Historical Kannada Handwritten Scripts Recognition System using Line Segmentation with LBP features

Parashuram Bannigidad[*], **Chandrashekar Gudada**[*]

[*] Department of Computer Science, Rani Channamma University, Belagavi, KA, India.

Abstract- The inscriptions or Epigraphical manuscripts written on different material such as rock carving, palm leaf, cloth, metal plates and paper are the cultural heritage of our country; our aim is to recreate the cultural importance of the Kannada Language and its traditionally writing through the historical manuscripts. Most of the resources are in degraded state, the degraded manuscripts are influenced by weather condition. The offline handwritten text recognition is one of the most challenging tasks in document image analysis. In the present digital era, we need to protect and digitize the resources of our Indian culture and heritage by digitizing the manuscripts which are losing its originality and status. In this paper, we have attempted to identify and recognize the historical Kannada handwritten scripts of various dynasties; namely, Vijayanagara dynasty (1460 AD), Mysore Wadiyar dynasty (1936 AD), Vijayanagara dynasty (1400 AD) and Hoysala dynasty (1340 AD) by using the improved seam carving text line segmentation method with LBP features. For recognition and classification purpose the LDA, K-NN and SVM classifiers are used. The average classification accuracy for different dynasties are computed. The LDA classifier yields 94.2%, K-NN classifier has yielded 94.9% and SVM classifier has 96.4%. Based on the experimentation, the SVM classifier has recorded good classification performance comparatively LDA and K-NN classifiers for historical Kannada handwritten scripts. The experimental results are verified by Epigraphists and language expert, which shows the robustness of the proposed method.

Index Terms- Restoration, Seam carving, Line segmentation, Kannada, LDA, K-NN, SVM, Recognition, LBP, handwritten script, historical documents, document image analysis.

I. Introduction

India is one of the oldest and ancient civilized country in the world, its civilization started before 7000 BCE with spiritual and astrological knowledge. This knowledge of information is stored and kept preserved in the form of historical inscription and epigraphical manuscripts in the manuscript resource centres, manuscript conservation centres, manuscript partner centres, gurukula and monasteries. Due to the negligence in maintaining, these scripts are in the state of degradedness. Hence, the digitization of these degraded documents is a important task to restore the deciphering inscriptions. Particularly, in the state of Karnataka, many dynasties have ruled and contributed their knowledge to the Indian civilization. In this work, we are trying to experiment with the available historical Kannada handwritten manuscripts (inscription) written on paper from various dynasties, namely; Vijayanagara dynasty (1460 AD), Mysore Wadiyar dynasty (1936 AD), Vijayanagara dynasty (1400 AD) and Hoysala dynasty (1340 AD) collected from various institutions or universities for identification and recognition of historical Kannada handwritten manuscripts.

Very few researchers have contributed to this area in the literature; Seam carving for text line extraction on colour and grayscale historical manuscript was proposed by Nikolaos et.al.[4]. Seam carving for content-aware image resizing has been investigated by Avidan et.al.[5]. Influence of text line segmentation in handwritten text recognition was presented by Romero et.al.[6]. The identification of writer using sparse radial sampling LBP features was proposed by Nicolaou et.al.[7]. Word spotting in English handwritten historical document by using LBP features has been proposed by Dey et.al.[8]. LBP based line-wise script identification was investigated by Ferrer et.al.[9]. Ghosh et.al.[10] proposed an algorithm for text / non-text separation from handwritten document images using LBP features. The evaluation for historical document image analysis using texture feature was carried out by Mehri et.al.[11]. Laurence et.al.[12] has done a survey on text line segmentation of historical documents. Text line segmentation for gray scale historical document images was proposed by Asi et.al.[13]. Parashuram and Chandrashekar [14, 15] have proposed an image enhancement method for degraded historical Kannada handwritten document images. The Identification and classification of historical Kannada handwritten document images using LBP features was proposed by Parashuram and Chandrashekar [16].

II. PROPOSED METHOD

The objective of the proposed method is to digitize and recognize the historical Kannada handwritten manuscripts based on their age-type using improved seam carving text line segmentation approach by extracting LBP features using LDA, K-NN and SVM classifiers. The proposed method mainly consists of data collection, segmentation, pre-processing, feature extraction and classification; which are discussed as below:

A. Data collection

The availability of standard datasets of historical Kannada handwritten manuscripts are rarely found in the literature. Hence these documents are collected individually by visiting many resource centres, like; Department of P. G. Studies and Research in Kannada, Gulbarga University, Kalaburgi and Department of Hasataprati, Kannada University, Hampi. These historical Kannada handwritten manuscripts are captured through Canon 1300D, 18 megapixels DSLR Camera at 5184×3456 resolutions in the JPEG format. There are 121 manuscripts of different dynasties are captured and stored them in a separate file.

