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Fuzzy Fusion of Colour and Shape Features for Efficient Image Retrieval

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ABSTRACT

Content Based Image Retrieval (CBIR) based on colour has been subjecting to research for many years. While partially successful in resolving some important theoretical and practical problems, it is also becoming clear that other sensory elements will also play the vital part as the supplementary signal inputs in enabling better judgements on digital imagery. For example, geometry shapes will provide important topological information on the image contents. On contrary to colour stimuli, image retrieval based on shapes is still relatively immature. This is due to the complexity and ambiguity on shape definition and the infinite possibility on shape combinations. In this paper, an innovative approach based on fuzzy fusion of colours and shapes for image retrieval is presented. In this work, the so-called feature vector will play a pivotal role in streamlining the colour and shape features based on the Pseudo Zernike Moments (PZM) for improving the efficiency and accuracy of a CBIR system.

Keyword: Fuzzy Colour histogram, Conventional Colour Histogram, Fusion of colour and Shape, Pseudo Zernike Moments

1. Introduction

The continually rising demand for multimedia storage and retrieval has led to the research and development of rapid image retrieval systems. Many applications such as medical image databases, policing and security data management systems are facing the ever growing size of digital image and video recordings. To improve the data handling efficiency, colour can be used as a feature vector to represent the content within an image [1].
Although colour can be an efficient representation for digital images, it carries no information about the shapes which exist in the image but sometimes using one feature extraction is not enough. Due to that this project plans to integrate two feature types - colour and shape - to make the search and retrieval process more reliable. As highlighted by Appas and Darwish [1], the key to a good retrieval system is the selection of feature spaces to ensure the images can be represented as close as possible. Our goal is to design a efficient and robust CBIR system which is insensitive to noise.

2. Review of Colour Features

In a typical CBIR system, each image can be represented using features such as colour, texture or shape. For example, the purpose of a color model or colour space is to facilitate the management of colour features in some specific order. It is a specification of a coordinate system and a subspace within that system where each colour is introduced by a single point [2]. There are many well-studied and applied colour systems such as RGB (Red , Green, Blue) ,HLS (Hue, Lightness, Saturation) and HSV (Hue, saturation, Value) [3] . In terms of human observation, it is nature to define a colour by its attributes of brightness, hue and color fullness. For computer graphics applications, it might be easier to describe a colour using the amounts of red, green and blue. In this research, the system converts RGB to HSV due to the advantages of HSV in representing colours in the way they are perceived. As shown in Figure 1, the HSV colour space can be considered as a cone with its apex pointing downward. It is viewed from the circular side of the cone; Hue is defined as an angle moving around the colour circle shown at the top edge of cone.

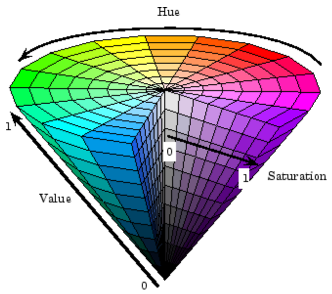

Figure 1. HSV colour model

2.1. The Design of Fuzzy Colour Histogram

Colour histogram was the most commonly used technique for obtaining image signatures. Although colour histogram has provided some satisfactory results in various practical applications, it also suffers from what is called the “curse of dimensionality”.
In a conventional colour histogram (CCH) system, three 256-bin histograms are generated to represent the red, green and blue colour. To measure the distance between any two images will require 768 operations [4]. Generally speaking, there are two major drawbacks in this approach: due to the nature of the RGB colour model, the CCH is too sensitive to lighting. Furthermore, the computations and processing query time is very costly. To cope with these problems, a technique to reduce the signature down to 42 bins by using the so-called Fuzzy Color Histogram (FCH) has been devised in this research. In this system, each pixel value is categorized by 6-level of Hue, 3-level of Saturation and 1-level of value, which are equivalent to 18 bin values. In addition, 3-level of Gray scale values can be added for special case where Hue is undefined to compute the signature from RGB histogram.
A signature histogram is then constructed by accumulating the values for each of the 21 histogram bins. The image signature in this design will consist of 21 values each of the 21 value represents the percentage of the values of the image that activate that bin and by how much it activates the bin. Some images have the same percentage of distribution of colours such as Hungarian and Italian flags. To overcome the colour orientation problem an input image needs to be divided into 2 regions with one fuzzy colour histogram obtained from each, therefore making the dimension of the signature equals to 2*21=42 bins.

As shown in Figure 2, the Hue value is represented by 6 subsets, where the centres of the subsets are defined empirically by the values: {0, 60.0, 120.0, 180.0, 240.0, 300.0 and 360.0}. Each value will activate only two subsets in this case.

