Novel Approach of Classification based Image Recognition using Thepade’s Sorted Ternary Block Truncation Coding and assorted Color Spaces

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ABSTRACT

Image classification is one of the important research field as huge number of images are getting generated everyday which gives a rise to a new horizon in research field called as image classification. Important activity in image classification is to categorize a given image in its exact class based on its content. Image classification is studied for many years. There are various techniques proposed to increase the accuracy of classification. In this paper a novel data mining based approach is proposed for content based cartoon image classification. Feature extraction and classification algorithms are two main important aspects in classification process. This paper proposes the uses the Thepade’s Sorted Ternary Block Truncation Coding to generate the feature vector and to investigate effectiveness of algorithm at different levels. The paper attempts performance comparison of seven diverse color spaces including RGB in TSTBTC algorithm for key frame extraction. The experimentation is done using a test bed of 21 images with diverse seven color spaces (KLUV, RGB, XYZ, YIQ, YUV, YCbCr and Kekre’s bi-orthogonal color spaces LXY) Experimentation is carried on different sizes of feature vectors which are formed by taking fractional energy coefficients. K Nearest Neighbour Classification algorithm is used for classification.

Keywords: Thepade's Sorted Ternary Block Truncation Coding, Image Classification, K Nearest Neighbor Classifier.

1. Introduction

Content based image classification is needed for efficient classification of relevant images before storage in large databases. Application includes digital libraries, commerce, web searching, biomedicine, surveillance, geographic information systems, education, commerce, crime prevention, etc. Developing automatic image classification system has been an important research field in recent years. Image classification system has two phases image registration where features are extracted from images and stored as feature vector and the query image classification. Content of images can be used as feature for registration process. Content of images can be extracted using various image processing techniques proposed in literature.

Extracting the color features and classifying the image based on color features is the Color Content Based Image classification for cartoon Images. For extraction primary features of frame BTC [1] algorithm is there in which binary bitmap are used determine frame property and threshold. In this paper proposed improved version of BTC i.e. Thepade's Sorted Ternary Block Truncation Coding (TSTBTC) with different color spaces. In TSTBTC [2] the image intensity values are divided into three clusters and average of each is considered to be the part of feature vector of the image. TSTBTC is used for preparing the color feature vector of Cartoon Image database. Image Classification is a procedure which classifies the relevant cartoon images for the test cartoon image from the huge collection of cartoon image database. It consists of two major phases. Among two phases of Image Classification system, the first phase consists of feature extraction. This phase is automated by using Thepade’s Sorted Ternary Block Truncation Coding for color feature extraction. The feature vector table of cartoon images is generated in first phase of image classification process and is classified in classification phase; second phase of Classification based Cartoon Recognition.

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The color space is just a 3D representation of colors. Different color spaces are used for different reasons, for example, RGB color space are used in representation of images on digital screen. RGB and various other color spaces use this concept to display images so that it can be visible to the human eyes, while this is the most common use of color spaces, some color spaces are made for very specific purposes.

For example, LUV [3] color space is used to reduce the color concentration from the image and even out every color tone. This paper is trying to analyze different color spaces to figure out which one is best suited for feature extraction of image using Thepade’s Sorted Ternary Block Truncation Coding.

2. Literature Survey

Images can be best described by the color contents. This research paper will emphasize on color content of cartoon images as a feature used for classification.

Color histogram of image is a representation of collective distribution of colors in an image. It is represented as number of pixels belonging to particular color shade. Color Histogram represents the image in frequency domain of shades. Color layout is spatial distribution of colors for particular image. Color layout with color histogram describes the image. Color mapping transforms the color traits of reference image to destination image. In Color mapping color pallets will be matched to destination image and accordingly it will be colored. Color content is the most important and prominent part of image.

2.1 Color Spaces

Color is most widely used and primary visual feature of video and found effective. This work has been carried out in seven color spaces explained as follows. The color space is a mathematical representation of the colors which are designed to help human for preprocessing a data easily.

1) **RGB Color Space** [4]

It is an additive color space which is based on a tri-chromatic theory. The RGB color space base colors viz., red, green and blue. RGB is very easy to use and implement, is very common and being used in television, video etc.

