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# Camera Captured Handwritten Kannada Character Recognition

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***Abstract:*** ***Optical Character Recognition (OCR) is an automatic reading of text components that are optically sensed to translate human-readable characters into machine-readable codes. In handwritten the style of writing vary from person to person, so it is very challenging task to segment and recognize the characters. In this paper we are proposing segmentation and feature extraction techniques to recognise camera captured, handwritten Kannada documents. The segmentation is done by using projection profile technique & Connected Component Analysis (CCA). The pre-processing technique to detect the edges of Kannada character, we have proposed our own technique by combining of Sobel and Canny edge detection. The feature selection and extraction is done in two level, global and local features. Global features are extracted from entire image. In local feature extraction we divided an input character image in to four quadrate based on centroid of character and we will extract local features from all quadrates rather than whole image. We have used Support vector machine (SVM) to classify the handwritten Kannada characters. To evaluate the efficiency of proposed system we have used KHDD dataset, our own document and character dataset. The experimental results shows that our proposed features selection and extraction achieved 96.31% of accuracy, results are encouraging.***

***Keywords: Centroid, Connected component analysis, OCR, Projection Profile, SVM.***

## I. INTRODUCTION

One of some common and well-studied study fields under pattern recognition is handwritten character recognition.Handwriting character recognition consist of essential and dependent processing steps, they are: pre-processing, binarization, segmentation, feature extraction and classification. Before recognition, the text in a document captured by a camera must be correctly segmented. Text segmentation's correctness or incorrectness directly impacts character recognition accuracies.

Line, word and character segmentation are the major steps in document segmentation. Handwritten recognition of character is a difficult job because they vary in shape, size, orientation, alignment, foreground and background color, and texture of a handwriting.

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There are several line segmentation methods [2]: projection-based, smearing, grouping, Hough transform, stochastic, etc. important proposed techniques are thinning approach based segmentation, segmentation using histogram approach, header line and base line detection method, Hough transform method, smearing method, grouping method, graph based method, Cut text Minimum approach, Block covering method text line identifications, all these segmentation techniques has their own pros and cons.

The feature extraction is another important phase in an optical character recognition system, a selection of well suited feature for the respective language in the world is the most important stage to achieve better accuracy in character recognition for the respective languages. Extracting features in handwritten character processing are challenging task because of the high degree of variability's and its inaccuracy. Generally there are three types of feature extraction they are: Structural, Statistical and Global transformations & moments. The major statistical features are zoning, projection profiles and crossings & distances. Structural characteristics are based on the character's topological and geometric characteristics, such as aspect ratio, cross points, loops, branch points, strokes and directions, two-point inflection, top or bottom horizontal curves, etc. The Fourier Transform (FT), Central, Zenrike moments that make the process of recognizing an object-scale, translation, and rotation invariant are based on Global transformations & moments.Zernike moments are used to extracting the features of printed digits in grayscale images [3]. The features selection is performing vital role in handwritten character recognition system, because of the direct relation between features of data patterns and the recognition system. The feature selection and extraction greatly affects the accuracy of recognition system [4]. Initial works on handwritten character recognition focused on transformation and statistical techniques for extracting the informative feature representation [2] & [4]. To recognize Handwritten Arabic characters uses multi-stage Hidden Markov Model (HMM), it is a statistical model [5]. In this system Arabic characters are represented in core shapes separated by diacritics, these core shapes are represented by smaller units and it's called sub-core shapes. Sub-core shapes improves the efficiency of contextual HMM models rather than the standard Arabic character shapes. For Kannada character recognition uses Zernike 10th Order moment as a features, projection profile and CCA is for segmentation purpose and SVM to classify the Kannada characters in [6].Hu's invariant moments, horizontal and vertical profile features are obtained as features from zoned image. Probabilistic neural network (PNN) is used for character recognition in [7].

The use of moments features on Kannada kaagunitha. Moments and statistical features are extracted from the cut images. These subspace features are used for recognition on Neural Network Classifier [8].

