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Preprocessing of Camera Captured Inscriptions and Segmentation of Handwritten Kannada text

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Abstract : Deciphering ancient inscriptions on rocks, pillars and other writing material is one of the most fascinating and instructive studies and provides us with an instrument for conservation and transmission of historical traditions from generation to generation. The automatic processing of degraded historical documents is a challenge in document image analysis field which is confronted with many difficulties due to the storage condition and the complexity of their content. Enhancement of historical records which are degraded and of poor quality is not an easy task. Preprocessing is aimed at removing the background noise and improving the readability of ancient degraded documents. Thereby these enhanced document images can be transcribed easily and help in preserving the cultural heritage and historical importance.

The proposed system is designed for preprocessing ancient epigraphs and also segmentation of handwritten documents of Kannada script. Preprocessing here mainly deals with the noise removal and image enhancement of degraded ancient epigraphical images, for better human perception and also to transform the input into computer recognizable form. This is achieved through three different filtering methods for smoothing or sharpening namely Gaussian blur, Unsharp mask and Laplacian filter. These filters are used according to the varying amount and nature of image quality causing degradations. Enhancement is achieved through appropriate filter, provided with different mask sizes and parameter values which can be specified by the user. This is followed by binarization of the enhanced image to highlight the foreground information. Binarization is performed using Otsu thresholding algorithm which calculates optimal threshold value for the document image. Finally segmentation of handwritten Kannada documents is implemented using connected component method which identifies the individual characters through pixel connectivity and bounding box is enclosed around connected region to segment the character which will be displayed subsequently by the system. The output from segmentation can be used in further stages of OCR.

The proposed project works well for preprocessing of ancient documents and provides flexibility to the user in controlling the process of image enhancement to obtain desired output. Segmentation provided by the system produces better results when connectivity is present in the characters of handwritten documents.

Keywords: Epigraphical Images, Filters: Gaussian blur, Unsharp mask and Laplacian filter, Otsu method.

I. INTRODUCTION

Document Analysis and Recognition (DAR) aims to extract automatically the information in the document and also addresses to human comprehension. Recent research fields are exploring the use of DAR techniques, in the processing of historical/ancient documents in digital libraries and the analysis of natural images containing textual information. Preprocessing is one of the most interesting and challenging topics in DAR. The main interest of enhancement step of historical documents is to remove unwanted information appearing in the background and highlight the foreground. Hence preprocessing is a very important stage, specifically in developing OCR system for ancient records, where the main focus is on enhancing the acquired image. The accuracy of OCR systems in terms of recognition heavily depends upon preprocessing stage.

This paper addresses the preprocessing of ancient epigraphs of varying degrees of degradation for noise removal, enhancement and binarization. The objective is to enhance the quality of textual information from these documents for better human perception and also to transform into computer recognizable form, so that it can be further used for implementing next stages of OCR for epigraphical scripts. Followed by this segmentation is performed on Kannada handwritten documents in order to extract characters from it and can be used for recognition stage in OCR's. During the preprocessing of ancient epigraphs, the enhancement is achieved through smoothening or sharpening filters of different mask sizes. The three filters used here: Gaussian blur, Unsharp mask and Laplacian filter provide different enhancing feature to the degraded epigraph image. The option of choosing filter and filter sizes are provided to the users. Then the enhanced image is subjected to binarization which is achieved using Otsu's algorithm and thus the binary image is obtained. Next segmentation is carried out on handwritten Kannada documents using connected component technique to identify the individual characters and a bounding box is enclosed around every segmented letter.

This paper is organized as follows: Section 2 provides an insight into the related works carried in the field. Review on Spatial Filters and Otsu's thresholding algorithm is provided in Section 3. The System architecture and Methodology is covered in Section 4. Experimental results and discussions are elaborated in Section 5, and Section 6 provides concluding remarks.

II. RELATED WORK

Quite often old documents are subject to background damage. Examples of background damages are varying contrast, smudges, dirty background, ink through page, outdated paper and uneven background. The old manuscripts which are a few hundred years of age, for example, are not legible even after preservation process by the library. Image processing offers a selection of approaches to counter these quality degradations and make the manuscripts readable. The Laplacian filter technique [1] is an edge enhancing algorithm. It performs local, or neighborhood equalization of the brightness levels of image pixels. The result is that the output/displayed image shows an increase in local contrast at the boundaries. The operator is understood to mean that the central pixel brightness value is increased by 8, while the brightness values of all the surrounding pixels are subtracted from the central pixel. A consequence of this is that in regions where the brightness values are uniform this operator sets the brightness values of the neighboring pixels to zero. But when one of these neighboring pixels becomes the central pixel, it has the same effect as the previous pixel. Thus all pixels with uniform brightness inadvertently get enhanced by a similar ratio with this procedure. This means that only points, edges or lines benefit from this operation since the brightness levels will be non-uniform within the neighboring pixels (a large change in brightness level usually indicates the presence of an edge). Hence the overall effect of this operation is that the edges of an image are enhanced. The output image produced from the application of the Laplacian algorithm [1] is not easily interpretable, but the subtraction of the original image with the Laplacian image produces an image which seems sharpened when compared with the original.

