

# Template Matching Method for Recognition of Stone Inscribed Kannada Characters of Different Time Frames Based on Correlation Analysis

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## Article Info

### Article history:

Received May 27, 2014

Revised Aug 13, 2014

Accepted Aug 25, 2014

### Keyword:

Template Matching

Cross Correlation

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## ABSTRACT

Stone in-scripted literature speaks about the history, language of different regions of the world. Preservation of such document through digitalization process is become very important. To stop degradation and missing further, the analysis of the same will through light on historical events of that region. In this connection present work proposes a simple method of digitization using ordinary digital camera further, the pre-processing algorithm is implemented to enhance the image and improve the readability. Here it recognizes the Kannada characters based on template matching. In this method is normally implemented by first picking template and then it call the search image, then by simply comparing the template over each point in the search image and it calculate the sum of products between the coefficient. Based on this calculated product value it recognizes the character. Cross correlation technique is implemented in matching the characters coefficient. Experimental results shows, it demonstrates relatively high accuracy in recognizing Stone inscriptions characters of both Hoysala, Ganga time frames and with better time efficiency when compared to previous methods.

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## 1. INTRODUCTION

India is praised for its rich past and the culture. The rich heritage of the country has been carried over generation through the manuscripts and historic writings. Rapid growth of technology and prevalent use of computer in the business and other areas, more and more organization are converting their paper document into electronic documents that can be processed by computer [1]. Recognition of any stone inscriptions character with respect to any language is difficult. Kannada language has got a history of more than 2000 years and Kannada inscriptions found on historical hero Stone, coin and temple wall, pillar, tablet and rock edict [20]. Analysis of any language with rich heritage and history is very important to understand the life and culture of that period. It is necessary to digitize Stone inscriptions by modern technique.

Here in the present work, the image is processed such that its character is recognized. The major problem which arises while identifying the characters in a stone inscription is the difference in the style in literature. Template matching, or matrix matching, is one of the most common classification methods. In template matching, individual image pixels are used as features [3]. Classification is performed by comparing an input character image with a set of templates from each character class. Each comparison results in a similarity measure between the input character and the template. One measure increases the amount of similarity when a pixel in the observed character is identical to the same pixel in the template image. If the

pixels differ the measure of similarity may be decreased. After all templates have been compared with the observed character image, the character's identity is assigned as the identity of the most similar template.

Structural classification methods utilize structural features and decision rules to classify characters. Structural features may be defined in terms of character strokes, character holes, or other character attributes such as concavities. For a character image input, the structural features are extracted and a rule-based system is applied to classify the character. Template matching for character recognition is straightforward and reliable. This method is more tolerant to noise than structural analysis method.

## 2. RELATED WORKS

The review of the literature pertaining to the present topic is presented to the readers. In [1] authors concentrate on Template Matching method for Recognition Musnad characters based on correlation analysis. In this paper, we extended that work and applied that algorithm for recognize Stone inscriptions Kannada characters. In [3] authors concentrate on the Era Identification and Recognition of Stone In-scripted Kannada Characters Using Artificial Neural Networks. In this paper we use same Gaussian filter for filtering, the Gaussian filter smoothing the image and it helps find edges of characters accurately. In [5] authors concentrate Printed Number Recognition using MATLAB. In this paper we use same thinning and cropping procedure for to extract desired characters shape. In [2] authors concentrate on Extraction of Kannada characters using SIFT. In this paper we extended that work and applied that algorithm for image Mosaic.

## 3. PROPOSED ALGORITHM

The proposed method consists of following steps see in Figure 1

- 1) **Create a Template of Kannada characters and each image in a template is in size of 24x42 dimensions.**
- 2) **Test images**  
Capture Kannada stone inscriptions characters using ordinary digital camera of 16Mega pixel resolution
- 3) **Image Mosaic based on SIFT algorithm**  
Steps involved in this is  
In this it read test images  
It perform mosaic based on key points found and Euclidian distance between test images  
If key points are found, then it decides that is the continuation of that image and it fuse those image, else it discard and again select another test image.
- 4) **Pre-processing**  
If Mosaic done successful then it perform pre-processing. In this it involves
  - a. Removing noise and Resizing of all pre-processed images into fixed pixel size and dimension
  - b. Finding Edge in an image using Sobel edge detection
  - c. Perform dilation and Use top-hat filtering to correct uneven illumination
  - d. Remove all objects in the image containing fewer than 80 pixels
  - e. Reconstruction of image by reconstructing its boundary and
  - f. Filling its holes
  - g. Thinning of characters and take complement of image for clear visibility
- 5) **Characters Cropping**
  - a. This is a user block; here user can crop any characters in an image for Recognition
- 6) **Cross correlation**
  - a. In this method we perform Cross correlation between Template and extracted character
- 7) **Recognition of Kannada Stone inscriptions characters**
  - a. Based on Cross correlation Analysis value it recognize Captured Kannada stone inscriptions character
  - b. If value of any two images should be high then it displays the recognized character and if correlation value appears low then it display character not recognized.