B. Segmentation

Image segmentation is a process of dividing an image into multiple regions. This is typically used to identify objects or other relevant information in digital images. For historical manuscript analysis, there are many different ways to perform image segmentation to extracts words or lines. In this work, we have considered the seam carving text line extraction method with the improved algorithm. Seam carving [5] algorithm is originally developed by Shai Avidan for content aware image resizing, it is also called as liquid rescaling. It works by building up various seams in image and consequently expels seams to diminish picture size or embeds seams to expand it. Seams cutting additionally permits manually characterizing regions in which pixels may not be adjusted and include the capacity to expel entire articles from an image. Many of the authors have used this algorithm for image retargeting, but in this work, we tried to improve the algorithm to extract text line in historical Kannada handwritten manuscripts.

C. Pre-processing

It is more important that the historical manuscript documents are badly affected by many factors [1, 2] namely; it contains smear, uneven background illumination, and spot due to age or marks resulting from the ink bleed-through. Apart from this, the style of writing varies from manuscript to manuscript [3], which leads to the confusion and complexity to recognize the historical manuscript documents. The preprocessing steps which include image enhancement and restoration, the enhancement method improves the quality of the image but also removes the unwanted objects, debris, uneven background illumination and noise, etc. In the previous papers, we have proposed a novel image enhancement and restoration technique for degraded historical Kannada handwritten manuscript document images [14, 15].

D. Feature Extraction

The feature extraction process used to obtain the feature vector sequence of individual images which describes the properties of the individual objects. The main contribution of the present work is the application of LBP (Local Binary Pattern) features for recognition of the historical Kannada handwritten scripts. The LBP characterize local image masks using binary codes that extract the relationship between a central pixel and its neighbors. LBP feature extraction usually computes the LBP descriptors at each pixel level of an image to create an image of integer code values, followed by pooling of these codes into a histogram [17].

E. Classification

The image classification mainly works with the numerical properties of an assorted image features with organized classes, the image classification contains two phases i.e., training and testing phase. In the initial training phase, characteristic properties of typical image features are isolated and based on these, unique description of each classification category, i.e. training class, is created. In the subsequent testing phase, these feature-space partitions are used to classify image features. In this experiment, we have used Linear discriminant analysis (LDA), K- nearest neighbor (KNN) and Support Vector Machine (SVM), with k-fold experimentation based on the LBP features with 59 and 19 features for classification of historical Kannada handwritten documents.

The detailed approach of the proposed method is discussed in the form of algorithm, which is described below:

Algorithm for recognition of Historical Kannada Handwritten manuscript

```
1. Input Camera capture historical Kannada handwritten manuscript of different age-types: namely
   Hoysala, Vijayanagara and Mysore dynasties.
2. Apply Improved seam carving text line segmentation method for line Extraction from historical
   manuscript:
    2.1. convert the given original colour image to grayscale image
    2.2. compute edge image using the Sobel edge detector
    2.3. medial seam computation with a projection profile matching
        2.3.1.Compute horizontal projection profiles of all edge image slices and find their local
              maxima
        2.3.2. Match local maxima of the projection profiles between two consecutive image slices
        2.3.3. Remove lines that start from some intermediate column of the image
        2.3.4. Extend the small lines towards the end column of the image
    2.4. Separating seam computation with constrained seam carving
        2.5.1. apply constrained seam carving for each pair of text lines
        2.5.2. compute minimum energy separating seam using dynamic programming
        2.5.3. overlay separating seams on the original image
            2.5.3.1. Compute the coordinate values of the overlay separating seam and store
                     them in temp
            2.5.3.2. Concatenate the present coordinate values with temp
        2.5.4. Using coordinate value, extract the region of interest by roipoly() function
        2.5.5. Apply the image enhancement technique for binarization to the extracted region of
               interest (text line)
    2.5. Original image overlaid with both types of seams
    2.6. Apply the skew correction to the segmented text line
3. Combination of Local Otsu and Global Otsu method is applied to each individual text line for
   binarizing the images on step 2
4. Apply size normalization to each individual text line on step 3
5. Extract LBP features of size normalized individual text line of different dynasties, namely; Hoysala,
   Vijayanagara and Mysore dynasties and store them as a knowledge base
6. Apply the classification techniques, namely; LDA classifier, K-nearest neighbour classifier and SVM
   classifier to classify and recognize the historical Kannada handwritten manuscripts, whether they
   belong to the Hoysala dynasty or Vijayanagara dynasty or Mysore dynasty?
```

The detailed approach of the proposed method is given in the Figure 1.

