

Edge Detection of Degraded Stone Inscription Kannada Characters Using Fuzzy Logic Algorithm

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Abstract Digital India is an initiative by the Government of India. This initiative encourages digitization and analysis in all walks of life. Digitization will preserve any historical document and that information can access by any individuals by his finger tip from any place. Stone inscriptions are one of the key historical evidences of literature and culture of that region in the passage of time. Recognition and analysis of stone inscriptions play a pivotal role in deciding the era/age it belongs ad to understand the content. A proper digitization and recognition technique is pre-requisite and desired. Here, in this work digitization of characters has been done by using ordinary digital camera. Further, the captured images are pre-processed in order to extract features. In this proposed algorithm, gradient analysis is carried out at every pixel in the x and y directions, based on the result it defines an edge using Fuzzy Inference System. The experiment was conducted on twenty set of analogous degraded stone inscriptions Kannada characters and result obtained was magnificent with better time efficiency compared to prior methods.

Keywords Digitalization • Edge detection • Fuzzy inference system

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1 Introduction

Feature extraction plays a vital role in stone inscription character recognition, for better feature extraction an enhanced pre-processing is required. Comprehensible feature extraction for any Kannada stone inscriptions is challengeable, especially in the stone inscriptions each character are not uniformly inscripted and some characters are degraded due to some natural calamities. Edge detection is imperative step in preprocessing; the prior methods like Sobel, Canny are deficient to find the edges of old stone inscription characters so new-fangled edge detection technique is required for better feature extraction. In this present work, the captured image is converted into gray scale and Fuzzy algorithm works only on double precision data so the gray scale image was again converted into double-precision. To determine image gradient in x -axis and y -axis, we define Fuzzy Inference System (FIS) using triangular membership function and defined rule such that, any pixel belongs to a uniform region is make it as white else make same pixel as black. Finally we compared the recognition results of proposed method with Sobel edge detection method.

2 Related Works

The review of the literature pertaining to the present topic is presented to the readers. In [1] authors concentrate on recognition of old Hoysala, Ganga characters, but in that work they achieved only 90% recognition rate for few set of Kannada stone inscriptions special characters and here that work was extended and that recognition rate was increased using advanced edge detection method. In [2] author concentrate on Fuzzy interface rule, here that work is extended and defined Fuzzy “logical or” for detect stone inscriptions image edges. In [3] author concentrate on Design of Fuzzy interface system and that work was tailored to construct a fuzzy interface system for extraction of old stone inscriptions Kannada characters. In [4] author concentrate on extraction of old stone inscriptions Kannada characters using Gaussian filter and some morphological operation but this approach doesn’t extract exact features of degraded Special stone inscriptions Kannada characters and pre-processing algorithm used was simple and that can’t be extended to large dataset.

3 Algorithm

Step 1: The Kannada Stone inscriptions characters are capture by using ordinary Camera of 16 Mega pixel Resolution.

Step 2: The Captured images are 3-Dimensional so in this step that images are converted into gray scale image (2-D array).

Step 3: Salt and pepper noise of captured image is remove by using Mean shift filter.

Step 4: Fuzzy logic tool box operates on double-precision data so the grayscale unit 8 array is converting into double array.

Step 5: Calculation of image gradient in X and Y direction and define Specify input and output to the Fuzzy interface system using Membership function. Specify Fuzzy Interface rule using Fuzzy Interface system and display of Edge detection image.

Step 6: The edge detected image features were extracted and Feed into Advance Recognition Algorithm for recognition.

4 Methodology and Implementation

The Block diagram of proposed work is shown in Fig. 1.