Histogram technique and connected component method is used for character segmentation and correlation method is used to recognize the characters [9].

In this proposed system, we are considering input as binarized line segmented image using previous work presented in [10], further projection profile used to segment word, Connected Component Analysis [11] & [12] for character segmentation and proposed global and local features are extracted to classify Kannada characters using SVM classifier.

## II. PROPOSED SYSTEM

In handwritten optical character recognition (OCR) system much work is reported in English and other European languages compared into south Indian language Kannada. Kannada handwritten recognition become a complex task as it contains diversification in handwriting style and vowel modifier. The proposed handwritten Kannada, camera captured document character recognition has two phases as show in Fig. 1, Phase-1: Word & character segmentation using the vertical projection profile technique. Phase-2: Extracting the global and local features & recognizing Kannada characters using the SVM classifier.

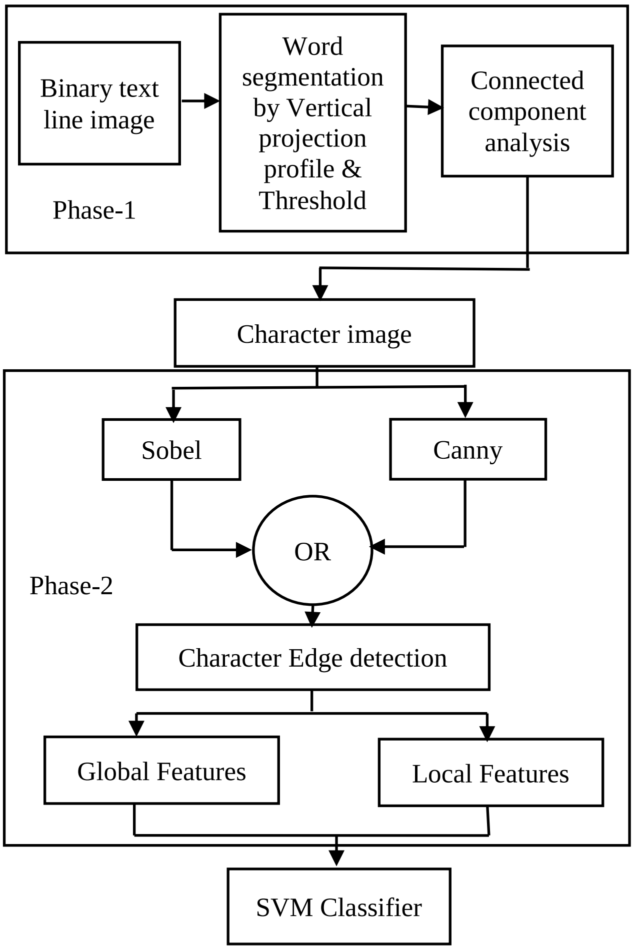


**Fig. 1. The Proposed System**

### A. Word & Character Segmentation

The input images are extracting lines from camera captured, handwritten Kannada documents using our previous work proposed in [10]. Word segmentation is done by applying vertical projection profile (VPP) and finding threshold value as showed in Fig. 3(b). The bounding box is drawn based on the segmented projection profile as showed in Fig. 3(c). After word segmentation, character segmentation is done by applying Connected Component Analysis and VPP by eliminating smaller and tiny blobs, as show in Fig.3 (h-k).

### B. Feature Extraction

Feature extraction is an important part in handwritten character recognition. The classification depends on the features extracted from the image once the features are extracted. The classifier is trained using these features. Kannada Characters are a combination of cursive and straight edges. Before extracting features we have detected the Kannada character edges by combining Sobel and canny edge detection techniques on binary character image. Sobel edge detection technique detects most of the straight edges in Kannada character, canny method detect most of the curved edges in Kannada characters. The process of detecting character edge is showed in Algorithm 1.

