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Automatic Car Number Plate Recognition

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***Abstract*— A traffic surveillance system includes detection of vehicles which involves the detection and identification of license plate numbers. This paper proposes an intelligent approach of detecting vehicular number plates automatically using three efficient algorithms namely Ant colony optimization (ACO) used in plate localization for identifying the edges, a character segmentation and extraction algorithm and a hierarchical combined classification method based on inductive learning and SVM for individual character recognition. Initially the performance of the Ant Colony Optimization algorithm is compared with the existing algorithms for edge detection namely Canny, Prewitt, Roberts, Mexican Hat and Sobel operators. The Ant Colony Optimization used in communication systems has certain limitations when used in edge detection like random initial ant position in the image and the heuristic information being highly dictated by transition probabilities. In this paper, modifications like assigning a well-defined initial ant position and making use of weights to calculate heuristic value which will provide additional information about transition probabilities are used to overcome the limitations. Further a character extraction and segmentation algorithm which uses the concept of Kohonen neural network to identify the position and dimensions of characters is presented along with a comparison with the existing Histogram and Connected Pixels approach. Finally an inductive learning based classification method is compared with the Support Vector Machine based classification method and a combined classification method which uses both inductive learning and Support Vector Machine based approach for character recognition is proposed. The proposed character recognition algorithm may be more efficient than the other two.**

***Index Terms*— Neural Networks, Edge Detection, Character Recognition**

I. Introduction

One of the most serious public health problems being recognized globally are road accidents. The problem is much more serious in our country where close to 5,00,000 road accidents caused nearly 1,46,000 deaths and left more than thrice that number injured. The growth rate of motorization in India is presently the highest. This accompanied by rapid urbanization and expansion of road networks has posed serious impacts on the levels of road safety. This has led to the demand of a system that can efficiently monitor and manage road mishaps. Conventional techniques of traffic monitoring using inductive loops, sensors etc. yield satisfactory results yet suffer from many shortcomings. They are expensive, extremely bulky, difficult to maintain and install. A typical traffic surveillance system involves the use of an efficient license plate recognition system. As the name suggests, it detects and identifies the license plate from the car image and then recognizes both the vehicle and owner as driver's fault is revealed to be the single most responsible factor for road accidents. This system finds application in toll collection, speed control and proper traffic management in busy streets.

A flow graph of license plate detector is as shown in Fig 1.

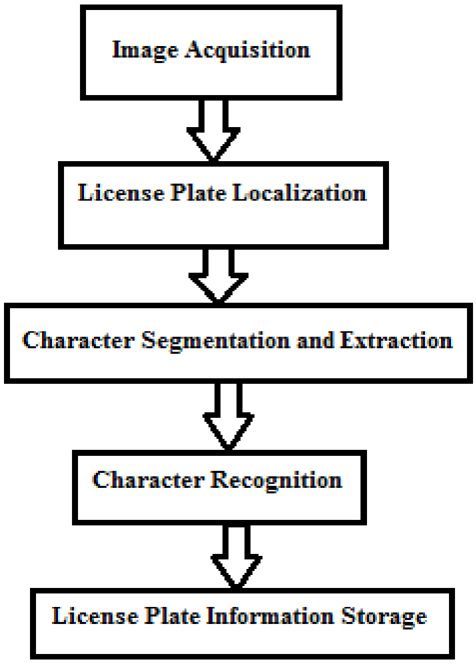

Figure 1: Flow Graph of License Plate Detector

There are mainly three challenges faced in license plate recognition. Firstly, the system has to deal with a variety of license plates as the format and style of numbers on the license plate varies from vehicle to vehicle in India. Secondly, the image quality taken by the camera may be affected by severe weather conditions, poor lighting conditions and low camera resolution. The third challenging issue to be addressed in license plate recognition is the large variations in camera perspective when license plate image is captured. The dataset used as input consists of noisy, blurred, night and day light license plate images.

