

Fan Beam Projection Based Features to Recognize Handwritten Kannada Numerals

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Abstract. The traditional goal of the feature extractor is to characterize an object by making numerical measurements. Good features are those whose values are similar for objects belonging to the same category and distinct for objects in different categories. In this paper the Fan beam projection, a variation of Radon transform is proposed for extracting the features of handwritten Kannada numerals. Features were computed using fan-beam geometry. For Fan-beam, 55 diverging beams are taken. Fan-beam takes projections at different angles by rotating the source around the center pixel at θ degree intervals. These projection data is considered as feature vector. For Fan-beam the average of the projections of one direction was taken which is the average of 55 parallel projections. Hence size of feature vector for one numeral is 1×360 . For classification K-Nearest Neighbor (K-NN) classifier is used. The proposed algorithm is experimented on nearly 1000 images of handwritten Kannada numerals and appreciable results are obtained.

Keywords: OCR, Kannada handwritten numeral, Fan beam projection, Radon transform, K-NN classifier.

1. Introduction

Character is a general invented system of symbol to communicate information expressing language with human voice. The concept of character in the abstract information is recorded in the concrete form by physical process with the help of a number of writing tools, so that the information is transmitted to the reader. As human's function of character recognition has been being studied in advanced form, the technology of character recognition, which is comparable to human's abilities, has been realized. Hence, character recognition has to be developed to the technology satisfying the requirement of automation of insertion and human-computer interface.

Handwritten character recognition (HCR) has received extensive attention in academic and production fields. The recognition system can be either on-line or off-line. Off-line handwriting recognition is the process of finding letters and words present in digital image of handwritten text. Several methods of recognition of English, Latin, Arabic, Chinese scripts are excellently reviewed in [1, 2, 3, 4]. Research in HCR is popular for various practical applications such as reading aid for the blind, bank cheques, automatic pin code reading for sorting of postal mail.

Although many pieces of work have been done on the recognition of printed characters of Indian languages, but only a few attempts have been made towards the recognition of handwritten characters. Most of the research was focused on recognition of off-line handwritten characters for Devanagari and Bangla scripts. It is observed from the literature survey that there is a lot of demand on Indian scripts character recognition and an excellent review has been done on the OCR for Indian languages [5]. A Detailed Study and Analysis of OCR Research on South Indian Scripts is presented in [6].

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Rajput and Mali [7] have proposed an efficient method for recognition of isolated Devanagari handwritten numerals based on Fourier descriptors. In [8] zone centroid is computed and the image is further divided in to n equal zones. Average distance from the zone centroid to the each pixel present in the zone is computed. This procedure is repeated for all the zones present in the numeral image. Finally n such features are extracted for classification and recognition. F-ratio Based Weighted Feature Extraction for Similar Shape Character Recognition for different scripts like Arabic/Persian, Devnagari English, Bangla , Oriya, Tamil, Kannada, Telugu etc is presented in [9].

Selection of a feature extraction method is most important factor in achieving high recognition performance in character/numeral recognition systems. In [10] a survey on the feature extraction methods for character recognition is reviewed.

Radon transform is used as one of the feature extraction methods [11]. Here the image of a character is Radon transformed and the result is used as features after passing through principal component analysis. Whereas the Fan-beam projection is a variation [12] of Radon transform. The fan-beam function computes projections of an image matrix along specified directions except that the projections are taken in a different way from that of Radon transform.

Literature survey reveals that the automatic recognition of handwritten digits has been the subject of intensive research during the last few decades. Digit identification is very vital in applications such as interpretation of ID numbers, Vehicle registration numbers, Pin Codes, etc. In Indian context, it is evident that still handwritten numeral recognition research is a fascinating area of research to design a robust optical character recognition (OCR), in particular for handwritten Kannada numeral recognition.