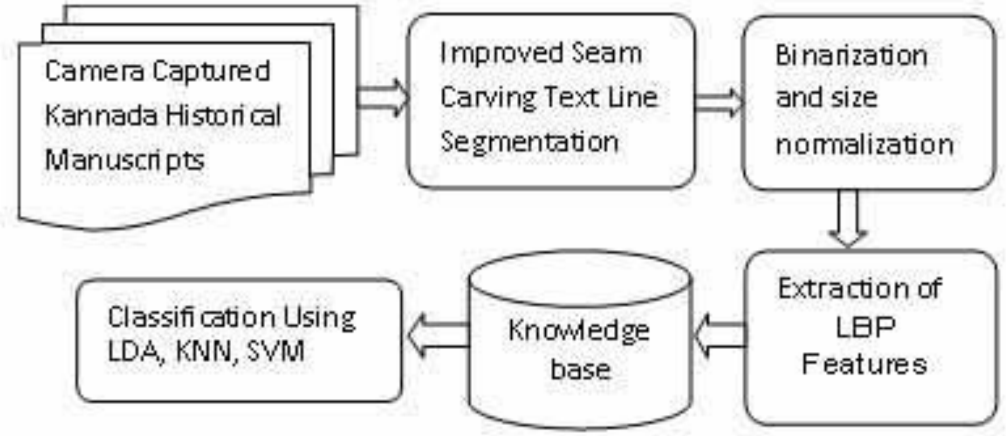
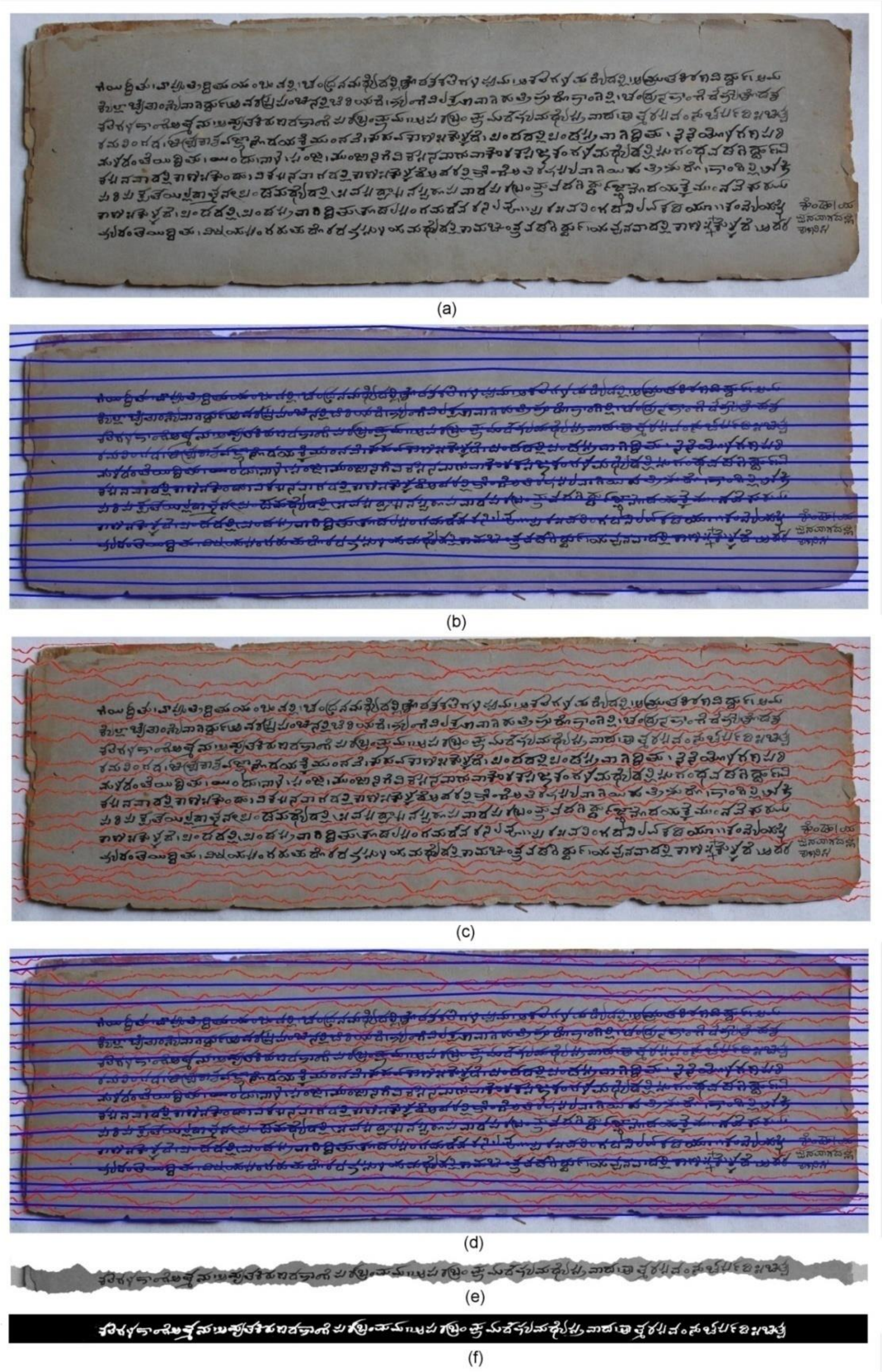