The organization of the paper is as follows. The Section 2 provides a clear idea regarding the literature survey carried out. In Section 3, localization of license plate from the car image is discussed along with ACO as an edge detection algorithm. In Section 4, a character extraction and segmentation method is discussed which uses the concept of Kohonen neural network. In Section 5, the concepts of inductive learning and SVM approach are discussed. Finally a hierarchical combined classifier method for character recognition using both inductive learning and SVM approach is proposed.

II. Literature Survey

Shan Du, Mahmoud Ibrahim, Mohamed Shehata and Wael presented a review by categorizing different techniques used in Automatic License Plate Recognition (ALPR) according to the features these techniques used in each stage. The author suggests recognition of plates with different styles, multiple plates and recognizing characters with ambiguity as the future area of research in ALPR [10]. G. T. Shrivakshan and Dr. C. Chandrasekar presents a comparison of various edge detection techniques used in image processing [14]. [8] explains the behavior of real ants that can be used to solve several combinatorial problems. Ant System (AS) is proposed to be a valid approach to stochastic combinatorial optimization in [1]. The paper implements AS to solve various problems like Travelling Salesman Problem, Quadratic Assignment and Job-Shop Scheduling. [6] proposes an ACO based edge detection approach by exploiting Ant Colony System. The performance of this approach is proved to be better than that discussed in [7] which is obtained by exploiting Ant System. [2] proposes a weighted heuristic ACO algorithm. The proposed approach provides better accuracy by setting weights to the intensities of neighboring pixels. This is very well exploited by the ants which move continuously over the image.

Namrata Dave discussed various methodologies to segment a text based image at various levels of segmentation. The author concludes that the pixel counting approach is the most suitable to segment printed text whereas histogram approach is flexible for both handwritten and prited text but is computationally slow [15]. Sunitha Beevi K. and Sajeena A. proposes an algorithm which focuses on segmenting the characters of two rows license plate image [16]. [3] addresses the issue of inaccurate license plate location. The paper further provides a solution of extracting characters in such a situation. However presence of noise is seen to introduce errors in the extraction procedure. Lihong Zheng, Xiangjian He, Qiang Wu, Wenjing Jia, Bijan Samali and Marimuthu Palaniswami designed a two stage classifier based on Inductive Learning and SVM-based classification which can be used to recognize characters in real time applications [4]. L. Zheng X. He, Q. Wu and T. Hintz proposed a number recognition algorithm on Spiral Architecture which is a hexagonal image structure [5].

In [11] the concept of manipulating images is used to recognize number plates. The method proposed yielded a success rate of 98.73%. However the research was only limited to the recognition of Indian license plates with a minimum resolution of 640X480. Najeem Owamoyo, A. Alaba Fadele and Abimbola Abudu presented Automatic Number Plate recognition for the Nigerian vehicular plates in which character extraction and segmentation was done using Sobel edge mask and Connected Component Analysis (CCA) with accuracy of 80%. A SVM based character recognition system is implemented which yielded 79.84% success rate. Low success rate is mainly due to the impact of deep shadows and reflections on the characters. The author suggests designing of two SVMs for digits and characters to improve recognition accuracy [12]. In [13], an Artificial Neural Network based OCR algorithm for Automatic Number Plate Recognition (ANPR) application is proposed. The proposed approach meets the requirements of real time ANPR system by recognizing character image in 8.4 ms with a 97.3% success rate

For experimental testing, two performance metrics namely Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) are used [9]. PSNR is used as a quality measurement metric to measure the quality between original and reconstructed image. Higher the PSNR value, better the quality of the reconstructed image. PSNR is as defined in Eq. 1.

$$\mathrm{PNSR}=10\log_{10}\left[\frac{\mathrm{R}^2}{\mathrm{MSE}}\right]. \tag{1}$$

where R is the maximum possible pixel and MSE is the Mean Square Error. MSE means the cumulative squared error between the original image and reconstructed image. Lower the value of MSE, lower is the error present in the image so better is the quality of reconstructed image. The mean square error (MSE) between original and reconstructed image is defined by Eq. 2.

$$\mathrm{MSE}=\frac{1}{\mathrm{MN}}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\Big(a(m,n)-b(m,n)\Big)^2. \tag{2}$$

where a (m, n) and b (m, n) represent the original image and reconstructed image respectively and M, N are number of rows and columns in the input image respectively.