***Algorithm 1: Character Edge Detection***

***Input:*** Let $B_i$ is the binary input character image with size 64x64, i.e., the input character image has to resize to standard dimension 64x64.

***Output:*** Binary image $bin_{final}$ with Kannada character edges.

***Step 1:*** ApplySobel edge detection on $B_i$. The result'$B_s$' is the sobel edge detected image, showed in Fig. 4(b)

***Step 2:*** Apply canny edge detection on $B_i$. The result '$B_c$' is the canny edge detected image, showed in Fig. 4(c)

***Step 3:*** The final edge image i.e '$bin_{final}$' is determined by applying following equation.

$$bin_{final}(i,j) = \begin{cases} 1 & if\ B_S(i,j)\ or\ B_C(i,j) = 1 \\ 0 & else \end{cases}$$

Where, i& j are co-ordinate values.

The proposed feature extraction contains global and local features, for both feature extraction we are using '$bin_{final}$' image as an input. '$bin_{fina}$' showed in Fig. 4(d).

#### i. Global Feature Extraction

The following features are extracted form whole image.

- *Centroid:*The centroid of a binary image is calculated by using following equation.

$$centroid = \left(\frac{\mu_{1,0}}{\mu_{0,0}}, \frac{\mu_{0,1}}{\mu_{0,0}}\right) \quad (1)$$

Where, $\mu_{0,0}$ is the number of pixels is the area of the image, $\mu_{1,0}$and $\mu_{0,1}$ are calculated as follows:

$$\mu_{1,0} = \frac{sum_x}{\mu_{0,0}} \& \mu_{0,1} = \frac{sum_y}{\mu_{0,0}}$$

$Sum_x$ is the sum of x coordinates of all white pixels, $Sum_y$ is the sum of y coordinates of all white pixels and these values are calculated using following equation:

$$sum_x = \sum\sum x, bin_{final}$$

$$sum_x = \sum\sum y, bin_{final}$$

The centroid of Kannada alphabet is shown in Fig. 4(e).

- *Total mass:*Thetotal number of white pixels in input '$bin_{final}$'.

- *Orientation (angle of major axis):* Angle between the *x*-axis and the major axis of the ellipse that has the same second-moments as the region. Orientation value is varying from -90º degrees to 90º.
- *Mean:*The mean of an input processed image 'A' is calculated by using following equation:

$$\mu = \frac{1}{N}\sum_{I=1}^{N} A_i \quad (2)$$

- *Standard deviation:* Standard deviation of random variable vector A is calculated using following equation:

$$S = \sqrt{\frac{1}{N}\sum_{i=1}^{N} |A_i - \mu|^2} \quad (3)$$

Where, N is the scalar observation & μ is the mean of image 'A' as defined in (2).

- *Contrast:* It differentiate or distinguish objects by differing the color or luminance of object in an image.
- *Correlation coefficients:* LetA and B are the two random variables, the scalar observation N in each variable, then correlation coefficient is:

$$\rho(A,B) = \frac{1}{N-1}\sum_{i=1}^{N}\left(\frac{A_i - \mu_A}{\sigma_A}\right)\left(\frac{B_i - \mu_B}{\sigma_B}\right)$$

Where, $\mu_A$- mean of A, as in (2), $\mu_B$- mean of B, as in (2). $\sigma_A$- standard deviation of A, as in (3), $\sigma_B$- standard deviation of B, as in (3).

The correlation coefficient *matrix* of two random variables is:

$$R = \begin{pmatrix} \rho(A,A) & \rho(A,B) \\ \rho(B,A) & \rho(B,B) \end{pmatrix}$$

