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Content Based Image Classification with Thepade's Static and Dynamic Ternary Block Truncation Coding

Dr.Sudeep Thepade[1], Rik Das[2], Saurav Ghosh[3]

[1]Pimpri Chinchwad College of Engineering, Pune Maharashtra, India
[2]Xavier Institute of Social Service, Ranchi, Jharkhand, India
[3]A.K. Choudhury School of Information Technology,University of CalcuttaKolkata-700009, WB, India

Abstract: Image data has been considered as a vital source of information with far-fetched growth of Information Technology. World Wide Web has facilitated easy and round the clock access of data. Archiving of image data in good proportion has been made possible with high capacity storage devices and communication links. Time and efficiency have been considered as most important factors for information recognition from these datasets. The huge numbers of information databases have diverse categories of image data. Limited number of major categories can be formed based on the contents of the images with the help of image classification. The authors have proposed two novel techniques of feature extraction in this work and have compared the same with the existing techniques of feature extraction for classification results. The proposed techniques have exhibited higher performance efficiency compared to the state-of-the art techniques and have principally contributed to boost up classification performance.

Key words: Content Based Image Classification, Block Truncation Coding, STTBTC, DTTBTC, Multilayer **Perceptron**

1. Introduction

Image capturing devices has undergone a paradigm shift in terms of innovation and intelligence. This eventually has given rise to huge number of image data with every passing day. Various applications including military services, criminology, entertainment, education, etc. find the image data as a wealthy source of information for numerous exercises. Increased efficiency has been imperative for effective utilization of the rich information hidden in image datasets [1]. Efficient use of image data required ready access and prompt retrieval. A supervised and systematized database with limited number of major classes [2] can be an useful tool for increased competence in searching of images from an image database. Classification of images inside the database has stimulated the searching process efficiency. The authors have proposed two novel techniques of feature extraction in this paper and have compared the classification performance of the techniques with the state-of-the art techniques of feature extraction. The proposed techniques have outperformed the existing techniques and have shown rise in classification performance.

2. Related Work

Interaction with the image data in terms of features has strongly narrated the inherent properties of the images [21]. Feature extraction was required for classification of images in heterogeneous collections of image data. The term “feature” in this context may be considered as colour, shape, texture of an image. Averaging and Histogram techniques were used to realize the colour facet of an image [3,4,5]. Texture can be obtained by using transforms [6,7] or vector quantization [8,9]. Shape aspects were achieved with gradient operator or morphological operator [10]. Earlier approaches have studied K-means clustering using Block Truncation Coding (BTC) and colour moments to classify images into various categories [11]. Mean threshold based techniques and global threshold based techniques were predominantly used for feature extraction by image binarization[12,13,14,15,16]. Feature extraction for image categorization was carried out with local threshold selection for binarization in case of unevenly illuminated or stained images[17,18,19,20]. The proposed methods have surpassed the classification results for feature extraction with exiting techniques and have revealed greater classification rate.

3. Block Truncation Coding

Block Truncation coding has been considered as a simple compression algorithm which has primarily segmented the image into nxn (typically 4x4) non overlapping blocks [23, 24]. The algorithm was developed in the year 1979, at the early stage of image processing. It was developed for the grayscale images and later extended for colour images. In this algorithm the blocks were coded one at a time. The reconstructed block comprised of new values calculated from the mean and standard deviation for each block. The value of mean and standard deviation remained same as of the original block. The proposed work has extracted each color component Red(R), Green(G) and Blue(B) as a block as in Fig. 1 and has implemented the concept of block truncation coding.

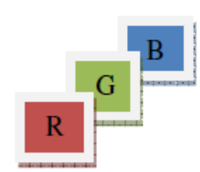

Fig. 1 Red, Green and Blue Component as blocks

4. Proposed Method

Two different methods of threshold selection were proposed in the following subsections.