The linear Unsharp Masking (USM) technique [2] is used to improve the visual appearance of an image by emphasizing its frequency contents to enhance the edge and detailed information in it. Even though this method is simple and works well in many applications it suffers from two drawbacks, one is it is extremely sensitive to noise and other it enhances high contrast areas much more than area that do not exhibit high image dynamics. Hence output image suffers from unpleasant overshoot artifacts. Adaptive Unsharp Masking [2] employs an adaptive filter that controls the contribution of sharpening in such a way that contrast enhancement occurs in high detail areas and little or no image sharpening occurs in smooth areas. This algorithm performs well when compared with several approaches available like linear unsharp masking filter.

A wide range of low-pass filtering operations are used in image processing – low pass in the sense of passing low spatial frequencies and rejecting high spatial frequencies. These are usually given names suggesting smoothing, averaging, or blurring. One of the most widely-used operations of this type is the so-called Gaussian blur [3], which has the advantages of being very smooth and also circularly symmetric, so that edges and lines in various directions are treated similarly. For digital image processing, blurring operators are often defined on small neighborhoods (e.g., 3x3, 11x11), and a small finite number of grey levels. In such cases, the ideal Gaussian "bell curve" must be approximated by a few integer values. The values usually used are based on Pascal's triangle. These approaches the true Gaussian curve more and more closely as the number of points increase. These coefficients have the very useful property that the set for N = k can be obtained by convolving the set for N = i with the set for N = j, where k = i + j. The absolute crucial implication of this is that repeated applications of small-neighborhood Gaussian blurs can achieve large-neighborhood Gaussian blurs. These results are exactly equivalent, except for the accumulated rounding errors due to the successive operations. This is true for one-dimensional Gaussian operators as well as for two-dimensional operators and all higher dimensions. Two-dimensional Gaussian blur operations are used in many image processing applications. The execution times of these operations can be rather long, especially where large kernels are involved.

The Ancient document Image processing is an important area attracting many researchers in the recent period. Binarization is the first step while cleaning the document for further processing. Based on the degradation of the original document, either global or local thresholding methods are preferred. The Otsu thresholding algorithm [4] using the histogram shape analysis. This is the most popular global binarization algorithm. This algorithm is very simple. The thresholding of Otsu [4] shows a favorable performance if the histogram has bimodal distribution. The global threshold (optimum threshold) is selected automatically by a discriminant criterion. Hence, one can divide pixels into background and objects by a threshold at level TH. The probabilities of class occurrence and the class mean level and the total mean level of the input gray-level image are obtained. It appraises all possible thresholds and finally finds the optimal threshold value that maximizes variance between-class and minimizes variance within-class. The optimal threshold is selected.

Another technique makes use of the image contrast that is defined by the local image maximum and minimum. Compared with the image gradient, the image contrast evaluated by the local maximum and minimum [5] has a nice property that it is more tolerant to the uneven illumination and other types of document degradation such as smear. The method is better while handling document images with complex background variation. Given a historical document image, the technique first determines a contrast image based on the local maximum and minimum. The high contrast image pixels around the text stroke boundary are then detected through the global thresholding of the determined contrast image. Lastly, the historical document image is binarized based on the local thresholds that are estimated from the detected high contrast image pixels. Compare with previous method

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based on image contrast, the method uses the image contrast to identify the text stroke boundary, which can be used to produce more accurate binarization results.

A general technique for cleaning the degraded documents is modified iterative global threshold algorithm [6]. A simple approach in the separation of object information from fore ground is to compute a global threshold of intensity value with which two clusters can be separated. It's an iterative approach which can handle various degraded conditions. In each iteration, the intermediate tones are shifted towards background there by providing efficient distinction between foreground and background. It is better suited for the documents having non-uniform distribution of noise.

The process of segmentation has immense importance in the handwritten script recognition. The algorithm based on connected components [7], segment the document image into non-overlapping equi-width vertical zones. The width of the zones has to be narrow enough so that the influence of skew to be neglected, and wide enough to include adequate amount of text. A zone width equal to 5% of the document image width seems to satisfy these requirements. Some vertical zones, mainly those that are close to the left and right edges of the document page, the so called "margin" zones, will not contain sufficient amount of text. Therefore disregard them and consider only the zones with a proportion of foreground pixels above a threshold (th), say, half of the median value of the foreground pixel density of all vertical zones. In the case where the writing style results in large gaps between successive words, a vertical zone may not contain enough foreground pixels for every text line.