Kannada along with other Indian language scripts shares a large number of structural features. Kannada has 49 basic characters which are classified into three categories: swaras(vowels), vyanjans(consonants) and yogavaahas (part vowel, part consonants). The scripts also include 10 different Kannada numerals of the decimal number system. The challenging part of Kannada handwritten character recognition is the distinction between the similar shaped components. A very small variation between two characters or numerals leads to recognition complexity and might affect the recognition accuracy. The style of writing characters is highly different and they come in various sizes and shapes. Same numeral may take different shapes and conversely two or more different numerals of a script may take similar shape.

The rest of the paper is organized as follows: the description of the proposed method is given in section 2, experimental results and conclusion in sections 3 and 4 respectively.

2. Proposed Methodology

The Radon transform of a function $f(x, y)$, denoted as $r(s, \theta)$, is defined as its line integral along a line inclined at an angle θ and at a distance s from the origin [13]. Fig. 1 shows the geometry of Radon transform. The geometry of the Radon transform can be expressed by the following equation:

$$\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y) \delta(x \cos \theta + y \sin \theta - s) dx dy, \quad -\infty < s < \infty, 0 \leq \theta < \pi \quad (1)$$

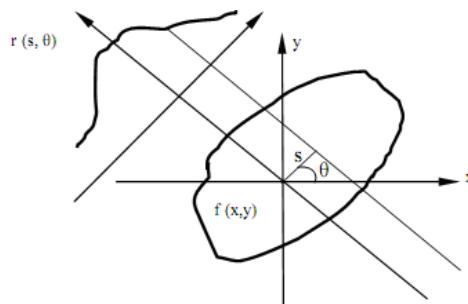


Fig. 1: Geometry of Radon Transform

Often the projection data is collected using fan-beams rather than parallel beams. This is more practical method because it allows rapid collection of projections compared to parallel beam scanning. These diverging beams are just like a fan and hence it is named as fan-beam geometry. Source S emitting a thin divergent beam of X-rays and a detector receiving the beam is shown in Fig.2.

The source position is characterized by the angle β , and each projection ray is represented by the coordinates (σ, β) : $-\pi/2 \leq \sigma \leq \pi/2, 0 \leq \beta < 2\pi$. The rays are related to the parallel beam coordinates (s, θ) as indicated in equations 2 and 3 [13]. Here D is the distance of the source from the origin of the object. Fig.3 shows the Fan-beam geometry.

$$s = D \sin \sigma \quad (2)$$

$$\theta = \sigma + \beta \quad (3)$$

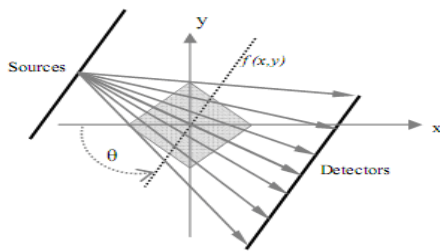


Fig. 2: Fan-Beam projection at rotation angle θ

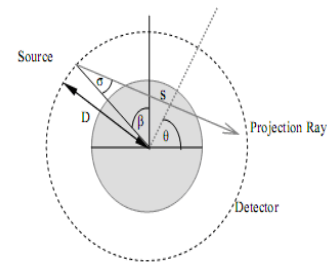


Fig. 3: Fan-beam geometry

Algorithm

Training:

Begin

Input: a set of preprocessed sample images

Output: a database i.e., a feature matrix of numerals

Method:

- Acquire the preprocessed sample
- Apply fan beam projection
- Store the obtained feature vector in the database

End

Testing:

Begin

Input: a set of preprocessed test image, a database i.e., a feature matrix of numerals

Output: class of test image

Method:

- Acquire the preprocessed test sample
- Apply fan beam projection
- Obtain the feature vector of the test sample
- Classify using K-NN classifier.

End

3. Experimental results

To the best of our knowledge standard dataset for handwritten and printed Kannada numerals is not available till today. Therefore, dataset of totally unconstrained handwritten Kannada numerals 0 to 9 is created by collecting the handwritten documents from nearly 100 writers belonging to different professions.

The skew in the documents has not been considered. A sample image of scanned document is shown in Fig 4. The individual numerals were extracted manually from the scanned documents and labeled and are preprocessed.

