A Survey on the Application of Image Processing Techniques on Palm leaf Manuscripts

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Abstract—*When the transmission of written knowledge was not effective enough, the value of that knowledge to society can be taught by the care and elegance of its recording(Manuscripts).Not just events, recordings of history includes teachings, interpretations and narrations, Teachings of great sages who came out of compassion for people, gathered them and taught them what the ancient seers taught, what had been passed down the generations through the Manuscript Teachings. In order to preserve these precious knowledge to mankind which are being damaged by aging or due to several other reasons they have to be digitized for future use. Manuscripts being a precious base of knowledge should be protected. Image processing over the past decade has undergone various developments, Many Image Processing techniques have been introduced for an efficient Data Retrieval such as Image Enhancement, Image Segmentation and Image Acquisition. All these techniques have various schemes in order to process the images and get the desired results. Here in this paper we discuss about few techniques proposed by various authors that help us in Enhancing, Assessing, Improvising and providing access to manuscript images for successful data retrieval.*

Keywords—Cultural heritage, Image processing, Image enhancement, Image segmentation, Character segmentation, Line segmentation, Color system transformation, Document analysis, Boundary tracing, Fourier descriptors, Shape similarity measure, Tree-search, Virtualization, OCR.

I. INTRODUCTION

Palm-leaf manuscripts (Talapatragrandham) aremanuscripts made out of dried palm leaves. Palm-leaf manuscripts are used since fifth century B.C.In countries like India vast knowledge in the field of medicine, architecture and mathematics from the ancient era has been recorded in the palm-leafs.

[1] The author used an old palm leaf manuscript from India, consisting of 66 folios. Originally the palm leaves are tightly bundled and are of same dimensions. The sequence of this folios (except the beginning 1-18) was lost because a part of manuscript bundle was eaten by a mouse. The mouse just destroyed about

5-10% of each leaf, mostly the left side (fig.1). The author here assumes that the mouse ate the leaves in a regular manner, the geometry of the harmed part is focused for re-sequencing this bundle. In order to segment an inner boundary-tracing algorithm was applied to all leaves. Two boundary based shape Descriptor algorithms: Fourier descriptors and a rotation-translation invariant boundary intersection-based shape descriptor were applied on the boundary data to find the most probable ancestor and successor leaves for any pointed leaf. A Tree search scheme that generates the most probable sequence was established that starts from 18^{th} and ends at 66^{th} leaf.

Fig.1: Left side of the leaves, eaten by mouse.

In this paper [2] the author proposes a transform based method which helps in enhancing the digitized manuscript images. The original leaves are not in a readable form because they are aged, leading to deterioration in writing media, smearing along cracks and seepage of ink, damage to the leaf is also caused due to the holes used for binding them. The reasons why we need to do background enhancement is that, while digitization of this images is done we cannot force flat the leaf manuscripts and the light source for digital cameras is usually uneven. This lead to a poor contrast between foreground and background.

The previous enhancement algorithms proposed have been designed primarily for segmentation of the textual content from the background of the image. There are many

thresholding algorithms proposed for this task namely, Otsu's thresholding technique [5], entropy techniques proposed by Kapur [6], and the minimal error technique by Kittler and Illingworth [7].This methods were designed mainly as a preparation stage for OCR processing. Others methods proposed for historical document enhancement are driven by a goal of improving human readability along with maintaining the original "***look and feel***" of the documents, example[8].The results produced by this methods were not satisfactory since, the contrast between foreground and background is typically low and the color intensity of the background varies throughout the image.

The author to enhance the legibility of the foreground text uses a dynamically selected pivoting background color to transform the image linearly. Two other image processing techniques developed earlier by the authors [9] are used for histogram normalization and background normalization .the proposed method shows significant improvement in readability

[3]Medieval manuscripts contain a wide variety of metadata such as text contents, layouts, typography, writing styles, document structure, author authentication, paper texture, signs, drawing, ornaments and decorated frames which helps historian to date and authenticate the manuscripts. These metadata are difficult to retrieve and a fine indexing would not be possible with a better automation by retroconversion process using image analysis. Metadata for medieval manuscript are defined by European project MASTER (Manuscript Access through Standards for Electronic Records).

[4] The key objective of the author is to develop a specific image processing system that could retrieve information from the historical palm-leaf manuscripts. The proposed techniques are used to develop an automated system to retrieve information from an ancient manuscript in Arya Ezhuthu, an ancient script used in Kerala. The techniques used are spatial change detection, text line segmentation and character segmentation.