A segmentation approach which uses vertical and horizontal density of black pixels along an axis in order to segment text lines, words and characters. To separate the text lines, from the document image, the horizontal projection profile of the document image is found. The horizontal projection profile [8][9] is the histogram of the number of ON pixels along every row of the image. White space between the text lines is used to segment the text lines. The spacing between the words is used for word segmentation [8][9]. For Kannada document, spacing between the words is found by taking vertical projection profile of an input text line. Vertical projection profile is the sum of ON pixels along every column of an image. The projection profile is the histogram of the image. In the profile, the zero valley peaks may represent the character or word space. It differentiates whether it is character or word spacing, find the maximum character space cluster and use it for separating the words.

A method for segmentation of text-lines of hand written documents using clustering based on thresholding approach. The method consists of three stages, (i) Drawing bounding box, (ii) Clustering of Bounding box and (iii) Text line segmentation. The groupings of wards are done by drawing the bounding box. It is because the connect components are easily identified and it helps in clustering. In this step, cluster the different bounding box [10] by measuring the area covered by each bounding box. Here compare the distance between two neighbor bounding boxes for threshold value. The two bounding boxes are combined by calculating the threshold value. This threshold value groups the different bounding boxes into one cluster. As clusters are formed, it helps in text line segmentation. Since the different clusters are obtained in previous step, it is easy to segment the text-line by assigning the different colors for different clusters.

Another method for segmentation is nearest neighbor algorithm [11] which is iterative in nature scans the character from the top left portion of the image. When it reaches the first black pixel, then the first symbol is identified through the connected component. If it is found to be the first character of the script, then it is placed as the first character of the new line used for placing the character of segmentation. The centroid of the character is computed and stored in an array separating the x and y coordinators. The document is again scanned from left top to locate the next black pixel and hence the next character in the document. The centroid of the character also computed. The distance between the centroid is computed using the distance formula. If the distance is less than or equal to threshold value then the character is assume to be of the same line. Otherwise the character is consider being the part of the next line and transferred to the next line in the result part. This process is continued until all the characters are scanned and whole image has been traversed. At the end of the iterative algorithm the separated lines are obtained from the source. The individual character can also be obtained in this process itself.

III. REVIEW ON SPATIAL FILTERS AND OTSU'S THRESHOLDING METHOD

A. Gaussian blur

A Gaussian blur also known as Gaussian smoothing is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen. Gaussian smoothing is used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales. The Gaussian blur[12] is a type of image-blurring filter that uses a Gaussian function for calculating the transformation to apply to each pixel in the image.

The equation of a Gaussian function in one dimension is

$$G(x) = \frac{1}{\sqrt{2\Pi\sigma^2}} e^{\frac{-x^2}{2\sigma^2}} \quad (1)$$

where *x* is the distance from the origin in the horizontal axis, *y* is the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution. The standard deviation σ of the Gaussian determines the amount of smoothing.

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B. Un-Sharp Masking (USM)

Un-Sharp Masking [13] (USM) is an image manipulation technique in digital image processing. The unsharp as the name derives from the fact that the technique uses a blurred, or unsharp, positive image to create a mask of the original image. The unsharped mask is then combined with the negative image, creating an image that is less blurry than the original. The resulting image, although clearer, probably loses accuracy with respect to the image's subject. Digital unsharp masking is a flexible and powerful way to increase sharpness, especially in scanned images. However, these effects can be used creatively, especially if a single channel of an RGB or lab image is sharpened. Undesired effects can be reduced by using a mask particularly one created by edge detection to only apply sharpening to desired regions, sometimes termed smart sharpen.

C. Laplacian Filter

The Laplacian[14] is a linear derivative operator and it forms an isotropic filter. In order to get a sharpened image, typically, the resulting Laplacian filtered image is added to the original image.

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (2)$$

If the blur in the picture is result of a diffusion process that satisfies the well known partial differential equation

$$\frac{\partial g}{\partial t} = D\nabla^2 g \qquad (3)$$

where g is a function of x,y and t (time) and D is a diffusion constant.

Discretisation of above equation with finite differences gives
g(x,y, t+ dt) = (1-4*dt*D/h^2) * g(x, y, t) +
dt * D/h^2 [g(x + h, y, t) + g(x-h, y, t) + g(x, y + h, t) + g(x,y-h, t)]
(4)

The unblurred picture '*f*' can be restored by subtracting from '*g*' a positive multiple of its Laplacian.

$$f = g - D * dt * \nabla^2 g \qquad (5)$$

Negative values for the diffusion constant D will sharpen the image, positive values will blur the image.

D. Otsu's method

Otsu's method is used to automatically perform histogram shape based image thresholding or the reduction of a gray level image to a binary image. The algorithm assumes that the image to be thresholded contains two classes of pixels or bi-modal histogram (foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. Otsu method exhaustively searches for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t) \qquad (6)$$

Weights ω_i are the probabilities of the two classes separated by a threshold t and σ_i^2 variances of these classes.

