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# Isolated Curved Gurmukhi Character Recognition Using Projection of Gradient

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**Abstract**

In this paper, we have presented a system for isolated curved Gurmukhi character recognition using projection of gradient. We have used projection of gradient features to extract the features of the character. The method relies upon the application of a projection based feature extraction using Radon transform, on both the original image and a set of produced images corresponding to different gradient orientations of the original image. Principal Component Analysis (PCA) is used for the recognition. The method is evaluated using the database of 525 samples images written by 15 persons which are prepared for experiment. We have achieved recognition accuracy of 95.23% using projection of gradient features with PCA.

**Keywords:** Handwritten character recognition, Feature extraction, Projection of gradient, PCA, Radon Transform

## 1. INTRODUCTION

Handwritten Character Recognition (HCR) is the process of changing scanned images of printed and handwritten text into computer processing text such as ASCII code. It is generally used for improve the speed of operations, reduced errors or noise in the documents and decrease storage space needed for papers documents. It is a simple method for fast retrieval, easily searched, saved more compressed data. It is an active field of research in pattern recognition and image processing field. HCR has many applications in 3D objects recognition, receipt processing, postal code recognize and banking sectors. The three main aspects accuracy, speed and flexibility make the best system.

In the past of character recognition area, a numerous methods are available for isolated character recognition for particular languages. But research for isolated curved Gurmukhi character recognition is not so wide. Recognition accuracy of text depends upon the feature set. Various feature extraction techniques like zoning, diagonal, directional, geometrical based features are described by different research scholar. Sharma and Jhajj [1] have described isolated characters recognition in Gurmukhi script through zoning features extraction. They have used 3075 images database to train the system by SVM and K-NN classifier and 2050 images for testing. They have achieved 73.02% accuracy by SVM with Polynomial kernel. Kumar et al. [2] have proposed Principal Component Analysis (PCA) with power curve & parabola curve fitting for extracting features for character recognition. For the purpose of classification, they have used k-NN, Linear-SVM, Polynomial-SVM and RBF-SVM based approaches. They have collected 7,000 samples of isolated offline handwritten Gurumukhi characters from 200 different writers and achieved recognition accuracy of 94.8% without PCA and recognition accuracy of 97.7% with PCA. In an another work, Kumar et al. [3] have described a grading system for writers based on off-line handwritten Gurmukhi character recognition using zoning, directional, diagonal, intersection and open end points and Zernike moments features. They have used k-NN, HMM and Bayesian classifiers for classification and compare the handwriting of one writer with other writers by attach a score with handwriting of a writer. Singh et al. [4] have recognized Gurmukhi character using two Gabor filter features extraction methods namely Gabor- GABM and Gabor-GABN. SVM classifier is used for recognition of character. With the help of Gabor-GABN feature extraction technique, they have achieved high recognition accuracy of 94.29% with dimensionality 200 as compared to Gabor- GABM. Retsinas et al. [5] have described projection based feature extraction technique for recognition of isolated characters. Radon transform algorithm is implemented on primary image as well as on a set of produced gradient orientation images of the initial image. SVM classifier is used for recognize accuracy of method and achieved result 94.35%. Siddharth et al. [6] have presented a technique to recognized isolated handwritten Gurumukhi character. They

have extracted two types of characteristics. They have used 16 ZD and 8 BDD features for every 16 zones. For classification SVM classifier with RBF kernel is used. They have obtained 99.93% accuracy for known writers and the average accuracy has achieved 95.07% for known and unknown writers. Aggarwal et al. [7] have presented single isolated handwritten Devanagari character recognition using gradient feature extraction technique. They have collected 200 samples of 36 Devanagari character from 20 different writers writing 10 samples of each 36 characters. All sample of Devanagari character are normalized to 90 × 90 pixel sizes. For classification, Support Vector Machine with RBF kernel is used and achieved better accuracy of 94%.

In this paper, we have proposed a system for isolated curved Gurmukhi character recognition using projection of gradient feature extraction technique. For recognition, we have used Principal Component Analysis. The procedure of HCR involves various steps including image acquisition, preprocessing, segmentation, feature extraction, and classification. In proposed system, we have taken pre-segmented character and hence the segmentation has been done.

## 2. PROPOSED METHODOLOGY

The methodology used has following steps:-

Step 1: Create digitized image of handwritten character.

Step 2: Change RGB image into gray scale image.

Step 3: Trained dataset by extraction of features of character using Gradient feature extraction technique and four gray scale gradient images are generated.

Step 4: Apply Radon transform to compute angle and projection features extraction of original image and Gradient images.

Step 5: Recognize characters using PCA method.

The main interpretation of projection based feature derivation is break-down the gray scale images into various projections under specified angles through the radon transform.