II. REVIEW

Re-sequencing

[1]For the rectification process three of the leaves are placed on an A4-sized white paper are digital images were taken. The A4-sized papers corners were used as reference points. Projective transformation and bi-linear resampling process were applied to each image for compensating the perspective effect. Projective transformation parameters (a_i) were calculated and then to obtain correct images bi-linear sampling process is applied in eq (1).

Below table (1) gives a brief view of challenges considered in the given paper and solution for the study done.

Challenges	Solution
Re-sequencing a mouse bitten manuscript bundle.	Using inner boundary tracing algorithm, two boundary base shaped descriptor algorithms : Fourier descriptors and a rotation-translation invariant boundary intersection-based shape descriptor, tree search.

Where i= {1,2,3,4}. Eq ---(1)

$$X_i = \frac{a_0 x_i + a_1 y_i + a_2}{a_6 x_i + a_7 y_i + 1} \quad , \quad Y_i = \frac{a_3 x_i + a_4 y_i + a_5}{a_6 x_i + a_7 y_i + 1}$$

An 8-connectivity mode inner boundary tracing method is used with upper right corner of all leaf parts as a starting point to segment the leaves from image background. Then the inner boundary coordinates were saved to an ASCII file. The author uses a 2-D boundary analysis method (Fourier descriptors), based on Fourier analysis of the function derived from the boundaries. The boundary points are represented as $(x_0,y_0),(x_1,y_1), (x_2,y_2),\ldots\ldots\ldots\ldots (x_{n-1},y_{n-1})$. The author for his convenience represent the coordinate pair as a complex numbers. Thus reducing a 2D problem to 1D.so we get eq (2)

$S(k) = x(k) + jy(k)$ $k=0,1,\ldots\ldots\ldots N-1$ ---------(2)

The discrete 1D Fourier transform s(k) is shown in eq(2)

$$a(u) = \frac{1}{N}\sum_{k=0}^{N-1} s(k)\exp[-j2\pi uk/N] \qquad u = 0,1,\ldots,N-1$$

--------- (3)

The inverse Fourier transform of a (u)'s restore s(k)in eq (4).

$$s(k) = \sum_{u=0}^{N-1} a(u)\exp[j2\pi uk/N] \qquad k = 0,1,\ldots,N-1$$

-------- (4)

To differentiate between boundary shapes the author uses few Fourier descriptors to capture the gross essence of a boundary. As a shape similarity measure the first 250 Fourier descriptors are used to calculate the shape similarity between two leaves. All Euclidean distances among the leaves were calculated and an overall symmetric matrix was generated:

$$D_{\text{fourier}} = \begin{bmatrix} 0 & d_{0,1} & \dots & d_{0,65} \\ d_{1,0} & 0 & \dots & d_{1,65} \\ \dots & \dots & \dots & \dots \\ d_{65,0} & d_{65,1} & \dots & 0 \end{bmatrix}_{66x66} \quad \text{-------- (5)}$$

One can derive the degree of similarity between leaves using $D_{fourier}$matrix as in eq (6).

Apart from Fourier descriptors the other uses another approach, spatial boundary intersection. Here every leaf pair were intersected, the intersected area and standard deviation of intersected distances are calculated. All values are stored in a matrix:

Similar to $D_{fourier}$this matrix (eq (6)) also gives useful metric information about the similarity of leaf pair.

$$D_{\text{intersection}} = \begin{bmatrix} 0 & dI_{0,1} & \dots & dI_{0,65} \\ dI_{1,0} & 0 & \dots & dI_{1,65} \\ \dots & \dots & \dots & \dots \\ dI_{65,0} & dI_{65,1} & \dots & 0 \end{bmatrix}_{66x66} \quad \text{-(6)}$$

To evaluate the information provided by above two matrices the author used evaluating of shape data using Tree search. The fig(2) shows the implementation of tree search Each group were marked internally and are then merged the below figures show the obtained results .

