Block-Based Neural Network for Automatic Number Plate Recognition

Deepti Sagar*, Maitreyee Dutta**

* M.E, Computer Science, NITTTR, Chandigarh
**Professor & Head, Department of Computer Science, NITTTR, Chandigarh.

Abstract- Automatic Number Plate Recognition (ANPR) system is highly accuracy-demanded application for car identification. This paper presents a new method of block-based ANPR system for recognition of Indian car license number plates. Since number plate guidelines are not strictly practiced in India and wide variations found on these plates in terms of font type, character size, screws/dots etc., it often becomes difficult to correctly identify the non-standard number plate characters. This proposed method works well with both standard and non-standard Indian number plate images taken under various illumination conditions. By using the block-based feature extraction process this method of recognition provides a high recognition rate of 98.2% and speed up the processing time of each character to 3.3ms when using a database of 3399 character images.

Index Terms*:Block-Based Character Recognition, Image acquisition, Image enhancement, Neural Networks,Segmentation.*

I. INTRODUCTION

Automatic Number Plate Recognition (ANPR) system is an image processing system, which lies under the computer vision field. It has been a special area of interest due to its many applications such as for traffic law enforcement; find stolen cars, parking lots and surveillances [4]. ANPR is used to identify vehicles by capturing license plates and recognize the characters. The software of recognition process generally composed of four main stages: 1) Image enhancement, 2) Segmentation, 3) Feature extraction and 4) Character recognition. This paper will discuss these stages in detail. A wide variety of techniques have been developed in the past, but most of them worked under restricted conditions and causes challenges in recognition task such as, projections and pixel connectivity are the most common methods for segmentation [1], [6], [7], [8]. There are also some paper proposed segmentation methods are using prior knowledge of characters [4], [12], character contour [14], combined features [11]. For the recognition of the characters, many classifiers can be used such as the most common used Artificial Neural Networks (ANN) is feed-forward ANN which has a simple architecture as compared to the other common pattern matching techniques like Self-Organizing neural network having problem with joined and missed characters, template matching which can recognize only single font, fixed size characters [1], [4], [9], [11]. Other methods like Normalized
Cross-Correlation (NCC) and Support Vector Machine (SVM) having high computational cost, HNN requires too much memory and fuzzy logic does not work well with bad quality images [13], [3], [2], [4]. The current methods of ANPR system worked accordingly to the guiding parameters of specific country traffic norms and standards [5]. Although, in India, number plate standards exists, but they are rarely practiced. As a result, wide variations are found in the number plates, in terms of font type, character size, screws/dots and location of the number plate, also many unnecessary characters are present on the number plate. Various other issues involved in the number plate recognition in terms of plate and environmental variations. The aim of this study is to develop a Block-Based ANPR system for recognition of Indian car license number plates by resolving these issues with non-standard number plates, to provide high recognition rate and to speed up the processing time as compared to the other ANPR system based on neural network in [13]. The proposed algorithm has been implemented and tested with a database of 3399 Indian binary character images using MATLAB.
The rest of this paper is organized as follows: Section II describes the proposed methodology used to develop an ANPR system. The MATLAB implementation and analysis of the results are presented in Section III. Section IV concludes the paper.

II. METHODOLOGY

The proposed Block-Based recognition system using neural network introduce a new method for segmentation and feature extraction process to extract the character features, which have a great effect on recognition process. By optimizing these two steps before recognition, the proposed system gives good results of recognition using feed-forward Artificial Neural Network. The proposed approach, use these basic concepts for each module as shown in the Figure 1: image pre-processing system and projection profiles for segmentation, block-based feature extraction using edge density calculations and neural network for recognition.

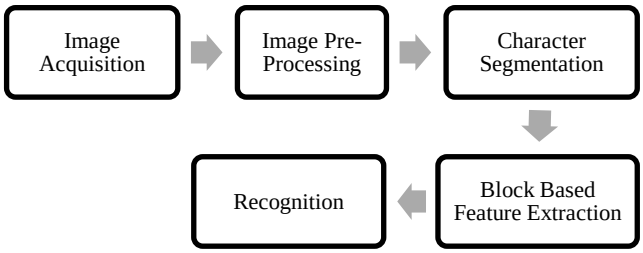


Figure 1: Modules of the Proposed System

Each module of the proposed ANPR system contains several processing steps and detailed description of each module is given based on its importance given in the proposed methodology of the proposed ANPR system.