The class probability $\omega_1(t)$ is computed from the histogram as t

$$\omega_1(t) = \sum_0^t p(i)$$
(7)

while the class mean $\mu_1(t)$ is:

$$\mu_1(t) = \left[\sum_0^t p(i)x(i)\right] / \omega_1 \qquad (8)$$

where x(i) is the value at the center of the i^{th} histogram bin. Similarly, compute $\omega_2(t)$ and μ_t on the right-hand side of the histogram for bins greater than t.

E. Median filtering

Often it is found that scanned documents or photographs of documents contain noises mainly salt and pepper noise. These noises should be reduced or removed in order to have a better image. In general, one of the techniques to reduce noise is filtering. In particular, median filter which is a nonlinear digital filtering technique is used to remove salt and pepper noise. Median filtering [16] is widely used in digital image processing because, under certain conditions, it
preserves edges while removing noise. The median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Median filter technique replaces the pixel value with the *median* of neighboring pixel values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighborhood considered contains an even number of pixels, the average of the two middle pixel values is used.)

F. Connected-component Labeling

Connected-component Labeling is an algorithmic application of graph theory, where subsets of connected components are uniquely labeled based on a given heuristic. It is used in computer vision to detect connected regions in binary digital images, although color

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images and data with higher dimensionality can also be processed. When integrated into an image recognition system or human-computer interaction interface, connected component labeling can operate on a variety of information. This approach is used in document images to segment the characters using connectivity among the components of the image.

Functionality: The distribution of bounding boxes[18] describes a great deal about the proper segmentation of an image consisting of noncursive characters. By calculating adjacency relationships merging can be performed, or their size and aspect ratios to trigger splitting mechanisms, much of the segmentation task can be accurately performed at a low cost in computation. Connected components have also served to provide a basis for the segmentation of scanned handwritten documents into characters.

Output: The output is segmented character from the input document which is extracted based on the connected component.

IV. Proposed System and Methodology

The proposed system enhances the camera grabbed epigraphical images of ancient times, which are handwritten historical records with varying amount of degradation. Also segmentation of handwritten Kannada scripts to extract characters is demonstrated. The methods and techniques used in the proposed system are described in this section:

A. The System Architecture

The system architecture shown in Fig 1 takes ancient handwritten epigraphical records, which are camera grabbed as its input for enhancement, which is enhanced and binarized. In other stage segmentation is carried out on present handwritten scripts to segment individual characters.
In the first subsystem, handwritten ancient documents to be preprocessed are taken as input image. After the acquisition of document image, enhancement is carried out through smoothing or sharpening filters. The system displays the results of enhancement on applying any of the three filters namely Gaussian filter, Laplace filter and USM (Unsharp Masking) filter, of varying size and also constant parameter as specified by the user. Then the filtered image is binarized using Otsu algorithm.
In the second subsystem, segmentation is carried out on present handwritten Kannada documents. Initially salt and pepper noises are removed using median filter, then using connected component labeling and bounding box technique individual characters are segmented which can be used in later stages of OCR.

B. Methodology

1) Preprocessing of Camera Captured Ancient epigraphical images:

Input: The Camera Captured Ancient epigraphical image in JPG format.

Output: Results of enhancement achieved through Spatial Filtering: Gaussian blur, Unsharp mask and Laplacian filter with varying mask size and filter parameters.

The steps towards Preprocessing of Ancient Epigraphs are as follows:

Step 1: [*Read Image*]: Read epigraphical image selected is input.

Step 2: [*Enhancement*]: The input ancient epigraph of poor quality and varying amount of degradation is enhanced using any of the following filtering methods, designed and implemented with different mask sizes, depending whether smoothing or sharpening is the requirement, for better human perception:

if method = 1 or method = 2,
Read the size of the mask nxn , where n=2,3,4,5
Read value of the Standard Deviation, sigma
Set value of sigma for display
Filter the input image using Gaussian blur method.
Filter the input image using USM method.

Else if method = 3, (For Laplace Filter)
Read and Display the Diffusion constant value D Read and display the step size of the mask, No. of Steps
Filter the input image using Laplacian method.

2a : [*Gaussian blur filtering*]: Gaussian function depending on the value of Standard deviation blurs/smoothens the input image, typically reducing image noise and reduce detail.

i. Calculate Gaussian function.
ii. Calculate Gaussian mask matrix , for the input value of standard deviation of the gaussian function and mask size, nxn.
iii. Apply the designed Gaussian mask to the input image to obtain output Filtered image
iv. Display the Output Filtered Image

2b: [*USM filtering*]: Unsharp/ Blurred positive image is used to create a mask of the original image, which is then combined with the negative image, creating an image that is less blurry than the original.

i. Filter input image using designed Gaussian mask to get Gaussian Blur image.
ii. Obtain the Output USM-filter image = Input image – Gaussian Blur image
iii. Display the Output USM-Filtered Image

2c: [*Laplacian filtering*]: The unblurred image 'f' can be restored by subtracting from blur image 'g' (blur due to diffusion process) a positive multiple of its Laplacian as in Equation (5)
Negative values of diffusion constant D will sharpen the image and positive values will blur the image.