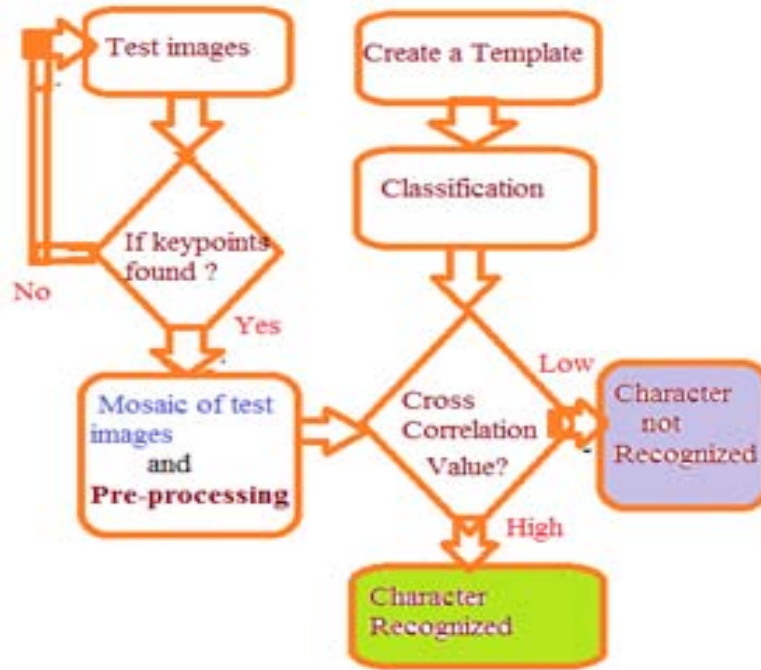


Figure 1. A Flow chart diagram of the Proposed Algorithm

## 4. METHODOLOGY AND IMPLEMENTATION

### 4.1. Image Mosaic Based on Simplified SIFT

This is the very important step in our proposal and we can't capture all characters in an image inscribed by single image with high resolution, for to maintain good resolution and to avoid overlapping of characters between two images in Mosaic, here we use new Mosaic technique called 'Image Mosaic Based on SIFT Algorithm', the main advantages of this algorithm is it will mosaic the two images with good resolution and it eliminate overlapping of characters between two images and it produce output mosaic image like naturally captured image. This mosaic image was helped future steps to extract all Kannada characters easily.

#### 4.1.1. SIFT

SIFT key points of objects are first extracted from a set of reference images and stored in a database. An object is recognized in a new image by individually comparing each feature from the new image to this database and finding candidate matching features based on Euclidean distance of their feature vectors. From the full set of matches, subsets of key points that agree on the object and its location, scale, and orientation in the new image are identified to filter out good matches. The determination of consistent clusters is performed rapidly by using an efficient hash table implementation of the generalized Hough transform. Each cluster of 3 or more features that agree on an object and its pose is then subject to further detailed model verification and subsequently outliers are discarded. Finally the probability that a particular set of features indicates the presence of an object is computed, given the accuracy of fit and number of probable false matches. Object matches that pass all these tests can be identified as correct with high confidence.

### 4.2. Pre-processing

In this we first removing the noise using Gaussian filter

#### 4.2.1 Median filter

Median filtering helps us by erasing the black dots, called the Pepper, and it also fills in white holes in the image, called Salt "impulse noise". It's like the mean filter but is better in 1- Preserving sharp edges 2- The median value is much like neighbourhood pixels and will not affect the other pixels significantly -this means that the mean does that.

Median filtering is popular in removing salt n paper noise and works by replacing the pixel value with the median value in the neighbourhood of that pixel.

