International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-9 Issue-2S, December 2019

Text Extraction and Recognition in Natural Scene Images using Contourlet Transform and PNN

Shivananda V. Seeri, P. S. Hiremath, J. D. Pujari, Prakashgoud Patil

Abstract*: *Of late, the rapid development in the technology and multimedia capability in digital cameras and mobile devices has led to ever increasing number of images or multi-media data to the digital world. Particularly, in natural scene images, the text content provides explicit information to understand the semantics of images. Therefore, a system developed for extracting and recognizing texts accurately from natural scene images, in real-time, has significant relevance to numerous applications such as, assistive technology for people with vision impairment, tourist with language barrier, vehicle number plate detection, street signs, advertisement bill boards, robotics, etc. The extraction of the texts from natural scene images is a formidable task due to large variations in character fonts, styles, sizes, text orientations, presence of complex backgrounds and varying light conditions. The main focus of this research paper is to propose a novel hybrid approach for automatic detection, localization, extraction and recognition of text in natural scene images with cluttered background. Firstly, image regions with text are detected using edge features (GLCM) extracted from Contourlet transformed image and SVM (Support Vector Machine) classifier. Secondly, horizontal projection is applied on text regions for segmenting lines and vertical projection is applied on each text line for segmenting characters. The proposed method for text extraction has produced the precision, recall, F-Score and accuracy of 98.50%, 90.85.62%, 95.00%, and 89.90%, respectively. And, these results prove that the proposed method is efficient. Further, the so extracted characters are processed for recognition using contourlet transform and Probabilistic Neural Network (PNN) classifier. The computed features are moment invariants. Only the English script is considered for the experimentation. The proposed character recognition method has accuracy of 79.07%, which is higher in comparison to accuracy of 75.15% obtained by KNN (K-Nearest Neighbors) classifier

Keywords: Scene Image, Text extraction, Character recognition, Contourlet transform, PNN.

I. INTRODUCTION

Huge quantities of textual data are present in the natural scene images and required to be automatically processed for text recognition in order to understand scene content. The challenge is due to text data that occur in an image with large variations in color, size, font style, orientation, complex background and variation in light condition. Humans have the peculiar ability of detecting presence of texts with varying scripts of different unknown languages, even when they are trained in only one or two languages. Hence, automation of text detection and recognition requires building suitable machine intelligence that imitates human ability for such tasks. Text localization, that is detection of region in a scene image that potentially contains texts, is the primary step in this processing of scene images captured by digital camera, which are embedded in various handheld devices, such as smartphones, tablet, PDA(Personal Digital Assistant), pens, wrist watches, head mounted devices, etc.

The text in an image can be a scene text or a caption text. The text present as a part of an image is the scene text, whereas text which is added artificially to the image is the caption text. The Fig. 1 illustrates the occurrence of scene text and caption text in the images.

(a) (b)

Fig. 1: Image with text and as (a) Scene text (b) Caption text

In this paper, the purpose is to develop a novel approach for text-localization, character-extraction and character-recognition for the text present in the scene image with heterogeneous cluttered background. It is done in five stages. In the first stage, an edge preserving transform, namely, the Contourlet transform is employed for the extraction of potential text regions in an image. In the second stage, the potential text regions are classified, using GLCM features and SVM classifier, as text and non-text. In the third stage, horizontal profiles are used for the line segmentation. In the fourth stage, character segmentation is done using vertical profiles. In the final stage, MI features and PNN classifier is used for recognizing characters (English) extracted in the previous stage. Although, the proposed novel approach deals with multilingual script, the character recognition stage is designed and experimented for English script only. Thus, the main purpose of this paper is to propose an algorithm that can

Revised Manuscript Received on December 12, 2019.

* Correspondence Author

Shivananda V. Seeri*, Department of MCA, KLE Technological University, Hubballi, Karnataka, India, E-mail: seeri123@gmail.com

P. S. Hiremath, Department of MCA, KLE Technological University, Hubballi, Karnataka, India, E-mail: hiremathps53@gmail.com

J. D. Pujari, Department of Information Science & Engineering, S.D.M. College of Engg. & Tech., Dharwad, Karnataka,India, E-mail: jaggudp@gmail.com

Prakashgoud Patil, Department of MCA, KLE Technological University, Hubballi, Karnataka, India, E-mail: prpatilji@gmail.com

Retrieval Number: B10561292S19/2019©BEIESP
DOI: 10.35940/ijitee.B1056.1292S19

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

be deployable in the wearable devices with limited computational power and memory for assisting visually challenged persons (text to speech conversion) and foreign tourists (language translation).