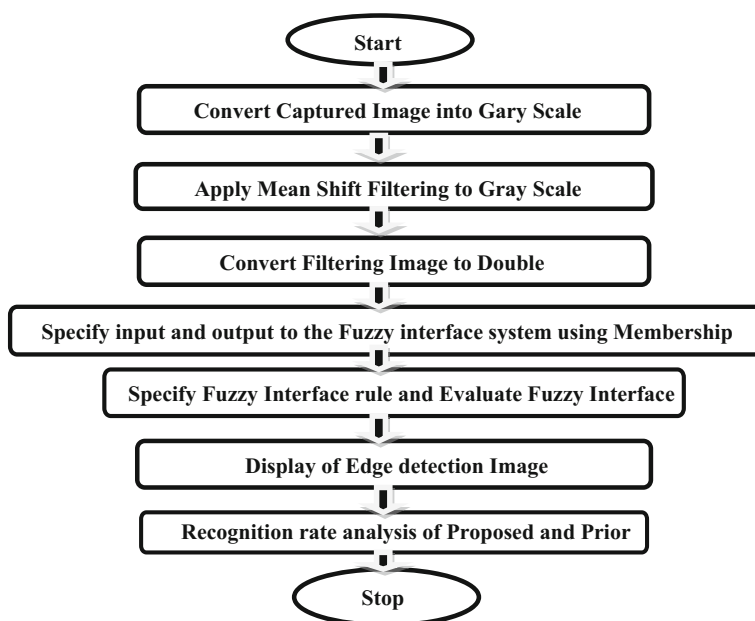


Fig. 1 Block diagram of proposed work

4.1 Image Conversion

Computation with 2-D array is simple than computation with 3-D array, the captured image contains red, green, blue intensities so standard NTSC conversion formula used to calculate the effective luminance of each pixel. Instead rgb2gray function can also be used.

$$I_{gray} = 0.2989 * I_{rgb}(, 1) + 0.5870 * I_{rgb}(, 2) + 0.1140 * I_{rgb}(, 3) \quad (1)$$

4.2 Mean Shift Filtering

Apply mean shift filtering for to remove salt and pepper noise and for image smoothing mean shift filtering used. Mean shift filtering basically works on non-parametric probability density estimation method in which each pixel in an image is replaces by probable local v

$$\{x\}_{i=1..n} = x_i \in \mathbb{R}^d \quad (2)$$

The multivariate kernel density $f(x)$ is estimate at point x with kernel $K(x)$ and windows radius r

$$\hat{f}(x) = \frac{1}{nr^d} \sum_{i=1}^n K\left(\frac{x - x_i}{r}\right) \quad (3)$$

Epanechnikov kernel is estimated by taking normalized density gradient and proportional mean shift:

$$\frac{r^2}{d+2} \frac{\nabla f(x)}{\hat{f}(x)} = M_r(x) = \frac{1}{n_x} \sum_{x_i \in S_r(x)} x_i - x \quad (4)$$

The mean shift procedure is a gradient ascent method to find local modes (maxima) of the probability density and is guaranteed to converge.

1. Calculation of the mean shift vector $M_r(x)$.
2. Translation of the window $S_r(x)$ by $M_r(x)$.
3. Iterations begin from each pixel (5D point) and typically converge in 2–3 steps.

4.3 Convert Image to Double-Precision Data

Fuzzy logic tool box operates on double-precision data so the grayscale unit 8 array is converting into double array.

4.4 Calculate Image Gradient

The image gradient measures the varying information of magnitude and direction along X and Y axis in an image. The image gradient vector is obtain by combining derivates of X and Y direction as shown in Eq. 5

$$\Delta I = \left(\frac{\partial I}{\partial X}, \frac{\partial I}{\partial Y} \right) \quad (5)$$

For a continuous function, the $I(x,y)$ can calculate by taking the partial derivative of I with respect to X and determining how rapidly the image intensity changes as X changes, by using Eq. 6

$$\frac{\partial I(X, Y)}{\partial X} = \lim_{\Delta X \rightarrow 0} \frac{I(X + \Delta X, Y) - I(X, Y)}{\Delta X} \quad (6)$$

For discrete case, a differences between $I(x,y)$ and the pixel before or after it could be taken shown in Eq. 7.

$$\frac{\partial I(X, Y)}{\partial X} = \frac{I(X + 1, Y) - I(X - 1, Y)}{2} \quad (7)$$

4.5 Define Fuzzy Inference System (FIS)

Fuzzy Inference System is a process of obtain an output value from an input on basis of fuzzy inference rules. Fuzzy Inference operation involves FIS Editor, membership functions, Fuzzy interface rule, Evaluate FIS.