Camera Captured Kannada Historical Manuscripts
Improved Seam Carving Text Line Segmentation
Binarization and size normalization
Extraction of LBP Features
Knowledge base
Classification Using LDA, KNN, SVM

Figure 1. The detailed approach of the proposed method

III. EXPERIMENTAL RESULTS AND DISCUSSION

We have considered the datasets of different dynasties, namely; Vijayanagara(1400 AD and 1460 AD), Hoysala(1340 AD) and Mysore Wadiyar(1936 AD) (described in Sect. II) for experimentation. The experimentation is done with Intel Core i5 system using Matlab R2018b. Input the camera captured historical Kannada handwritten manuscript document images (Figure 2a) for extraction of text line segmentation. To extract text line segmentation, we applied the improved seam carving method which includes the computation of medial seam (Figure 2b), Separating seam computation with constrained seam carving based on medial seam (Figure 2c), overlaid with both type of seam (Figure 2d), region of interest i.e., text line is extracted based on the overlaid seam using roipoly() function (Figure 2e). And then apply the image enhancement method for binarization, restoration and size normalization to each individual text line (Figure 2f). Extracted the LBP features for all the text lines and store them as a knowledge base. Finally, apply classification techniques; i.e., LDA classifier, K-NN classifier and SVM classifier for classification and recognition of the historical Kannada handwritten manuscripts based on their age-type. The other sample images of the proposed algorithm used for other dynasties namely, Mysore Wadiyar(1936 AD) dynasty, Vijayanagara(1400 AD) dynasty and Hoysala(1340 AD) dynasty, which are shown in Figure 3, Figure 4 and Figure 5, respectively. The results of the text lines extracted from the manuscripts of various dynasties based on their age-type are given in the Table 1. The average classification accuracy of the proposed method is given in the Table 4. Initially, we have extracted the LBP features with 59 features using k-fold experiment and these results are given in the Table 2. Further, to improve the results we have reduced the LBP features with 19 features and certainly results are improved. The results of these reduced features with k-fold experiments using LDA, K-NN and SVM classifiers are given in the Table 3. As per the results, it is observed that LBP features with 19 features are given better results comparatively 59 features. Hence, we propose only 19 features by reduced features from 59 and overall accuracy is calculated and represented only based on 19 LBP features.

The classification accuracy for different dynasties represents that the LDA classifier has yielded 94.2%, K-NN classifier has 94.9% and SVM classifier has 96.4%. Based on the experimentation, it seems that the SVM classifier has got a good classification performance comparatively LDA classifier and K-NN classifier for historical Kannada handwritten manuscript document images. Which indicates better recognition rates towards historical Kannada handwritten manuscript document images.



(a)

(b)