Since *A* and *B* are directly correlated to themselves, the diagonal elements are 1, i.e.,

$$R = \begin{pmatrix} 1 & \rho(A,B) \\ \rho(B,A) & 1 \end{pmatrix}$$

- *Kurtosis:* The normal distribution for kurtosis three. If the kurtosis value is greater than 3, then the distributions will be having more outlier prone than normal kurtosis, if kurtosis is less than three then distribution will be having less outlier prone. The kurtosis (k) of a distribution is:

$$K = \frac{E(\chi - \mu)^4}{\sigma^4}$$

Where, $\mu$ is mean of $x$, $\sigma$ is standard deviation of $x$, and $E(t)$ is the quality t with the expected values.
If flag is 1, then we need to use following equation:

$$K_1 = \frac{\frac{1}{n}\sum_{i=1}^{n}(\chi_i - \bar{\chi})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(\chi_i - \bar{\chi})^2\right)^2}$$

If flag is zero (0), then:

$$K_0 = \frac{n-1}{(n-2)(n-3)}\left((n+1)k_1 - 3(n-1)\right) + 3$$

X- Minimum of 4-elements.

- *Skewness:* Is the process of identify the skewness of asymmetry of data moving over the sample mean. For negativeskewness, data is distributed along the left side of mean, for positive skew value, the data is distributed along the right side of mean. If it is zero, then it's a normal distribution.
The skewness of distribution is

$$S = \frac{E(\chi - \mu)^3}{\sigma^3}$$

If flag is set to 1, skewness is:

$$S_1 = \frac{\frac{1}{n}\sum_{i=1}^{n}(\chi_i \bar{\chi})^3}{\left(\sqrt{\frac{1}{n}\sum_{i=1}^{n}(\chi_i - \bar{\chi})^2}\right)^3}$$

If flag is set to 0, skewness is:

$$S_0 = \frac{\sqrt{n(n-1)}}{n-2} S_1$$

X contain minimum of 3 elements.

- *IDM(Inverse Difference Moment)*

The IDM is:

$$IDM = \sum\left(\frac{P(i,j)}{[1 + (i-j) * 2}\right)$$

If the contrast is less, then the IDM value is negative. If the image uniformity is more then it shows positive value. Where p(i,j) is the GLCM matrix and i and j are the intensities.

### ii. Local Feature Extraction

To extract the local features we divided input image into 4-regions based on centroid valued defined in (1). The centroid of input character image is showed in Fig. 4(e).Let region-1 is the left top sub image, region-2 is the right top sub image, region-3 is left bottom sub image and region-4 is right bottom sub image. These region images are used during feature extraction process, feature extraction is applied on individual regions rather whole image.

The following features are extracted from individual region images:

- *Centroid-Euclidian Distance:* Distance calculation from centroid of region character to centroid of the whole character image.

The centroid of the whole character image and centroid for all 4-regions are calculated by using (1). Sometimes centroid of regions will give more than one centroid because of multiple edges created due to partition, in this case will take average of centroid values. The multiple centroid in each region is showed in Fig. 4(f) and average of multiple centroid value is showed in image Fig. 4(g) respectively.

By using these average co-ordinate values calculate the Euclidean distance from regional centroid to centroid of whole image (global centroid) using following equation.

If p = $(x, y)$ is the centroid of whole character image with co-ordinates x & y.

q = $(x_1, y_1)$ is the centroid of region-1 image, then the Centroid-Euclidian distance for region-1 is given by

$$d_1(p,q) = \sqrt{(|x_1 - x|)^2 + (|y_1 - y|)^2} \quad (4)$$

$d_2$, $d_3$& $d_4$ are calculated for region-2, region-3 and region-4 respectively using (4) as defined for $d_1$ (region-1).

The centroid and distance between regional centroid to global centroid showed in Fig.4 (g).

- *Eccentricity:* Eccentricityis determined by

$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

Where 'a' is the major axis, i.e., the longest diameter of character ellipse & 'b' is the minor axis, i.e., shortest diameter of character ellipse.
The Eccentricity is calculated for all 4 regions.

- *Extent:* Extent is determined by:

$$Extent = \frac{Pixels\ in\ region\ (area)}{Pixels\ in\ total\ bounding\ box\ (area)}$$

- *Orientation:* Angle between the *x*-axis and the major axis of the ellipse that has the same second-moments as the region. It will be calculated for all the regions and orientation value is varying from -90° degrees to 90°.
- *Extrema:* 8 co-ordinate (x- and y-axis) values defines the extrema points in the region, these points are shown in Fig. 2.