4.1. Static Thepade’s Ternary BTC(STTBTC)

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The proposed method has followed Block Truncation Coding (BTC) by dividing the image into Red(R), Green (G) and Blue (B) components and treating each of the components as blocks. Primarily, threshod values for each color component were calculated as in equation 1. The overall luminance threshold was calculated from the individual threshold values of each color component as in equation 2. The process was followed by calculation of individual color threshold intervals as illustrated in equation 3 and 4. Calculation of color threshold intervals involved the alteration of degree value *n* every time for calculating upper and lower threshold values. The value of *n* was in the range of 1 to 5.

$$T_x = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n} x(i,j) \qquad (1)$$

$$T_{overall} = \frac{\sum T_x}{3} \qquad (2)$$

$$T_x lo = T_x - n\left|T_x - T_{overall}\right| \qquad (3)$$

$$T_x hi = T_x + n\left|T_x - T_{overall}\right| \qquad (4)$$

where n= 1,2,3,4 and 5

x= Red(R), Green(G) and Blue(B) for each color component

4.2. Dynamic Thepade's Ternary BTC (DTTBTC)

The technique has differed from Static Thepade's Ternary BTC in calculating the degree value *n* associated with threshold calculation. The absolute ratio of the threshold for each color component to the overall threshold value of luminance was calculated to determine the value of *n* as given in equation 5. Three different values were received from equation 5 for three color components and were compared to each other to select the largest value out of the three. The largest value was further considered as the degree value *n* to be associated dynamically for threshold calculation.

$$n = \begin{cases} \left|\dfrac{T_r}{T_{overall}}\right|, iff\left|T_g\right| < \left|T_r\right| > \left|T_b\right| \\ \left|\dfrac{T_g}{T_{overall}}\right|, iff\left|T_r\right| < \left|T_g\right| > \left|T_b\right| \\ \left|\dfrac{T_b}{T_{overall}}\right|, iff\left|T_r\right| < \left|T_b\right| > \left|T_g\right| \end{cases} \qquad (5)$$

4.3. Feature Extraction

In case of ternary BTC a value 'one' was allotted to the corresponding pixel position if a pixel value of respective color component was higher than the respective higher threshold interval (*Txhi*). A lesser pixel value than the respective lower threshold interval (*Txlo*), corresponds to a value of 'minus one' for the consequent pixel position of the image map; else it gets a value 'zero'. The process has been shown in equation 6

$$T_x(i,j) = \begin{cases} 1 & if \quad x(i,j) > T_x hi \\ 0 & if\ T_x lo <= x(i,j) <= T_x hi \\ -1 & if \quad x(i,j) < T_x lo \end{cases} \qquad (6)$$

The mean of the values of the three clusters thus formed were taken as the feature vectors. Thus the number of feature vectors for each color component was three and on the whole nine feature vectors were generated for three color components for each image in the dataset as in equation 7-9.

$$T_x up = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} Tx(i,j), iffTx(i,j)=1} * \sum_{i=1}^{m}\sum_{j=1}^{n} x(i,j), iffTx(i,j)=1 \qquad (7)$$

$$T_x mid = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} Tx(i,j), iffTx(i,j)=0} * \sum_{i=1}^{m}\sum_{j=1}^{n} x(i,j), iffTx(i,j)=0 \qquad (8)$$

$$T_x lo = \frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} Tx(i,j), iffTx(i,j)=-1} * \sum_{i=1}^{m}\sum_{j=1}^{n} x(i,j), iffTx(i,j)=-1 \qquad (9)$$

5. Experimentation Evaluation

The experimentation process for the proposed feature extraction technique was implemented using Matlab 7.11.0(R2010b) with Intel core i5 processor having 4 GB RAM. Evaluation of classification results were performed with a neural network classifier namely multilayer perceptron as shown in Fig.2.