2) **Kekre’s LUV Color Space** [4]

It is a special case of Kekre Transform results in Kekre’s LUV color Space. Here, L stands for luminance, where U and V represent chromaticity values of the color image. Equation (1) shows conversion from RGB to Kekre's LUV [5] [6].

\[
\begin{bmatrix}
L \\
U \\
V \\
\end{bmatrix} = \begin{bmatrix}
1 & 1 & 1 \\
-2 & 1 & 1 \\
0 & -1 & 1 \\
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B \\
\end{bmatrix}
\] (1)

3) **YCbCr Color Space** [4]

In this color space Y stand for luminance and Cb and Cr are blue and red chromaticity respectively. This color space used in digital video encoding and high definition digital camera, etc. Using equation (2) YCbCr values are derived from RGB components [5] [6].

\[
\begin{bmatrix}
Y \\
Cb \\
Cr \\
\end{bmatrix} = \begin{bmatrix}
0.2989 & 0.5866 & 0.11451 \\
-0.1688 & -0.3312 & 0.5000 \\
0.5000 & -0.4184 & -0.0816 \\
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B \\
\end{bmatrix}
\] (2)

4) **YUV Color Space** [4]

Here Y used as brightness and U and V for color i.e. one luminance and two chrominace. This color space used for standard video encoding like NTSC, PAL, SECAM [7]. Conversion of RGB to YUV given in equation (3) [5].

\[
\begin{bmatrix}
Y \\
U \\
V \\
\end{bmatrix} = \begin{bmatrix}
0.2989 & 0.587 & 0.144 \\
-0.14713 & -0.22472 & 0.436 \\
0.615 & -0.51498 & 0.10001 \\
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B \\
\end{bmatrix}
\] (3)

5) **YIQ Color Space** [4]

Here I represent phase blue chrominance and Q stands for quadrature also said as red chrominance. I-Q channels are rotated from the U-V channels in YUV. NTSC is use this color space for video encoding [8] [10]. Equation (4) gives the required conversion of the RGB to YIQ.
6) **XYZ Color Space [9]**

Y value is luminance. Values of red, green, and blue to be undesirable for creating a standardized color model which is suitable for all devices. Positive integers as values as shown in the following equation (5).

\[
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix} =
\begin{bmatrix}
0.412453 & 0.357580 & 0.180423 \\
0.212671 & 0.715160 & 0.072136 \\
0.019334 & 0.119193 & 0.950227
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B
\end{bmatrix}
\]

(5)

7) **LXY- Kekre's Bi-orthogonal Color Space [9]**

This color space also called as Kekre's YCgCb color space [4]. L (Y) signifies luminance and X (Cg) and Y (Cb) as chromaticity values [8] [10]. Equation (6) for conversion of RGB to LXY.

\[
\begin{bmatrix}
L \\
X \\
Y
\end{bmatrix} =
\begin{bmatrix}
1 & 1 & 1 \\
1 & -1 & 0 \\
1 & 0 & -1
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B
\end{bmatrix}
\]

(6)

### 2.2 Thepade's Sorted Ternary block Truncation Coding (TSTBTC)

Block truncation coding was developed in 1979 and was used initially for grayscale images. Block Truncation Coding (BTC) always proves to be the best method to extract color feature from the video [11]. BTC is basically formulation of blocks based on the thresholds considered (in this case threshold is mean of all pixel values of video). Based on whether these blocks are two are three BTC can be categorized as Binary BTC and Ternary BTC. The paper proposes key frame extraction using an advanced version of BTC said as TSTBTC [2]. In this intensity value of respective color components (Red, Green, Blue) of individual image are divided into three parts and average of each of these parts are considered to be the feature vector of the particular image. Suppose 'I' is a image having Red, Green, Blue color components R, G, B of size m×n.