A. Image Acquisition

The input to the proposed ANPR system is the original images of car number plates captured by average resolution camera of 14 Mega pixels which are cropped manually. The captured images are taken from 5-12 feet away from the vehicle mounted with standard high security Indian number plates and normal number plates.The two separate sets of 1000-cropped license plate images are then acquired in MATLAB for further processing of training and testing of ANN.

B. License Plate Image Pre-Processing

Figure 2 shows the basic block diagram of the pre-processing steps. The block shows different techniques that are performed for improving the image quality.

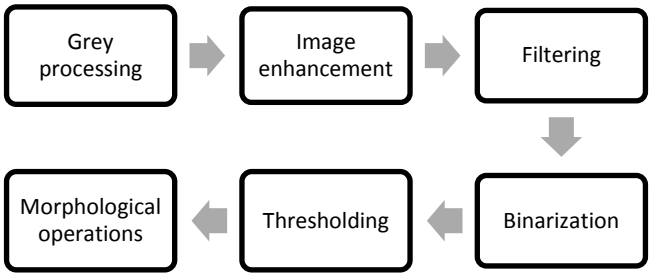


Figure 2: Steps for Image Pre-Processing

a. Converting RGB to Gray-Scale Images

Gray scale processing is a very important step in an image pre-processing; its results are the foundation of later steps. The true-color to gray-scale conversion is performed by [11]:

Gray = (0.299 x R) + (0.587 x G) + (0.114 x B) ----- (1)

Where Gray is the new pixel value and RGB are the red, green, and blue values of the original pixel.

b. Image Enhancement

The principle objective of the image enhancement is to process an image for a specific task so that the processed image is better viewed than the original image [1]. The technique of image pre-processing falls into image enhancement. Due to various limitations of the image extraction devices, images acquired by them are prone to errors like spatial and temporal limitations. The effect of all these limitations includes noise, bad illumination and blur in the acquired images. Image analysis required often pre-processing in which different filters are applied for removing the noise by preserving clinically important structures. This may help to improve the performance of subsequent tasks [6]. It typically consists of two tasks, noise removal and binarization. Simple spatial linear filter like mean filter that is easy to implement and used to remove impulsive noise is used for smoothing purposes in the proposed ANPR system.

a. Algorithm of Mean Filter

The algorithm of the mean filter is as follows:

Step 1: Select a 2D image $I_{(i,j)}$select two-dimensional window W of size 3*3. Assume that the pixel being processed is C (x,y).

Step 2: Compute W_{mean} the mean of the pixel values in window W using following equation:

$$I_{(i,j)} = \frac{\sum_{i=1}^{i=3} \sum_{j=1}^{j=3} I_{(i,j)}}{9} \text{---------- (2)}$$

Where, $i \neq 2$ and $j \neq 2$

Step 3: Replace the C (x,y) by W_{mean}.

Step 4: Repeat Steps 1 to 3 until all the pixels in the entire image are processed.

c. Binarization

The image of various grey level intensities are converted, into binary image with one representing white and zero represents black [11]. This is used for two purposes: highlighting characters and suppressing the background [1]. Binarization greatly affects the character segmentation and accuracy of character recognition [5]. The proposed method uses Otsu's method of binarization. This method is globally adopted which would increase processing speed as compare to the Niblack's Method. The size of the grayscale license plate image has M rows and N lines that define f(x,y) ($0 \leq x < M$, $0 \leq y < N$) as a grey pixel, so binarization can be expressed at any pixel if the value of the pixel f(x,y) > Th. It is converted into white (1) pixel else black (0), expressed by the following formula [8]:

$$f(x,y) = \begin{cases} 1, & if\ f(x,y) > Th \\ 0, & if\ f(x,y) \leq Th \end{cases} \text{------- (3)}$$

Th is the threshold and is computed as:

$$Th = A \times \sum_{i=0}^{m} \sum_{j=0}^{n} \frac{Gray\,(i,j)}{M \times N} \text{------- (4)}$$

Where, $Gray(i,j)$ is the gray value of pixel, M is the Height of the image and N is the width of image. The background of the license plate image determines the coefficient of A. If the background has little noise this coefficient A is large and vice-versa [8].

d. Morphological Operations

Somemorphologicaloperationsare performed on the binary imageconsists of three steps as shown in the Figure 3.

