stroke based handwritten Chinese character recognition using neural networks", *Pattern Recognition Letters* Oct 1993 pp.:833-840.
15. P. Solanki, M. Bhatt "Printed Gujurati script OCR using Hopfield Neural network*", International Journal of Computer Applications (IJCA)* Vol. 69 no 13,may 2013 pp. 33- 37.
16. M.Shalini ,B.Indira "Implementing of Hindi word recognition and classification system Using Artificial neural network", *International Journal of Pure and applied mathematics*,Vol.117 no.15 2017,pages:455-464.
17. B.B Chaudhuri and U.Pal, " Complete printed Bangla OCR system" *Pattern Recognition* Vol. 31, Issue 5, 1 Mar 1998, pp. 531-549
18. O. P. Jena, S. K. Pradhan, P. K. Biswal and S. Nayak, "Implementation of linear discriminant analysis for Odia numeral recognition", *Internatioanl conference on Information Technology (ICIT)*, 2018, pp. 166-171.

AUTHORS PROFILE

Om Prakash Jena obtained his M.Tech (CS) from Utkal University, Odisha , India in 2013 and Continuing his PhD degree in the same University. He was qualified UGC-NET JRF in Dec. 2012. Currently he is working as Assistant Professor in the department of Computer Science, Ravenshaw University, Cuttack, India. He has 9 years of teaching and research experience. His research interest includes Pattern Recognition, Machine Learning, Natural Language Processing, Deep Learning, Soft Computing. He has published several papers in national, international journals and conference Proceedings.

Sateesh Kumar Pradhan is Professor at Utkal University, Bhubaneswar, Odisha. He earned his Ph.D in Computer Science from Utkal University. He has published more than 35 research articles in conference proceedings and journal. His current research interest includes Cloud Computing, Network Security, Computer Security and IT Forensics and Intrusion Detection.

Pradyut Kumar Biswal obtained his AMIE and M.Tech from Institution of Engineer's (India) and Visvesvaraya National Institute of Technology, Nagpur, India in 2000 and 2002 respectively. He joined the Ph.D. program in the Department of E&ECE, IIT Kharagpur as an institute scholar in 2007. He successfully completed his Ph.D. degree in 2012. Currently, he is positioned as an Assistant Professor in International Institute of Information Technology (IIIT), Bhubaneswar, India. He teaches Microprocessor, Digital Signal Processing, VLSI Design. He has a teaching experience of 8 years. His research interest includes Digital Image processing, Architecture design for image processing algorithms and FPGA implementations. Mr. Biswal is a Member of IEEE, USA and associate member of IEI (India). He has published several papers in international journals and conference Proceedings.

Alok Ranjan Tripathy positioned as an Assistant Professor in the Department of Computer Science, Ravenshaw University, Cuttack. He obtained his M.Tech and Ph.D in Computer Science from Utkal University. He is a life member of ISTE and Odisha Information Technology Society (OITS). His current research interest includes Algorithms, Pattern Recognition, Cloud Computing, Network Security and WSN.