The total intensity of the R component of m×n can be presented in the form of a single dimensional array (SD) having elements with indices 1 to m×n. This SDR can be sorted in ascending order as ‘sorted SD’. The features of red component can be computed using this ‘sortedSDR’ as given in equation (7), (8) and (9).

\[
IR = \left( \frac{3}{m \times n} \right) \times \sum_{c=1}^{m \times n} sortedSDR(c)
\]

(7)

\[
mR = \left( \frac{3}{m \times n} \right) \times \sum_{c=1}^{2 \times m \times n} sortedSDR(c)
\]

(8)

\[
uR = \left( \frac{3}{m \times n} \right) \times \sum_{c=1}^{2 \times m \times n / 3+1} sortedSDR(c)
\]

(9)

Similarly the features of green and blue color components can be obtained as (lG, mG, uG) and (lB, mB, uB) from equations (10), (11), (12) and (13), (14), (15) respectively with the help of sorted SDG & SDB.

\[
lG = \left( \frac{3}{m \times n} \right) \times \sum_{c=1}^{m \times n} sortedSDG(c)
\]

(10)

\[
mG = \left( \frac{3}{m \times n} \right) \times \sum_{c=1}^{2 \times m \times n / 3+1} sortedSDG(c)
\]

(11)
Thus the final video frame feature vector using Thepade’s sorted ternary block truncation coding (TSTBTC) will be \([lR, mR, uR, lG, mG, uG, lB, mB, and uB]\). These feature vectors then are used for image storage. The paper studies effect of different levels of TSTBTC for Classification based Cartoon Image Recognition.

2.3 Classification using KNN classifier

Classification is predicting certain outcome based on a given input. For classification a classifier is built on a training (known dataset) and then the test dataset is applied for predicting the classes. Classification is done by locating the nearest neighbour in the instance space and then the unknown instance is designated with the same class of the identified nearest neighbour [12, 13, 14].

KNN (K-Nearest Neighbour) classifier is an instance based classifier. K nearest neighbours is a simple algorithm that stores all available cases and classifies new cases based on a similarity measure. A case is classified by a majority vote of its neighbours, with the case being assigned to the class most common amongst its K nearest neighbours measured by a distance function. If K = 1, then the case is simply assigned to the class of its nearest neighbour.

3. Proposed Classification Cartoon Recognition Technique

Proposed Classification Based Cartoon Recognition technique consist of three phases – Feature Extraction, Creating classifier and classifier based recognition

3.1 Feature Extraction Phase

In the feature extraction phase a feature vector table is built up from color features of each cartoon image. Algorithm for registration phase is as below

1. Select a image from cartoon image dataset.
2. Arrange Red, Green and Blue components of each image in respective sorted column vector.
3. Apply different levels of Thepade’s Sorted Block Truncation Coding (TSTBTC).
4. Get a feature vector of image for individual Red, Green and Blue color components.

Figure 1 gives the details about the steps for generating the feature vector for TSTBTC level 2.
3.2 Classifier Creation

From the Feature vector of Training Database the training classifier is created using KNN classifier. Figure 2 shows the step of creating the KNN classifier.

3.3 Classifier Based Recognition

Detailed algorithm for classifier based recognition is given as below.

1. Features of test cartoon images are extracted are given in feature extraction phase.
2. Test feature set is evaluated on KNN classifier instances created from phase 2.
3. Based on test image classification result, Cartoon Image is recognized from the test image set.
4. Accuracy of classifier is calculated for each instance of KNN classifier.

Detailed diagram for classification using KNN is given in Figure 3.
Block Diagram for proposed system is as shown in Figure 4.

Fig-4: Block Diagram for Classification Based Cartoon Image Recognition

The proposed research paper aims at increasing the performance of Cartoon Image recognition using classification and reducing the feature vector size with TSTBTC levels and increase in accuracy by using various color spaces for matching the query feature vector with database of feature vectors.

To assess the retrieval effectiveness, proposed system has used the Correct Rate as statistical comparison parameter. Higher Correct rate indicates more accurate method for feature extraction. Correct Rate is fraction of correctly classified cartoon images that are relevant as given in equation 16.

\[
\text{Correct Rate} = \frac{\text{Number of Relevant images retrieved}}{\text{Total number of images retrieved}}
\]

4. Experimentation Environment

Here the platform used for experimentation is MATLAB with processor CORE i3.

The experimentation test bed has 42 images of cartoons across 7 categories, each category has 6 images. The testing dataset consist of 21 images of cartoons each category has 3 images. Fig. 5 shows the sample from collection of Cartoon Images considered in data set.