III. Edge Detection And License Plate Localization

A. Localization of License Plate from car image

The flow graph for license plate localization is as shown in Fig 2. The first step is to capture the input vehicle image by means of a camera. This image can be a blur, noisy, an image taken in daylight or at night. All these cases are taken into consideration. The basic aim of pre-processing stage is to improve the contrast and reduce the noise in the image which in turn enhances the processing. Thus visibility and quality of input image is improved. Various steps are included in pre-processing namely conversion of RGB to Gray scale image, Noise reduction by median filtering and Adaptive Histogram Equalization for contrast enhancement. Morphological Opening operation is performed on the adaptive contrast enhanced image by using a disc shaped structural element followed by image subtraction wherein the morphological opened image is subtracted from adaptive contrast enhanced gray scale image so that the number plate region gets highlighted.

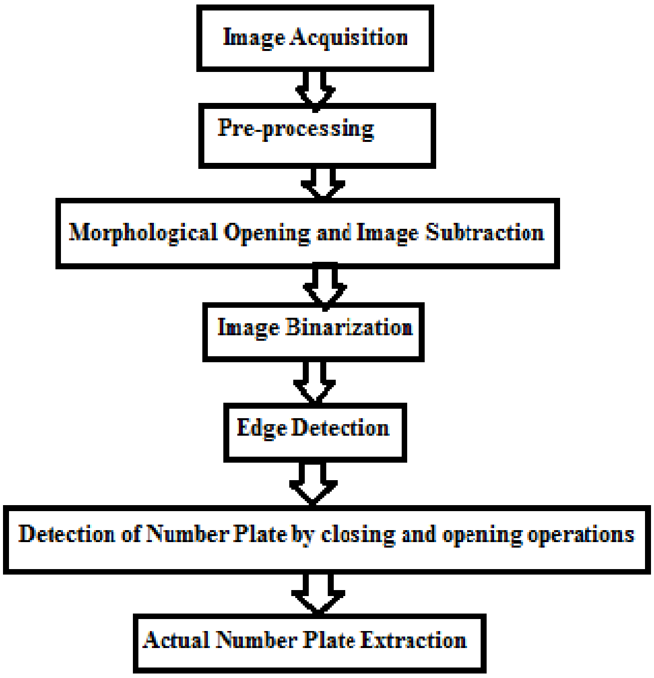

Figure 2: Flow Graph of License Plate Localization

Binarization results in the reduction of a digital image consisting of L+1 levels where $0 \le L \le 255$ to 2 values i.e. 255 and 0 where 255 represents white and 0 represents black. An iterative process is used to compute t_{opt} which is the threshold value in thresholding step. The values which are below t_{opt} are placed in Class 1 (value 0) and those above t_{opt} are placed in Class 2 (value 255). Otsu's method is used to compute t_{opt}. The binarized image is then converted to edge detected image by using the edge detection technique discussed in Section III B and III C. The next step includes closing operation which is obtained by performing dilation first and then followed by erosion. Let the matrix be called X (m, n) where (m, n) denotes the position of the pixel. A structural element B is another binary matrix but that of a smaller dimension as compared to X. The shape and size of the pixel's neighborhood is determined by matrix B. The transposed structural element of B is called $\widehat{B}$ [3]. Dilation is performed by first selecting a pixel (m, n) in the X matrix. The origin of $\widehat{B}$ is set at (m, n). The value of pixel (m, n) is changed to the maximum value of neighboring pixels as given by $\widehat{B}$. After this the unwanted portion of image is removed by using opening operation and finally erosion is carried out. This is done by selecting a pixel (m, n) in the X matrix. The origin of B is set at (m, n). The value of pixel (m, n) is changed to the minimum value of neighboring pixels as given by B. The main purpose of carrying out dilation is to disconnect the regions with low connectivity whereas erosion is done to reconnect regions that suffered disconnect due to dilation. Finally after the detection of number plate area that area is extracted from the image. The output for license plate localization is as shown in Fig 3.