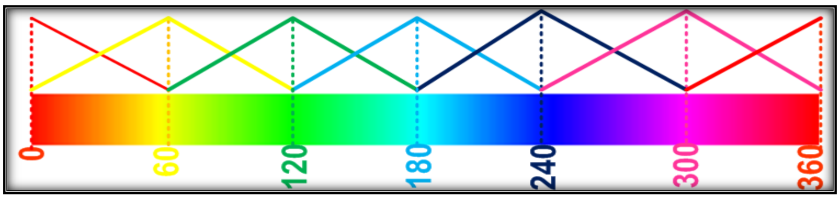

Figure 2. Hue subset

The saturation represents the strength of the colour. The higher the saturation, the higher the membership. The highest saturation value is 255 which corresponds to 1 in the membership scale, while 0 corresponds to 0 for the membership. Each Hue value is multiplied by the saturation. Values which are not activated will be zero and will not be affected by the saturation. Figure 3 illustrates an example of the saturation of the blue colour. The first subset is from 0 to the 128, the second is 0-255, and the third is 128-255. Each value will activate two subsets. For example, the Hue is multiplied by the saturation and the value.

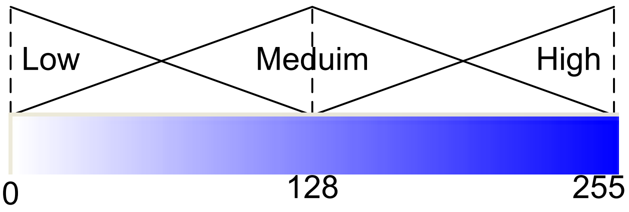

Figure 3. Saturation subset fuzzy centers

The value is of one degree of freedom ranging from 0 to the 255 as shown in Figure 4.

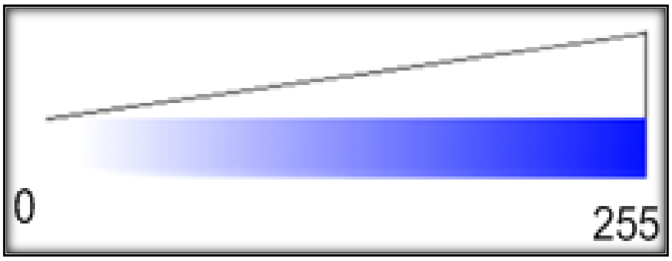

Figure 4. Value fuzzy of blue colour

Black, Gray and white colours are represented by 3 separate bins since they are not included in the Hue bins and the value of the Hue is undefined when colours are equal as shown in Figure 5.

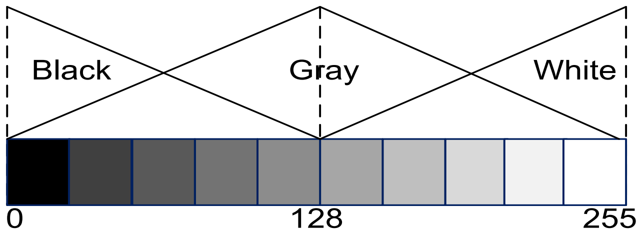

Figure 5. The fuzzy Representation when R=G=B

3. The Pseudo Zernike Moments

Similar to the colour-related operations, shape can also be characterised by pre-defined features and be used to recognize objects and retrieving images. Among various approaches, the Chain Code, Invariant Moments, Fourier Descriptors and Zernike Moment are the most important features. Statistic-based techniques for extracting features are popular in pattern recognition applications due to their precise computational algorithm which relies on the global information existed on images [5].

The recent trend of adopting the “orthogonal moments” – XXX – is a significant development in Digital Image Processing (DIP) due to its sensitivity under the noisy signal scenario. The invariant properties of the “moments” are utilized as pattern sensitivity features in classification. The Pseudo Zernike Moments (PZMs) are widely used among several moment-shape descriptors for shape recognition [6]. To derive moment features, a set of parameters called Zernike polynomials are used to define these features as shown in Equation (1).

$$Vnm(x,y) = R_{nm}(x,y)exp^{jm\ tan^{-1}\left(\frac{y}{x}\right)} \qquad (1)$$

Where $x^2 + y^2 \le 1, n \ge 0, |m| \le n$

The kernel of PZMs is expressed as equation (2):

$$V_{nm}(x,y) = V_{nm}(\rho,\theta) = R_{nm}(\rho)exp^{(jm\ \theta)} \quad (2)$$

Where $\theta = \arctan(\frac{y}{x})$ is the the angle between x axis and radius, m and n are integers and the polar coordinates $\rho = \sqrt{x^2 + y^2}$

The radial polynomials are defined as equation (3):

$$R_{nm}(x,y) = \sum_{s=0}^{n-|m|} D_{n,|m|,s}(x^2 + y^2\ )^{(n-s)/2} \quad (3)$$

Where $D_{n,|m|,s} = (-1)^s \frac{(2n+1-s)!}{s!(n-|m|-s)!(n-|m|-s+1)!}$

The radial polynomials $R_{nm}(\rho) = \sum_{s=0}^{n-|m|} \ (-1)^s \frac{(2n+1-s)!\ \rho^{n-s}}{s!(n+|m|+1-s)!(n-|m|-s)!}$ (4)

The continuous image function for PZM of order n with m is defined [7] as equation (5):

$$A_{nm}(x,y) = \frac{n+1}{2} \iint_{x^2+y^2\leq 1} f(x,y)\ V^*{}_{nm}\ \ f(x,y)dxdy \quad (5)$$

The star means complex conjugation.