Step3: [*Gray Conversion*]: The filtered image is converted into gray scale image.

Step 4: [*Binarize*]*:* The grayscale image is converted to binary image consisting of ones and zeros.

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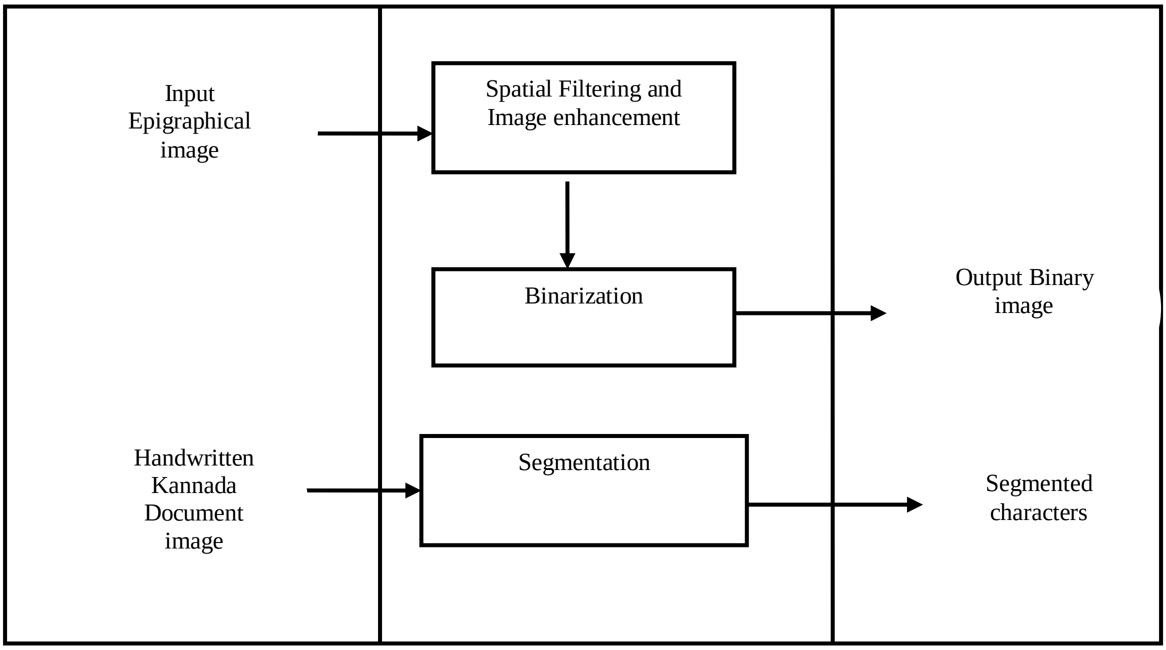

Fig. 1. System architecture of Preprocessing of handwritten Kannada documents

4a: [***Threshold Detection***] : Otsu's algorithm is designed and implemented to determine suitable threshold for conversion.

4b: [***Conversion***] : Threshold detected is used to convert Gray scale image to Binary form.

Step 5: [*Display*] : A plot of threshold determined for the conversion and The enhanced binary image is displayed on separate output windows.

2) Noise Removal and Segmentation of Characters from Document images of Kannada Script:

Input: The scanned Kannada document image in JPG format.

Output: Noise Removal and Segmented characters.

The steps towards Noise Removal and Segmentation of Characters are as follows:

Step 1: [*Read Image*]: Kannada document image of modern times is read as input.

Step 2: [*Gray Conversion*]: The input image is converted into gray scale form.

Step3: [Noise removal]: The input scanned documents mainly containing salt and pepper noise are reduced or removed by subjecting it to the designed Median Filtering approach.

i. Consider the window of 3-by-3 neighbour values in the input image
ii. Store these into an array, sort and find the middle element (Median)
iii. Place the median element in the output matrix
iv. Repeat the above steps for entire input image to obtain Median Filtered image.

Step 4: [*Segment*] : Using the approach of Connected Components labeling, the noise-free document image is segmented and thus characters are extracted.

Step 5: [*Display*] : A bounding box enclosing segmented characters in the document image is displayed and also results of sampled characters are displayed on separate output windows.

V. EXPERIMENTAL RESULTS, ANALYSIS AND DISCUSSION

The system mainly performs preprocessing of the ancient epigraphical images, which comprises of the stages namely noise removal, image enhancement, and binarization. Segmentation is also a part of the system which samples the characters from the input document images of modern Kannada Script. The preprocessing stage is mainly designed by taking into account the images of ancient inscriptions and segmentation is performed on present Kannada handwritten text documents. This section discusses the experimental results and comparative analysis of the proposed work.