II. BACKGROUND LITERATURE

In this is section, various methods adopted for extraction and recognition of text present the scene images, proposed by various authors are analyzed and categorized. The methods proposed in the literature were used different techniques such as wavelet transform, edge techniques, morphological based algorithms, artificial neural network, and so on. And, hence these methods are classified based on region properties, morphology properties and texture properties.

The techniques based on region properties adopt a bottom-up process, in which smaller sections are grouped into bigger regions successively until all sections are captured from the image. A geometrical approach is adopted to merge text sections based on their spatial organization for filtering non-text components and then demarcate the text areas. Different region properties are employed for the extraction of text objects, based on the information that differentiates textual patterns from the background. Edges and connected components are the significant elements used in this approach. Isack Bulugu, et al. [1] presented a methodology for license plate detection and localization in a video of vehicle tracking, in which high contrast variation is used for detecting the plate region and the visual quality of the plate region in the video frame is enhanced by using noise removal and smoothing methods. Jonghyun Park, et al. [2] developed method for mobile system applications to detect text regions in signboard image in which text detection utilizing edge information and region segmentation utilizing fuzzy c-means is adopted. Zongyi Liu, et al. [3] designed a technique for detecting text present in scene images, in which intensity filter, shape filter, and component-based framework are employed.

Mathematical morphology is an image analysis technique based on topological and geometrical methodology. It enables extraction of geometrical structures and representative shapes suitable for different applications. It is useful for the extracting significant text features in the preprocessed scene images. These features are invariant with respect to geometrical image transformations, namely, translation, rotation, and scaling, and also invariant to illumination conditions. Brij Mohan Singh, et al, [4] proposed technique based on morphological operations and were used for extracting multi oriented and multi script text-lines. Marcin Pazio, et al. [5] presented a technique based on color image segmentation, feature based segment filtration and hierarchical segment clusterization for text detection system. Sourav Roy, et al. [6] designed a technique comprising edge detection, morphological operation, and mid-filtering noise removal method and contrast enhancement using histogram equalization, to localize number plate of vehicles, and identified each number separately. T. Pratheeba, et al. [7] proposed morphological based algorithm, wherein, a morphological closing image and opening image are subtracted to yield a binary map. Then dilation operation is carried out to obtain candidate regions.

Texture based techniques rely on textural properties of image objects. The texture features of a text region, which are different from its background, are employed for the text extraction. These methods involve Gabor filter, Wavelet, FFT, spatial variance, and also machine learning algorithms such as SVM, KNN, PNN, MLP and adaBoost. These techniques follow top down process. First texture features are extracted from potential text regions and then these features are used for text recognition. Alvaro Gonzalez, et al. [8] designed an algorithm to recognize individual characters in a natural scene image utilizing a gradient direction histogram features and KNN classifier. Ankita Sikdar, et al. [9] designed a procedure for extracting Bengali text present in still images. In the first step, entropy thresholding is adopted for localizing potential text components. In the second step, Bengali text features such as matra, strokes and curves are used to locate Bengali text. P. S. Hiremath, et al. [10] designed a texture feature extraction algorithm for texture classification based on wavelet decomposition. P. S. Hiremath, et al. [11] described a method for classifying image texture using local directional binary patterns (LDBP) in contourlet transformed image, in which PCA (Principal Component Analysis) is used for reduction of feature space dimensionality and LDA is used for enhancing class discriminality. Finally, classification is done using the k-NN classifier. Shreepad S. Sawant, et al. [12] used PNN classifier for image classification and explained its advantages.

III. PROPOSED METHODOLOGY

The proposed method for extraction and recognition of text present in natural scene images comprises of three phases: text region segmentation, character extraction from text regions and character recognition. While the first two phases are concerned with multilingual text, the third phase concerning the character recognition is with reference to English script. Often, the natural scene images may have text regions with cluttered backgrounds. The Figs. 2, 3 and 4 show the block diagrams of the three phases of the proposed approach, namely, text localization, character segmentation and character recognition, respectively, which are explained below.