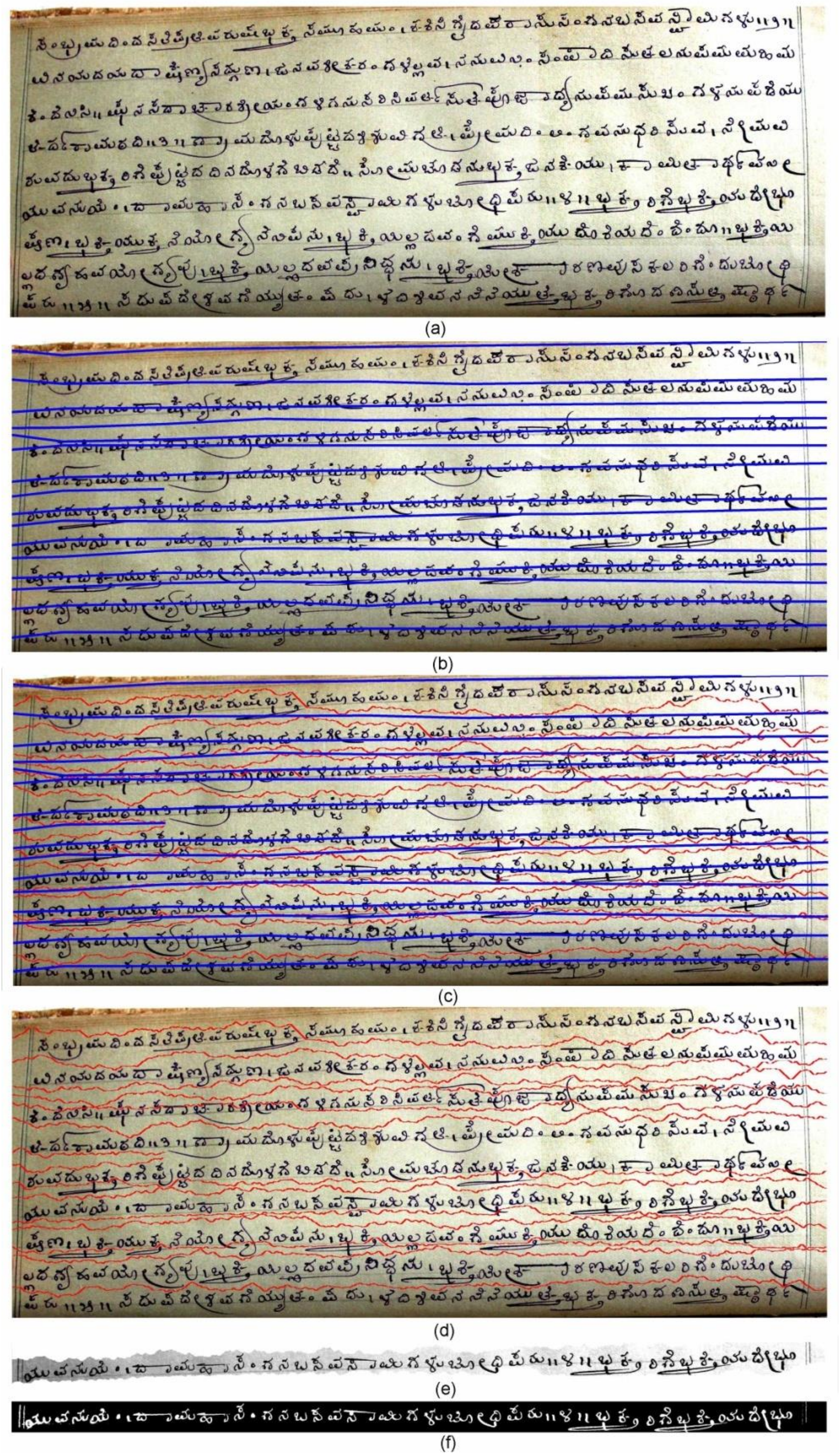
(c)

(d)

(e)

(f)

Figure 2. Sample image of the proposed algorithm (a) Original camera captured historical Kannada handwritten manuscript document image of Vijayanagara dynasty (1460AD) (b) medial seam computed image (c) Separating seam computation image with constrained seam carving based on medial seam (d) overlaid image with both type of seam (e) text line is extracted based on the overlaid seam (f) Enhanced and size normalized image



(a)

(b)

(c)

(d)

(e)

(f)

Figure 3. Sample image of the proposed algorithm (a) Original camera captured historical Kannada handwritten manuscript document image of Mysoure wodeyar dynasty (1936AD) (b) medial seam computed image (c) Separating seam computation image with constrained seam carving based on medial seam (d) overlaid image with both type of seam (e) text line is extracted based on the overlaid seam (f) Enhanced and size normalized image