Figure 3: Plate Localization. (a) Original Image (b) After applying plate localization

B. Ant Colony Optimization Algorithm (ACO)

ACO is a general-purpose heuristic algorithm which can be used to solve combinatorial optimization problems [1]. The inspiration behind the ACO algorithm is the fact that blind animals like ants could establish shortest paths from their colonies to feeding sources and back. In fact researches on the real behavior of ants have greatly influenced this algorithm. The only difference is that the agents in this algorithm are artificial ants with some special features such as these artificial ants will have some memory, will not be blind and will live in an environment with discretized time domain.

In an ACO algorithm, ants move through images which are assumed to be consisting of nodes and edges. The transition probabilities control the movement of ants. Thus these probabilities will decide whether an ant will move from one node to another. The heuristic and pheromone information are two major parameters that influenced transition probabilities [2].

The probability of an ant moving from node i to node j is given by Eq. 3.

$$P(i,j)= \frac{\tau(i,j)^{\alpha}\ \eta(i,j)^{\beta}}{\sum \tau(i,j)^{\alpha}\ \eta(i,j)^{\beta}}. \tag{3}$$

where τ(i, j) is the amount of pheromone on edge (i , j)
η(i, j) is the desirability factor of edge (i , j)
$\propto$ is a parameter that controls $\tau(i,j)$
β is a parameter to control the influence of $\eta(i,j)$

The desirability factor η(i, j) is given by Eq.4.

$$\eta(i,j) = 1/d(i,j). \tag{4}$$

where d(i, j) is the Euclidean distance between i and j.

Equation 5 gives the local pheromone update

$$\tau(i,j)=(1-\varphi).\tau(i,j)+\varphi.\tau o. \tag{5}$$

where $\varphi \in [0\ 1]$ is the pheromone delay coefficient
τo is the initial value of pheromone

The global pheromone update is given by Eq. 6.

$$\tau(i,j)=(1-\rho).\tau(i,j)+ \sum_{k=1}^{m} \Delta\tau(i,j)^{k}. \tag{6}$$

where ρ is the evaporation rate
m is the number of ants
$\Delta\tau(i,j)^k$ is pheromone quantity laid on edge (i, j) by the k^{th} ant.

$$\Delta\tau(i,j)^k = \begin{cases} 1/L_k & \text{if ant k travels on edge (i, j)} \\ 0 & \text{otherwise} \end{cases}$$

where Lk is the tour length of the k^{th} ant.

Figure 4 shows the results of Ant Colony Optimization when used for edge detection.

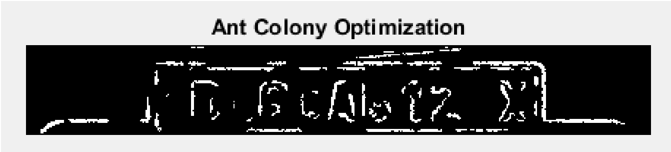

Figure 4: Result for ACO Edge Operator.

C. Modified Ant Colony Optimization (MACO)

The modified ACO has two changes as compared to the existing ACO discussed in section III B. Suppose K ants are used to find the optimal solution in a problem space of M1 × M2 nodes. Firstly, weights are used for calculating the heuristic value which is used to determine the probability using which ants will move from one pixel to another [2].

The heuristic value at pixel (i, j) is given by Eq. 7.

$$\eta(i,j) = \frac{Vc(I(i,j))}{Vmax}. \quad (7)$$

where V max = maximum intensity variation in the image

Vc(I(i, j)) = function that operates on the local group of pixels around the pixel (i, j)

Secondly, the initial pheromone matrix is assigned by an initial value of Eq. 8.

$$1/M1M2. \quad (8)$$

Figure 5 shows the results of the Ant Colony Optimization algorithm with the discussed modifications.