Retrieval Number: B10561292S19/2019©BEIESP
DOI: 10.35940/ijitee.B1056.1292S19

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Text Localization

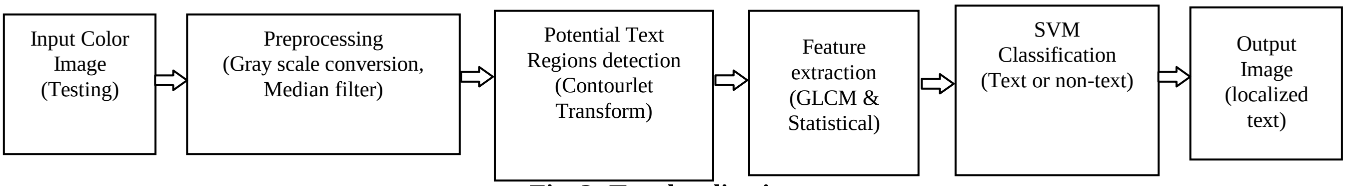


Fig. 2: Text localization

Character Extraction Extraction

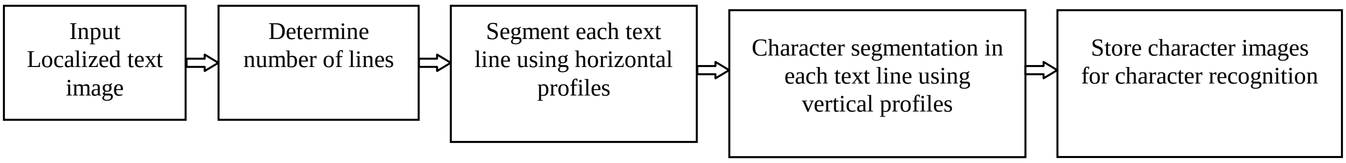


Fig. 3: Character extraction

Character Recognition

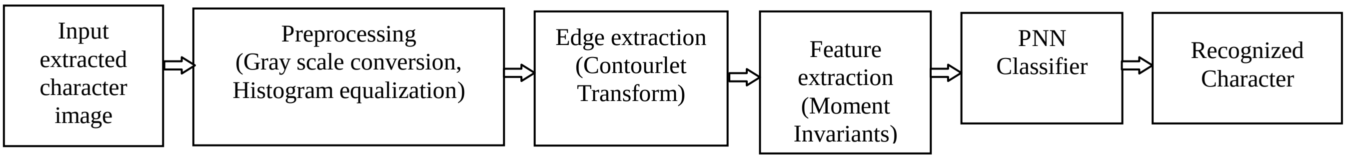


Fig. 4: Character recognition

A. Text Localization

In this phase, the input is a natural scene image and the output is an image with localized text.

Preprocessing: In this step, the grayscale conversion followed by median filter is carried out on input color image to obtain filtered image.

Segmentation: In this step, the median filtered image is subjected to contourlet transform process to obtain an image with rich edge features. Then, binary segmented image is obtained by applying the morphological operations on transformed image. Each segment in the binary image corresponds to the potential text part of the input image.

Feature extraction: For segmented potential text regions present in an input image, the gray level co-occurrence matrix (GLCM) is constructed. Then, the four Haralick textural features [14], such as, Contrast (F1), Homogeneity (F2), Energy (F3) and Entropy (F4), of these segmented potential text regions are computed from GLCM. These features are used for training SVM classifier to classify the potential text regions as text or non-text.

Text region detection: In the training phase, a dataset of images containing only text regions and those containing only non-text regions, which are cropped from natural scene images, is prepared. The Sobel operator is applied to locate strong edges in the training image. The features F1-F4, standard deviation and mean absolute deviation are calculated for both text and non-text images of training data set. With these values, feature vectors are constructed which are then normalized and stored as knowledge base. Then SVM trained using this knowledge base with the Gaussian Radial Basis Function (RBF) Kernel. In the Fig. 2, the contourlet transform is applied on preprocessed image to yield the edge map [12]. The statistical features (mean and standard deviation) based thresholding technique is applied on edge map to retain the prominent edges of text content. The resultant image is then subjected to morphological operations (disk of radius=3 and 6), yielding two distinct images having potential text regions. Next, the logical OR operation applied on these two images yields binary image which is used for cropping potential text regions from which texture features are extracted. These features are used for classifying these regions as text or non-text by employing trained SVM classifier. The text region may occur with single line or multiple lines of text as shown in the Fig. 5.

B. Character Segmentation

The localized text regions (section A) may contain text of different scripts laid in multiple lines, which need to be segmented for character extraction. Firstly, the image with localized text is further processed for the purpose of detection of multiple lines of text in the image by using horizontal projection. Then, vertical projection is performed on each line segment to segment the characters as shown in the Fig. 6. The horizontal and vertical projections, H(i) and V(j), respectively, of a binary nxm image B(i,j) are given by Equations (1) and (2).