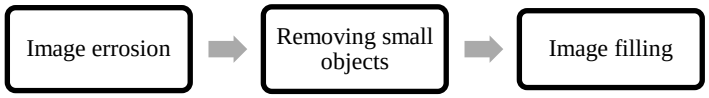


Figure 3:Steps for Morphological Operations

i. Image Erosion

Binary erosion is performed in which the binary objects i.e. characters and numbers in the candidate image that are combined with the unwanted small objects are eroded or shrinked slightly

by the small amount using structuring element (SE) of disk shape having diameter 2 for the proposed system. This step refines the binary image, which are further processed for other morphological operations to remove small objects and image filling on the image.

ii. Removing Small Objects and Image Filling

Along with the numbers and characters on the number plate, it also contains small lines and dots/screws in middle and upper part of the number plate region. These objects are considered as small regions in the candidate region, which creates problem for segmentation and recognition process. In this step, all those regions, which have pixels less than P-pixels are removed from the plate region. In this way, there will be only characters, numbers exist on the number plate, and all other small and unwanted objects are removed from the plate image.

C. Character Segmentation

To ease the process of identifying the characters, it is preferable to divide the extracted plate into different images, each containing one isolated character [10]. Segmentation is a step where plates elements i.e. characters and numbers are being extracted from the plate's background [11]. Segmentation of the characters of the number plate is done by extracting each connected components from the binary plate region, which are either 4-connected or 8-connected, and by default, it is 8-connected [11].The proposed segmentation process as shown in the Figure 4 is able to deal with the problem of characters like joined or broken characters, different character font types etc. as well as gives good results for bad quality images (blurred images), some degree of inclination, and dirty plates images to segment the characters from the number plate.

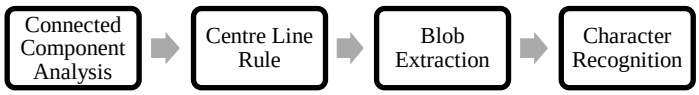


Figure 4: Segmentation Process

a. Connected-Component Analysis

Connected-Components are the individual components or objects in an image that are formed by pixel connectivity.After morphologicaloperations, label the each 8-connected-component in the binary license plate image with a unique number to make an indexed image. The components in the indexed image consists the large size components of blobs of characters and numbers with small line and rectangular components. This image is further analysed to find components of blobs from an indexed image.

b. Centre-Line Rule

This is an important step of segmentation process where main task is to extract only the characters and numbers of the number plate from the plate region and eliminate all other unwanted connected-components like unnecessary textual details mostly found at the bottom of the Indian number plates. This centre-line rule works on the principal that, for each connected component in the binary plate image this rule check, if the surface of character or number touch with the centre-line of the binary image where this centre-line is calculated by taking half the image of the row dimension as shown in Figure 5. Thus, the resulting indexed image contains only the required blobs from the number plate image.

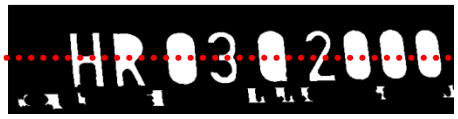


Figure 5: Centre Line Method

c. Blob Extraction

In order to extract each blob from the plate image, the image is processed vertically and horizontally to find the starting and ending positions of each blob using maximum and minimum parameters.

In this height and width of each blob is calculated by taking its minimum and maximum row and column dimensions. In this, the horizontal segmentation is first executed, in which top and bottom edges of the characters and numbers are found by examining the minimum and maximum value of row dimension of the characters, by adding and subtracting 10 pixels from both values (min and max) and using the left most boundaries of the binary plate image. Similarly,thevertical segmentation of the characters is based on finding the left and right boundaries of the characters by examining the minimum and maximum value of column dimension of the characters, as shown in Figure 6.

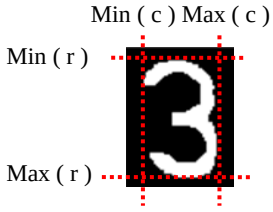


Figure 6: Starting and Ending Positions of Character

Finally, after analysing the height to width ratio of each blob only useful blobs of characters and numbers are extracted. After extracting each blob of the plate images from the database these extracted blobs are further processed for recognition process as shown in Figure 7 and these are re-sized to the universal font size 70 mm x 50 mm.