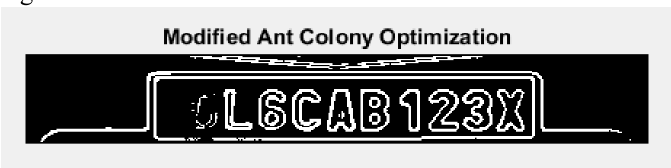

Figure 5: Result for Modified ACO Edge Operator.

TABLE I. COMPARISON OF EDGE DETECTION ALGORITHMS IN TERMS OF MSE

Edge Detection	Blur	Shadow	Night Light	Day Light	Noisy
Sobel Edge Detection	135.88	128.96	174.36	150.6	149.9
Prewitt Edge Detection	135.80	128.89	174.42	151.1	150.3
Roberts Edge Detection	135.40	129.65	174.84	154.2	153.5
Canny Edge Detection	131.03	124.26	170.41	141.1	140.4
Mexican Hat Edge Detection	134.31	115.43	164.31	127.7	126.7
ACO Edge Detection	150.78	130.67	190.67	166.98	179.9
MACO Edge Detection	126.77	115.20	163.12	122.21	126.2

The modified ACO and the existing ACO are compared with the conventional methods of edge detection namely Robert, Canny, Prewitt, Sobel and Mexican Hat edge detectors in terms of MSE and PSNR are shown in Table I and Table II.

TABLE II. COMPARISON OF EDGE DETECTION ALGORITHMS IN TERMS OF PSNR

Edge Detection	Blur	Shadow	Night Light	Day Light	Noisy
Sobel Edge Detection	4.171	4.586	3.168	3.762	3.779
Prewitt Edge Detection	4.172	4.588	3.167	3.747	3.765
Roberts Edge Detection	4.174	4.575	3.155	3.671	3.686
Canny Edge Detection	4.327	4.729	3.260	4.037	4.055
Mexican Hat Edge Detection	4.211	5.092	3.418	4.506	4.510
ACO Edge Detection	3.552	2.898	2.778	2.66	2.45
MACO Edge Detection	4.467	5.132	4.889	4.982	4.533

IV. Character Extraction and Segmentation Algorithm

This module deals with the segmentation of license plate into constituent parts thereby obtaining individual characters. Once the region occupied by the license plate with respect to the car image is obtained from the algorithm discussed in Section III, Kohonen neural networks is used to identify the location and dimensions of individual characters by similarity [3]. The section focuses on identifying the region occupied by the character. The proposed character segmentation and extraction algorithm is divided into two phases.

- Connected Component Analysis (CCA)
- Kohonen Neural Network

Connected Component labelling is used to group pixels of an image into different components depending upon its pixel connectivity. The different objects in the license plate image obtained from Section III A are labelled using CCA with 8 point connectivity. These labelled objects include noise, undesired objects as well as the characters to be segmented. Figure 6 shows the results obtained after the CCA phase. The red rectangle shows the different connected objects detected in the license plate image. The length and width of this rectangle is then used as training pattern for Kohonen neural networks. The Kohonen neural network then classifies the data into two classes.

- Class 1: The region occupied by the rectangle is a character.
- Class 2: The region occupied by the rectangle is not a character.

