EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 4 Number 7 (July-2016) pp. 114-124

Journal home page: http://www.ijcrar.com

doi: http://dx.doi.org/10.20546/ijcrar.2016.407.015

Mathematical Modeling of Content Based Image Classification Techniques for Artificial Vision

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KEYWORDS

CBIR, Image Retrieval, SVM, Image classification, image processing, pattern recognition, computer vision.

A B S T R A C T

Recent years have seen a rapid increase in the size of digital image collections. Any advance in our ability to organize unlabelled images according to their semantic content is a very useful step in managing these collections. Image is a collection of row and column that is called pixel values. Extracting best matched image from large collection of database is emerging task. Image retrieval is mainly used in image processing, pattern recognition and computer vision. CBIR technique used in many areas such as medical, academic, art, fashion, entertainment. Generally image have colour, texture, shape and size are relevant feature so extract all the relevant and irrelevant features of image. After extracting all the feature of image applies SVM i.e. supervised learning algorithm get optimal result for image classification.

Introduction

The main goal of CBIR to build new technique for extracting similar image from large collection of image i.e. database based on their content or features. Image retrieval system is used to find out similar image to query image. In CBIR, image retrieved low level feature of image like colour, shape, texture and high level feature entropy, mean, standard deviation.

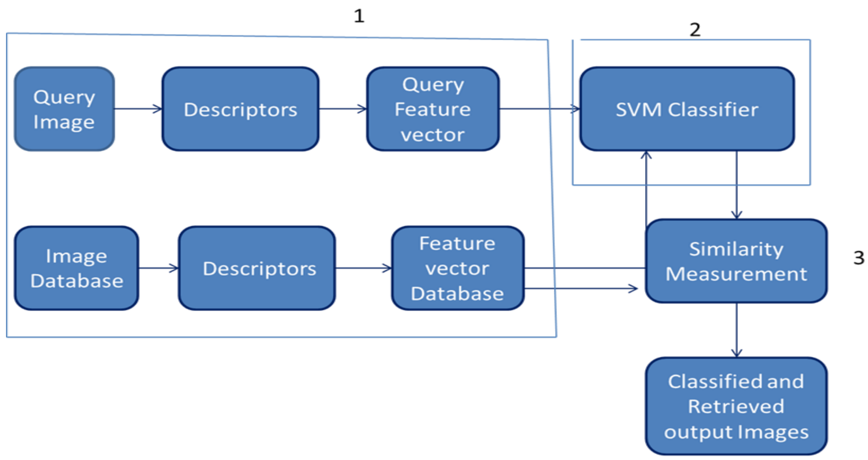
Colour feature use image histogram technique, entropy gives statistical representation of image and text feature gives polite and regularity of histogram. It is most widely used technique for managing, searching, browsing and extracting visual content of image from large collection of images. These feature are stored in database for further use, when we need to find out an image, give a query image for matching, the feature of query image are extracted and matched by stored database image, so that a group of same image comes from the query image as a result.

To reduce complexity of CBIR system and to increase precision a feature reduction or feature selection algorithm is used. It uses an automatic indexing scheme, to reduce search time of retrieval system from the database.

At searching time, user select best matched image from resultant image and then repeat the process again new matched image found. Repeat the step until an image matches to query image. Here Support Vector Machine used to find out optimal result of all the feature of image. It improves efficiency as well as accuracy of all the process of CBIR.

Content Based Image Retrieval

The block diagram shows the pertinence between a query image and resultant image. It applies feature extraction method to all the images and matches the features of query image and resultant image. An image that has best similar feature is extracted from database.



Colour Feature

Colour is one of the most important features in CBIR. It is most widely used for both human perception & computer vision. In colour feature extraction mainly image histogram value calculated. Image histogram is a graphical representation of an image. As we know image is a collection of pixels i.e. row and column, so the image histogram shows the proportion of pixels of each colour within the image. Image histogram for each image is then stored in the database. At search time user can specify the desired proportion of each colour. Image histogram shows how many times the particular colours occur in image. The main advantage of histogram is variation in scale, rotation &translation of image. Currently RGB i.e. Red, Green, Blue colour model is used in digital image because it is more convenient for displaying image in CRT. But it does not give good result in CBIR so we use HSV which is mostly used in CBIR system. In this colour should be matched with human expectation. In this, Hue represents different colours, saturation represents percentage of white colour and Value represents light intensity. Advantages of HSV are suitable with human perception [GuoyongDuan *et al*., 2011].

Texture features

Texture refers to a structural collection of pixels of an image. Many features of image can be extracted by texture features. (GLCM). He proposed some parameters for texture extraction [NidhiSingh *et al*., 2012].