In this work, FIS is created by specifying X, Y image gradient and zero-mean Gaussian membership function for each input. If the gradient value for a pixel is 0, then it belongs to the zero membership function with a degree of 1.

The standard deviation S_x and S_y are the zero membership function for the I_x and I_y inputs. These values can change; increasing the values of S_x , S_y makes the algorithm less sensitive to the edges in the image and decreases the intensity of the detected edges. Specify triangular membership function for black, white pixel in I_{out} .

4.5.1 Specify FIS Rules

The rule editor is used for editing list of rules that defines the behavior of the system. In proposed work “logical or” rules is used as shown in Table 1. I_x , I_y are

Table 1 Fuzzy inference system rules

I_X	I_Y	$I_{OUT} (I_X \text{ or } I_Y)$
0	0	0
0	1	1
1	0	1
1	1	1

**Fig. 2** Captured Kannada stone inscription character ‘SHA’ and ‘VA’

image gradients in X and Y direction. I_{out} is the output of the system. Logical one and zero is represent white Pixel and black pixel respectively.

4.5.2 Evaluate FIS

Evaluate the output of the edge detector for each row of pixels in I_{out} using corresponding rows of I_x and I_y as inputs.

4.6 Advance Recognition Algorithm (ARA)

The pre-processed characters were passed into Advance Recognition algorithm (ARA) [2]. The ARA algorithm recognizes each Kannada character in an image by two steps, first it calculates Mean and Sum of absolute difference value of featured extraction character and database characters. Based on its shape and size it recognizes stone inscriptions Kannada characters in a test image [6].

The Mean and Sum of Absolute difference value of an image is calculate by using Eqs. 8, 9 and 10.