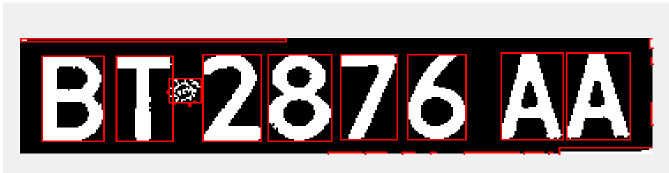

Figure 6: Red rectangles obtained from CCA

The Kohonen neural network consists of two models namely- Learning Vector Quantization (LVQ) model and Self

Organization Map (SOM) model [3]. The LVQ model is one dimensional whereas the SOM model can either be two or three dimensional. The LVQ model is used in this study. There are two layers present in LVQ neural network. The input vectors are mapped into clusters by the first layer. During the training phase, the network forms these clusters. Groups of first layer clusters are merged into final classes by the second layer. These final classes are defined by target data. The number of input neurons N is 50. The input training patterns are defined as points $\{w^k, h^k\}$ in plane where w^k and h^k represents the width and height of the rectangle corresponding to the k^{th} image. The w^k and h^k are normalized as given by Eq. 9 and Eq. 10. A total number of M=550 input training samples are used to train the neural network.

$$wk = \frac{wk - \mu w}{wmax - wmin} . \quad (9)$$

$$hk = \frac{hk - \mu h}{hmax - hmin} . \quad (10)$$

where $\mu w = \frac{\sum_{k=1}^{M} wk}{M}$ and $\mu h = \frac{\sum_{k=1}^{M} hk}{M}$.

The confusion matrix and the performance plot are shown in Fig. 7 and Fig. 8 respectively.

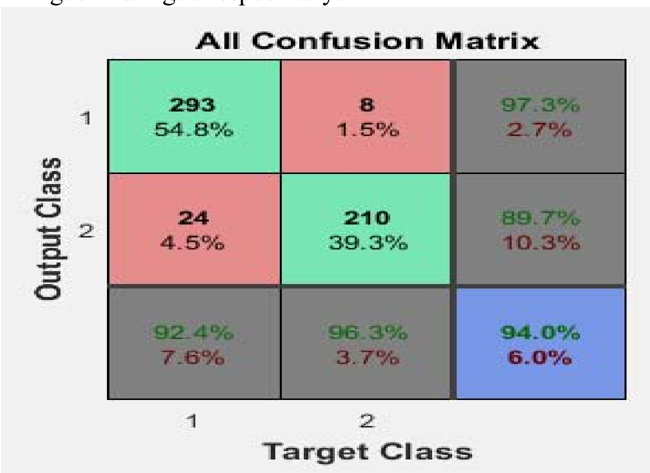

Figure 7: The Confusion Matrix obtained

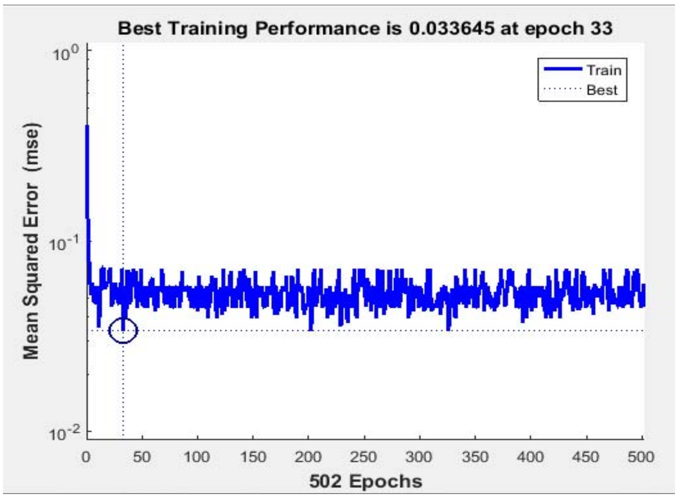

Figure 8: Performance Plot

Table III shows the comparison between CCA and the proposed hybrid network using CCA and Kohonen neural network. A1 stands for the accuracy of CCA and A2 stands for the accuracy of the proposed hybrid approach.