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

(a) (b)

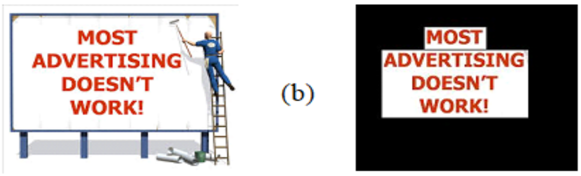
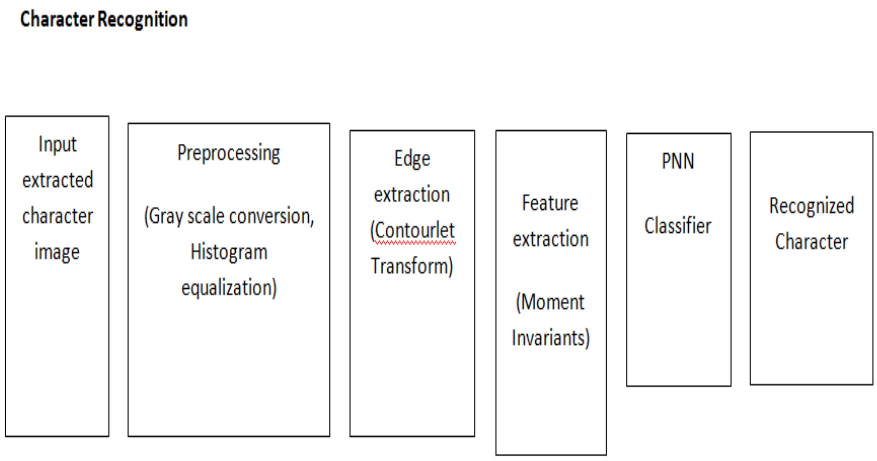
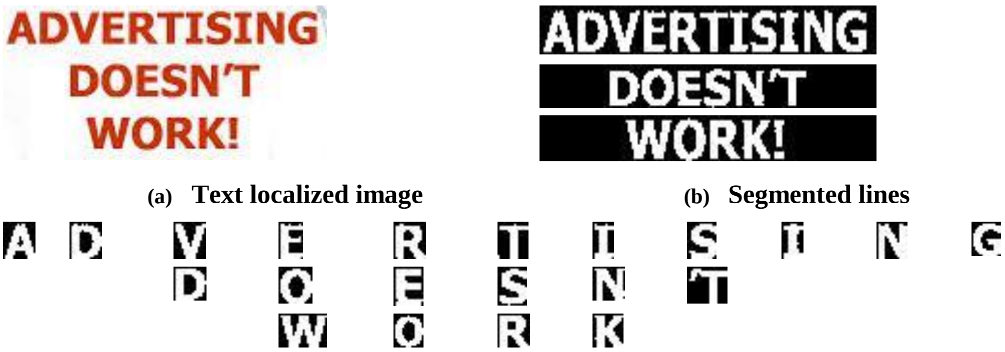


Fig. 5: Sample result: (a) input image and (b) output image with localized text





(a) Text localized image **(b) Segmented lines**

(c) Segmented characters

Fig. 6: Sample results: (a) the text localized image of Fig. 5 as input, (b) the corresponding segmented lines and (c) segmented characters.

$$H(i) = \sum_{j=0}^{m-1} B(i,j) \quad (1)$$

$$V(j) = \sum_{i=0}^{n-1} B(i,j) \quad (2)$$

C. *Character Recognition*

The third phase of proposed methodology involves character recognition of segmented characters (section B) with reference to English script (Digits and Letters of both upper and lower cases) only. The segmented text character, as obtained in the section B, is the input for this phase. The proposed approach encompasses: (i) Apply contourlet transform to the input character segmented image, (ii) Extract the seven MI features of characters from transformed image, (iii) Use PNN classifier for character recognition.

PNN classifier

PNN classifier is employed for character recognition, with reference to English script, in the extracted text. For each class in the training samples, the probability density function (PDF) is computed using the Equation (3) in the PNN algorithm.

$$pdf(x) = \frac{1}{\sigma} w\left[\frac{x - x_k}{\sigma}\right] \quad (3)$$

where, x is input, x_k is the kth sample, w is the weight function and σ is the smoothing factor.

The smoothing factor is used to control the classification effectiveness of the PNN and depends on the input. In the proposed architecture, PNN with 62 neurons (62 classes) are used in the pattern layer. Similarly, PDF of the n samples in a given population is computed by the Equation (4).

Retrieval Number: B10561292S19/2019©BEIESP
DOI: 10.35940/ijitee.B1056.1292S19

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

$$pdf(x) = \frac{1}{n\sigma}\sum_{i=1}^{n} w\left[\frac{x - x_k}{\sigma}\right] \quad (4)$$

The Fig. 7 shows PNN architecture [15] with its four layers: input, pattern, summation and decision layers.