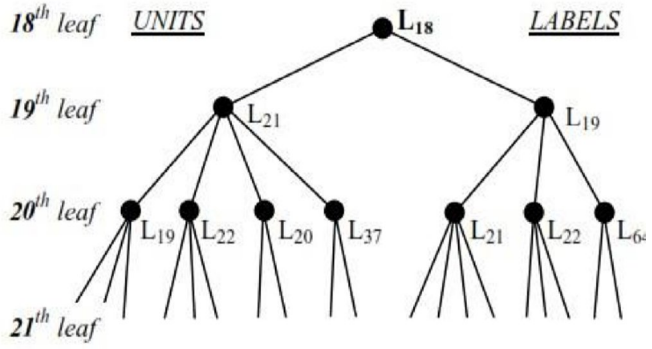

Fig.2: A sample part from the implemented Tree search

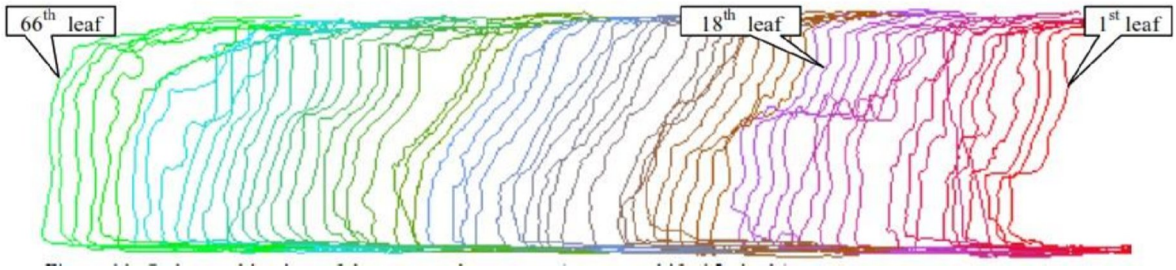

Fig.3: Orthographic view of the proposed sequence

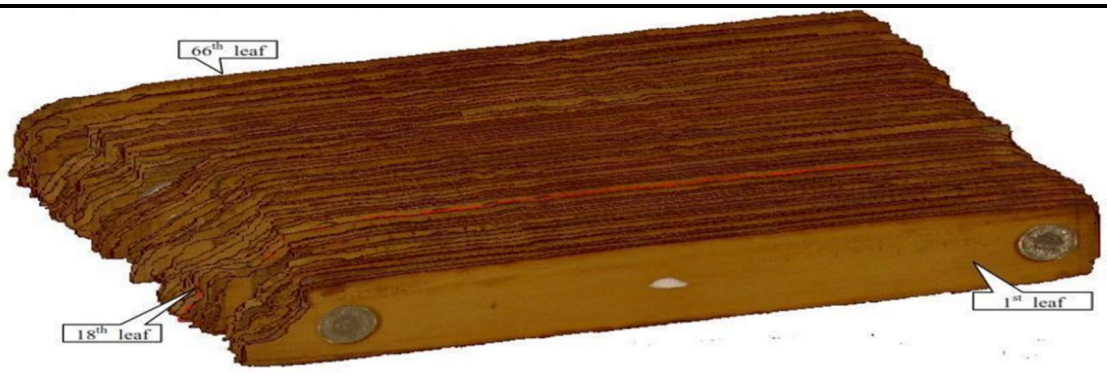

Fig.4: Texture mapped model of the palm leaf manuscript.

Digital Enhancement

Below table (2) gives a brief view of challenges considered in the given paper and solution for the study done.

Table. II

Challenges	**Solution**
Text Enhancement to make the manuscript readable.	Color bleaching transform, histogram normalization and background normalization techniques.

The author in the paper [1] designs a transform to bleach out the background colors to the extent possible .At this stage, the text color level is still close to the bleached background. To further enhance the text level from the background we use histogram normalization. Finally, background normalization is applied to eliminate the uneven background problem, which helps in enhancing the image to make it more legible to the eye as well as facilitating segmentation of the text from non-text background.

To wash out the background color the author selects a background color(assuming that most dominant color from a leaf are from the background) dynamically for every individual leaf simply by calculating a color histogram .This base color(r_0,g_0,b_0) helps in designing a linear model in terms of the following transform as in eq(7):

$$L = \frac{R}{r_0} + \frac{G}{g_0} + \frac{B}{b_0} \quad \text{---------- (7)}$$

After applying this transformation a grey-scale image is created. To increase the contrast between the text and the background the histogram normalization is done. Small percent of values at both ends of the grey spectrum are cut-off. Further normalization is done using the nonlinear approximation. The normalized pixel value for any pixel at location *(x,y)* with pixel value $Z_{orig}$is computed as in eq (8)

$Z_{new} = Z_{orig} – z + c$ ---------- (8)

Where z is correspondent pixel value on the approximated background; c is the constant fixed at some number close to white color value 255.The Original image and Resultant images are shown in fig (5) tofig (9) respectively.