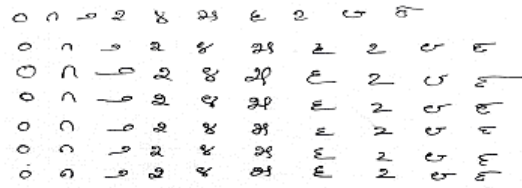


Fig. 4: A sample sheet of Kannada Handwritten numerals 0 to 9

Features were computed using fan-beam geometry discussed above. For Fan-beam, 55 diverging beams are taken. The distance D from the fan-beam source to the center of rotation has to be determined first (Fig. 3). D must be large enough to ensure that the fan-beam source is outside of the image at all rotation angles. D is taken a few pixels larger than half the diagonal image distance, where the diagonal image distance is, $d = \sqrt{i^2 + j^2}$, where i and j are rows and columns of the image respectively. Fan-beam takes projections at different angles by rotating the source around the center pixel at θ degree intervals. These projection data is considered as feature vector.

The accumulator of Fan beam is shown in Fig. 5. It can be seen from the figure that after 180 degree the signal repeats itself in the reverse direction. This is because projections taken from 0 to 180 degree are exactly equal to the projections taken from 181 to 360 degree. Average value of the obtained projection data is taken to build the feature vector. For Fan-beam the average of the projections of one direction was taken which is the average of 55 parallel projections. Hence size of feature vector for one numeral is 1×360 . Fig.6 shows the plot to feature vector generated using Fan-beam for one numeral. K-NN classifier with a Euclidean distance measure between input image pixel maps is used for classification.

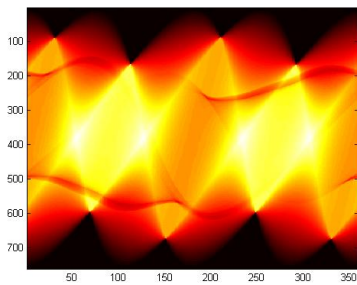


Fig .5: Accumulator data of Fan-beam

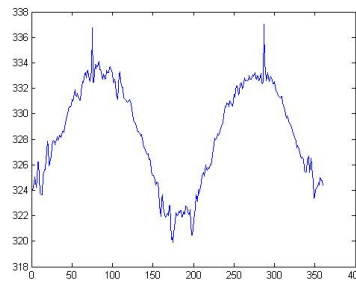


Fig. 6: Plot of feature vector generated by Fan-beams

Table 1 Recognition rate of each numeral

Numerals	೦	೧	೨	೩	೪	೫	೬	೭	೮	೯
No. Of Training Samples	50	50	50	50	50	50	50	50	50	50
No. of Testing samples	35	35	35	35	35	35	35	35	35	35
No of samples recognized	32	29	30	30	29	31	30	31	28	32
Recognition Accuracy (%)	91	83	85	85	83	88	85	88	80	91

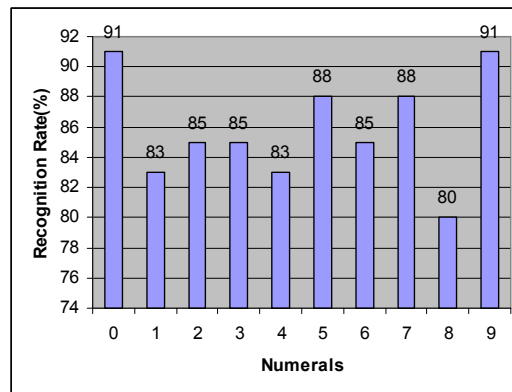


Fig. 7: Graphical representation of recognition rate vs. numeral

4. Conclusion

In this paper, Fan beam projection a variation of Radon transform is used to extract the features of the handwritten Kannada numerals .Nearest neighbor classifier is used for classification and recognition. The recognition rate of 86.29% is achieved. The total time elapsed from preprocessing to recognition is 10.29s. An effort will be made to reduce the dimensionality of the feature vector and improve the accuracy.

5. References

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