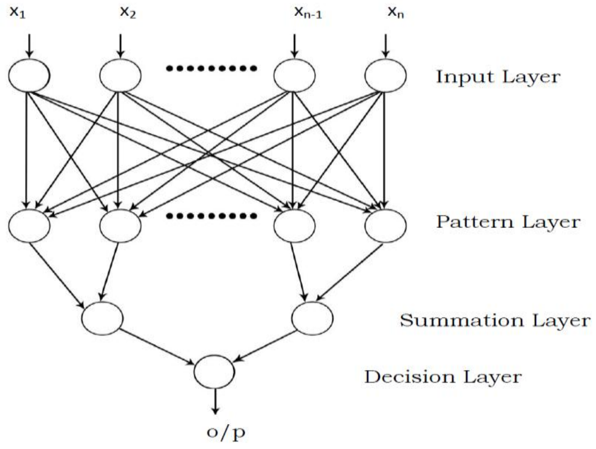


Fig. 7: General architecture of PNN [15]

The PNN, being a feed-forward neural network, works as a Bayesian classifier. It makes use of the Parzen PDF estimation [13] [16] for computing the PDF value for each class of samples, present in training samples.

Each class corresponds to an English character. Hence, the characters of English script form 62 classes comprising 52 upper case letters, lower case letters and 10 digits. The n_i, i=1, 2, …, 62, represents the total count of sample images of i^{th} class. The PDF function g_i of i^{th} class is:

$$\underset{1\leq i\leq 62}{g_i}(x) = \max_{1\leq k\leq n_i}\{e^{-\|x-x_{ik}\|^2/\sigma^2}\} \quad (5)$$

$$Output_{Class} = \max_{1\leq i\leq 62}(g_i) \quad (6)$$

$Output_{Class}$ is the i^{th} class for which the maximum is attained in Equation (6) and hence is the predicted character as an output of the PNN classifier. The n_i is the number of sample images in i^{th} class, while k is the index, k=1 to n_i.

In the 4-layer PNN architecture for character recognition phase, the input layer has 7 neurons (7 MIs), which accepts seven components of feature vector as input data. Pattern layer has 62 neurons (62 classes), in which PDF is computed for each class. The Gaussian and Radial Basis Functions (RBF) are used for activation functions in pattern layer nodes with smoothing factor SD (σ) =0.02.

Summation layer has 62 neurons (62 classes), in which summation of PDF of samples for each class is computed. Output layer has 1 neuron (Recognized character), in which classification decision is done as given in the Equation (6).

Each character extracted from the localized text region is submitted to PNN classifier for the character recognition. The PNN classification, training as well as testing phases, for English character recognition is given below.

Training phase

In this phase, contourlet transform is applied on the segmented character image to yield edge image. Then, MIs (M1, M2… M7) are computed from the resultant image and stored as a knowledge base (KBase). The training image set contains the images of all the 62 characters (upper and lower case letters and digits). Then, this KBase is employed to train the PNN.

Testing phase

Here in, after preprocessing input image, the contourlet transform is applied to obtain the edge image. The MIs M1,…,M7 are calculated from the resultant edge image. For each class i, where i=1,2,…,62, the $g_i(x)$ for x=(M1,…,M7), is calculated. The class label i of the predicted character corresponds to the maxima of $g_i(x)$. This process is done for each of the test samples.

IV. RESULTS AND DISCUSSIONS

The proposed algorithm is implemented using MATLAB R2013b. The images are in JPEG format and in RGB color space.

A. Text Localization and Character Segmentation

For experimentation, a data set of 324 natural scene images is considered, which includes images taken from own data set and also ICDAR (International Conference on Document Analysis and Recognition) data set. Out of which, the training set contains 224 images, having 112 text images and 112 non-text images, which are used to train SVM classifier. The testing set contains 100 images. The text contents in these images are multilingual with varying font style, size, scale, orientation, lighting conditions, complex background, and also shadowing of text. The training images with textual content have English, Kannada and Hindi scripts only and thus SVM is trained with texts of these three scripts only. However, the testing set comprises the images with textual contents having different scripts, namely, Hindi, Kannada, English, Bengali, Marathi, Telugu, Urdu, Punjabi, Oriya, Malayalam, Tamil, Russian, Japanese and Chinese.

The performance metrics, namely, precision, recall, F-Score and accuracy [17] are used for analyzing proposed algorithm and results obtained are shown below.