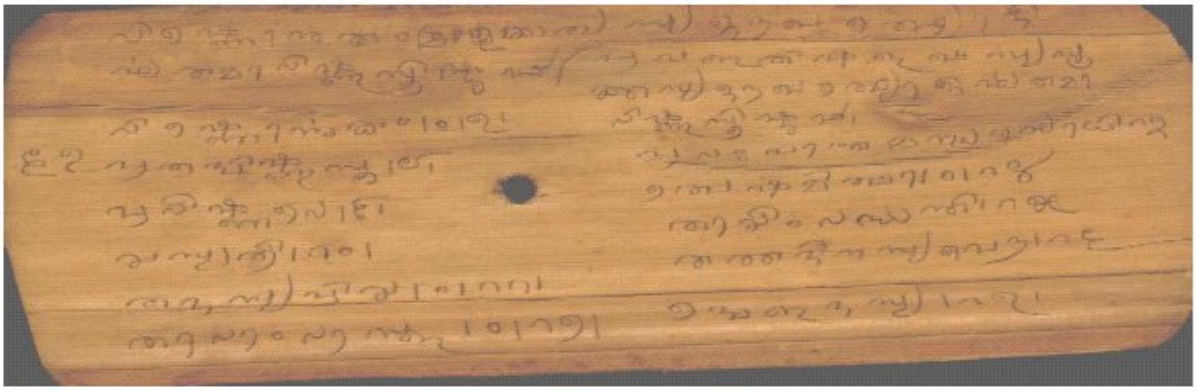

Fig.5: Original Image

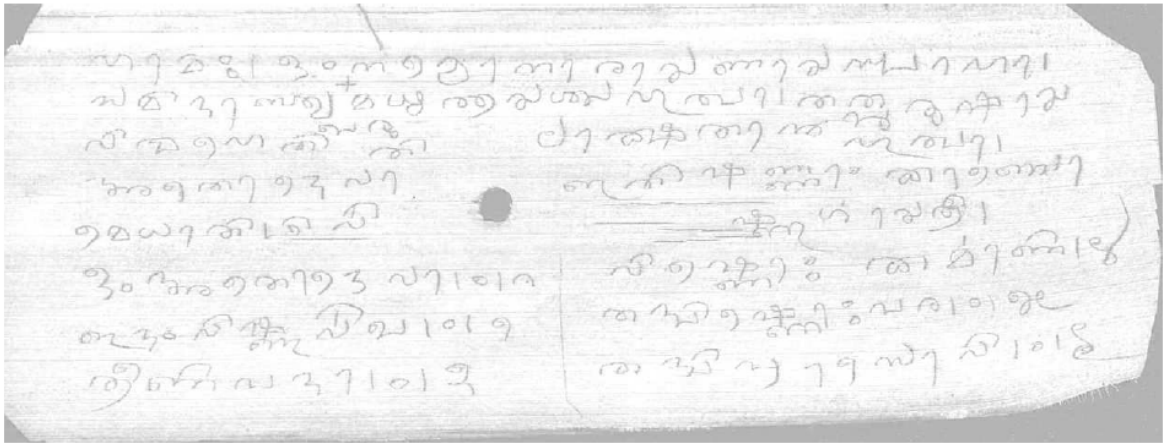

Fig.6: Resulting image after applying color-bleaching transform.