A. Experimental Results

1) Experiment Dataset:

The experimental dataset consists of degraded, ancient, handwritten historical images for preprocessing and present handwritten Kannada document images for segmentation. There are totally nearly 100 samples of varying amount of degraded images of inscriptions, considered to illustrate the enhancement process and 70 samples of present handwritten Kannada document images to demonstrate segmentation.

Fig 2 represents the snapshot of the system for Gaussian blur filter for smoothing of the input image. The example image tested is anc.jpg which is an ancient script. The

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selected image from the file store is smoothened successfully using Gaussian blur filter and displayed on the axes.

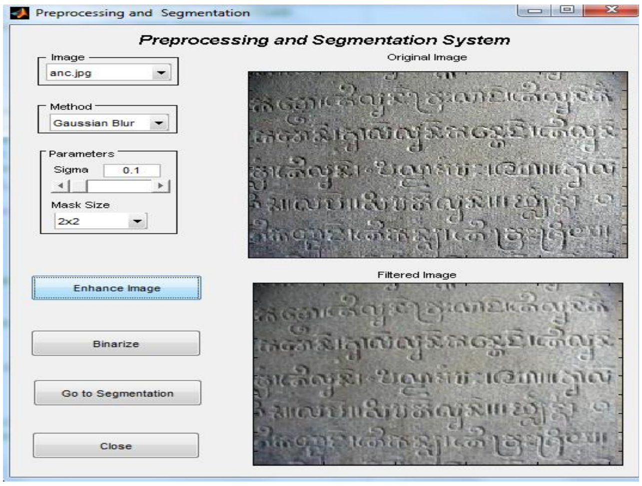

Fig. 2. Result of Gaussian Blur filtering

Fig 3 shows test case for USM filter for sharpening of the input image. The example image tested is anc.jpg which is the ancient script. The selected image from the file store is sharpened successfully using USM filter and displayed on the axes.

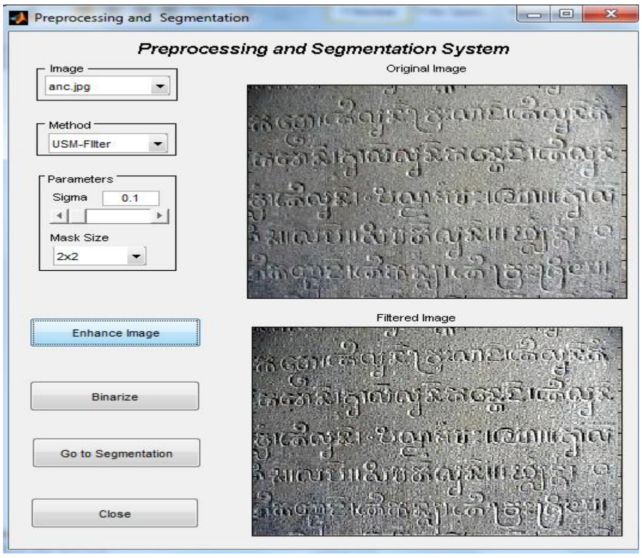

Fig. 3. Result of USM-filtering

Fig 4 shows test case for Laplacian filter for smoothing of the input image. The example image tested is anc1.jpg which is an ancient script. The selected image from the file store is smoothened successfully using Laplacian filter and displayed on the axes.

The test case for binarization of the filtered image is shown in Fig 5. The example image tested is anc1.jpg which is an enhanced ancient script. The enhanced image is binarized successfully using Otsu's method and displayed on the separate window.