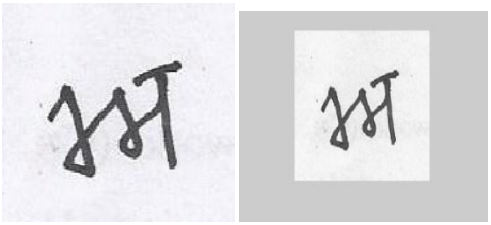
### 2.1 Data Acquisition

There is no standard dataset available for Gurmukhi handwritten character. So database is prepared from handwritten data written by 15 different people on A4 sheet. In this work, we have used 35 basic Gurmukhi consonants. In data acquisition, the input image is scanned Gurmukhi character. The image is acquired through a HP

scanner in 300 dpi. Then these handwritten characters are converted into electronic forms i.e. bitmap images like .jpg, .png, .gif, .tiff, .bmp, .pcx. We have converted all handwritten character into .jpeg images.

### 2.2 Pre-Processing

Pre- processing is next step, in which RGB images have been converted into gray scale images. In Figure 1(a) and 1(b), the digitized image '**ਨ**' has been converted into gray scale image. It has been assumend that images are noise free. The image has been converted into pixel matrix. We have standardized the size of image into 180 × 200 pixels.



(a) (b)

**Figure 1:** Gurmukhi Character 'ਨ': (a) Digitized image (b) Gray scale image

### 2.3 Feature Extraction

Feature extraction technique is the most important part of recognition system. Feature extraction phase is used to remove redundancy from data. There are various feature extraction techniques like statistical and structural features. We have used Projections of Oriented Gradient (POG) feature extraction technique. POG (Projections of Oriented gradient) feature extraction technique comprises of two stages:-

a) Computation of the oriented gradients of the image.

b) Extraction of projection based features for each image gradient and for original image.

#### 2.3.1 Gradient Features

This step is necessary for capturing information of image, such as directional change in the intensity in small neighborhood of each pixel in an image through presented the gradient orientations as gray scale images.

The computation of two directional gradients Gx and Gy of initial image through horizontal (x-axis) and vertically (y-axis).To calculate gradient orientation at every pixel; a transformation is performed uisng Equations 1 and 2. Only G is performed because values of orientation lie in interval [0, 180°] instead of [0, 360°].

The gradient magnitude is then calculated as:-

$$|G(x,y)| = \sqrt{(G_x{}^2(x,y) + Gy^2(x,y)} \text{.....(1)}$$

Gradient direction is calculated as:-

$$\angle G(x,y) = \tan^{-1}(\frac{Gy(x,y)}{G_x(x,y)}) \quad \text{..... (2)}$$

The gradient filter possible orientations are (0°, 45°, 90°, and 135°) that four gray scale images are constructed.

### 2.3.2 Projection Based Feature

The Projection based features extraction is to divide the gray scale images into various projections under the selected angles, through Radon transform technique. Total projections are $n_\theta = 4$ and every projection sampled at 180°/ $n_\theta$, such that angles of projections are $\theta_p = p(180°/n_\theta)$, $p \in [0 \ldots\ldots\ldots n_\theta\text{-}1]$ i.e. 0°, 45°, 90° and 135°. The size of image is denotes as ($I_x$, $I_y$), foreground pixel of image represent by ($x_i$, $y_i$) (i = 1……N), center of image represent by ($x_c$, $y_c$) and θ represent the select angle of projection. In Figure 2(a) and 2(b), we change the digitized image '**ਨ**' into gray scale image.The projection $p_i$ of every pixel into the chosen angle vector is calculated through Equation 3.

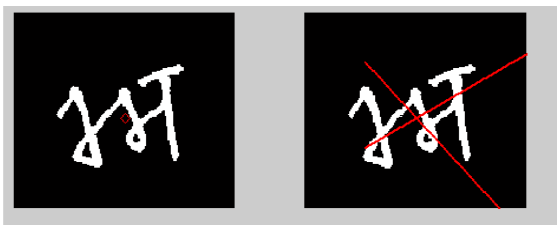


**Figure 2:** (a) Find center of the image (b) Visualization of a projection of angle 45°

$$pi = (x_i - x_c)\cos(\theta) + (y_i - y_c)\sin(\theta),\ i \in [1, N] \quad \text{.....(3)}$$

Finally, the goal is to reduce the redundancy and excessive variability of image. The obtained matrix of radon transform is large to be useful descriptor and variations of same character may convert into distortions of projections. The important information related to smoothed regions of high pixel concentration after calculating the Discrete Fourier transform coefficients cj , j ∈[0, k-1] of the projection vector.