Contrast (Moment of inertia): Image contrast can be a sharpness of image. Contrast is higher whenimage grooves are deep [GuoyongDuan *et al*., 2011].

Energy: It can be measure by gray distribution of image. Coarness of image depends on high energy level.

Entropy: It is a quantity which is used to describe the amount of information of an image. If entropy level is low, then image having more black area. An image that is perfect having entropy zero [NidhiSingh *et al*., 2012].

Correlation: It is used to calculate the degree of similarity of the elements of image.

Wavelet Features

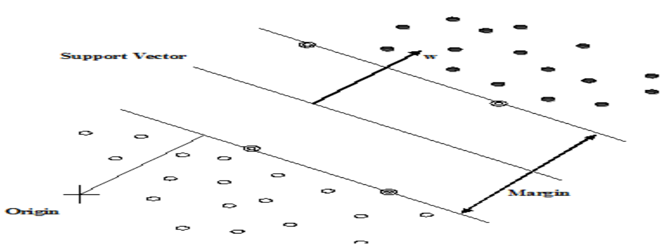
A wavelet is a mathematical function used to divide a given function into different frequency components. A wavelet transform is the representation of a function by wavelets, which represent scaled and translated copies of a finite length or fast-decaying oscillating waveform (known as the "mother wavelet"). Wavelet analysis represents a windowing technique with variable-sized regions.

Wavelet analysis allows the use of long time intervals where more precise low-frequency information is needed, and shorter regions where high frequency information is necessary.All wavelet transforms may be considered forms of time frequency representation for continuous-time (analog)signals.

The discrete wavelet transform (DWT) of a signal is calculated by passing it through a series of filters (high and low pass filters) and then down-sampled. At each level, the signal is decomposed into low and high frequencies, and this decomposition halves the resolution since only half the number of samples are retained to characterize the entire signal

Support Vector Machine

SVM is a supervised learning process in machine learning. The main purpose of SVM is to build optimal separating hyper planes. It accepts data and identifies patterns which are used for classification and regression analysis [Patheja *et al*., 2012]. It takes a set of input data and produces an inferred function called classifier (if input is discrete) or regression (if output is continuous) [Keping Wang Xiaojie Wang *et al*., 2010]. The main aim is to draw hyper plan as wide as possible for a good separation that means largest distance to nearest training data of pixel values [Vanitha *et al*., 2011]. The distance between two hyper planes is the margin of the hyper planes with respect to the sample. The purpose of SVMs is to maximize this distance .If distance of pixels to hyper plan is large than generalization error of classifier is low [Patheja *et al*., 2012].



SVMs method consists of the following phases:

1.Mapping input data to high-dimensional feature space.

2. Selecting a kernel and computes the hyper planes.
3. To maximize the distance from the closest points, this is called the margin.
4. To detect the outer boundaries.

Its performance was auspicious because it reduces prediction error and complexity at the same time.

Feature Extraction

In the proposed system there are three phases:

Pre-processing, Feature extraction, SVM classifier

Pre-processing: the main aim of pre-processing is to remove the noise and error from image. The purpose of removing noise is to get error free exact extraction of feature. If any noise remains in image then extraction gives unsatisfactory result.

Feature extraction: In this step more features of image like colour, texture, shape, mean, standard deviation, histogram value, length to width ratio, entropy are extracted.

SVM classifier: SVM is act as a classifier. Basically it is used for image classification of those features of image which are extracted from previous step.

Following figure shows the step wise working of feature extraction. When input image is ready for feature extraction first it goes through pre-processing phase than goes to next phase here feature extraction is performed.

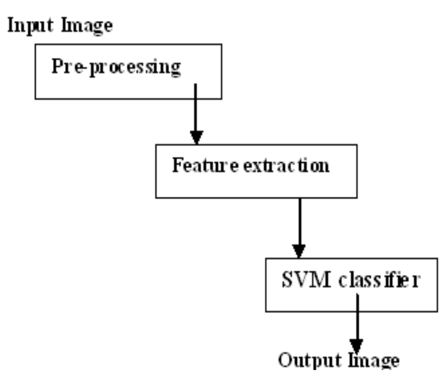
Flow of Content Based Image Categorization System