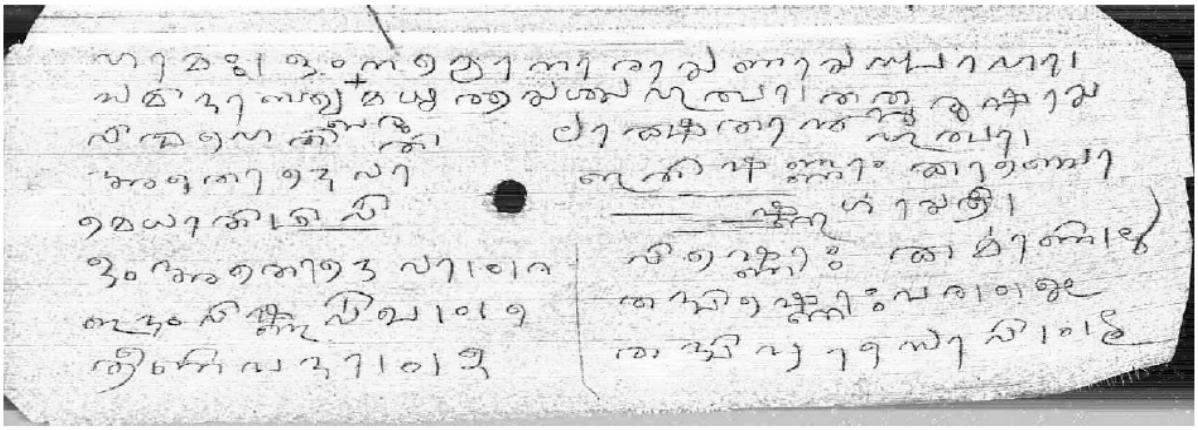

Fig.7: Further enhancing the contrast using Histogram Normalization.

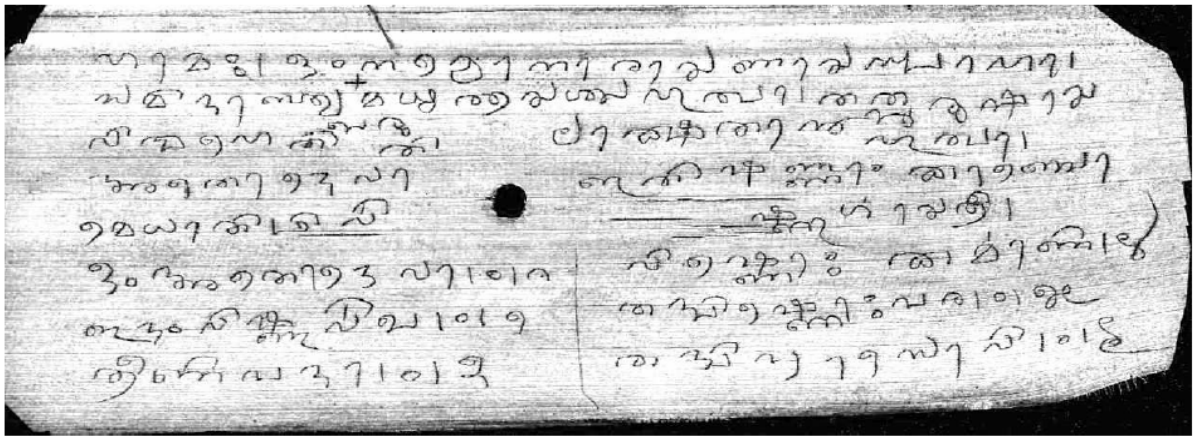

Fig.8: Resulting image after applying background normalization

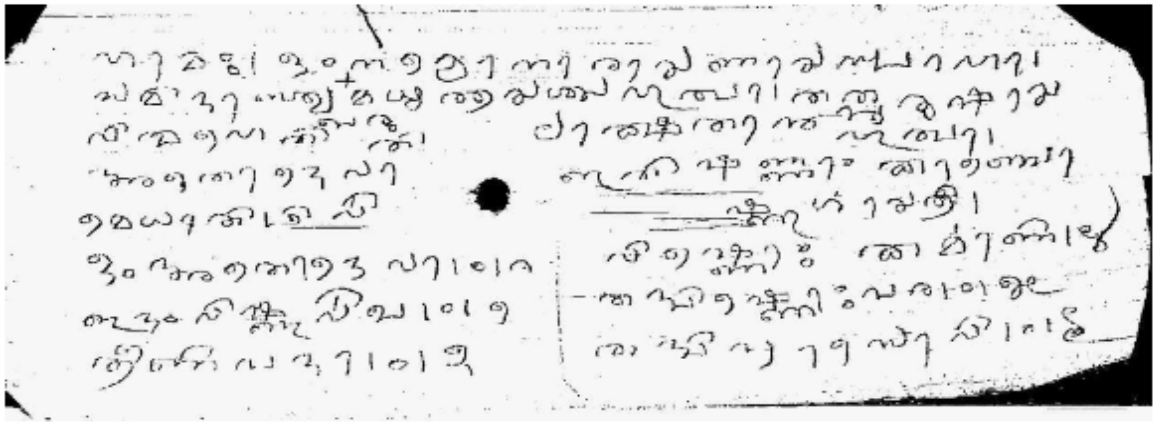

Fig.9: The enhanced image obtained after applying the normalization techniques.