TABLE III. COMPARISON OF CCA AND THE PROPOSED KOHONEN NEURAL NETWORK APPROACH

Plate Number	Total number of characters	Total number of characters segmented by CCA	Total number of characters segmented by the proposed approach	A1 (%)	A2 (%)
DL49AK49	8	15	9	53.3	88.8
BT2876AA	8	19	7	42.1	87.5
MH04BQ7186	10	13	10	76.9	100
KA19P8488	9	15	9	60.0	100
AP9BD3459	9	10	8	90.0	88.8

The total number of characters is obtained by counting the characters manually. The accuracy A is calculated using the Eq. 11. if the total number of characters present is less than the number of characters segmented. However if the total number of characters present is greater than the number of characters segmented, then accuracy A is given by Eq. 12.

$$A = \frac{Total\ number\ of\ characters\ present}{Total\ number\ of\ characters\ segmented} X\ 100 \quad (11)$$

$$A = \frac{Total\ number\ of\ characters\ segmented}{Total\ number\ of\ characters\ present} X\ 100 \quad (12)$$

V. CHARACTER RECOGNITION

The two most important requirements for real time detection of license plates include high accuracy and fast recognition speed. There are three well known methods for character recognition which are:

- Character recognition using commercial OCR software.
- Template matching method in which the images of characters are stored as templates in the memory.
- In case of learning methods, training samples provide complete knowledge of the character. This includes the inductive learning RULES-3 approach and the Support Vector Machine (SVM) based character recognition approach.

The proposed method combines the two approaches of learning method. Thus a hierarchical combined classification method based on both inductive RULES-3 approach and SVM approach is proposed [4]. The first stage in hierarchical classifier method will be inductive learning RULES-3 approach. The classification accuracy of inductive learning approach is very weak. However the approach is simple and fast. Hence it will be used as a coarse classifier to classify 36 characters into several groups. The next stage which will follow is the SVM based approach whose classification accuracy is very high.

The proposed classification algorithm will thus consist of the following three stages:

- Coarse classification layer
- Fine classification layer
- Classification tree

CONCLUSION

There are many different algorithms available for edge detection, character segmentation and character recognition which are used in a typical automatic license plate recognition system. The paper implements algorithms for edge detection, character extraction and segmentation. It has been found out that edge detection using Modified Ant Colony Optimization yields the best results with low MSE and maximum PSNR as compared to all the other algorithms. The proposed algorithm for character segmentation and extraction is capable of segmenting a character image with an accuracy of 94%. A hierarchical combined classification method using inductive learning and SVM approach is proposed for character recognition. The proposed recognition system is expected to have good performance and accuracy as compared to the already existing license plate recognition system.

REFERENCES

[1] M. Dorigo, V. Maniezzo, and A. Colorni, "Ant System: Optimization by a Colony of Cooperating Agents," IEEE Transactions on Systems, Man and Cybernetics, Part B, vol. 26, pp. 29-41, 1996..

[2] Puneet Rai, Maitreyee Dutta, "Image Edge Detection using Modified Ant Colony Optimization Algorithm based on Weighted Heuristics", International Journal of Computer Applications (0975 – 8887), Volume 68– No.15, April 2013..

[3] Silvestre Garcia-Sanchez, Jesus Olivares-Mercado, Gabriel Sanchez-Perez, Karina Toscano-Medina, Hector Perez-Meana, "Extraction system of characters in vehicular plates", Fourteenth Mexican International Conference on Artificial Intelligence, 2015.

[4] Lihong Zheng, Xiangjian He, Qiang Wu, Wenjing Jia, Bijan Samali and Marimuthu Palaniswami, "A Hierarchically Combined Classifier for License Plate Recognition",IEEE Transactions on Systems, Man and Cybernetics, 2008.

[5] L. Zheng X. He, Q. Wu and T. Hintz, "Learning-based Number Recognition on Spiral Architecture", Proceeding of IEEE ICARCV2006. Singapore, pp.897-901, 2006

[6] Jing Tian, Weiyu Yu, and Shengli Xie, "An Ant Colony Optimization Algorithm For Image Edge Detection",IEEE Congress on Evolutionary Computation, 2008. CEC 2008. (IEEE World Congress on Computational Intelligence).