Flow of Content Based Image Categorization System Using Color Feature

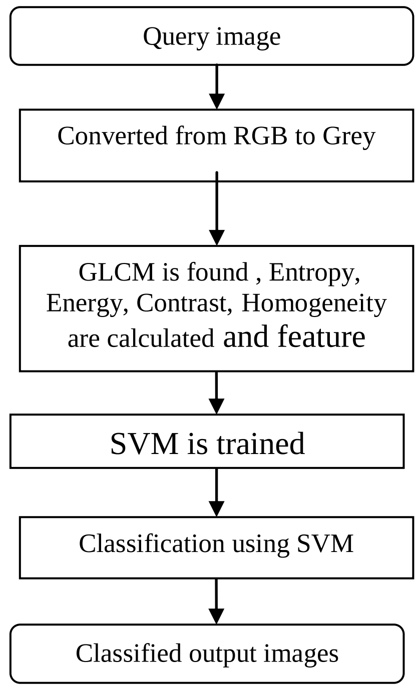
In this work the images are categorized based on color feature. Main steps involved in this workare extraction of features, training of SVM and classification.

Flow of Content Based Image Categorization System Using Texture Feature

In this system categorization is carried out using texture which is an important low level feature. The features like energy, entropy, homogeneity, correlation are calculated.



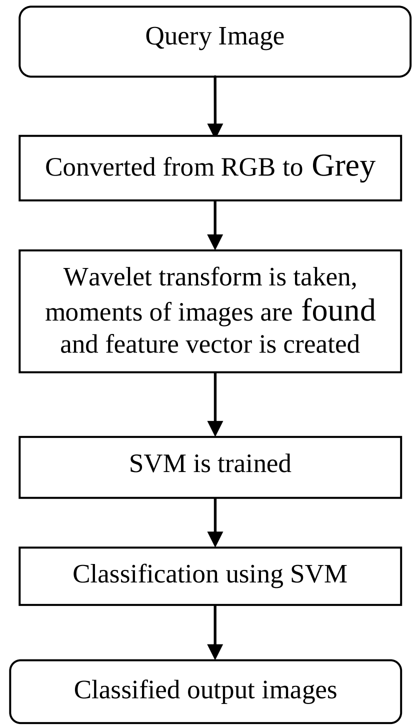
Block diagram of Feature extraction system



Flow of Content Based Image Categorization System Using Wavelet Feature

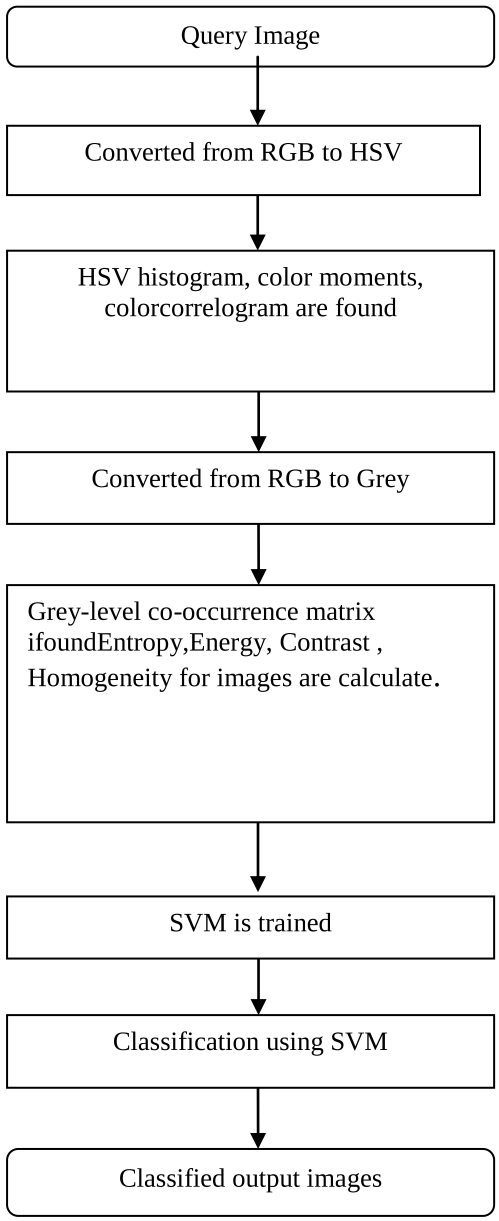
In this section the image is first converted from RGB to Grey.

Coiflet wavelet transform is then allpied to grey image. The coefficients are used to create feature vector.