III. DOCUMENT ANALYSIS

In this paper [3] the process flow of the proposed method for document analysis is as follows:

1) Spatial change detection.
2) Text line segmentation.
3) Character segmentation.

Table. III

Challenges	**Solution**
To separate foreground text from the background, Separating lines and characters.	Binarization Technique, Spatial change detector, computing histogram column wise, row wise and applying threshold,

Above table (3) gives a brief view of challenges considered in the given paper and solution for the study done.

Spatial change detection

In this technique binarization is done by which the foreground text will be segmented from the background, though the text is segmented it doesn't solve the actual problem i.e. the manuscripts may be damaged by insects and several other reasons and so when the image is converted to a grey scale image noise can be generated and can be included in the image. So, in order to reduce these effects we use cognitive memory network to perform the spatial change detection.

An image is passed as input to the spatial change detector which is a cognitive memory network. A window size of 1 x 2 pixels is selected for the horizontal spatial detection, which will take the two adjacent values of the image, then this window values will apply two input cognitive memory cell which are used to set the resistor value. If there is any change between the window values the cell will detect and write a low ('0') in the second pixel value of the window, in the result image. If there is no change, then the cell will not record any change.

Fig.10: Original image (top) and the output of the spatial change detector (bottom)

After detecting the horizontal spatial changes we select a 2 x 1 window size for vertical facial changes. When both horizontal and vertical spatial changes are found we do OR function on the resulted images to add both the changes to a single image.

Text line segmentation

To count the number of line in the manuscript we have to separate each line from the image after spatial change detection. For that we use a function which will take the histogram along the row wise and apply a threshold which will separate s the area with data from the empty line, In this way line segmentation is done.

Fig.11: Image after line separation

Character segmentation

For character segmentation we have to compute the histogram column wise and apply threshold, which creates a separation between characters. In order to segment the characters we have selected the pixel regions which change from black to white and white to black. Example for segmented characters Fig.

Fig.12: After character segmentation

Metadata Retrieval

In this paper [4] the author proposed techniques to retrieve metadata successfully by image analysis system for both Latin and Arabic scripts.Below table (4) gives a brief view of challenges considered in the given paper and solution for the study done.

Below table (5) shows the various types of metadata from both Latin and Arabic manuscripts.

Table. IV

Challenges	**Solution**
Retrieving metadata successfully by image analysis system for Latin and Arabic scripts.	Various Morphological operations.

Table. V

Medieval Latin Manuscripts	**Arabic Manuscripts**
Illuminated objects, Main body page, Physicallayout, Miniatures, Initial, Writing styles, Keywords, Separating different text colors, Page references.	Main body page, The writing on the margin, Ornaments, The chapter title, Illustrations, Page layout.

Table (5): Table showing various types of metadata from Latin and Arabic manuscripts

IV. IMAGE ANALYSIS SYSTEM

In this paper [4] the author's Objective is to study the feasibility to process automatically digitized manuscripts by using a generic platform in order to retrieve the information from the manuscript. In this we use Bottom up process for efficient data retrieval. Image quality of the digitized manuscripts is not regular. Making it easy by using digitized microfilm of the manuscript rather than the originals which is faster and cheaper.But in the other hand, it provides bad quality images generally using very few gray levels because the microfilm process clarifies the background and enhances the contrast in which information loss during the digitization process cannot be restored. As we do not have a proper model of the layout for the manuscripts we choose bottom up approach. For Example, to remove frames and the shadow of the book borders in bi-level images we apply several morphological operations. The resulting image describe each component in a grey scale image as shown in the Fig (13).

