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# NANDINAGARI PALM LEAF WORD IMAGE RETRIEVAL SYSTEM

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***Abstract***

***This paper provides the first attempt for the recognition of Nandinagari handwritten word in a handwritten Palm Leaf manuscript. We take a set of very aged Palm Leaf and take a representative sample containing over 1000 characters and perform a set of preprocessing steps including background subtraction, de noising using Gaussian filter, contrast enhancement using histogram equalization and binarization using adaptive thresholding technique to obtain high quality readable manuscript. The words are subsequently extracted using annotation method to get a set of 100 meaningful Handwritten Nandinagari words of different sizes. A dictionary of these vocabulary words is formed and stored. Effective corner based feature extraction technique is applied to these images and the corresponding scale and rotation invariant features are extracted and stored in the database. The query word image is then compared with the dictionary words and the matched similar word images are retrieved.***

***Keywords:***

***Invariant Feature extraction, Scale Invariant Feature Transform, Background Subtraction, Denoising, Contrast Enhancement, Auto Thresholding***

## 1. INTRODUCTION

Nandinagari Palm Leaf manuscripts are one of the popular written documents for over a thousand years in Southern and Northern part of India [1]. Palm Leaf manuscripts used to preserve vast knowledge covering history, tradition, culture, politics, agriculture, business, arts and crafts, astrology, medicine, religion etc. Over time, most of the Palm Leaves, if left unattended, will deteriorate as they are coming to the end of their natural lifetime. They affected by dampness, fungus, bacteria, ants and cockroaches. Many of the Palm Leaf images have varying contrast and illumination, smudges, smear, stains, and contaminations. Immeasurable information could be passed on to the next generation if we preserve them in a proper format. Such manuscripts are scanned, archived and stored in digital libraries.

It is required to unearth the hidden treasure of these manuscripts and made available to the society. Document image processing techniques are important to improve the readability of the ancient palm leaf manuscripts. First, the manuscript is scanned into a RGB image and then it is converted to a grayscale image. We perform a set of preprocessing steps such as background subtraction using rolling ball method, denoising using Gaussian filter method, contrast enhancement using histogram equalization method and binarization using auto thresholding technique to improve the readability of the manuscript. These techniques are used to remove unwanted information from the ancient manuscripts.

To perform efficient retrieval of similar word images, it is necessary to extract robust invariant features from the images to detect even under changes in image scale, rotation and illumination. Such points usually lie on high contrast regions of the image. From such interest points identified in an Image, feature descriptors are generated for matching. Image Matching is a technique used to find the differences or similarities between two or more images.

In this paper we focus on extracting robust invariant features using Scale Invariant Feature Transform (SIFT) [2] technique. The detection and description of local image features can help in object recognition. The SIFT features are local and based on the appearance of the object at particular interest points, and are invariant to different sizes and orientations. They are also robust to changes in illumination, noise, and minor changes in viewpoint. In addition to these properties, they are highly distinctive, relatively easy to extract and allow for correct object identification with low probability of mismatch.

Here after extracting invariant features using SIFT method, the landmark correspondences of these features are identified as per the Random Sample Consensus (RANSAC) approach proposed by Fischer and Bolles [10]. Based on number of matches across the images, similar word images from the vocabulary are retrieved.

## 2. LITERATURE REVIEW

The background subtraction method removes smooth continuous backgrounds from gels and other images. This is based on the rolling ball algorithm described in Stanley Sternberg's article [2]. The Gaussian smoothing operator is a 2D convolution operator which is used to blur images and remove detail and noise [5]. Contrast Enhancement is used to improve the visual effects and the clarity of image or to make the original image more conducive for computer to process [6]. The gray levels of pixels belonging to an image are quite different from the gray levels of the pixels belonging to the background. Thresholding becomes an effective tool to separate foreground from the background. The output of the thresholding operation is a binary image whose gray level of 0 (black) will indicate an object pixel and a gray level of 1 (white) will indicate the background [3] [4] [7]. SIFT is one of the most important robust algorithm for extracting key features of an image accurately which identifies the scripts even in deformed state [8]-[10]. The scale and variety of applications using this SIFT is discussed in many papers on pattern recognition [11] - [14]. The Random Sample Consensus RANSAC algorithm is used as a transformation model for matching [15]. The key advantage of this approach is this can be extended to other newer and unexplored versions of character or word variations.