Flow of Content Based Image Categorization System Using Color + Texture Feature

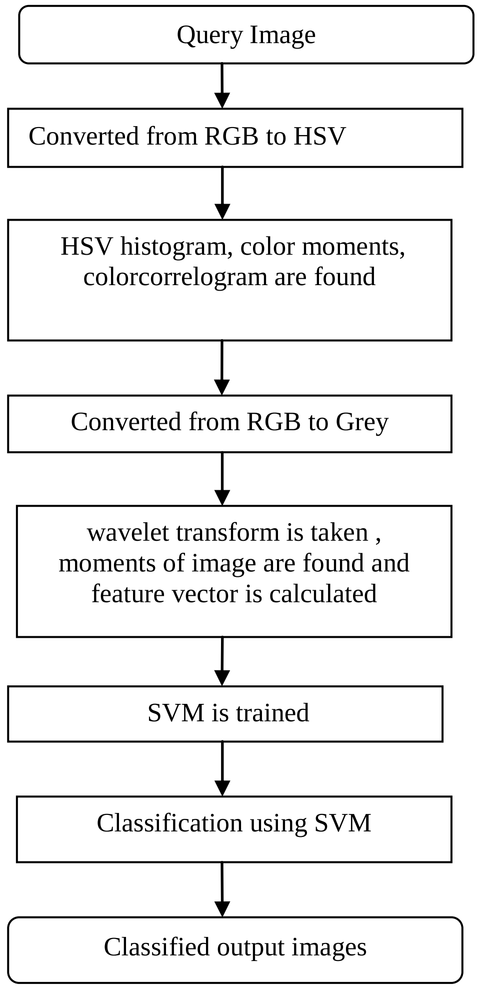
In this system combination of color and texture feature is used. First the color features such as color histogram, color moments, auto correlogram are found. Similarly texture features are extracted from image by using GLCM .



Flow of Content Based Image Categorization System Using Color + Wavelet Feature

In this system combination of color and wavelet feature is used.

First the color and wavelet features are extracted from image. These features are used to create feature vectors.



Results and Discussion

Algorithms for categorization based on different image features are implemented in matlab on 500 images from SIMPLicity database in .jpg format and size 384 × 256 or 256 ×384.The database used contains five different categories, 100 cityscopes, 100 Interior designs, 100 Big trucks, 100 Apples, 100 birds. Here three well known parameters are used to evaluate the performance of the image classification algorithm accuracy, precision and recall.

$$\text{Accuracy} = \frac{\text{Sum of correctly classified pixels}}{\text{Total no. of pixels}} = \frac{\text{Sum of diagonal elements}}{\text{Total no. of pixels}}$$

Precision: In a classification task, the precision for a class is the number of true positives (i.e. the number of items correctly labeled as belonging to the positive class) divided by the total number of elements labeled as belonging to the positive class.

$$\text{Precision} = \frac{t_p}{t_p + f_p}$$

Recall :Recall in this context is defined as the number of true positives divided by the total number of elements that actually belong to the positive class

$$\text{Recall} = \frac{t_p}{t_p + f_n}$$

Where, t_p : true positive predictions , f_p : false positive predictions, f_n: false negative predictions

Table.1 Performance analysis of image categorization on the basis of Precision and Recall for color feature

Class	Using color			
	Using L1		Using L2	
	Precision	Recall	Precision	Recall
Cityscopes	0.69885	0.67172	0.68263	0.7504
Interiordesign	0.73079	0.70063	0.70428	0.72803
Big trucks	0.76344	0.69274	0.70428	0.72803
Apples	0.65415	0.7333	0.6938	0.73279
Birds	0.73239	0.70582	0.70020	0.72319

Table.2 Performance analysis of image categorization on the basis of Precision and Recall for Texture feature

Class	Using Texture			
	Using L1		Using L2	
	Precision	Recall	Precision	Recall
Cityscopes	0.97538	0.95340	0.9689	0.94875
Interiordesign	0.98487	0.95427	0.97538	0.95340
Big trucks	0.98529	0.975	0.995	0.96459
Apples	0.97979	0.94479	0.98409	0.956
Birds	0.95599	0.98944	0.96665	0.99479

Table.3 Performance analysis of image categorization on the basis of Precision and Recall for Wavelet feature

Class	Using Wavelet			
	Using L1		Using L2	
	Precision	Recall	Precision	Recall
Cityscopes	0.98584	0.96904	0.85053	0.86743
Interiordesign	0.82706	0.84508	0.833	0.85
Big trucks	0.78423	0.88338	0.7522	0.84784
Apples	0.82641	0.8439	0.83367	0.84611
Birds	0.78129	0.92439	0.77154	0.88333

Table.4 Performance analysis of image categorization on the basis of Precision and Recall for Color + Texture

Class	Using Color + Texture			
	Using L1		Using L2	
	Precision	Recall	Precision	Recall
Cityscopes	0.84137	0.91195	0.85409	0.87983
Interior design	0.85634	0.91744	0.85833	0.78510
Big trucks	0.86837	0.91723	0.86075	0.82231
Apples	0.88704	0.85745	0.88419	0.86590
Birds	0.91242	0.89692	0.85303	0.96201