#### 4.2.2 Edge detection

The Edge Detection block computes the automatic threshold using the mean of the gradient magnitude squared image. However, you can adjust this threshold using the Threshold scale factor (used to automatically calculate threshold value) parameter. The block multiplies the value you enter with the automatic threshold value to determine a new threshold value. Here we are used sobel edge detection.

#### 4.2.3 Dilation

The dilation operator takes two pieces of data as inputs. The first is the image which is to be dilated. The second is a set of coordinate points known as a structuring element (also known as a kernel). It is this structuring element that determines the precise effect of the dilation on the input image. Note that in this and subsequent diagrams, foreground pixels are represented by 1's and background pixels by 0's. Simple dilation operation is as shown in figure

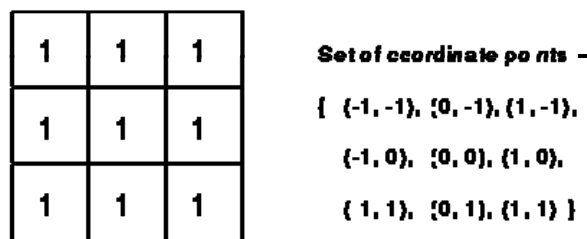


Figure 2. A 3×3 square structuring element

In above figure is 3×3 structuring element, the effect of this operation is to set to the foreground color any background pixels that have a neighbouring foreground pixel (assuming 8-connectedness). Such pixels must lie at the edges of white regions, and so the practical upshot is that foreground regions grow (and holes inside a region shrink). Dilation is the dual of erosion i.e. dilating foreground pixels is equivalent to eroding the background pixels

#### 4.2.4 Removing of Small object

The dilated image contains some small object, so we remove all small object using BWAREAOPEN operation, this operation will remove all small pixel object and it remove small pixel object based on user need and here in our work we removing all small object whose size less than 80 pixel

#### 4.2.5 Reconstruction of image

The dilated image contain some breaking border so In this we reconstructs the character by eliminating its breaking border, for reconstruction it use this block for reconstruct border and IMFILL operation for fill holes in images

#### 4.2.6 Thinning

Thinning process removes selected parts of foreground pixels of a binary image. The thinning operation is related to the hit-and-miss transform and can be expressed quite simply in terms of it. The thinning of an image I by a structuring element J is

$$\text{thin}(I,J) = I - \text{hit and miss}(I,J) \quad (1)$$

### 4.3 Template Matching Method

Template matching is one of the Character Recognition techniques. It is the process of finding the location of a sub image called a template inside an image. Once a number of corresponding templates is found, their centres are used as corresponding points to determine the registration parameters. Template matching involves determining similarities between a given template and windows of the same size in an image and identifying the window that produces the highest similarity measure. It works by comparing derived image features of the image and the template for each possible displacement of the template.

This process involves the use of a database of characters or templates. There exists a template for all possible input characters. For recognition to occur, the current input character is compared to each template to find either an exact match, or the template with the closest representation of the input character. If  $I(x, y)$  is

the input character,  $TN(x, y)$  is the template  $n$ , then the matching function  $s(I, TN)$  will return a value indicating how well template  $n$  matches the input character. Some of the more common matching functions are based on the following

Formulas

$$S(I, Tn) = \sum_{i=0}^W \sum_{j=0}^H |(i, j) - Tn(i, j)| \quad (2)$$

$$S(I, Tn) = \sum_{i=0}^W \sum_{j=0}^H |(i, j) - Tn(i, j)|^2 \quad (3)$$

$$S(I, Tn) = \sum_{i=0}^W \sum_{j=0}^H |(i, j) Tn(i, j)| \quad (4)$$

$$S(I, Tn) = \frac{\sum_{i=0}^W \sum_{j=0}^H |(i, j) - |I|| (Tn(i, j) - Tn)|}{\sqrt{\sum_{i=0}^W \sum_{j=0}^H |(i, j) - |I||^2 (Tn(i, j) - Tn)^2}} \quad (5)$$

Matching approaches: (2) City block, (3) Euclidean distance, (4) Cross Correlation, (5) 2-D Normalized Correlation.

#### 4.3.1 Cross-correlation

Cross-correlation is a measure of similarity of two waveforms as a function of a time-lag applied to one of them. This is also known as a sliding dot product or sliding inner-product. It is commonly used for searching a long signal for a shorter, known feature. It has applications in pattern recognition, single particle analysis, electron tomographic, averaging, cryptanalysis, and neurophysiology.