Figure 7: Blob Extraction

D. Block-Based Character Recognition

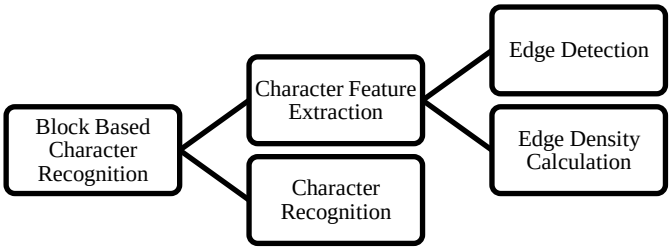


Figure 8: Block Based Character Recognition

It is a critical stage of ANPR system. After each character is segmented from the plate image, the final operation is the character recognition process. The block-based character recognition process consists of two parts: character feature extraction and character recognition as shown in Figure 8.

a. Character Feature Extraction.

The block-based feature extraction process is used in the proposed system to extract the specific features of each single segmented blob of the number plate rather than all the character pixels. It consists of two steps: edge detection and edge density calculation.

i. Edge Detection

Find edges of each blob for calculating edge density of each blob in the next step. The edge is composed by a set of joined pixels, which lies on the region of the blobs images. In this method, scan every horizontal line of the image, then get the value of zeroes and ones between white and black pixel for every line. In the up and down scanning of lines the change value of pixel at character region is more than other lines. The up and down horizontal scanning of lines will produce the up and down border of the character image. The boundary object image for each extracted blob can be created as shown in Figure 9 and is further used for edge density calculation.

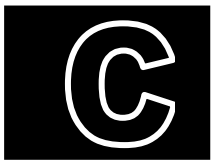


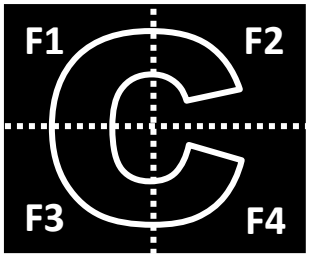
Figure 9: Boundary Object Image

ii. Edge density calculation

In this method, initially the character is divided into four equal blocks and four features are extracted from every block [15]. These features are formed by calculating edge density in each block. Then these features are used to obtained feature vector of each character, which is compared with feature vectors of all the stored templates. For each block k=1 to 4, the features vector of four features are { f1, f2, f3, f4 } where, f1 is the first feature which is formed by edge density calculation in first block using the following equation:

$$F(k) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} B_k(i,j)}{m*n} \quad \text{---------} \quad (5)$$

Where, $B_k(i,j)$ is the edge magnitude of each block, m and n are the dimensions of boundary object image.



Feature Vector of ('C')

= [0.2974, 0.2544, 0.3772, 0.3447]

Figure 10: Edge Density Calculation

Similarly, f2 is formed by edge density calculation in second block and so on as shown in the Figure 10. The value of the four window blocks represents the feature vector of that character as feature vector of 'C' character.

After calculating the edge density in each block the 2-D binary image is converted into 1-D feature vector for each character. The feature vector table of these values are used as inputs to the neural network for training purpose of the proposed system. Separate FVT of outputs is maintained for setting the target categories of zeroes and ones of the neural networks to classify the inputs patterns. For example, FVT of inputs for the given number plate as shown in the Figure 11 which is used for training of ANN are shown in Table 1.

Figure 11: License Plate Image

Char → / Feature (F) ↓	H	R	0	3	Q	2	0	0	0
F1	0.25	0.20	0.22	0.16	0.21	0.17	0.23	0.23	0.23
F2	0.24	0.18	0.25	0.30	0.24	0.30	0.24	0.24	0.24
F3	0.22	0.26	0.25	0.19	0.24	0.24	0.24	0.25	0.24
F4	0.26	0.31	0.24	0.30	0.27	0.22	0.24	0.24	0.24

Table 1: Feature Vector Table of Figure 11

b. *Character Recognition*

After feature extraction, feed-forward Artificial Neural Network is employed for character recognition at the second level. The proposed system gives more recognition accuracy; reduce the complexity of the network and increase the processing speed of recognition of characters.