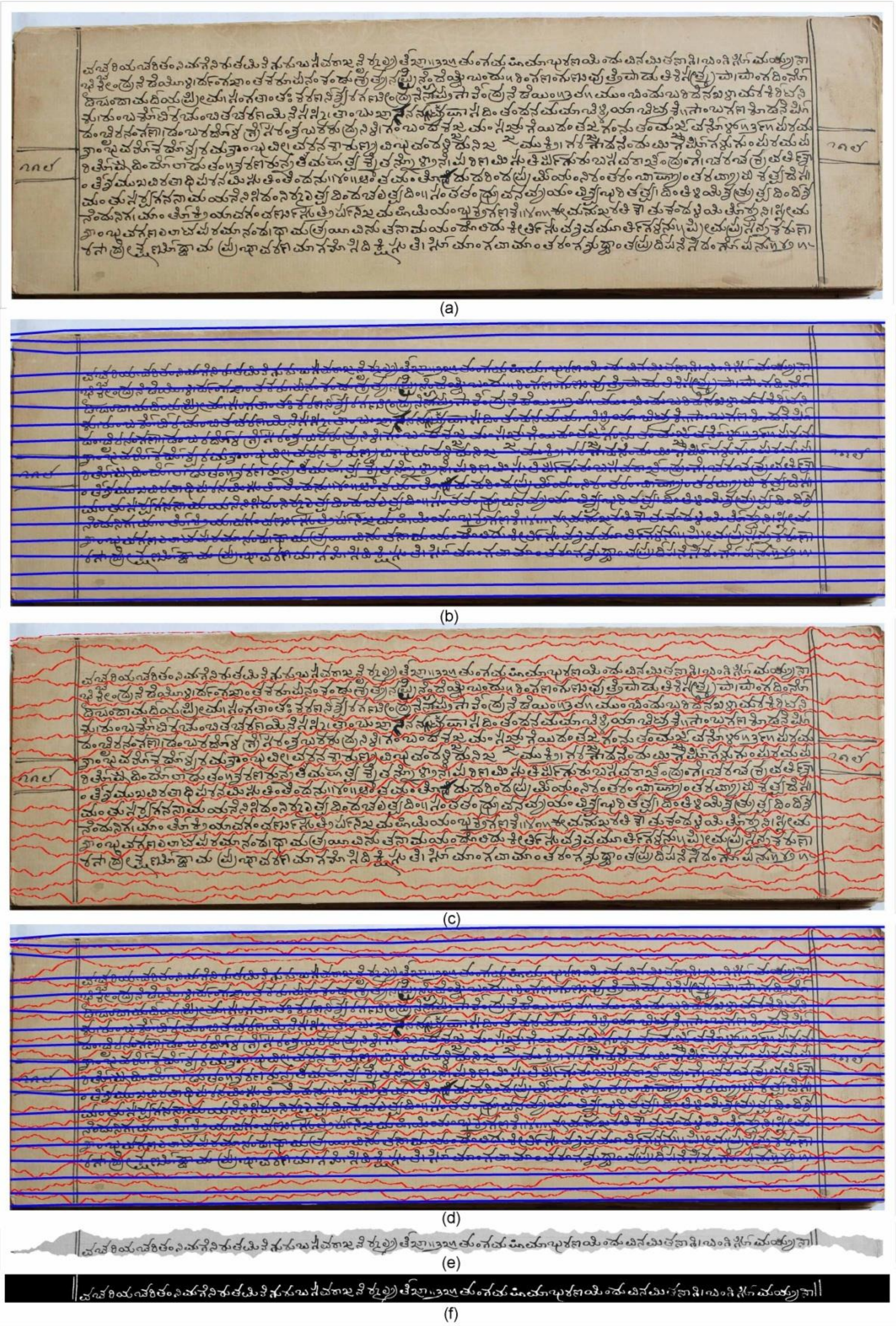


Figure 4. Sample image of the proposed algorithm (a) Original camera captured historical Kannada handwritten manuscript document image of Vijayanagara dynasty (1400AD) (b) medial seam computed image (c) Separating seam computation image with constrained seam carving based on medial seam (d) overlaid image with both type of seam (e) text line is extracted based on the overlaid seam (f) Enhancedand size normalized image