[7] H. Nezamabadi-Pour, S. Saryazdi, and E. Rashedi, "Edge detection using ant algorithms," Soft Computing, vol. 10, pp. 623–628, May 2006.

[8] J. L. Denebourg, J. M. Pasteels and J. C. Verhaeghe, "Probabilistic behavior in ants: A strategy of errors?," J. Theoret. Biol., vol. 105, pp. 259-271, 1983.

[9] Sarbjit Kaur, "An Automatic Number Plate Recognition System under Image Processing", I.J. Intelligent Systems and Applications, Vol. 3, pp.14-25, 2016.

[10] Shan Du,Mahmoud Ibrahim,Mohamed Shehata and Wael Badawy, "Automatic License Plate Recognition (ALPR):A State-of-the-Art Review", IEEE Transactions on Circuits & Systems for Video Technology, Vol. 23, Issue.2, pp.311-325, 2013.

[11] Sahil Shaikh, Bornika Lahiri, Gopi Bhatt and Nirav Raja,"A novel approach for Automatic Number Plate Recognition", IEEE International Conference on Intelligent Systems and Signal Processing (ISSP), pp.275-380, 2013.

[12] Najeem Owamoyo, A.Alaba Fadele and Abimbola Abudu, "Number Plate Recognition for Nigerian Vehicles", Academic Research International Journal (ARIJ), Vol.4, Issue.3, pp.48-55, 2013.

[13] Xiaojun Zhai, Faycal Bensaali and Reza Sotudeh,"OCR-Based Neural Network for ANPR", IEEE International Conference on Imaging Systems and Techniques (IST), pp. 393-397, 2012.

[14] G.T. Shrivakshan and Dr.C. Chandrasekar," A Comparison of various Edge Detection Techniques used in Image Processing", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, pp. 269-276, September 2012.

[15] Namrata Dave," Segmentation Methods for Hand Written Character Recognition ", International Journal of Signal Processing, Image Processing and Pattern Recognition, Vol. 8, No. 4, pp. 155-164, 2015.

[16] Sunitha Beevi K. and Sajeena A.," A Novel Method for Character Segmentation of Vehicle License Plates", International Journal of Research in Engineering and Technology, Volume: 02 Issue: 11, pp. 152-156, 2013.

[17] Poobathy D and R. Manicka Chezian, ―Recognizing and Mining Various Objects from Digital Images, Proceedings of 2nd International Conference on Computer Applications and Information Technology (CAIT 2013), pp. 89-93, 2013.

[18] Pinaki Pratim Acharjya, Ritaban Das and Dibyendu Ghoshal, ―Study and Comparison of Different Edge Detectors for Image Segmentation‖, Global Journal of Computer Science and Technology Graphics & Vision, Volume 12 Issue 13, pp. 28-32, 2012.

[19] Pushpajit A. Khaire and Dr. N. V. Thakur, ―A Fuzzy Set Approach for Edge Detection‖, International Journal of Image Processing (IJIP), Volume 6 Issue 6, pp. 403-412, 2012.

[20] Chirag N. Paunwala, Dr. Suprava Patnaik and Manoj Chaudhary,"Multiple License Plate Detection Algorithm Based on Mathematical Morphology and Component Filtering", IEEE International Conference on Advances in Recent Technologies in Communication and Computing, pp.240-242, 2010.

[21] Reza Azad and Hamid Reza Shayegh," New Method for Optimization of License Plate Recognition system with Use of Edge Detection and Connected Component", IEEE International Conference on Computer and Knowledge Engineering (ICCKE), pp. 21-25, 2013.

[22] Sourav Roy, Amitava Choudhury and Joydeep Mukherjee, "An Approach towards Detection of Indian Number Plate from Vehicle", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Vol.2, Issue.4, pp.241-244, 2013.

[23] Rupali Kate, "Number Plate Recognition Using Segmentation", International Journal of Engineering Research & Technology (IJERT), Vol.1, Issue.9, pp.1-5, 2012.