For continuous functions  $f$  and  $g$ , the cross-correlation is defined as:

$$(f * g)(\tau) = \int_{-\infty}^{\infty} f(t)g(t + \tau)dt \quad (6)$$

Where  $f^*$  denotes the complex conjugate of  $f$  and  $\tau$  is the time lag. Similarly, for discrete functions, the cross-correlation is defined as:

$$(f * g)(n) = \sum_{m=-\infty}^{\infty} f[m]g[m + n] \quad (7)$$

#### 4.3.2 Implementation of Kannada Character Recognition

The implementation of Kannada character recognition is done by firstly refining the extracted characters to fit them into a window without white spaces on all the four sides and creating the template for each extracted character. The templates are normalized to 42x24 pixels and stored in the database. Normalization is done using window to view port transformation. This mapping is used to map every pixel of the original image to the corresponding pixel in the normalized image. The extracted character of the input test image, after normalization, is matched with all the characters in the database using 2-D normalized correlation coefficients approach to identify similar patterns between a test image and the standard database images. This approach is shown in Equation 4.

## 5. RESULTS AND ANALYSIS

### 5.1 Results

Step 1: Create a Template of Kannada characters and each image in a template is in size of 24x42 dimensions as shown in Figure 3.



Figure 3. Kannada characters Template images

Step 2: Capture Stone inscriptions Kannada characters images using ordinary digital camera of 16 Mega Pixels resolution, as shown in Figure 4



Figure 4. Captured Kannada Stone Inscriptions Characters

Step 3: Image Mosaic based on SIFT algorithm

This is the very important step in our proposal and we can't captured all Characters in an stone inscribed by single image with high resolution, for to maintain good resolution and to avoid overlapping of characters between two images in Mosaic, here we use new Mosaic technique called 'Image Mosaic Based on SIFT algorithm', the main advantages of this algorithm is it will mosaic two images with good resolution and it eliminate overlapping of characters between two images and it produce output mosaicking image like naturally captured image. This Mosaic image was helped future steps to extract all Kannada characters easily. The steps during Mosaic based on SIFT Algorithm results are shown in figure 5.

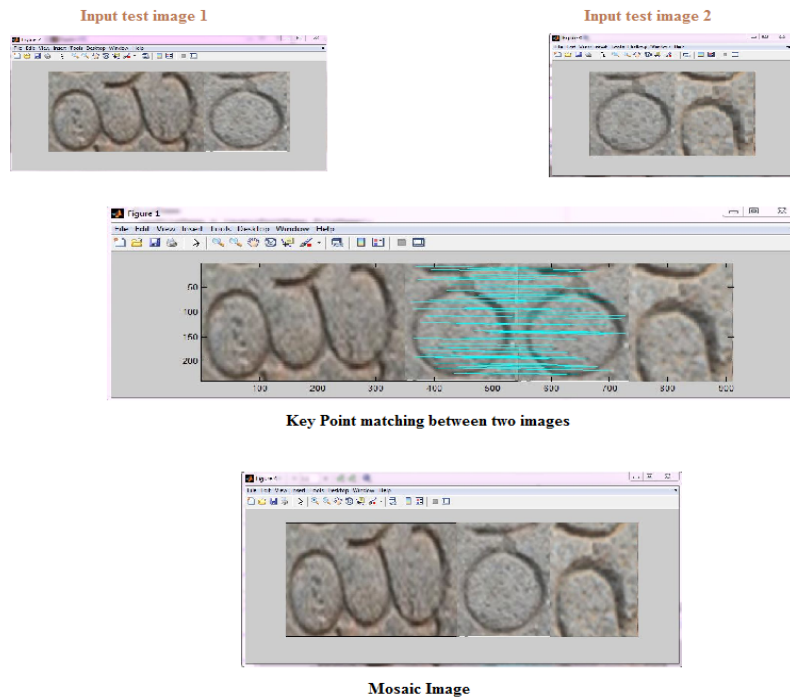


Figure 5. Image Mosaic based on SIFT.