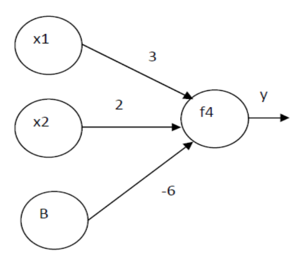


Fig. 2 Multilayer Perceptron

Fig. 2 has shown a perceptron having three inputs including a bias input with three different weights of 3, 2 and -6 respectively [22]. The function of activation is f4 which was applied to the value S = 3x1+3x2-6. A unipolar step activation function has given the assessments of f4 as shown in equation 10.

$$f_4 = \begin{cases} 1 & if \ldots S > 0 \\ 0 & otherwise \end{cases} \quad (10)$$

The classification process has followed a 10 fold cross validation process. The process has primarily divided the entire dataset into 9 training set and 1 testing set and repeated the process for 10 trials. The final results for classification was deduced by averaging the 10 outputs received from the 10 iterations of cross validation [25].

A widely used public dataset named Wang dataset was considered for the evaluation purpose as in fig. 3. The dataset comprised of 10 categories with 100 images in each category. On the whole 1000 images were considered for the assessment work.

Fig.3 Sample of Wang Dataset

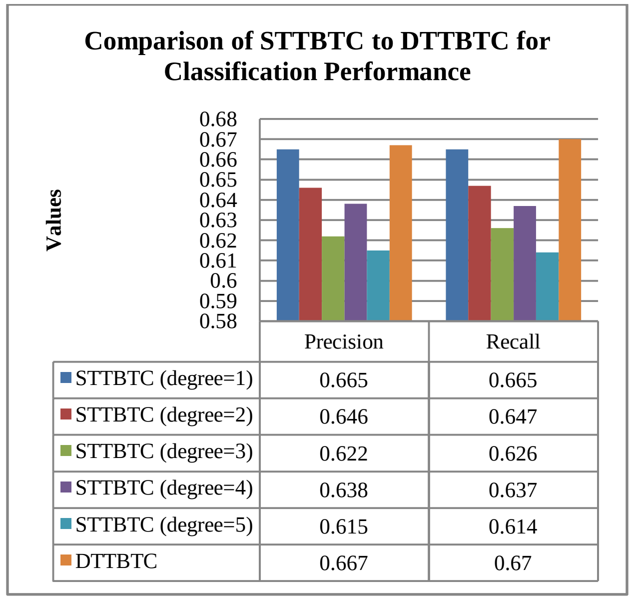
The metrics for evaluation were considered to be Precision and Recall as in equation 11 and 12. Accuracy of the classification process was measured with precision and the completeness of the process was measured by recall.

$$\text{Precision} = \frac{No.of \text{ Relevant Images}}{TotalNo.of \text{ Images Retrieved}} \quad (11)$$

$$\text{Recall} = \frac{No.of relevant \text{ Images Retrieved}}{TotalNo.of \text{ Relevant Images in the dataset}} \quad (12)$$

6. Results and Discussion

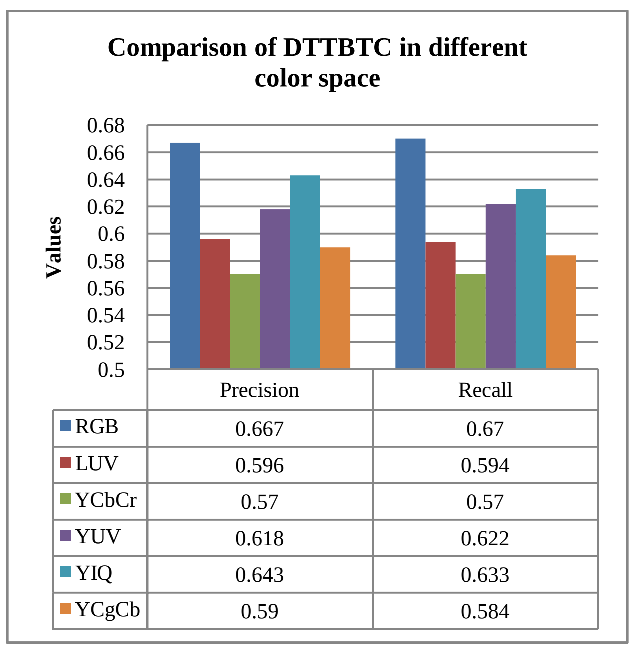
The proposed techniques of feature extraction were primarily compared to each other as seen in Fig. 4. It was observed that Dynamic Thepade's Ternary BTC(DTTBTC) has exhibited the highest precision and recall values when compared to the different degrees of Static Thepade's Ternary BTC(STTBTC). However, the precision and recall values for degree 1 of STTBTC was highest compared to the remaining degrees of STTBTC as shown in Fig. 4.