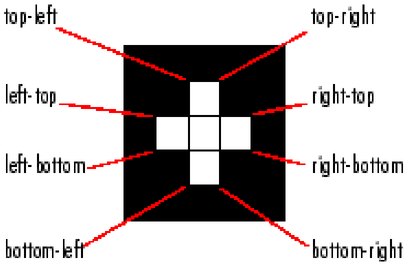


**Fig. 2. Extrema points in the region.**

### C. Classification

Classification in image processing is the process of categorise the images into different categories using the various image features and data. Classification has two stages, training and testing. In training stage, the images features are trained with unique properties, based on these properties each categories are labelled with unique description, in other-words, it creates training classes. In testing phase, the extracted features from new incoming data will be classify with the same unique properties. Classifying data has been one of the major parts in machine learning. We have used Support Vector Machine (SVM) classifier to classify handwritten Kannada characters.

## III. Experimental Result

The proposed feature extraction method was tested on conventional dataset extracted characters, Kannada Handwritten Text Document (KHTD) Dataset which was proposed in [13] and also tested on our own dataset.

The KHTD dataset contains 228 document images, in four categories, they are general news, culture news, film news and medical news. These category data is written by different age group and education qualification. Each document contains 18 to 24 lines, on average 21 lines per document. General news document contains 137 to 139 words, 128 words in film news, 125 words in culture news and 114 words in medical news. These documents are scanned using a flatbed scanner at a resolution of 300 dpi.We have tested our proposed system on 12 documents (KHTD), selected 3 document from each categories (4-categories), and achieved 91.6% of recognition accuracy.

Our own dataset is made up of 120 handwritten Kannada document images with three categories being national news, news of religion and news of court. These papers are collected by 40 individuals with distinct age groups, written in single columns, 15-20 lines, and only text items are included. We developed images of documents by using camera phones to capture handwritten documents. We have tested our proposed system on 9 documents (Own Dataset), selected 3 document images from each categories (3-categories), and achieved 93.7% of recognition accuracy.

The proposed features are tested on ourKannada Hand dataset. Dataset contains 657 classes, each class contains 40 handwritten Kannada character samples collected from different age group and education qualification. 657 classes as defined in Chars74k dataset. We have total of 26,280 character samples, we have used 80% for training purpose i.e., 21024 character images and 20% for testing i.e., 5256 character images. We have achieved 96.31% recognition rate for our features by using SVM classifier. The proposed global features extracted for five characters are shown in Table-I, local features for five characters are shown in Table-II. The comparison of proposed system with other feature extraction technique and efficiency is shown in Table-III.

**Table- I: Global features for five Kannada alphabet binary image.**

| Global Features |  |  |  |  |  |
|---|---|---|---|---|---|
| Centroid | 34, 33 | 33, 33 | 29, 31 | 31,29 | 32,35 |
| Total mass | 616 | 796 | 680 | 769 | 646 |
| Orientation | 45.01128 | 25.91535 | 43.97526 | 46.6743 | 31.48078 |
| Mean | 0.150391 | 0.194336 | 0.166016 | 0.187744 | 0.157715 |
| Standard deviation | 0.357498 | 0.395737 | 0.37214 | 0.390555 | 0.364518 |
| Contrast | 0.053075 | 0.063244 | 0.042163 | 0.049107 | 0.089286 |
| Correlation coefficients | 0.794976 | 0.800142 | 0.849642 | 0.840921 | 0.668202 |
| Kurtosis | 4.826362 | 3.386941 | 4.222593 | 3.557537 | 4.527804 |
| Skewness | 1.956109 | 1.544973 | 1.795158 | 1.59923 | 1.878245 |
| IDM | 24.97033 | 29.52414 | 48.88949 | 48.96602 | 31.55839 |