#### Step 4: Pre-preprocessing

In this step we extract the each Kannada Characters and steps involved are shown in Figure 6

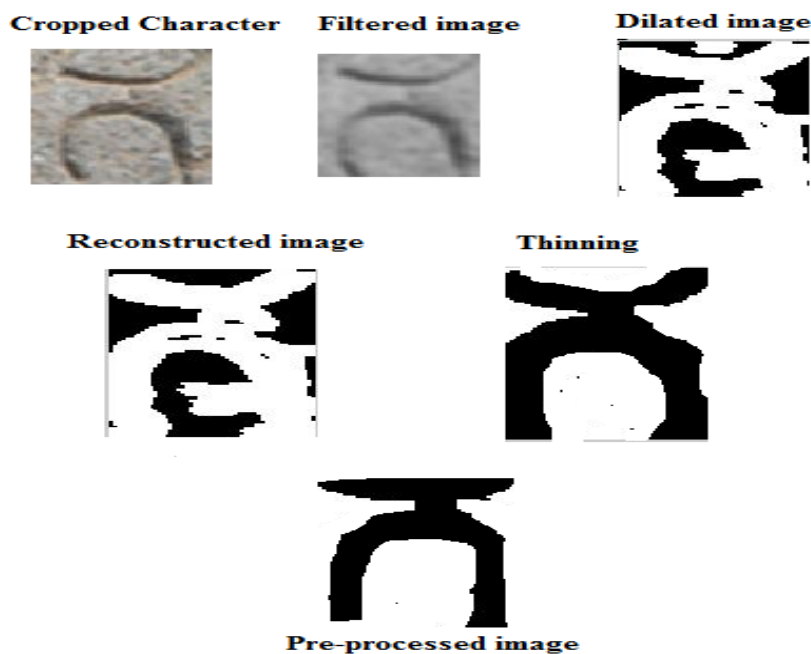


Figure 6. Image Processing and Extraction of Each Kannada Character

In this we removing noise content in an captured images using Gaussian filter and we Resizing of all pre-processed images into fixed pixel size and dimension and we Finding Edge in an image using Sobel edge detection and then we Perform dilation and Use top-hat filtering to correct uneven illumination. We remove

all objects in the image containing fewer than 30 pixels and we reconstruction of image by reconstructing its boundary and filling its holes, finally by calculating its connected components we extract the character in an image.

#### Step 5. Cross correlation

In this we perform cross correlation between pre-processed image with template. Based on their result value we recognize the characters as shown in Figure 7, 8, 9.

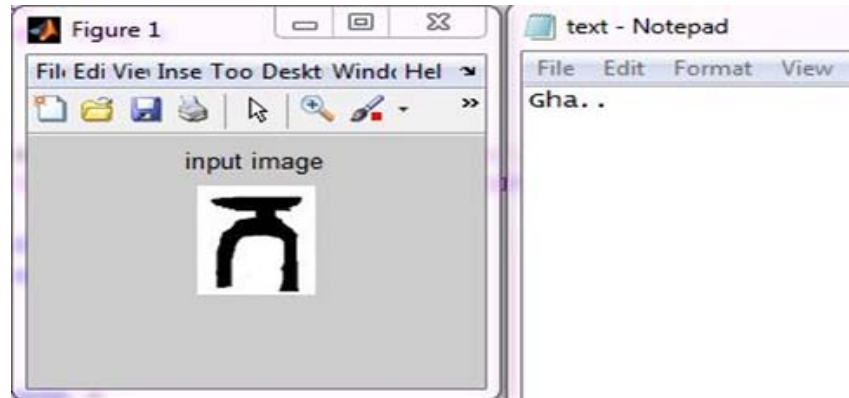


Figure 7. Recognition of Kannada stone inscriptions character Gha.

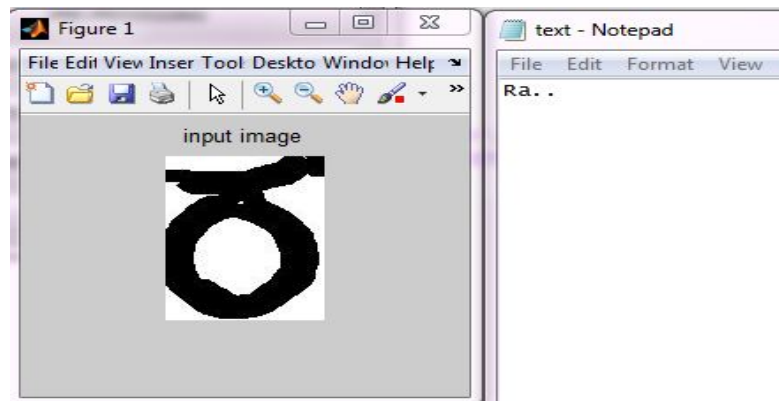


Figure 8. Recognition of Kannada stone inscriptions character Ra.

