2 Directional 2 Dimensional Pairwise FLD for Handwritten Kannada Numeral Recognition

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Abstract. In this paper a two dimensional two directional pairwise Fisher's linear discriminant (FLD), ($2D^2$ pairwise FLD) is proposed which is employed for representation and recognition of Kannada numerals. The proposed methodology is robust as it is an extension of 2D pairwise-FLD[3] which is theoretically more efficient than conventional FLD.

1 Introduction

Kannada is the official language of the south Indian state of Karnataka. With a population of 44 million Kannada speaking people in south India, and with large presence of bilingual documents in Karnataka in Hindi/English – Kannada format, an OCR for Kannada numeral recognition becomes imperative. An efficient OCR is important for any DL initiative to succeed. 2D variant of pairwise FLD is proposed by Guru and Vikram[3] for face recognition in the literature and on similar lines we propose the Alt.2D and $2D^2$ pairwise FLD for handwritten Kannada numerals in this paper. Kannada characters are highly irregular in nature and hence any subspace method would out perform structural feature based method.

2 Proposed Model

2D Pairwise FLD [3] is modeled similarly on the lines of 2DFLD[1]. Let A_i^j be an image of size $a \times b$ representing the j^{th} sample in the i^{th} class. Let C_i be the average image of the i^{th} class. The image between class scatter matrix G_b and within class scatter matrix G_w are computed as follows:

$$G_b = \frac{1}{N}\sum_{i=1}^{T-1}\sum_{j=i+1}^{T} k_i k_j (C_i - C_j)^T (C_i - C_j) \tag{1}$$

$$G_w = \frac{1}{N}\sum_{i=1}^{T}\sum_{j=1}^{k_i} (A_i^j - C_i)^T (A_i^j - C_i) \tag{2}$$

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The Fisher's criterion thus is as follows.

$$J(E) = \frac{E^T G_b E}{E^T G_w E} \tag{3}$$

Similarly let another image between class scatter matrix H_b and within class scatter matrix H_w be computed as follows:

$$H_b = \frac{1}{N}\sum_{i=1}^{T-1}\sum_{j=i+1}^{T} k_i k_j (C_i - C_j)\ (C_i - C_j)^T \tag{4}$$

$$H_w = \frac{1}{N}\sum_{i=1}^{T}\sum_{j=1}^{k_i} (A_i^j - C_i)(A_i^j - C_i)^T \tag{5}$$

$$J(F) = \frac{F\ H_b F^T}{F\ H_w F^T} \tag{6}$$

Projection of a training image onto these optimal projection axes results with a feature matrix of the respective training image. That is if X_i^j represents the feature matrix of X_i^j, then $X_i^j = F^T A_i^j\ E$ (7)

Euclidian nearest neighbor classifier is employed for recognition.

3 Experimentation and Conclusion

In order to create a large handwritten numeral dataset we asked one hundred volunteers in the University of Mysore campus, to write all the Kannada numerals from 0-9, 5 times. Images were cropped to 20 X 15 pixels. Features obtained by projecting images on J(F) (eq. 6) is referred to as Alt. 2D Pairwise-FLD and that from eq. 7 is referred as $2D^2$ Pairwise FLD. 300 training samples were selected with atleast 10 images per class and tested on the remaining 4700 images. The results along with comparative study is given in Table 1. The proposed methodology outperforms the its FLD variants as observed and hence its theoretical efficiency is corroborated.

Table 1. The best recognition performances of the proposed subspace methodology on the Kannada numeral dataset

Methodology	Dimension of feature vector	Optimal recognition rate (%)
Alt. 2D-FLD[2]	7×15	87.00
$2D^2$-FLD[2]	4×3	84.34
2DPairwiseFLD [3]	5× 20	91.08
Alternative 2D_Pairwise –FLD	**4×15**	**93.17**
$2D^2$ Pairwise-FLD	**5 × 5**	**94.23**

References

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