i. Learning Mechanism

The two-layer feed-forward neural network used in the proposed system has simple architecture, which classifies the inputs to the set of target categories. In this mechanism, characters are taught to the neural network in a supervised manner. A character is presented to the system and is assigned a particular label. Several variant patterns of same character are taught to the neural network under the same label. During the training process, the input to the neural network is the 1-D input matrix of the character after feature extraction process. This set of input vectors are used to make feature vector tables of inputs, which are used for training purpose of the neural network. The neural network will get these inputs and outputs in a matrix form

and understand to which set of target categories that input character belongs. The set of target categories or outputs of the neural network are developed based on; in Indian number plate system, there are 26 letters and 9 numbers out of which the number plate contains the two letters, two numbers, a space followed by one or two letters and four further numbers. For each 36 characters and numbers, a unique code is provided that are used to make FVT of outputs. Simple two-layer feed-forward neural network architecture for the proposed system network has 4 inputs for each character and 36 outputs using 10 neurons in the hidden layer are shown in the Figure 12.

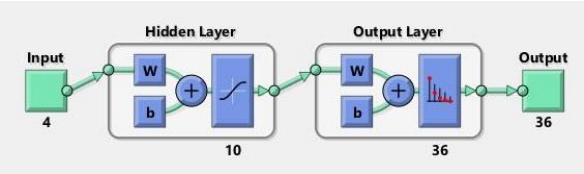


Figure 12: Two-Layered Feed Forward Network

When each candidate character taught to the neural network, it possesses a corresponding weight matrix. As the learning of the network progresses, this weight matrix is updated which is initialized to zero because of supervised training. The Scaled Conjugate Gradient (SCG) algorithm is used in this as a training method of the neural network, due to its advantages that it is a faster method and give better results than the traditional back propagation algorithm [13]. The network uses the following activation function for both hidden and output layers:

$$\tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + x^{-x}} \quad \text{------} \quad (6)$$

For the neural network, using more neurons in the hidden layer will give the more character recognition rate but this will results in higher number of multiplications, which significantly increase the scale of the neural network. Therefore, the developed system optimizes the numbers of neurons give a very large advantage of decreasing complexity. This network is trained using a separate set of 1000 license plate image samples.

III IMPLEMENTATION AND RESULTS

The presented work is to recognize the Indian vehicle number plates, over a two separate datasets of 1000 license plate images, used for training and testing the performance of the proposed system. Simulation in MATLAB environment-using PC equipped Intel® Core i3-3227U CPU and 2.00 GB of RAM running on Microsoft Windows 8, 64-bit Operating System, and x64-based processor.

Figure 13 shows an example of the output result of the testing images for testing this proposed method which can correctly predict the Indian number plate.

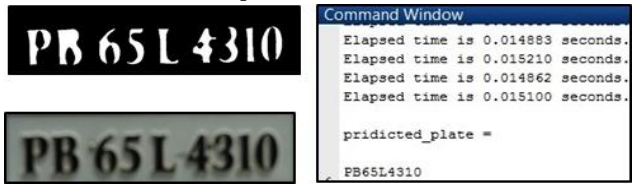


Figure 13: Predicted output result of testing image

The output results of some more sample images having shadow affects, ambiguous characters like 'B' & '8', '0' & 'O', 'V' & 'Y' etc, blurred images and broken character images is shown in the Figure 14.

Figure 14: Output results of testing images having ambiguities

Dataset of 1000 License Plate Images are divided into 3 sets. 1st set contains dataset of 3450 character images recognition rate of which is shown in Figure 15. 2nd set contains 6071 character images recognition rate of which is shown in Figure 16 & 3rd set contains 8699 character images recognition rate of which is shown in Figure 17.

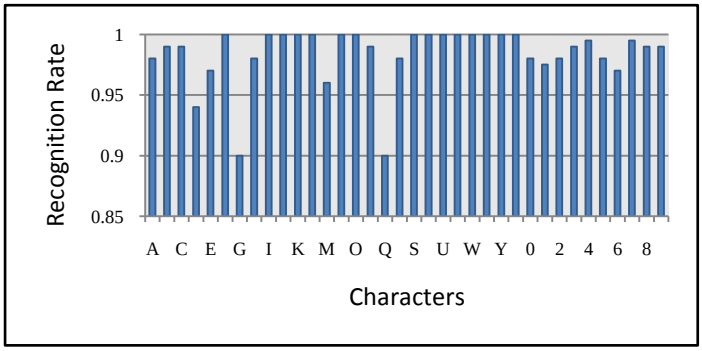


Figure 15: Character recognition rate of each character for 3450 character images