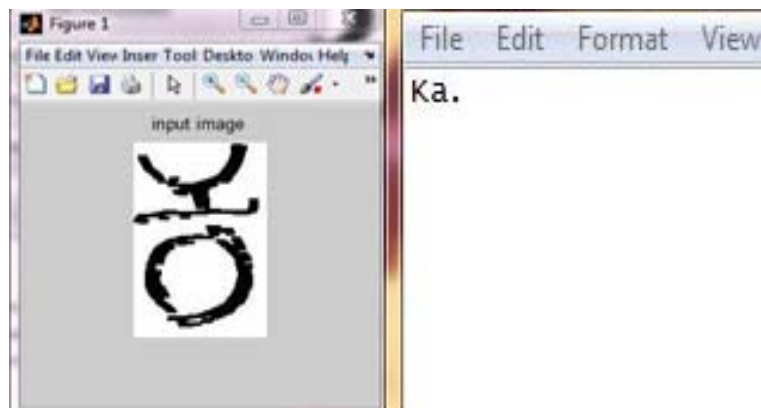


Figure 9. Recognition of Kannada stone inscriptions character Ka.



## 5.2. Experimental results

Experiments have been performed to test the proposed method. MATLAB (R2009a) is the software tool that was used for Recognition of Kannada Characters. The Experiments were performed captured many stone inscriptions characters of **Hoysala** and **Ganga** times frames and Table 1 and Table 2 gives the results of Recognition rate between the character images and their Templates images.

The Recognition rate can be obtained by formula









$$\sigma = \delta - \alpha \quad (8)$$

Where  $\sigma$ = Recognition rate,  $\alpha$  = sum of correct match,  $\gamma$  = sum of incorrect match,  $\delta$ = Number of test samples

Table 1. The Recognition rate analysis of Kannada stone inscription characters for Hoysala time frames.

Test images	The Recognition rate analysis of Kannada Hoysala Period stone inscription characters				
	Recognized Character	$\alpha$	$\gamma$	$\delta$	$\sigma$ (in %)
	JA	18	2	20	90%
	H	19	1	20	95%
	MA	18	2	20	90%
	KA	19	1	20	95%
	GA	18	2	20	90%
	YA	19	1	20	95%
	NA	18	2	20	90%
	SHA	19	1	20	95%
	KHA	19	1	20	95%

Table 2. The Recognition rate analysis of Kannada stone inscription characters for Ganga time frames.

<i>The Recognition rate analysis of Kannada Ganga Period stone inscription characters</i>					
<i>Test images</i>	<i>Recognized Character</i>	$\alpha$	$\gamma$	$\delta$	$\sigma$ (in %)
	JHA	18	2	20	<b>90%</b>
	YA	18	2	20	<b>90%</b>
	MA	18	2	20	<b>90%</b>
	DA	19	1	20	<b>95%</b>
	BU	19	1	20	<b>95%</b>
	SE	19	1	20	<b>95%</b>
	E	18	2	20	<b>90%</b>
	VA	18	2	20	<b>90%</b>

From Table 1 and Table 2, it is shown that our proposal recognition rate should be **92.7% accuracy** in recognition of stone inscriptions characters of Hoysala time frames and **91.87% accuracy** for Ganga time frames.

## 6. CONCLUSION

A simple and effective Recognition method for identification of different time frames Kannada stone inscriptions characters were introduced in this paper. This provides a good tool for the people for identification of the stone inscriptions. It also helps a common man knowing the present Kannada literature to read the ancient literature Here we are used ordinary mobile camera of 16 Mega pixel resolution camera to capture characters so it is very easy to implement and it is costless when compare to other methods. For recognition process, the extracted character was compared to each template in the database to find the closest representation of the input character. The matching metric was computed using 2-D correlation coefficients approach to identify similar patterns between the test image and the database images. Experimental results show that the proposed method is efficient for identification Kannada stone inscriptions characters.

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