Precision	98.85%
Recall	90.85%
F-Score	95.00%
Accuracy	89.90%

Table-I: Comparison of proposed method with other methods in the literature

Method	Precision (%)	Recall (%)	F-Score (%)
Proposed method	98.85	90.85	95.00
S V Seeri et al., 2015.[18]	97.14	89.81	94.00
S V Seeri et al., 2015. [17]	77.60	88.62	83.00

Shraddha Naik et al., 2015. [19]	86.00	84.00	85.00
Sumathi, et al., 2014. [20]	78.00	91.00	84.00
M.S. Pavithra, et al., 2014. [21]	71.10	91.00	77.00
Niti Syal et al., 2014. [22]	95.71	92.69	94.00
Too Kipyego Boaz et al., 2016. [23]	93.00	96.00	94.00
Xiaopei Liu et al., 2014. [24]	63.20	67.8	65.00

The text contains digits as well as alphabets of the scripts considered. The performance comparison of proposed approach with other techniques in the literature is presented in the Table I, which demonstrates effectiveness of the proposed approach. The Fig. 8 shows the sample results of the proposed approach with that of the wavelet based approach in [18].

For the proposed method, the precision, recall, F-Score and accuracy are 98.85%, 90.85%, 95.00%, and 89.90%, respectively. The results show that the proposed technique is efficient for localization of text, which are superior to that in [17, 18]. It also outperforms other methods given in the Table I, which are experimented with ICDAR dataset and own dataset, and the accuracies are as given in the literature.

The superior performance of the proposed technique is due to the Contourlet transform, which is edge-preserving that leads to accurate localization of text regions as compared to methods in [17, 18] based on the wavelet transform. For example, in the last row of the Fig. 8, non-text regions localized as text by the wavelet based in [18] are correctly recognized as non-text by the proposed contourlet transform based technique. Further, it is witnessed that the robustness of the method is established by the fact that, although SVM is trained with only three scripts (Hindi, English, Kannada), it is able to accurately localize text having different scripts.

The extracted text regions having multi-line text are segmented effectively. The character extraction for each segmented line is done, as shown in the Fig. 9.

In the case of tilted text lines contained in the localized text regions, the proposed method fails to extract characters.

However, there are methods of document image analysis for skew detection and correction, which can be applied to obtain images with horizontal text lines. Then, the proposed method for character extraction becomes applicable. The Fig. 9 shows the sample line segmented images and the corresponding character segmentation.

Fig. 8: Sample results: Input images and corresponding output images with localized text for the wavelet based method [18] and the proposed contourlet based method.

B. Character Recognition (English)

For experimentation, a data set [The Chars74K dataset + Own dataset] of 4654 natural scene character images of digits and letters (lower and upper cases) is considered. The training set comprises of 2628 images to train PNN classifier and testing set comprises of 2026 images. The Fig. 10 depicts the sample images of English characters used for the experimentation.

The proposed technique is tested on four sets: (i) digits only, (ii) lower case letters only, (iii) upper case letters only and (iv) mixed set of all characters. The comparison of character recognition accuracy of the proposed approach using KNN and PNN classifier is presented in the Table II. The recognition accuracy of individual characters is presented graphically in the Figs. 11(a)-(c).

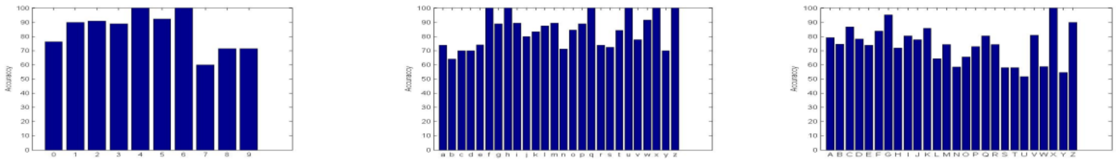
Retrieval Number: B10561292S19/2019©BEIESP
DOI: 10.35940/ijitee.B1056.1292S19

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Line segmented image **Character segmented image**

Fig. 9: Sample line segmented images and the corresponding character segmentation

Fig. 10: Sample character images used for experimentation



(a) (b) (c)

Fig. 11 (a) Recognition accuracy for (a) Digits, (b) Lower case letters, (c) Upper case letters

Table-II: Comparison of recognition accuracy of the proposed technique

Characters	Recognition accuracy (%)	
	PNN	KNN
Numerals/Digits (0 to 9)	84.13	72.98
Letters (Lower case)	84.04	74.80
Letters (Upper case)	74.24	69.01
Mixed (digits, upper and lower case letters)	79.07	75.15

For mixed set of characters, the recognition accuracy is 79.07% by PNN classifier and 75.15% by KNN. Also, the classification experiments are repeated by considering training sample images as test images and classification accuracy is found to be 100%

V. CONCLUSION

The main objective of the proposed technique in this paper is to develop a hybrid technique for the extraction of multilingual text present in the natural scene images with cluttered background and recognize the so extracted text. The proposed approach combines region, morphological and texture based methods to build a hybrid approach for the extraction and recognition of text regions present in scene images. It involves three stages, namely, text localization (detection), text extraction and text character recognition. The text localization is based on Contourlet transform and SVM classification using GLCM features. The English characters are considered for developing the character recognition algorithm. The proposed technique has yielded better text localization than the methods in [17] and [18], and also other methods in the literature. The Contourlet transform conserves the prominent text edges in the image, which results in more precise text region localization in scene images.