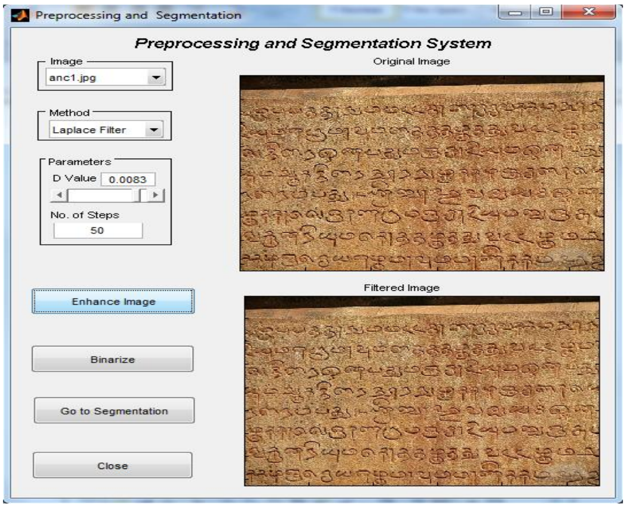

Fig. 4. Laplacian filtering output

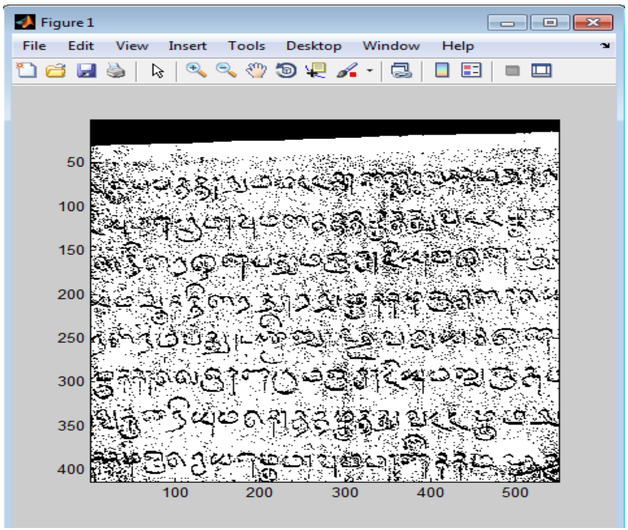

Fig. 5. Result of binarization using Otsu's method

In the second subsystem, Kannada document image is considered as input. The input document image is subjected to median filtering to remove salt and pepper noise noise and later segmented using Connected-Component labeling approach and segmented characters are enclosed in bounding box as shown in Fig 6.

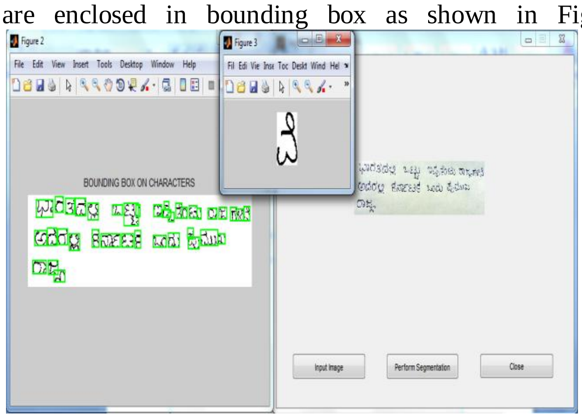

Fig. 6. Segmentation of present handwritten Kannada text

B. Comparative Analysis of results from different Spatial Filters

In this work, 100 samples of ancient document images and 70 samples of present handwritten Kannada document images were considered. The results of the image enhancement for few of the samples for three filtering techniques namely Gaussian blur, USM filter and Laplacian filter for different mask sizes are shown. The enhancement is found to be appreciable for mask size of 3X3 for Gaussian blur, 5X5 for USM filter and in case of Laplacian filter input image is sharpened for negative values of diffusion constant, smoothened for positive values. Segmentation was carried out on 70 samples and system segments the compound characters correctly when connectivity is present. Few cases where in connectivity is absent, compound character is segmented separately.

1) Gaussian blur Filtering:

The Gaussian blur method is used to blur the sharpen image so that a less edge highlighted image is produced for further stages of preprocessing and segmentation system. The Fig 7(b), (c) and (d) shows various results of Gaussian blur method for mask size of 2X2, 3X3 and 4X4 respectively on 7(a). As it can be seen that when the mask size is moderate then the output image will appear to clear and use of low mask size results in blurred image as in Fig 7(b). The use of high mask size also results in the same.

2) Unsharp Masking (USM) filtering:

Unsharp Masking (USM) filter on the other hand is a sharpening filter which enhances the blurred input image. The results of applying USM filter for a sample image in Fig 8(a) using mask size of 2X2, 3X3 and 5X5 are shown in Fig 8(b), (c) and (d) respectively. If the mask size is 2X2 the image is more sharpened and as the mask size increases the image is less sharpened resulting in a good output image.

7 (a)

7(b)

7 (c)

7(d)

Fig 7. Result of Gaussian blur on input image (a) for mask size (b) 2X2 (c) 3X3, and (d) 4X4.

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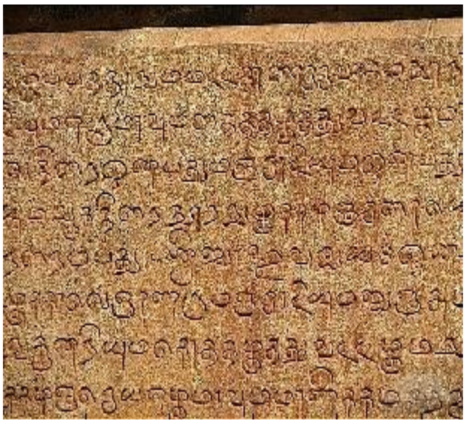
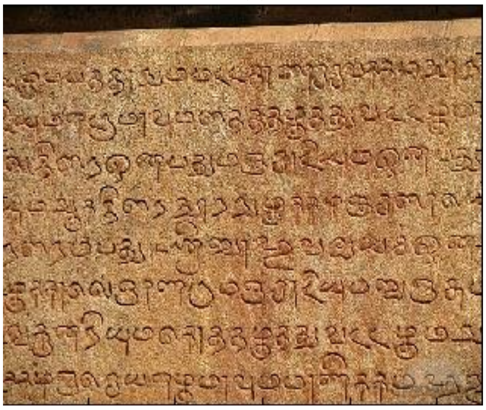