Table.5 Performance analysis of image categorization on the basis of Precision and Recall for Color + Wavelet

Class	Using Color + Wavelet			
	Using L1		Using L2	
	Precision	Recall	Precision	Recall
Cityscopes	0.83805	0.81473	0.84523	0.7919
Interiordesin	0.84500	0.87165	0.83620	0.90473
Big trucks	0.85056	0.85243	0.85049	0.83229
Apples	0.86628	0.85978	0.82130	0.85380
Birds	0.82231	0.86724	0.83472	0.88758

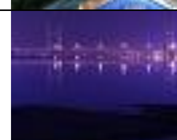
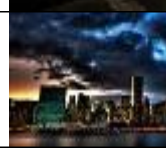
Table.6 Accuracy using (Manhattan Distance) L1

Class	ACCURACY in (%) using L1				
	Using Texture	Using Color	Using Wavelet	Using Color + Texture	Using Color + Wavelet
Cityscopes	96.40	59.25	79.20	55.20	72.80
Interior design	94.00	72.80	78.90	95.20	71.20
Big trucks	96.40	54.80	74.80	81.20	72.80
Apples	96.00	80.80	74.00	69.60	63.60
Birds	94.00	56.00	79.20	80.80	74.00

Table.7 Accuracy using (Euclidean Distance) L2

Class	ACCURACY (in %) using L2				
	Using Texture	Using Color	Using Wavelet	Using Color + Texture	Using Color + Wavelet
Cityscopes	95.20	52.80	76.00	83.60	72.00
Interiordesign	93.60	58.60	78.12	77.20	74.80
Big trucks	92.67	95.20	72.80	57.60	77.60
Apples	77.20	55.20	77.20	78.00	83.20
Birds	79.20	56.00	79.20	80.00	74.00

Table.8 Output Images For Cityscopes Class

Query Image	Output Images For Cityscopes Class				
	Using Wavelet feature	Using Texture feature	Using Color feature	Using Color + Texture feature	Using Color + Wavelet feature
					
					
					
					
					

Result of Categorization Using Color Feature

Experiment is carried out on 500 images of SIMPLIcity database. Here categorization is based on color feature and its performance is evaluated by calculating accuracy, precision and recall.

Result of Categorization Using Texture Feature

This method utilizes texture feature for the categorization process. The parameters accuracy, precision and recall are calculated for both Manhattan distance(L1) and Euclidean distance (L2)

Result of Categorization Using Wavelet Feature

In this method coiflet wavelet is used for categorization process. The parameters accuracy, precision and recall for Manhattan distance (L1) and Euclidean distance

Result of Categorization Using Color + Texture Feature

In this section combination of color and texture is used for categorization. Experiment is carried out on images taken from SIMPLIcity database and results are enlisted in the table 4.4

Result of Categorization Using Color + Wavelet Feature

The categorization is performed using combination of color and wavelet . The corresponding values of accuracy, precision and recall for Manhattan distance and Euclidean distance are enlisted in table 4.5

Accuracy Using L1

The accuracy values for the implemented methods are enlisted in following table

Accuracy Using L2

The accuracy values for the implemented methods are enlisted in following table

Output Images

Output images retrieved for each class after categorization procedure. Here select a fig.no.4 from database of cityscopes as a query image and returned images are found by their features like color feature, texture feature, wavelet feature, color+texture feature, color+wavelet feature. This image is from Cityscopes class.

Conclusion

We have extracted features such as color, texture, and histogram value of an image using feature extraction method. In this proposed work we have used SVM as a classifier for classification of various categories of image such as City scopes, Interior design, Bigtrucks, Apples, Birds. Accuracy of the classifier using texture feature seems to be better as compared to that using color and wavelet. Highest value of accuracy is 96.40% for Big trucks class using texture while it is79.20%,72.80% for Interior designs classes using wavelet and color respectively. The accuracy of color + texture combination is high for Birds class 80.00% and it is high for City scopes class using combination of color + wavelet 72.80%. Also the accuracy value is better for combination of color and texture as compared to color feature only. The precision and recall values for the color feature are again poor as compared to texture, wavelet, combination of color and wavelet, color and texture.

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How to cite this article:

Rajashri Mahajan and S.V. Patil. 2016. Mathematical Modeling of Content Based Image Classification Techniques for Artificial Vision. *Int.J.Curr.Res.Aca.Rev.*4(7): 114-124.
doi: http://dx.doi.org/10.20546/ijcrar.2016.407.015