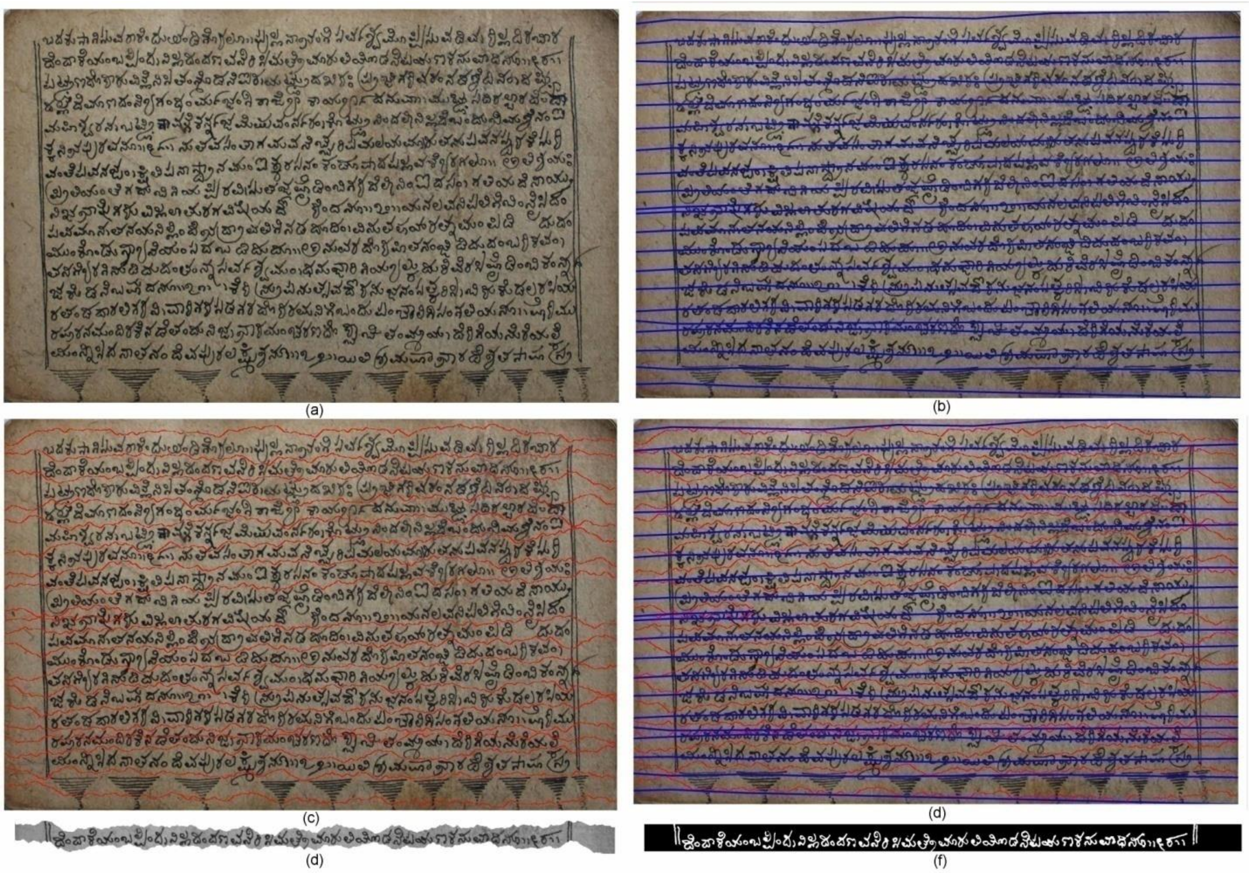


Figure 5. Sample image of the proposed algorithm (a) Original camera captured historical Kannada handwritten manuscript document image of Hoysala dynasty (1340AD) (b) medial seam computed image (c) Separating seam computation image with constrained seam carving based on medial seam (d) overlaid image with both type of seam (e) text line is extracted based on the overlaid seam (f) Enhanced and size normalized image

Table 1. The results of the text lines extracted from the manuscripts of various dynasties based on their age-type

Dynasties	No. of Manuscript Images	Total No. of Text lines in the Manuscript images	Correctly Identified and Segmented text lines	Unidentified Text lines
Vijayanagara (1460)	24	252	250	2
Mysoure Wodeyar (1936)	28	235	224	9
Vijayanagara (1400)	39	674	552	122
Hoysala (1340)	30	336	335	1

Table 2. Classification accuracy of LBP with 59 Features for different k-fold experimentation

Classifiers	5 Fold	4 Fold	3 Fold	2 Fold
LDA	NA	NA	NA	NA
KNN	94.9	94.5	94.8	93.9
SVM	96.4	96.1	95.4	95.7

Table 3. Classification accuracy of LBP with 19 Features for different k-fold experimentation

Classifiers	5 Fold	4 Fold	3 Fold	2 Fold
LDA	94.2	94.1	93.8	93.9
KNN	94.9	94.9	93.5	93.7
SVM	96.4	96.1	94.5	95.9

Table 4. The average classification accuracy of proposed method with LDA, K-NN and SVM classifiers

Dynasties	LDA		K-NN		SVM	
	Recognition Rate	**Error Rate**	**Recognition Rate**	**Error Rate**	**Recognition Rate**	**Error Rate**
Vijayanagara(1460)	96	4	98	2	97	3
Mysoure Wodeyar(1936)	89	11	87	13	92	8
Vijayanagara(1400)	97	3	97	3	98	2
Hoysala(1340)	93	7	95	5	97	3
Average accuracy	**94.2%**		**94.9%**		**96.4%**	

IV. CONCLUSION

In this paper, we have proposed an algorithm to identify and recognize the historical Kannada handwritten scripts of various dynasties; namely, Vijayanagara dynasty (1460 AD), Mysore Wadiyar dynasty (1936 AD), Vijayanagara dynasty (1400 AD) and Hoysala dynasty (1340 AD) by using the improved seam carving text line segmentation method with LBP features. For recognition and classification purpose the LDA, K-NN and SVM classifiers are used. The average classification accuracy for different dynasties are computed. The LDA classifier has yielded 94.2%, K-NN classifier yields 94.9% and SVM classifier has 96.4%. Based on the experimentation, the SVM classifier has proved good classification performance comparatively LDA and K-NN classifiers for historical Kannada handwritten script recognition. The experimental results are verified by Epigraphists and language expert, which shows the robustness of the proposed method. The same algorithm may be used for other dynasties with different feature sets, which will be done as future work.

ACKNOWLEDGMENT

The authors are grateful to The Chairman, Department of P. G. Studies and Research in Kannada, Gulbarga University, Kalaburgi and Dept. of Hastaprati, Kannada University, Hampi for providing the historical Kannada handwritten manuscripts and visualization of manual results.