The recognition of Handwritten Nandinagari words using SIFT approach is not available till date. An attempt to recognize Nandinagari characters is made in article by Prathima et al. [16]. An attempt to check the invariance properties using different types of moments is made by the same authors [17]. However, processing a real time Palm Leaf handwritten manuscript Nandinagari including the end to end flows from preprocessing

and extracting handwritten words is even more complex and sufficient work need to be done in every step of recognition.

Hence there is a need to process the raw handwritten Palm Leaf manuscripts from the image form to identifiable form by a set of preprocessing steps where their recognition is visually distinct and suitable for word recognition. After preprocessing the words are to be segmented and extracted and their features need to be stored in a database for future access. This should aid the system to recognize and retrieve the matching characters whenever any client tries to query this system with a typical Nandinagari word. We try to fill this gap in this paper.

## 3. METHODOLOGY

The proposed architectural framework is as shown in Fig.1 and consists of following steps:

In step 1, the Bulk images are scanned and are placed in an images folder of a personal computer. The format is typically a TIFF, JPEG or PNG format. The guidelines for preservation and collection maintenance as mentioned in the Cornell University library is used as benchmarking the palm leafs before being used for preprocessing.

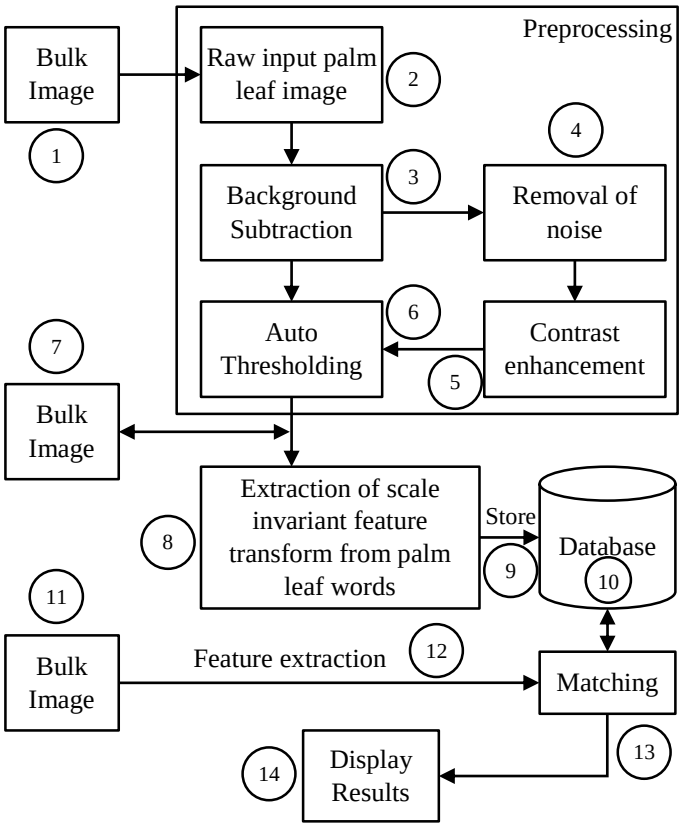



Fig.1. Proposed Architectural Framework

### 3.1 PREPROCESSING

This is an important step to clean up the ancient manuscript document images. Each image is retrieved and we programmatically remove unwanted redundant information from the manuscripts. This is implemented in following steps.