Further, the horizontal projection profile is adopted for segmenting text lines and vertical projection profile is adopted for character segmentation.

Retrieval Number: B10561292S19/2019©BEIESP
DOI: 10.35940/ijitee.B1056.1292S19

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

A novel approach based on Contourlet transform, Moment Invariants (MI) and PNN classification is developed for character recognition with reference to English characters (lowercase letters, uppercase letters and digits) and is tested on characters with large variations in font size, style, orientation and also illumination conditions. The experimentation is done with images containing multiscript and multiline text. For character recognition, the PNN classifier yielded better results than the KNN classifier. The limitation of the proposed technique is that it is applicable for images containing horizontal line text. The cases of skewed text lines and curved text lines will be considered in the future work.

REFERENCES

1. Egyul Kim, SeongHun Lee, JinHyung Kim, Scene Text Extraction using Focus of Mobile Camera 10th International Conference on Document Analysis and Recognition 2009, 978-0-7695-3725-2/09 $25.00 © 2009 IEEE, DOI 10.1109/ICDAR.2009.21, pp. 166-170.
2. Isack Bulugu, Algorithm for License Plate Localization and Recognition for Tanzania Car Plate Numbers, International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064, Volume 2 Issue 5, May 2013, pp. 12-16.
3. Jonghyun Park, Toan Nguyen Dinh, and Gueesang Lee, Binarization of Text Region based on Fuzzy Clustering and Histogram Distribution in Signboards, Proceedings Of World Academy Of Science, Engineering And Technology, ISSN 2070-3740 Volume 33 September 2008, pp. 85-90.
4. Zongyi Liu, Sudeep Sarkar, Robust Outdoor Text Detection using Text Intensity and Shape Features, 19th International Conference on Pattern Recognition, 2008 (ICPR 2008), DOI: 10.1109/ICPR.2008.4761432, 978-1-4244-2175-6/08/$25.00 ©2008 IEEE, pp. 1-4.
5. Brij Mohan Singh, Rahul Sharma, Debashis Ghosh, Ankush Mittal, Multi-Oriented Text Extraction in Stylistic Documents, International Journal of Image and Graphics, Vol. 15, No. 1, world Scientific Publishing Company, DOI: 10.1142/S0219467815500023, February 2015, pp. 1-11.
6. Marcin Pazio, Maciej Niedzwiecki, Ryszard Kowalik, Jacek Lebiedz, Text Detection System for the Blind, 15th European Signal Processing Conference (EUSIPCO), Poznan, Poland, September 3-7, 2007, copyright by EURASIP, 2007, pp. 272-276.
7. Sourav Roy, Amitava Choudhury, Joydeep Mukherjee, An Approach towards Detection of Indian Number Plate from Vehicle, International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-2, Issue-4, March 2013, pp. 241-244.
8. T. Pratheeba , Dr V. Kavitha , S Raja Rajeswari, Morphology Based Text Detection and Extraction from Complex Video Scene, International Journal of Engineering and Technology, ISSN : 0975-4024, Vol.2(3), 2010, pp. 200-206.
9. Alvaro Gonzalez, Luis M. Bergasa, J. Javier Yebes, Sebastian Bronte, A Character Recognition Method in Natural Scene Images, 21st International Conference on Pattern Recognition (ICPR 2012), 978-4-9906441-1-6 ©2012, November 11-15, 2012, pp. 621-624.
10. Ankita Sikdar, Payal Roy, Somdeep Mukherjee, Moumita Das and Sreeparna Banerjee, A Two Stage Method For Bengali Text Extraction From Still Images Containing Text, Natarajan Meghanathan, et al. (Eds): SIPM, FCST, ITCA, WSE, ACSIT, CS & IT 062012. © CS & IT-CSCP 2012, DOI : 10.5121/csit.2012.2306, 2012, pp. 47–55,
11. P. S. Hiremath, S. Shivashankar, Wavelet based Features for Texture Classification, GVIP Journal, Volume 6, Issue 3, December, 2006, pp. 55-58.
12. P. S. Hiremath and Rohini A. Bhusnurmath, Non-subsampled contourlet transform and local directional binary pattern for texture image classification using support vector machine, Int. Jl. Of Engineering Research and Technology, Vol. 2, Issue 10, Oct. 2013, pp. 3881-3890.
13. Shreepad S. Sawant, Preeti S. Topannavar, use of Probabilistic Neural Network for Image Classifications, International Journal of Advanced Research in Computer Science and Software Engineering, ISSN: 2277 128X, Volume 5, Issue 4, 2015, pp. 279-283.
14. Robert M. Haralick, K. Shanmugam, ITS'Hak Dinstein, Textural Features for Image Classification, IEEE transactions on systems, MAN, Cybernetics, Vol. SMC-3, No. 6, November 1973, pp. 610-621.
15. Vincent Cheung, Kevin Cannons, an Introduction to Probabilistic Neural Networks, Signal & Data Compression Laboratory, Electrical & Computer Engineering University of Manitoba, Winnipeg, Manitoba, Canada, June 10 2002.
16. E. Parzen, "On estimation of a probability density function and mode", Ann. Math. Statist. vol. 33, pp. 1065–1076, 1962.
17. S. V .Seeri, J. D. Pujari, P. S. Hiremath, Multilingual Text Localization in Natural Scene Images using Wavelet based Edge Features and Fuzzy Classification, International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 4, Issue 1, ISSN 2278-6856, February 2015, pp. 210-218.
18. S. V. Seeri, J. D. Pujari, P. S. Hiremath, Multilingual Text Detection in Natural Scene Images using Wavelet based Edge Features and SVM Classifier, International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), ISSN 2277-128x Volume 5, Issue 11, November 2015, February 2015, pp. 81-89.
19. Shraddha Naik, Sankhya Nayak, Text Detection and Character Extraction in Natural Scene Images, International Journal of emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 2, February 2015, pp. 178-182.
20. Sumathi, C.P. and G. Gayathri Devi, Automatic Text Extraction From Complex Colored Images Using Gamma Correction Method, Journal of Computer Science, published Online 10 (4) 2014, ISSN: 1549-3636, 2014, pp. 705-715.
21. M.S. Pavithra , V.N. Manjunath Aradhya, A comprehensive of transforms, Gabor filter and k-means clustering for text detection in images and video, Applied Computing and Informatics (2014), Article In Press, Production and hosting by Elsevier B.V., pp. 1-20.
22. Niti Syal, Naresh Kumar Garg, Text Extraction in Images Using DWT, Gradient Method And SVM Classifier, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 6, June 2014, pp. 477-481.
23. Too Kipyego Boaz, Prabhakar C. J, Extraction of Scene Text Information from Video, International Journal of Image, Graphics and Signal Processing (IJIGSP), ISSN: 2074-9082 (Online), Volume 8, Issue 1, January 2016, pp. 15-26.
24. Xiaopei Liu, Zhaoyang Lu, Jing Li, Wei Jiang, Detection and segmentation text from natural scene images based on graph model, WSEAS Transactions on Signal Processing, E-ISSN: 2224-3488, Volume 10, 2014, pp. 124-135.