REFERENCES

[1] Manjunath, M.G., Devarajaswamy G.K., “*Kannada Lipiya Vikasa*”, Published by Jagadhguru Sri Madhvacharya Trust, Sri Raghavendra Swami Matta, Mantralaya

[2] Narasimha Murthy, A.V., “*Kannada Lipiya Ugama Mattu Vikasa*”, Kannada Adhyayana Samsthe, Mysore University, Mysore (1968)

[3] Reddy D., “*Lipiya HuttuMattu Belavanige—Origin and Evolution of Script*”, Kannada Pustaka Pradhikara (Kannada Book Authority), Bangalore

[4] Nikolaos Arvanitopoulos and Sabine Susstrunk, “*Seam Carving for Text Line Extraction on Color and Grayscale Historical Manuscripts*” 14th IEEE International Conference on Frontiers in Handwriting Recognition, DOI: 10.1109/ICFHR.2014.127, pp.726-731.

[5] S. Avidan, A. Shamir, “*Seam Carving for Content-Aware Image Resizing*,” ACM Transactions on Graphics, vol. 26, no. 3,p. 10, 2007.

[6] Veronica Romero, Joan Andreu Sanchez, Vicente Bosch, Katrien Depuydt and Jesse de Does, “*Influence of Text Line Segmentation in Handwritten Text Recognition*” 13th IEEE International Conference on Document Analysis and Recognition (ICDAR), 2015, 978-1-4799-1805-8/15, pp.536-540

[7] Anguelos Nicolaou, Andrew D. Bagdanov, Marcus Liwickiy, and Dimosthenis Karatzas, "*Sparse Radial Sampling LBP for Writer Identification*", 2015 13th International Conference on Document Analysis and Recognition (ICDAR), doi: 10.1109/ICDAR.2015.7333855, pp.716-720.

[8] Sounak Dey, Anguelos Nicolaou, Josep Llados , and Umapada Pal, "*Local Binary Pattern for Word Spotting in Handwritten Historical Document*", Structural, Syntactic, and Statistical Pattern Recognition. S+SSPR 2016. Lecture Notes in Computer Science, vol 10029. Springer, Cham, pp.574-583.

[9] Miguel A. Ferrer, Aythami Morales and Umapada Pal, "*LBP Based Line-wise Script Identification*", 2013 12th International Conference on Document Analysis and Recognition, doi:10.1109/ICDAR.2013.81, pp.369-373.

[10] Sourav Ghosh, Dibyadwati Lahiri, Showmik Bhowmik, Ergina Kavallieratou and Ram Sarkar, "*Text/Non-Text Separation from Handwritten Document Images Using LBP Based Features: An Empirical Study*", J. Imaging 2018, 4, 57; doi:10.3390/jimaging4040057, pp.1-15.

[11] Maroua Mehri, Pierre Héroux, Petra Gomez-Krämer, Rémy Mullot, "*Texture feature benchmarking and evaluation for historical document image analysis*", International Journal on Document Analysis and Recognition, Springer Verlag, 2017, pp.1-35. doi:10.1007/s10032-016-0278-y.

[12] Laurence Likforman-Sulem, Abderrazak Zahour and Bruno Taconet, “*Text line segmentation of historical documents: a survey*” IJDAR (2007) pp:123–138, DOI 10.1007/s10032-006-0023-z

[13] Abedelkadir Asi, Raid Saabni and Jihad El-Sana, “*Text Line Segmentation for Gray Scale Historical Document Images*”, HIP '11 Proceedings of the 2011 Workshop on Historical Document Imaging and Processing, DOI: 10.1145/2037342.2037362, pp. 120-126, 2011.

[14] Parashuram Bannigidad and Chandrashekar Gudada, “*Restoration of Degraded Historical Kannada Handwritten Document Images using Image Enhancement Techniques*”, International Conference on Soft Computing and Pattern Recognition (SoCPaR 2016), 2016. pp. 498-508

[15] Parashuram Bannigidad and Chandrashekar Gudada, “*Restoration of Degraded Kannada Handwritten Paper Inscriptions (Hastaprati) using Image Enhancement Techniques*”, IEEE International Conference on Computer Communication and Informatics (ICCCI -2017), 2017. Pp.1-6.

[16] Parashuram Bannigidad, Chandrashekar Gudada, “*Identification and classification of historical Kannada handwritten document images using LBP features*”, International Journal of Intelligent Systems Design and Computing, Jan 2018, Vol. 2, Issue 2, pp. 176-188.

[17] T. Ojala, M. Pietikainen, and T. Maenpaa, “*Multiresolution gray-scale and rotation invariant texture classification with local binary patterns*,” Pattern Analysis and Machine Intelligence, IEEE Transactions on, vol. 24, no. 7, pp. 971–987, 2002.