#### *3.1.1 Background Subtraction Method:*

In step 2, each image is retrieved as a single raw input Palm Leaf image file. In step 3, we separate the foreground objects from the background, which is an important step in historical document images due to uneven background structure. The rolling ball background subtraction method is used to correct the uneven illuminated background.

By averaging over a very large ball around the pixel, a local background value is determined for every pixel. The radius of the ball chosen for our Palm Leaf is 25. This value is subtracted from the original image by removing large spatial variations of the background intensities.

#### *3.1.2 Removal of Noise:*

Removing or minimizing the noise in an image results in blurring of image which is done as part of step 4. The value of the Gaussian smoothing operation which is 2D convolution operation is chosen for our Palm Leaf is 2.0.

This is used to blur images and to remove noise and detail. Gaussian filter smoothens by replacing each image pixel with a weighted average of the neighboring pixels such that the weight given to a neighbor decrease with distance from the central pixel.

#### *3.1.3 Contrast Enhancement:*

The contrast enhancement is one of the commonly used image enhancement and histogram equalization (HE) is one of the most frequently used techniques which we use in step 5. The fundamental principle of HE is to make the histogram of the enhanced image approximate to a uniform distribution so that the dynamic range of the image can be fully utilized. It works by flattening the histogram and stretching the dynamic range of the gray levels by using the cumulative density function of the image.

#### *3.1.4 Auto Thresholding:*

In thresholding, image pixels are separated as foreground and background and categorized as global and local methods. In global, single threshold value is used for entire image. But in local methods, threshold value is determined locally based on pixel by pixel, or region by region.

For thresholding the ancient Palm Leaves, Sauvola, the adaptive local thresholding technique is used as indicated in step 6. It adapts the threshold according to the local mean and standard deviation over a window size. The threshold is calculated as:

$$T(i,j) = m(i,j) + \left[1 + k \cdot \left(\frac{\sigma(i,j)}{R} - 1\right)\right] \quad (1)$$

where $m(i,j)$ mean and $\sigma(i,j) = 0.5$ and $R = 128$

#### *3.1.5 Segmentation:*

Step 7 indicates manual segmentation done to extract meaningful words from Handwritten Nandinagari Palm Leaf based manuscripts. The words are of different sizes.

### 3.2 FEATURE EXTRACTION

In step 8, we focus on extracting Invariant Features of Handwritten Nandinagari Palm Leaf words of various forms using the Scale Invariant Feature Transform (SIFT) technique. The criterion for robust detection is derived based on analysis patterns of word images and its applicability thus forming the basis for

efficient word image retrieval. SIFT is one of the most popular algorithm for extracting key features of an image accurately which identifies the scripts even in deformed state. Candidate points from the input image are extracted using the Scale invariant feature transform (SIFT) technique. From each candidate point 128 feature descriptors are generated which are invariant to scale, rotation and illumination. These features Descriptors of reference word images are stored as indicated in step 9 to a database to form Handwritten Nandinagari word vocabulary. The database is indicated in step 10.

### 3.3 MATCHING

In step 11, a new query word image is fed to the system. The SIFT features for this image is extracted in step 12 and matched by comparing each feature from the new image to the Handwritten Nandinagari words vocabulary and finding candidate matching features. The matching is done as part of step 13.

This is based on a transformation model to identify the landmark correspondences of these features as per the RANSAC approach. For each image *i* out of *N* images, match points are found with every other image and the number of match points from image *A* to image *B* are identified.

If the number of match points from *A* to *B* is $n_A>B$ and *B* to *A* is $n_B>A$, the minimum number of match points is computed as $n_{Min}$ i.e.

if $(n_A>B<n_B>A)\{n_{Min} = n_A>B;\}$

else $\{n_{Min} = n_B>A;\}$

If $n_{Min}$ value is greater than threshold value then the image is termed as similar and we are retrieving from the Nandinagari Palm Leaf word vocabulary.