$$x = f^{-1} \frac{1}{n} \sum_{i=1}^n f(x_i) \quad (8)$$

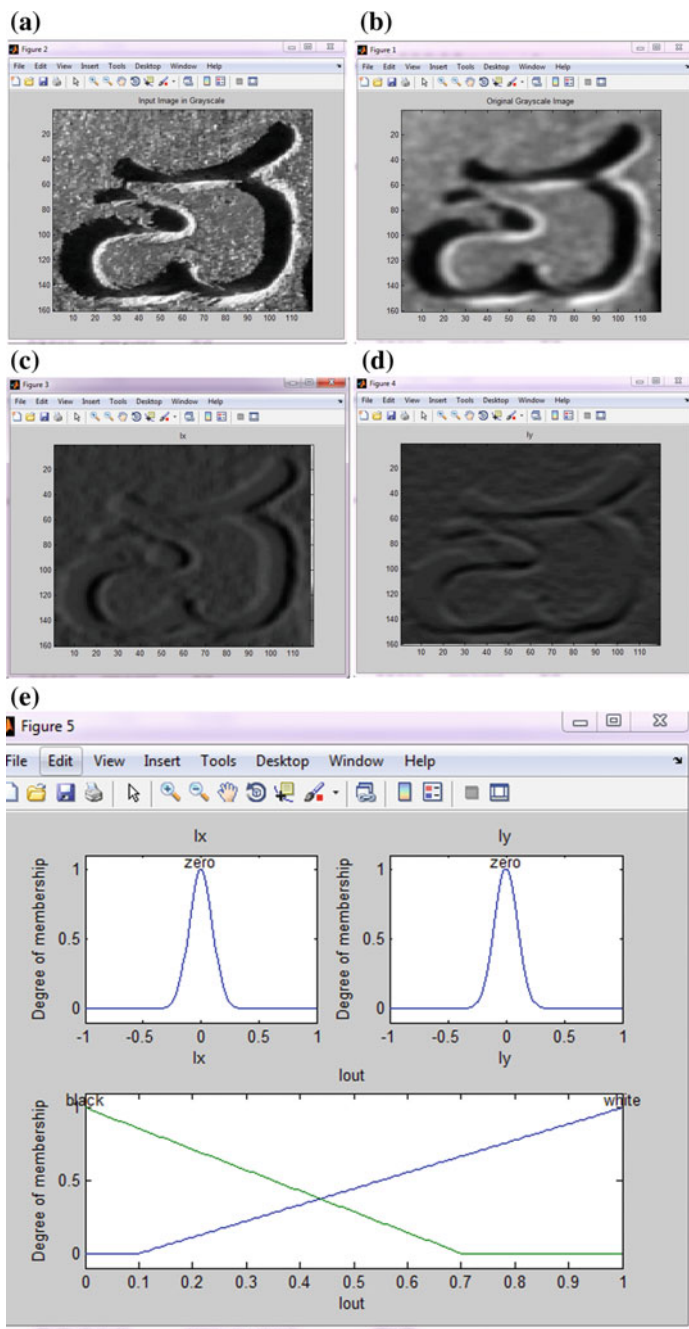


Fig. 3 **a** Input image, **b** gray scaled image, **c** gradient I_x , **d** gradient I_y , **e** degree membership I_x , I_y

$$Z = \sqrt{(x^2 - y^2)} \quad (9)$$

$$A = |Z| \quad (10)$$

5 Results and Discussion

The experimental results of developed algorithm are discussed in this section. Initially the degraded special Kannada characters are captured using ordinary digital camera as shown in Fig. 2. Here 'SHA' and 'VA' characters are selected. These characters are look identical, so they are called special characters. Due to identical look, in degraded mode the exact feature extraction of these characters are difficult.

The captured image was filtered by using mean shift filter. Using Fuzzy logic edge detection, the I_X , I_Y , coordinators and degree of Membership was calculated. Based on fuzzy rule each edge is identified (white or black) shown in Fig. 3.

The most important deference between 'SHA' and 'VA' characters is top left portion curves, these curves differentiate both characters shown in Fig. 4. In fuzzy this significant portion was indentified exactly when compared Sobel, it was affirmed that proposed edge detection method is preeminent for to detect edges of degraded stone inscription Kannada characters as shown in Fig. 4.

The Fuzzy logic and Sobel edge detection images features were extracted [4] and feed into Advance recognition algorithm (ARA) for recognition. In this stage the ARA Properly recognized the Fuzzy logic edge detection character and it improperly recognized the Sobel edge detection character as shown in Fig. 5. The Sobel edge detection method fails' to detect the left portion curves in 'SHA' character so from Fig. 5 it is shown that the proposed method is a best compared to

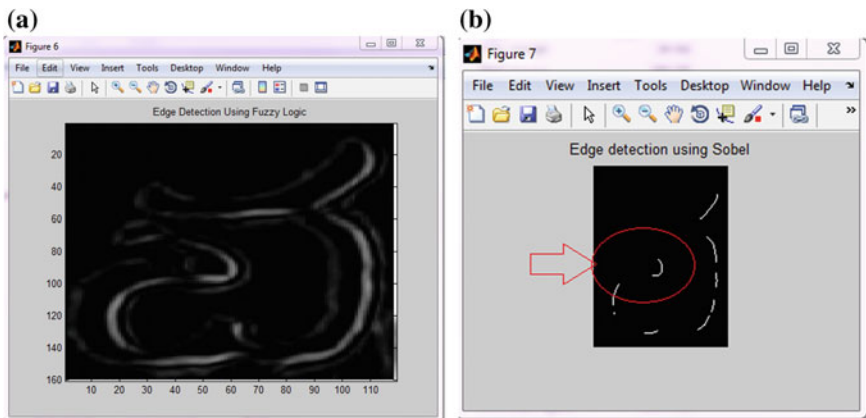


Fig. 4 Comparison of fuzzy logic edge detection image (*left*) and Sobel edge detection (*right*) image