	Precision	Recall
STTBTC (degree=1)	0.665	0.665
STTBTC (degree=2)	0.646	0.647
STTBTC (degree=3)	0.622	0.626
STTBTC (degree=4)	0.638	0.637
STTBTC (degree=5)	0.615	0.614
DTTBTC	0.667	0.67

Fig. 4 Comparison of precision and recall values of classification for STTBTC and DTTBTC

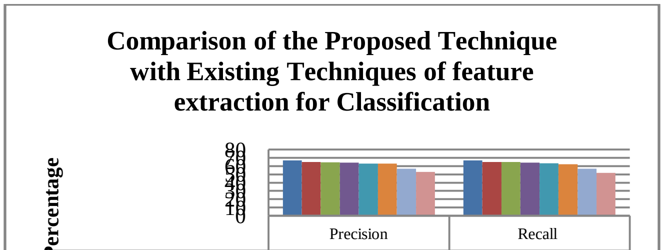
Further, different color spaces were considered for the comparison of precision and recall values for classification of Dynamic Thepade's Ternary BTC (DTTBTC). It was found that the precision and recall values for RGB color space was maximum compared to five other color spaces namely, LUV, YCbCr, YUV, YIQ and YCgCb. The graphical illustration of the comparison has been shown in fig. 5.



	Precision	Recall
RGB	0.667	0.67
LUV	0.596	0.594
YCbCr	0.57	0.57
YUV	0.618	0.622
YIQ	0.643	0.633
YCgCb	0.59	0.584

Fig. 5 Comparison of precision and recall values of classification of DTTBTC with different color spaces.

Finally, the feature extraction method performed by using Dynamic Thepade's Ternary BTC (DTTBTC) was compared for percentage values of precision and recall for classification with the state of the art techniques of feature extraction as shown in Fig. 6



	Precision	Recall
Proposed	66.7	67
Feature extraction from Image Bit Planes with mean threshold selection (Kekre et. al [14])	65.1	64.8
Feature extraction from Even + Odd Image using Mean threshold (Thepade et. al [15])	64.7	64.9
Feature Extraction by Binarization with Bernsen's Local Threshold Technique (Yang and Zhang [19])	64.2	64
Feature Extraction by Binarization with Sauvola's Local Threshold Technique (Hamza et. al [18])	63	63.3

Fig.6 Comparison of precision and recall values of classification of DTTBTC with different color spaces.

The comparison shown in Fig. 6 has clearly established the supremacy of the proposed technique over the existing techniques. The proposed technique has outperformed the existing techniques both in case of precision and recall values and has extended significant contribution towards improvement of classification results.

7. Conclusion

Image classification has its increasing importance due to the growing size of visual databases with the advent of high end image capturing devices and social media. It has necessitated the unstructured image data to be analyzed and interpreted properly for interpretation of important and relevant timely information. The authors have proposed two novel techniques for feature extraction from the visual data which has predominantly increased the classification performance. The work can be extended as a precursor for content based image retrieval where the data can be classified for maximizing the probability of relevant searching in minimized space with decreased time.

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