Step 14 indicates that corresponding matches between the query image and the corresponding matches found in the database.

The algorithm of the above steps mentioned in the following steps:

**Step 1:** The Bulk Palm Leaf images are scanned and placed in an images folder

**Step 2:** Each image is retrieved as a single raw input Palm Leaf image file

**Step 3:** The rolling ball background subtraction method is used to correct the uneven illuminated background.

**Step 4:** Noise reduction is done by Gaussian filter method

**Step 5:** Image quality is enhanced using the contrast enhancement technique – histogram equalization method

**Step 6:** Convert the image to its gray scale format

**Step 7:** An adaptive local thresholding technique is used to get clean image- Sauvola thresholding used for this purpose.

**Step 8:** Manual segmentation is done to extract meaningful words from Handwritten Nandinagari Palm Leaf based manuscripts. The segmented words are of different sizes.

**Step 9:** Extracting Invariant Features of Handwritten Nandinagari Palm Leaf words of various forms using the Scale Invariant Feature Transform (SIFT) technique

**Step 10:** These features Descriptors of reference word images are stored in the database

**Step 11:** The database of Handwritten Nandinagari word vocabulary is indicated here

**Step 12:** An unknown query word image fed to the system.

**Step 13:** The SIFT features for this image is extracted

**Step 14:** Matching process is done by comparing each feature from the new image to the Handwritten Nandinagari words vocabulary and finding candidate-matching features.

**Step 15:** Indicates the number of corresponding matches between the query image and the corresponding matches are found in the database.

## 4. EXPERIMENTAL RESULTS

For this experiment, the image data set is based on ancient handwritten Nandinagari Palm Leaf manuscripts called Aithereya Upanishad. The data sets are over 700 years old and obtained from Poornaprajna Samshodhana Mandir, Kathriguppe and Bengaluru.

A digital camera with a resolution of 3450×1050 pixels and 24bit color would be a good choice for materials up to 23 inches. We used a digital camera with resolution of 5856×750. Sticking to a widely accepted file format like TIFF will make migration later a lot easier.

### 4.1 PREPROCESSING

The manuscripts consist of single sheets with covers string tied together. Palm leaves have concave and convex sides. Writing is inscribed on both sides of the leaf, with holes used for holding the leaves together. All of the old palm leaf manuscripts are fragile, brittle and stained. The number of lines on each leaf range from 8 to 10 lines. Palm leaf are cased with wood and pierced with two round holes. The traditional way of using the manuscripts is to insert two small bamboo sticks to hold the manuscript bundle in place, preventing the leaves from falling. Strings are inserted through the holes when storing the manuscripts. Some of the palm leaves in the collection have edges that are now black. The average width of the Palm Leaf is about 21 inch.

The sequence of palm leaf preprocessing done to the raw image is shown in a sequence of steps between Fig.1 and Fig.5.

1. Original image: physical leaf dimensions: height: average 3 inches; width: 18 inches to 23 inches, average of 21 inches.

Fig.1. Original Image in RGB format of size 5856×750

2. Gray Scale version

Fig.2. Gray Scale version of original image

3. Background Subtraction using Rolling Ball method

Fig.3. Image after background subtraction

4. Removal of Noise using Gaussian filter

Fig.4. Image after Denoising

5. Contrast Enhancement using Histogram Equalization

Fig.5. Image after Contrast Enhancement

6. Auto Thresholding using Sauvola adaptive thresholding

Fig.6. Image after Auto Thresholding

## 4.2 FEATURE EXTRACTION USING SIFT METHOD

The words are subsequently extracted using annotation method to get a set of 100 meaningful Handwritten Nandinagari words of different sizes. A dictionary of these vocabulary words is formed and stored. The Table.1 indicates a sample list of words used to form the word vocabulary.