Please give a brief justification here on how this method can be used to form a functional module in the proposed system/approach to tackle shape-based image retrieval tasks; and how this method will be complementary to the colour-based CBIR work introduced in Section 2.

3.1. A Proposed Hybrid Approach

In this project, a new hybrid approach based on colour and shape fusion is proposed and investigated. It correlates FCH signatures with Shape features when retrieving images in order to to enhance the matching results through using the aforementioned PZM features. Figure 6 provides a brief illustration of the envisaged operational pipeline.

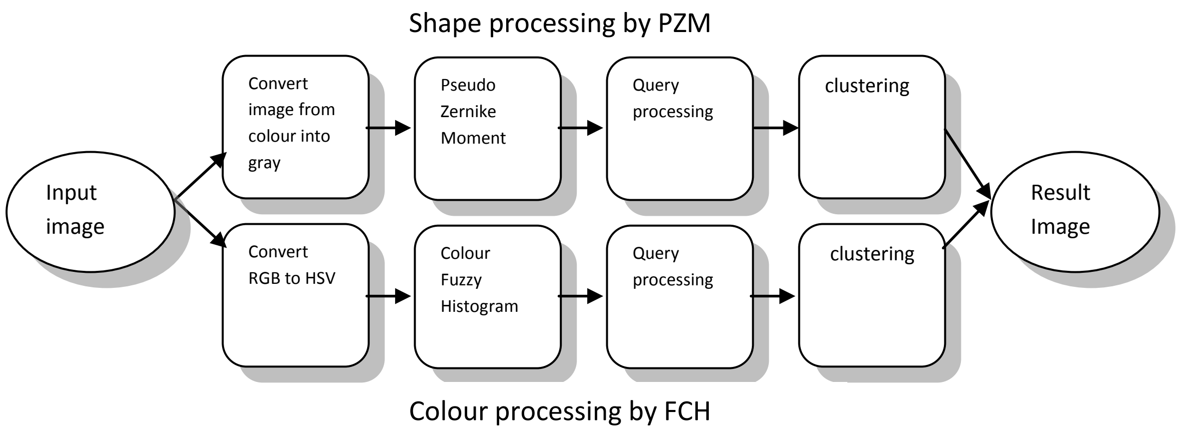

Figure 6. Colour and Shape Fusion Operation

4. Preliminary Test Results on Colour-only Approach

At the time of writing, several experiments have been carried to test the feasibility and validity of the design ideology. The tests are performed over a number of popular online image databases through querying the distances between the sample and image database signatures. The result of the search is a list of images sorted by their similarity to the query. It can be seen from Figure 7 that the sample images are shown in the left column and the results are displayed at right. The answer set contains the closest 16 images obtained by the proposed Fuzzy Color Histogram (FCH) system in comparison to the Conventional Colour Histogram (CCH) system. The experiment is repeated over three databases - VARY database, which contains about 10,000 of natural scenes of images of sizes ranging from 128 x 85 to 128 x 96 pixels; COUNTRY FLAGS database, which contains the flags of about 285 countries; and the self-developed image database that contains over 600 1024 x 256 colour images taken under different conditions by the investigator. Based on visual observation, it becomes obvious that the proposed FCH method has performed far better than the conventional CCH method never mention the speed gain from the much reduced "bin" numbers. The next stage will be looking at the potential benefit that might be introduced by the fusion of shape features with the FCH.

Query Image	Retrieval Results Using	
	FCH	
	CCH	
	FCH	
	CCH	

Figure 7. Results are obtained using VARY database.

5. Conclusions and Future Works

In this paper, a novel CBIR technique has been introduced to integrate colour and shape features based on Fuzzy Theory to enhance the speed and accuracy of the image retrieval processes. The process starts from the computation of the contribution from each colour pixel in an image to the colour signature before sending the preliminary results for refinement by shape feature-based filters. The PZM method is adopted in this design to harness its distinctive charastistic of robustness over interferences and signal noise. To come up with improved idea of searching databases, we are considering the use of Pseudo Zernik Moment (PZM) as a shape feature vector, which has been successfully applied to identify and retrieve human faces.

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