8(a)

8(c)



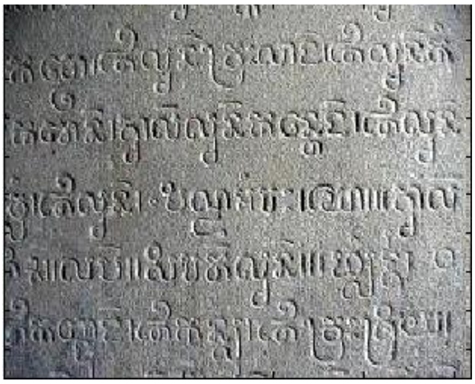
8(b)

8(d)

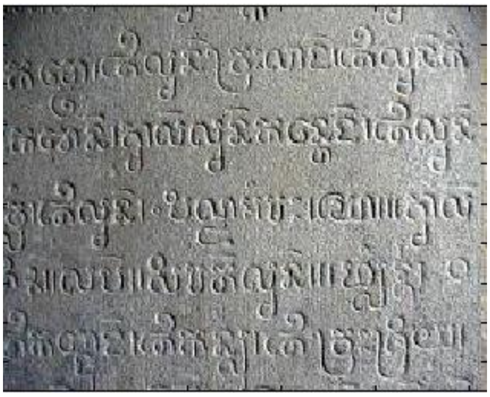
Fig. 8. Result of USM filter on input image (a) for mask size (b) 2X2 (c) 3X3 and (d) 5X5

3) Laplacian filtering:

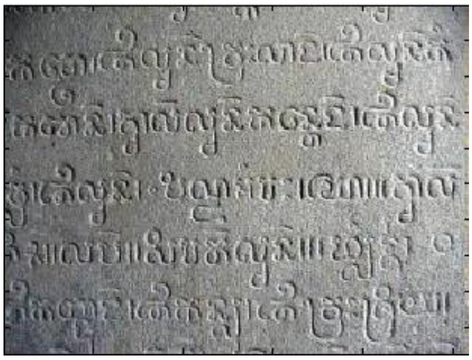
Laplacian filter is another smoothing filter. Fig 9 (b) and (c) shows results of applying Laplacian filter on the input image shown in Fig 9(a) using the diffusion value of -0.01 and +0.001 respectively. For D-value of -0.01, the input image is slightly sharpened and as the D-value increases the image smoothened. As a result for D-value of +0.01, the input image is smoothened. As compared to other filters, Laplacian filter shows less difference in output compared to input.



9(b)



9(a)



9(c)

Fig. 9. Result of Laplacian filter on input image (a) for D-value of (b) -0.01 (c) +0.01

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C. The following inferences are drawn from the experimentation:

The smoothing filters used in this system will result in good accuracy if the edges of the input image are very thick, where as in case of sharpening filter namely, USM filter better output is achieved for the degraded input image. The two smoothing filters used in the proposed system are Gaussian blur and Laplacian filter, depending on the input image the required filter can be used with different mask sizes to get the filtered image.

The segmentation in the proposed system is achieved using Connected Component and Bounding box method. The accuracy of this algorithm for compound characters is mainly dependent on connectivity of the components of characters in the document image.

VI. CONCLUSION

Preprocessing is one of the most important and challenging phase in ancient document analysis and recognition. It involves converting scanned images or photographed images of handwritten text into a computer processable format. The proposed work preprocesses camera grabbed, ancient epigraphical documents by enhancing the quality of ancient scripts, which are degraded and non readable due to various factors by using suitable Spatial filtering techniques. The ancient document image is taken as input which is fed to the preprocessing phase where the image is enhanced using sharpening or smoothing filtering techniques. . Three filtering techniques Gaussian blur, Laplacian filter and USM filter are designed and implemented and results are obtained for different filter sizes and filter parameters. The enhanced image is then fed to the binarization phase which is carried out using Otsu method. Then segmentation of characters is achieved on the present handwritten Kannada scripts using connected component technique and bounding box method. Thus the paper presents the enhancement of historical records, with varying amount of degradations into better perceivable images. The output of segmentation phase is the individual Kannada characters which can be used in the next stages of OCR for feature extraction and recognition. Preprocessing of documents of ancient periods finds scope in automatic decipherment of ancient scripts, which would help to know the cultural and historical importance of the civilization. Hence this knowledge can be used by archaeologists and historians for further study.

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