Table.1. Sample Nandinagari Palm Leaf words in different Sizes and orientations

| Nandinagari Palm Leaf words | Size and orientation |
|---|---|
|  | 124×57, 0º |
|  | 336×335, 45º |
|  | 346×124, 0º |
|  | 192×59, 0º |
|  | 356×64, 0º |
|  | 298×8, 135º |
|  | 238×56, 0º |
|  | 304×46, 0º |

Effective corner based feature extraction technique is applied to these images and the corresponding scale and rotation invariant features and extracted and stored in the database. A typical SIFT Key point identified for Nandinagari word is indicated in Fig.7.

Fig.7. SIFT Key points identified on Nandinagari word

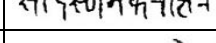
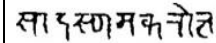
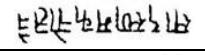
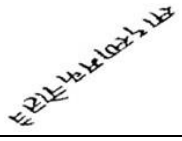
The orientation assignment on the Nandinagari work using SIFTS is shown in Fig.8.

Fig.8. Orientation Assignment on Nandinagari word

## 4.3 MATCHING

The query word image is compared with the dictionary words and the matched similar word images are retrieved. The Table.2 and Table.3 indicates the list of matches found for each query image.

Table.2. List of Retrieved Nandinagari Palm Leaf words in different sizes and orientations for a given Query Image1

| Input | Nandinagari words | Size | Orientation |
|---|---|---|---|
| Query Image |  | 356×64 | 0 |
| Retrieved image 1 |  | 356×64 | 0 |
| Retrieved image 2 |  | 298×298 | 45 |
| Retrieved image 3 |  | 298×298 | 180 |
| Retrieved image 4 |  | 298×298 | 135 |

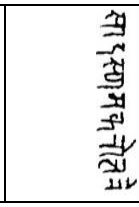
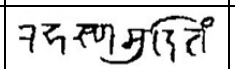
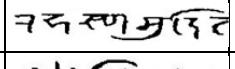
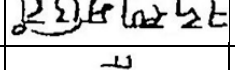
| | | | |
|---|---|---|---|
| Retrieved image 5 |  | 298×298 | 90 |

Table.3. List of Retrieved Nandinagari Palm Leaf words in different sizes and orientations for a given Query Image2

| Input | Nandinagari words | Size | Orientation |
|---|---|---|---|
| Query Image |  | 270×58 | 0 |
| Retrieved image 1 |  | 346×126 | 0 |
| Retrieved image 2 |  | 346×126 | 180 |
| Retrieved image 3 |  | 346×126 | 90 |
| Retrieved image 4 |  | 346×126 | 45 |
| Retrieved image 5 |  | 346×126 | 135 |

The Matching of the Nandinagari query word with the word vocabulary database using RANSAC is shown Fig.9.

Fig.9. Corresponding matches between Nandinagari Palm Leaf words (Query to a matched image in word vocabulary)

## 5. CONCLUSION

The ancient handwritten Nandinagari manuscripts contain valuable information on various discipline but there are only a few scholars who can read and interpret this fluently. The proposed Nandinagari Palm Leaf word image retrieval system is based on data visualization method and is highly scalable. The manuscripts come with poor quality and they need to go through series of preprocessing steps to improve the quality of the image before extracting valuable information.

The preprocessing steps include background subtraction, Removal of noise, contrast enhancement and auto thresholding methods. Then invariant feature descriptors are extracted using SIFT method. This form Nandinagari word image vocabulary. For a given query image we retrieve similar word images from the vocabulary. With the robust features we achieve the recognition accuracy up to 98% by identifying the images in different scales, orientations, which is shown in Table.4. The scope of this work could be further improved by possible automation of segmentation which needs to the system to be first trained by a scholar knowledgeable of the Nandinagari manuscript. We could also increase the Nandinagari word vocabulary and fasten up the process of image retrieval by storing the indexed features and in a search engine.