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**Table- II: Local features for five Kannada alphabet binary image.**

| Local Features | |  |  |  |  |  |
|---|---|---|---|---|---|---|
| Centroid-Euclidian Distance | Region-1 | 7.81025 | 18.43909 | 10 | 9.433981 | 15.81139 |
| | Region-2 | 31.1127 | 30.80584 | 24.83948 | 23.34524 | 25 |
| | Region-3 | 31.82766 | 26.24881 | 26.90725 | 26.1725 | 34.20526 |
| | Region-4 | 12.04159 | 24.59675 | 9.219544 | 8.602325 | 15.6205 |
| Eccentricity | Region-1 | 0.945313 | 0.944387 | 0.873417 | 0.780477 | 0.654773 |
| | Region-2 | 0.697536 | 0.986013 | 0.925708 | 0.845127 | 0.945209 |
| | Region-3 | 0.904909 | 0.880624 | 0.696271 | 0.721289 | 0.757485 |
| | Region-4 | 0.956182 | 0.858683 | 0.844685 | 0.858364 | 0.724228 |
| Extent | Region-1 | 0.255952 | 0.309172 | 0.506993 | 0.503571 | 0.367521 |
| | Region-2 | 0.364583 | 1 | 0.206989 | 0.30512 | 0.237931 |
| | Region-3 | 0.217391 | 0.299679 | 0.339719 | 0.343704 | 0.308081 |
| | Region-4 | 0.785714 | 0.351779 | 0.31856 | 0.371429 | 0.258 |
| Orientation | Region-1 | 44.46481 | 37.82803 | 3.999127 | -6.5693 | 15.214 |
| | Region-2 | 51.78519 | 90 | 26.03542 | 42.5352 | 57.80373 |
| | Region-3 | -48.0344 | -30.568 | 73.53757 | 82.18638 | 18.57435 |
| | Region-4 | 86.94225 | 44.31649 | 54.41724 | 77.60056 | 15.6116 |
| Extrema | Region-1 | 31.5 10.5<br>33.5 10.5<br>33.5 10.5<br>33.5 24.5<br>15.5 34.5<br>12.5 34.5<br>12.5 34.5<br>12.5 32.5 | 28.5 7.5<br>31.5 7.5<br>33.5 8.5<br>33.5 16.5<br>10.5 33.5<br>7.5 33.5<br>7.5 33.5<br>7.5 31.5 | 30.5 16.5<br>31.5 16.5<br>31.5 16.5<br>31.5 23.5<br>28.5 29.5<br>23.5 29.5<br>9.5 25.5<br>9.5 23.5 | 23.5 17.5<br>29.5 17.5<br>29.5 17.5<br>29.5 31.5<br>29.5 31.5<br>22.5 31.5<br>9.5 25.5<br>9.5 23.5 | 18.5 19.5<br>23.5 19.5<br>27.5 29.5<br>27.5 32.5<br>27.5 32.5<br>9.5 32.5<br>9.5 32.5<br>9.5 31.5 |

**Table- III: Comparative analysis of Handwritten Kannada characters with other existing methods.**

| Authors | *Feature Extraction technique* | *Number of images in dataset* | *Classifier used* | *Accuracy (%)* |
|---|---|---|---|---|
| S.A.Angadi [14] | Structual features | - | SVM | 82.49 |
| G.G.Rajput [15] | Zone based crack code | 24500 | MulticlassSVM classifier | 87.24 |
| Shashikala Parameshwarappa and B.V.Dhandra [16] | Normalised Chain code and Wavelet packet | 9600 | SVM | 90.09 |
| Rajashekharaaradhya S V et.al [17] | Vertical projection distance with zoning | 2000 | Feed forward back propagation neural network | 93 |
| Karthik S and Srikanta Murthy K [18] | Histogram of Oriented Gradient | 18,800 | SVM | 95.02 |
| Proposed | Global & Local features based on centroid | 26,280 | SVM | 96.31 |