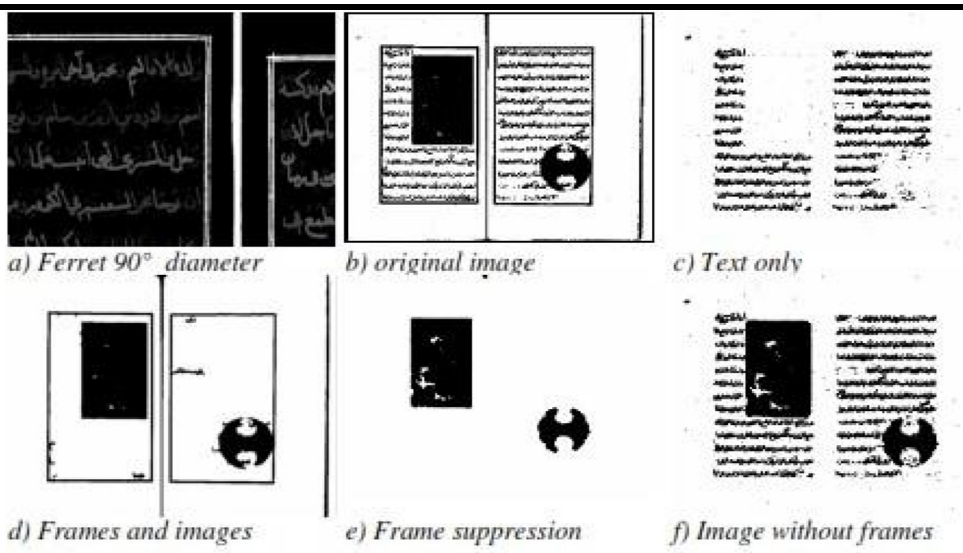

Fig.13: frames suppression by morphology

Main body Segmentation.

$$P(x) = 1 - \frac{|Size(x) - AverageSize|}{\underset{\text{For each object } y}{Max} |Size(y) - AverageSize|}$$

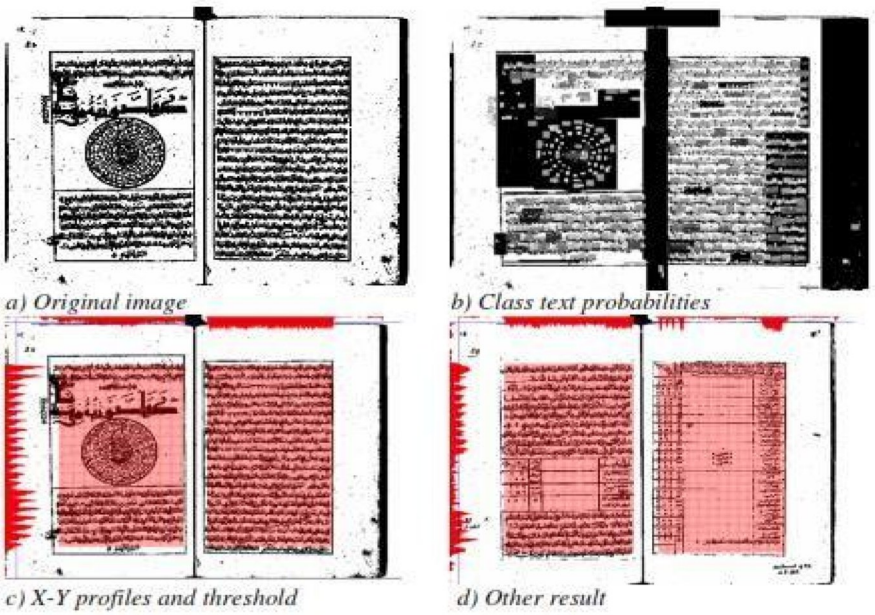

Fig.14: Main body segmentation using text zones

The location of the main text of the layout in the given manuscript is a very important issue because the classification of the objects may change basing on the positioning of the text. For example, text zone is classified as annotations if it is located outside the main body and regular text if it is inside. In this proposed methodology the detection of the main body is done by locating the text even though the text is not always justified and filling the entire page. We Estimate the average size of text symbols by computing the size average of all components. In a Second step, we compute a text probability value for each component based on the normalized differences between the size of the component and the average text symbol size. A high value indicates that there is a high probability to be a text symbol, then we sum horizontally and vertically to get X-Y profiles.

Feature analysis

There are 3 families of features:

1) Color features
2) Shape features
3) Geometry

The recognition of several metadata is based upon its features such as color, shape and table etc…We should also consider the spatial relations between objects such as regularity of words, alignment are important to recognize text in tables. To recognize the neighboring object an augment vector of each object with the features of neighboring objects. The dimension of the feature space is reduced by an automatic feature algorithm using the principle component analysis.

Papers surveyed pertaining to different stages of processing the digitized manuscripts.