### 2.4 Final Descriptor

The final feature vector is the concatenation of projection features applied in the original image as well as in every four gradient orientation images ($G_0$, $G_{45}$, $G_{90}$ and $G_{135}$) as shown in Figure 3. Total length of descriptor is: 5(images) × $n_\theta$ (projections) × $2n_c$ (Fourier coefficients) = 80.

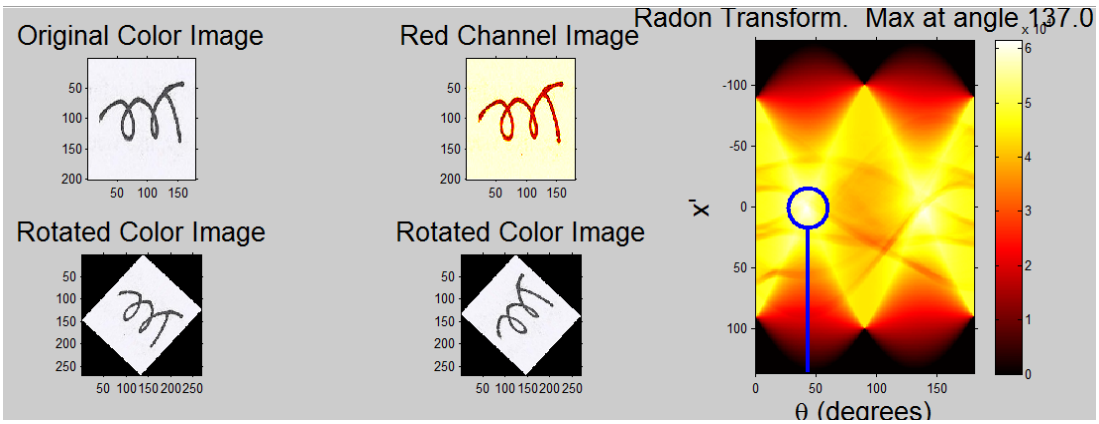



**Figure 3:** Final descriptor is the concatenation of features of original image and its oriented gradients.

### 2.5 Classification and Recognition

Classification phase is the decision making part of a recognition system and it uses the features extracted in the previous phase for identify character. It improves accuracy & reduces the misclassification in system. In this work, we have used Principal component analysis (PCA) method. PCA is a mathematical process that uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components Analysis. The number of principal components may be less than or equal to the number of original variables. PCA is a dimensionality reduction or data compression method. The goal is dimension reduction and there is no guarantee that the dimensions are interpretable.

## 3. EXPERIMENT RESULTS

### 3.1 Database

For our proposed technique, we have created handwritten Gurmukhi character database. The database comprises of 35 basic Gurmukhi characters written by 15 persons. The resulting 35 classes consist of 525 isolated characters, in which 350 characters are used for training and the remaining 175 characters are used for testing.

### 3.2 Recognition Results

Figure 4 shows the overall recognition results of the Gurmukhi character. Character recognition with PCA method and Projection of Gradient Orientation feature extraction technique is used for feature extraction. We take 15 samples of each character and described how many characters recognize correct, which characters are misclassified with it and show accuracy of each character. The overall accuracy is achieved by divided the recognized characters with total characters.

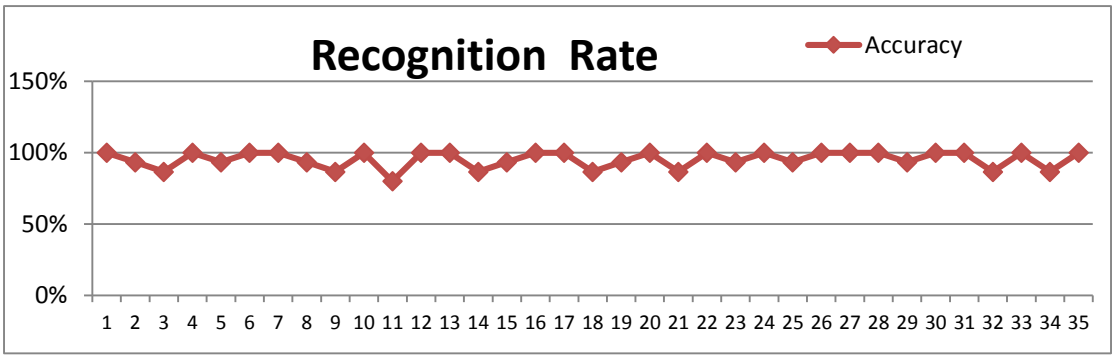
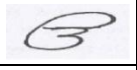
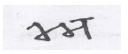
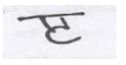
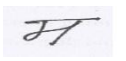
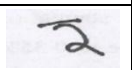
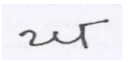
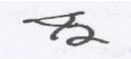
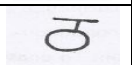
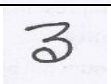
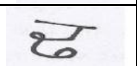
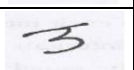