Fig-5: Samples from the Categories of Test Bed

5. Results and Discussion

The purpose of the experimentation here is to figure out the impact of different TSTBTC levels and Color spaces on classification based Cartoon Image Recognition using Classification Correct Rate as performance evaluation measure.
In the proposed research work KNN classification is used for purpose of Cartoon Image Recognition. Performance of TSTBTC Levels- 1, 2, 3 and 4 with different color spaces (KLUV, RGB, XYZ, YIQ, YUV, YCbCr and Kekre’s bi-orthogonal color spaces LXY). The similarity measures used in KNN classification to comparison of features is Euclidean Distance. Variations in experimentation are carried out to find best suitable value of TSTBTC level and different color spaces.

The experimentation is conducted using Cartoon Image dataset of 63 images across 7 categories of cartoons. Out of 63 images 42 images are used as training dataset to build the classifiers with variations in TSTBTC levels and different color spaces. Remaining 21 images are used as testing dataset used to check the accuracy of classifier with Classification Correct Rate. Similarity measure used for finding the nearest neighbor is Euclidean distance. The Classification Correct Rate for RGB color space with TSTBTC levels 1, 2, 3 and 4 is shown in figure 5.

From figure 5, it can be observed that TSTBTC level 3 outperforms level 1, 2. Level 3 and 4 performs equally with 76.19% classification rate.

![Classification Correct Rate in RGB Color Space](image)

**Table-1: Classification Correct Rate with Different TSTBTC Levels and Color Spaces**

<table>
<thead>
<tr>
<th>Color Spaces</th>
<th>Classification Correct Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TSTBTC 1</td>
</tr>
<tr>
<td>RGB</td>
<td>57.1429</td>
</tr>
<tr>
<td>KLUV</td>
<td>61.9048</td>
</tr>
<tr>
<td>LXY</td>
<td>61.9048</td>
</tr>
<tr>
<td>YCbCr</td>
<td>61.9048</td>
</tr>
<tr>
<td>YIQ</td>
<td>42.8571</td>
</tr>
<tr>
<td>YUV</td>
<td>71.4286</td>
</tr>
<tr>
<td>YCbCr</td>
<td>66.6667</td>
</tr>
<tr>
<td>RGB</td>
<td>57.1429</td>
</tr>
</tbody>
</table>

It is observed from table I and figure 7, out of four TSTBTC levels, level 3 outperforms level 1 and 2. TSTBTC level 3 and 4 performs equally. For all seven color spaces TSTBTC level 3 performs best as we are taking more values to represent the given image. Once more average values are taken to represent the image more detail about image content is available so level 3 performs best. But there is saturation of number of values required to represent the given image so level 3 and 4 performs equally.
Fig. 7. Classification Correct Rate for various Color Spaces and TSTBTC levels

From Figure 7, it is observed that with all seven Color Spaces, TSTBTC level 3 and 4 performs best and equal.

Figure 8, details about the best performing Color spaces. All 7 Color spaces (KLUV, RGB, XYZ, YIQ, YUV, YCbCr and Kekre’s bi-orthogonal color spaces LXY) are compared for classification Correct Rate for TSTBTC level 3. The best performance of Color space is found for best performing TSTBTC level 3.

Fig. 8. Classification Correct Rate for various Color Spaces and TSTBTC level 3

In the proposed research work, with the variations of the TSTBTC levels for color feature extraction of cartoon images with varied color spaces, the KLUV and YCbCr Color space performs best at TSTBTC level 3 with 80.95% classification rate.

6. CONCLUSION

Novel approach of classification of Cartoon images using KNN classifiers with feature extraction using different TSTBTC levels and diverse color spaces. To reduce the feature vector size of the Cartoon images, different TSTBTC levels has been experimented.

From the result it is concluded that TSTBTC level 3 is giving highest classification rate than level 1 and 2 with all color spaces. At level 3 most color averages are taken which describes the image hence level 3 outperforms the level 1 and 2.
The observation of experimentation conducted have shown that the Luminance Chromaticity color spaces give better classification rate than normal RGB color space. KLUV and YCbCr color space outperformed other considered color spaces in all TSTBTC levels for classification based cartoon Image Recognition. Overall Kekre’s LUV color space and YCbCr has shown best performance for Thepade's Sorted Ternary Block Truncation Coding (TSTBTC) for level 3 for Classification Based Cartoon Image recognition.

REFERENCES