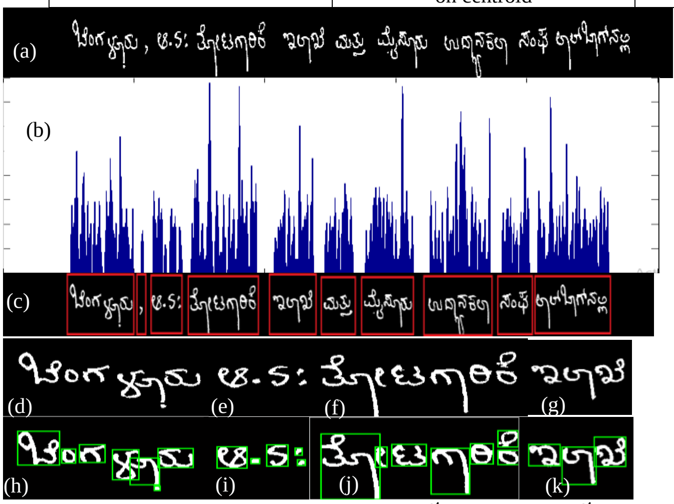
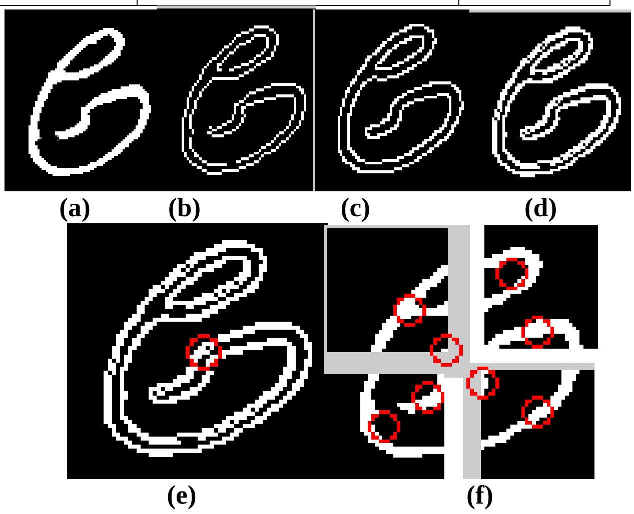
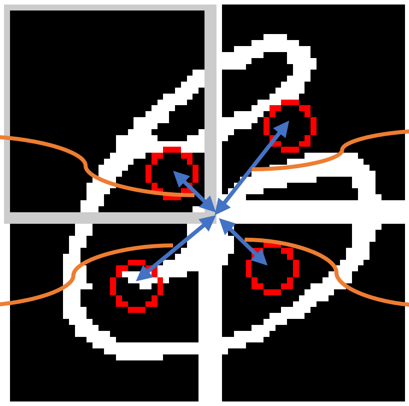


**Fig. 3. (a) Input line image (KHTD 1st document 1st line). (b) Vertical projection for input line. (c) Bounding box for word segmentation. (d)-(g) Segmented word images. (h)-(k) Character segmentation.**






(g)

**Fig. 4.(a) Input character image. (b) Sobel edge detection. (c) Canny edge detection. (d) OR Operation (Sobel OR Canny). (e) Centroid of global image. (f) 4-quadrate or 4-region based on centroid. (g) Average of centroid for all region and distance from region centroid to global centroid {d1, d2, d3 and d4}.**

## IV. CONCLUSION

Due to the varying style and size of individual personality, the camera captured, Kannada handwritten character recogni tion is challenging. In the proposed system we have used projection profile and CCA for word and character segmentation respectively. We have extracted global and local features to classify characters using SVM. The experimental result shows that, our proposed features are better and gives 96.31% accuracy. Further, we can introduce more efficient techniques for character segmentation, because if the characters are connected, CCA technique efficiency is low. Better the character segmentation efficiency, recognition accuracy will also improve.

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