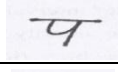
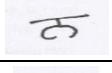
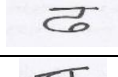
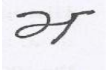

**Figure 4:** Recognition results of Gurmukhi characters with PCA

### 3.3 Character confusion matrix & percentage of recognition

In character recognition of Gurmukhi script similar patterns are creating confusion. Table 1 shows confusion matrix of Gurmukhi characters recognized. In this table n gives 93.33% recognition rate. The most confused characters that occur are observed in table:-n with j; u with T, G, y; M with B, N and R with t. These confusions are decreasing the performance of recognition.

**Table 1:-** Confusion matrix of handwritten isolated curved Gurmukhi characters of best result with PCA

| S. No. | Character | Test Image | Angle of Character | No. of Samples | Recognized | Misclassified with | Percentage Accuracy |
|---|---|---|---|---|---|---|---|
| 1 | T |  | 138 | 15 | 15 | NIL | 100% |
| 2 | n |  | 137 | 15 | 14 | 1(j) | 93.33% |
| 3 | J |  | 137 | 15 | 13 | 1(;), 1(d) | 86.66% |
| 4 | ; |  | 137 | 15 | 15 | NIL | 100% |
| 5 | j |  | 137 | 15 | 14 | 1 (B) | 93.33% |
| 6 | e |  | 41 | 15 | 15 | NIL | 100% |
| 7 | y |  | 41 | 15 | 15 | NIL | 100% |
| 8 | r |  | 41 | 15 | 14 | 1(B) | 93.33% |
| 9 | x |  | 137 | 15 | 13 | 1(e), 1(;) | 86.66% |
| 10 | C |  | 137 | 15 | 15 | NIL | 100% |
| 11 | u |  | 140 | 15 | 12 | 1(T), 1(G), 1(y) | 80% |
| 12 | S |  | 42 | 15 | 15 | NIL | 100% |
| 13 | i |  | 137 | 15 | 15 | NIL | 100% |
| 14 | M |  | 41 | 15 | 13 | 1(B), 1(N) | 86.66% |
| 15 | R |  | 138 | 15 | 14 | 1(t) | 93.33% |
| 16 | N |  | 41 | 15 | 15 | NIL | 100% |
| 17 | m |  | 137 | 15 | 15 | NIL | 100% |
| 18 | v |  | 41 | 15 | 13 | 1(X),1(s) | 86.66% |
| 19 | Y |  | 138 | 15 | 14 | 1(D) | 93.33% |
| 20 | D |  | 42 | 15 | 15 | NIL | 100% |
| 21 | S |  | 41 | 15 | 13 | 2(G) | 86.66% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | E |  | 40 | 15 | 15 | NIL | 100% |
| 23 | D |  | 44 | 15 | 14 | 1(N) | 93.33% |
| 24 | X |  | 40 | 15 | 15 | NIL | 100% |
| 25 | B |  | 42 | 15 | 14 | 1(X) | 93.33% |
| 26 | g |  | 41 | 15 | 15 | NIL | 100% |
| 27 | c |  | 137 | 15 | 15 | NIL | 100% |
| 28 | p |  | 42 | 15 | 15 | NIL | 100% |
| 29 | G |  | 41 | 15 | 14 | 1(s) | 93.33% |
| 30 | w |  | 40 | 15 | 15 | NIL | 100% |
| 31 | : |  | 137 | 15 | 15 | NIL | 100% |
| 32 | o |  | 42 | 15 | 13 | 2(r) | 86.66% |
| 33 | b |  | 40 | 15 | 15 | NIL | 100% |
| 34 | t |  | 40 | 15 | 13 | 1(T), 1(R) | 86.66% |
| 35 | V |  | 42 | 15 | 15 | NIL | 100% |
| **Total** | | | | **525** | **500** | **25** | **95.23%** |

## 4. CONCLUSION

In this isolated curved handwritten Gurmukhi character recognition system, an average recognition rate of 95.23% is obtained. The proposed technique has tested on created database in which consist of 35 basic Gurmukhi character writing from 15 different persons. The database is containing 525 isolated characters, among which 350 characters are used for training and the remaining 175 characters for testing. In this research we have used PCA algorithm and Radon transform. Radon transform is used to find out projection angle of curved character. In future, we can extend this work using other languages characters recognition like Devanagari characters, English characters etc. We have used segmentation free isolated characters, so extend up the work we can also consider words and slant correction in characters will be performed in future.

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