Table.4. Recognition Accuracy

| Sl. No | Number of related word Images in the Database | Number of Images Matched | % Recognition |
|---|---|---|---|
| 1 | 5 | 5 | 100 |
| 2 | 5 | 5 | 100 |
| 3 | 10 | 9 | 90 |
| 4 | 8 | 8 | 100 |
| Average Recognition Accuracy | | | 98% |

## REFERENCES


[1] P. Visalakshi, "*Nandinagari Script*", 1st Edition, DLA Publication, 2003.

[2] Stanley Sternberg, "Biomedical Image Processing", *IEEE Computer*, Vol. 16, No. 1, pp. 22-34, 1983

[3] Lalit Prakash Saxena, "An Effective Binarization Method for Readability Improvement of Stain-Affected (Degraded) Palm Leaf and Other Types of Manuscripts", *Current Science*, Vol. 107, No. 3, pp. 489-496, 2014.

[4] Rapeeporn Chamchong, Chun Che Fung and Kok Wai Wong, "Comparing Binarisation Techniques for the Processing of Ancient Manuscripts", *Proceedings of International Symposium on Entertainment Computing*, pp. 55-64, 2010.

[5] Salem Saleh Al Amri, N.V. Kalyankar and S. Khamitkar, "Deblured Gaussian Blurred Images", *Journal of Computing*, Vol. 2, No. 4, pp. 132-139, 2010

[6] Tarik Arici, Salih Dikbas and Yucel Altunbasak, "A Histogram Modification Framework and Its Application for Image Contrast Enhancement", *IEEE Transactions on Image Processing*, Vol. 18, No. 9, pp. 1921-1935, 2009.

[7] Mehmet Sezgin and Bulent Sankur, "Survey Over Image Thresholding Techniques and Quantitative Performance Evaluation", *Journal of Electronic Imaging*, Vol. 13, No. 1, pp. 146-165, 2004.

[8] J. Sauvola and M. Pietikainen, "Adaptive Document Image Binarization", *Pattern Recognition*, Vol. 33, No. 2, pp. 225-236, 2000.

[9] D.G. Lowe, "Distinctive Image Features from Scale-Invariant Key Points", *International Journal of Computer Vision*, Vol. 60, No. 2, pp. 91-110, 2004.

[10] E.N. Mortensen, H. Deng and L. Shapiro, "A SIFT Descriptor with Global Context", *Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, pp. 184-190, 2005.

[11] Ives Rey-Otero, Jean-Michel Morel and Mauricio Delbarcio, "An Analysis of Scale-Space Sampling in SIFT", *Proceedings of IEEE International Conference on Image Processing*, pp. 27-30, 2014.

[12] Yishu Shi, Feng Xu, Feng-Xiang Ge Yishu Shi, Feng Xu and Feng-Xiang Ge, "SIFT-Type Descriptors for Sparse-Representation Based Classification", *Proceedings of 10th International Conference on Natural Computation*, pp. 1-12, 2014.

[13] D.G. Lowe, "Object Recognition from Local Scale-Invariant Features", *Proceedings of 7th IEEE International Conference on Computer Vision*, pp. 20-27, 1999.

[14] Martin A. Fischler and Robert C. Bolles, "Random Sample Consensus: A Paradigm For Model Fitting With Applications To Image Analysis And Automated Cartography", *Journal on Communications of the ACM*, Vol. 24, No. 6, pp. 381-395, 1981.

[15] Prathima Guruprasad and Jharna Majumdar, "Multimodal Recognition Framework: An Accurate and Powerful Nandinagari Handwritten Character Recognition Model", *Proceedings of International Multi Conference on Information Processing*, pp. 836-844, 2016.

[16] Prathima Guruprasad and Jharna Majumdar, "Achieving Premier Invariance to Scale and Rotation for Nandinagari Character Recognition by Comparing Multi Moment Features", *Proceedings of 6th International Conference on Advances in Computing and Communications*, pp. 564-570, 2016.