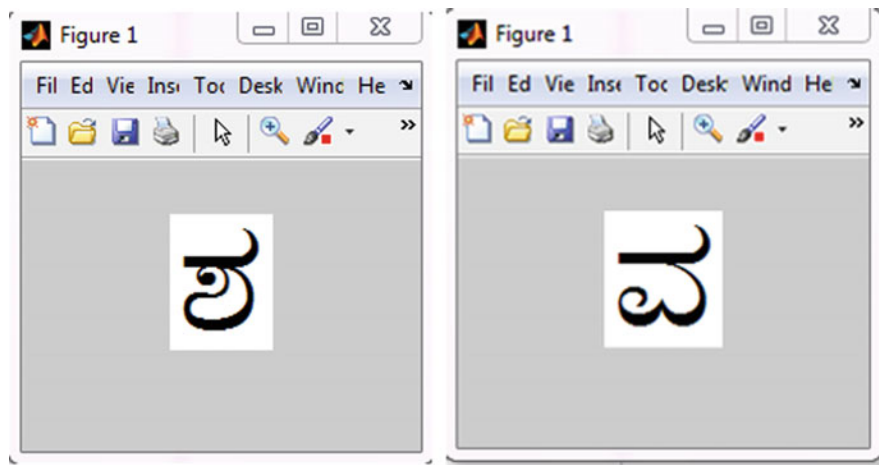


Fig. 5 Accurate recognition of ‘SHA’ Character (*left*) and inaccurate recognition of ‘SHA’ Character (*right*)

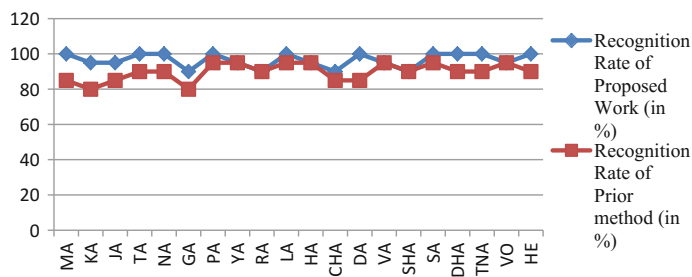


Fig. 6 Results comparison

Sobel detection algorithm in recognition of old degraded Kannada stone Inscriptions characters.

6 Results Validation

The extracted feature from twenty degraded stone inscription characters are feed into Advance Recognition algorithm (ARA) [1] and Characters recognition rate is compared with Sobel edge detection method [5]. Figure 6 it is shown that the proposed work have 99.8% accuracy when compare to prior method (Sobel).

7 Conclusion

Recognition and feature extraction of any degraded stone inscription characters is massive confront. In Kannada 20 plus characters are analogous and comprehensible distinction is very difficult. Edge detection is performed by two methods that is gradient based, which is more sensitive to noise and another is Laplacian based, which is less sensitive to noise. Canny edge detection gives better performance, but it still suffers from detecting weak edge along with strong edges. The disadvantages of first order and second order edge detection can be overcome by using fuzzy logic based edge detection. In this work mainly concentrate on edge detection of degraded stone inscriptions Kannada characters using triangular membership function. From experimental results it conclude that fuzzy logic based edge detection are able to detect thin and clear edges of degraded analogous stone inscriptions Kannada characters using Mean shift filtering. The edge detection feature of character can be extracted easily and then it directly fed into any intelligence network for recognition.

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