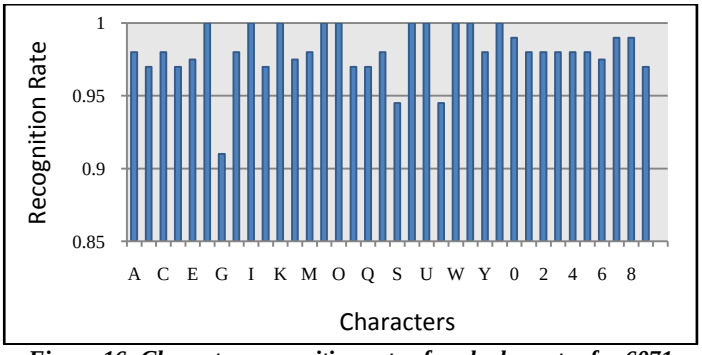


Figure 16: Character recognition rate of each character for 6071 character images

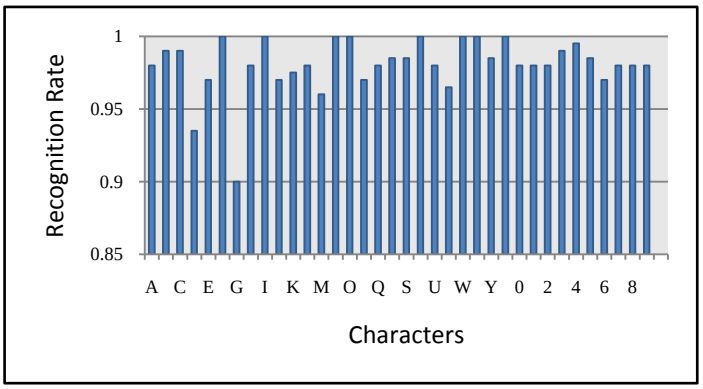


Figure 17: Character recognition rate of each character for 8699 character images

The proposed ANPR system achieved its promising results of giving high character recognition rate and high processing speed.Results of three datasets having different character images are given in Table 2.

Table 2: Table of results showing Recognition Rates of Proposed System

S.No	Character Images	Match Cases	Unmatch Cases	Recog. Rate	Process Time
1	3450 Characters	3399 Characters	51 Characters	98.521%	115.006 s
2	6071 Characters	5955 Characters	116 Characters	98.089%	256.451 s
3	8699 Characters	8532 Characters	167 Characters	98.080%	379.374 s
		Average Recognition Rate		**98.2%**	

The proposed system have higher character recognition rate of 98.2% as shown in the Table 4.2 as compared to the other neural network based systems in [13] which was 97.3% for 3700 character images. Total processing time of the proposed system is 115.006 s for 3399 characters, which comes out to be only 3.39 ms for each character, as compared to 8.4 ms of the existing system in [13].

IV CONCLUSION

In this paper, the ANPR system for Indian number plates is presented, as the proposed system consist of five main modules, in which by using morphological operations, the problems with the bad quality images are resolved and by optimizing the segmentation process, which gives a good results for segmentation of characters and numbers, having great impact on the recognition accuracy. Using block-based recognition process which extract only particular features of the characters and numbers, by processing only useful pixels of character images, instead of using pixels for the whole image. The presented system in this paper provides a good recognition accuracy of 98.2%, which is the main target of the proposed system This system also works well for joined or broken characters, dirty images, can handle some degree of inclination and as well as have good results with the bad quality images, which the other ANPR systems have problem with these images.

This system can be further improved to recognize different shapes of number plates like square plates and having plates with coloured backgrounds. More improvement in system can be, done in recognizing of shadow images and images have glare.

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AUTHORS

First Author – Deepti Sagar, M.E (CSE),National Institute of Technical Teachers Training and Research, Sector 26, Chandigarh.

E-mail: er.deeptisagar@gmail.com

Second Author – Dr. Maitreyee Dutta, Professor and Head, Department of Computer Science, National Institute of Technical Teachers Training and Research, Sector 26, Chandigarh.
E-mail: d_maitreyee@yahoo.co.in