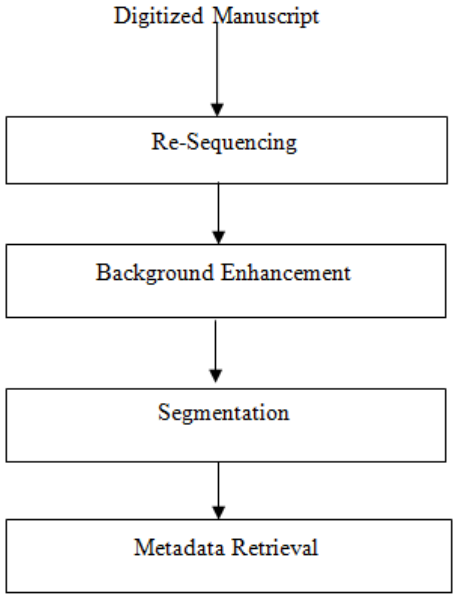

Fig.15: Diagram showing the techniques applied on palm-leaf manuscripts

Table .6: Table showing brief details about all the papers

Reference No.	Authors	Title	Methodology used	Summary
[1]	D. Akca, A. Gruen	Re-Sequencing A Historical Palm leaf Manuscript With BoundaryBased Shape Descriptors	Fourier descriptors , rotation translation invariant boundary intersection based shape descriptor and Tree-search	Re-Sequencing of a bundle of manuscripts using boundary based shape descriptors.
[2]	Zhixin Shi, Srirangaraj Setlur and Venu Govindaraju	Digital Enhancement of Palm Leaf Manuscript Images using Normalization Techniques.	Histogram normalization and Background normalization.	An approach that can help us in enhancing manuscript images which improves readability
[4]	Neethu S Kumar, Dinesh S Kumar, Swathikiran S, Alex Pappachen James	Ancient Indian Document Analysis Using Cognitive memory network	Spatial change detection, text line segmentation and Character segmentation	An automatic approach to detect and identify the characters from a manuscript.
[5]	Frank Le Bourgeois, HalaKaileh LIRIS	Automatic Metadata retrieval from Ancient Manuscripts.	Image segmentation, Main body segmentation	An automated system that can retrieve metadata is created and checked with various types for its accuracy .

V. CONCLUSION

Finally, Image processing plays a vital role in Enhancing, Assessing and improvising manuscripts. Many methodologies have been proposed by various authors in order to retrieve the information from the manuscripts efficiently. All the methodologies gave good results when compared to the existing techniques, But still many of these fail miserably in case of Indian languages because it contains large character set and linguistic features, Whereas The cognitive memory network method using spatial change detection also gave a better results in extracting the

information from an Indian manuscript. From all these proposed techniques some new techniques are to be developed in order to retrieve efficient data from the medieval manuscripts which forms the future scope of the proposed methods.

REFERENCES

[1] D. Akca, A. Gruen,Re-sequencing a historical palm leaf manuscript with boundary based shape descriptors.Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology (ETH) Zuerich, ETH Hoenggerberg, CH-8093 Zuerich,, Switzerland.

[2] Zhixin Shi, SrirangarajSetlur and VenuGovindaraju.Digital Enhancement of Palm Leaf Manuscript Images using Normalization Techniques,Centre of Excellence for Document Analysis and Recognition (CEDAR), State University of New York at Buffalo, Amherst, USA

[3] Neethu S Kumar, Dinesh S Kumar, Swathikiran S, Enview R&D Labs, Trivandrum, India Alex Pappachen James, Nazarbayev University, Astana, Kazakhstan. Ancient Indian Document Analysis using Cognitive Memory Network.

[4] Frank Le Bourgeois, HalaKaileh LIRIS, Automatic Metadata retrieval from Ancient Manuscripts, INSA de Lyon, FRANCE.

[5] N.Otsu. A threshold selection method from gray level histogram. IEEE Transactions In Systems, Man, and Cybernetics, 9:62–66, 1979.

[6] P.K.SahooJ.N.Kapur and A.K.C.Wong. A new method for Gray-level picture thresholding using the entropy of the histogram. Computer Vision, Graphics, and Image Processing, 29:273–285, 1985.

[7] J.Kittler and J.Illingworth. Minimum error thresholding.Pattern Recognition, 19(1):41–47, 1986.

[8] C.A.B.Mello and R.D.Lins. Generation of images of historical Documents by composition. In ACM Symposium on Document Engineering, McLean, VA, USA, 2002.

[9] Z. Shi and V. Govindaraju. Historical document image enhancement Using background light intensity normalization. 17th International Conference on Pattern Recognition, Cambridge, UnitedKingdon, 23-26 August 2004.