AUTHORS PROFILE

Dr. Shivananda V. Seeri has obtained Ph.D. (Computer Science) in digital image processing. He is presently working as Associate Professor, Dept. of Computer Applications (MCA), KLE Technological University, BVBCET Campus, Hubballi, and Karnataka. His research areas of interest are Image Processing and Pattern Recognition, Big Data Analytics, Cyber Security, Machine learning, BI, Software Engineering, Data Mining, cloud computing and Computer Networks, . He has published ten research papers.

Dr. Jagadeesh Pujari has obtained Ph.D. (Computer Science) in digital image processing (CBIR). He has B.E and M.S degrees in Computer Science and Engineering. He has Published 5 papers in International Journals and Presented 19 papers in International conferences (Several of them are IEEE International conferences), 1 in national conference. He has been presently working as Professor and Head, Department of Information Science and Engineering, S.D.M College of Engg. & Tech., Dharwad, Karnataka.

Dr. P. S. Hiremath was born in May 1952, and has obtained Ph.D. (1978) in Applied Mathematics and M.Sc. (1973) in Applied Mathematics, from Karnataka University, Dharwad, Karnataka, India. He had been in the Faculty of Mathematics and Computer Science of various institutions in India, namely, National Institute of Technology, Surathkal (1977-79), Coimbatore Institute of Technology, Coimbatore (1979-80), National Institute of Technology, Tiruchirapalli (1980-86), Karnataka University, Dharwad (1986-1993), Gulbarga University, Gulbarga (1993-2014) and has been presently working as Professor, Dept. of Computer Applications (MCA), KLE Technological University, BVBCET Campus, Hubballi. His research areas of interest are Computational Fluid Dynamics, Image Processing and Pattern Recognition and Computer Networks. He has published 220 research papers in peer reviewed International Journals and Proceedings of International Conferences.