

A STUDY OF CONTENT BASED IMAGE RETRIEVAL USING ENHANCED RADON TRANSFORM SPACE FEATURES SET BY PCS AND LDA TECHNIQUES

STUDIJA DOHVATA SLIKA POMOĆU POJAČANE TRANSFORMACIJE RADONA I PCS I LDA TEHNIKA

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Abstract

Image Retrieval is very one of the biggest task in the recent years. It is widely used in many real time databases to retrieve related images in various fields like medicine, military, online shopping etc. This paper offers with using radon transform followed by PCA and LDA techniques for image retrieval is called as Combined Radon Space Features Set (CRSFS). Caltech 101 database image sets used in this paper. The correct direction is select means the computation time and complexity of operation is less to achieve good retrieval rate.

Sažetak

Obrada slika je jedan od najvećih zadataka u posljednjih nekoliko godina. Naširoko se koristi u mnogim bazama podataka kad se u realnom vremenu koriste povezane slike u različitim područjima kao što su medicina, vojska, online trgovina, itd. Ovaj rad nudi pomoć radon pretvorbe i zatim PCA i LDA tehnika za popravljavanje slike (CRSFS). Korištena je Caltech 101 baza slika. Ispravan smjer je odabrati način računanja vremena i složenosti rada da bi se postigla manja cijena preuzimanja.

Introduction

Content based image retrieval (CBIR) is a one of the popular techniques which is visual contents to search and browsing digital images from image databases according to user's interests. The CBIR systems is used many real time applications and databases in medical, military, human identification & security systems and online searching & shopping. The term 'content based' means the actual contents of the image rather than keywords, tags or descriptions associated with the image. The CBIR classified in two ways first one is text based retrieval and second one in content based retrieval. In our proposed method mainly concentrate in content based image retrieval. The two mode of CBIR is analyzed first one is low level features like color, shape and texture value to classified and retrieved the images.

Low level features future classified in to two ways like global features and local features. Global features mean its measure the color, shape and texture information on entire image. Local features means its measure the color, shape and texture information on some specific region and condition based to analyze the image. /1/

Existing Work

Ho young /2/ used spatial color descriptor for image retrieval and video segmentation using the color histogram and angle histogram and spatial distribution of color pairs at color edges in an image. The error rate is 28.6%. The classical image database used it contains 5000 images.

Gwenole /3/ introduced adaptive non separable wavelet transform to CBIR its extracted

image signature is derived from this new method. The error rate is 4.6%. The medical database DRD , DDSM & nonmedical database FD ,VisTex is used.

Manesh kokare /4/ used new rotated complex wavelet filters to measure the texture values based on image retrieval. The error rate is 17.2%. The texture image database like Brodatz and VisTex is used.

Hui hui /5/ proposed a novel techniques for object spatial relationships semantic extraction and low level features extraction values was integrated. The error rate is 8.3%. The classical image database used.

Te -wei /6/ used multi resolution wavelet features of interest is apply to CBIR in discrete wavelet transform. The error rate is 23.7%. The classical image database used it contains 1000 images.

Gwenole /7/ is integrated to proposed estimate query image in two function wavelet basic and regression function. The error rate is 3.1%. The Caltech 101 , MOSSIDOR , face database and VisTex database used.

Yue Gao /8/ proposed an approach that simultaneously utilize both visual and textual information to estimate the relevance of user tagged images using hypergraph learning approach. The error rate is 2.4%. The Flicker datasets used it contains 104,000 images and 83,999 unique tags is used.

Qianni /9/ used to automatically combine heterogeneous visual features for histology image retrieval. The approach is multi objective learning methods. The error rate is 24%. The BiMed image database used it contains 20000 images.

Kekre /10/ proposed innovative idea of sectorization of full haar wavelet transformed images for extracting features. The paper proposed two phases to sector the image plane is forward and backward plane. The error rate is 24%. The classical image databases used.

Yi-chen /11/ is using radon transform to examine in-plane rotation and scale invariant clustering in cbir objects. The error rate is 6.4%. The Smithsonian isolated leaf and Kimia - shape based database & Brodatz - texture based database used.

Proposed Method

The method used in this paper for content based image retrieval is fig(1). It has a query phase and another one is data/database registered phase. In the data/database registered phase the set of images are transformed in to radon space using radon transform. Here radon transform performed based on 2D-FFT slice theorem is applied in this method. The data generated by radon transform are reduced using principal component analysis (PCA). From those reduced dataset (ie. the mainly valuable components) a set of basic vector which maximize the ratio between-class scatter and within-class scatter using linear discriminant analysis(LDA). One basic vector for each image is derived and stored in the database. So for image database there are set of basic vectors are stored regardless of the number of images used for each dataset in the training set. The length of the basic vector depends on the number of components selected by the PCA stage. The query phase the input image is transformed into the radon space using radon transform based on 2D-FFT slice theorem. The PCA reduction is carried out as same as in the data/database registered phase. The resultant vector is calculated using distance measure comparison methods was used to check the query phase weight vector values W was compared to data/database registration phase weight vectors values. The most similar weight vectors values images are listed in retrieval results. In this work two types of distance measure used, L1 Norm and L2 Norm. L1 Norm measures the absolute distance between the pixels of the original and the corrected image. L2 Norm measures the Euclidian distance between the pixels of the original and the corrected image. The method which is stated in this paper was evaluated using the Caltech 101 database datasets which contains classical images & texture images. There are 8 different datasets used in this work .The images are color with a resolution of 120x120. For some of the datasets, the image were taken at different angle, scaling and apply for our experiments. The subsequent part discussion of each main part of the method process is presented.

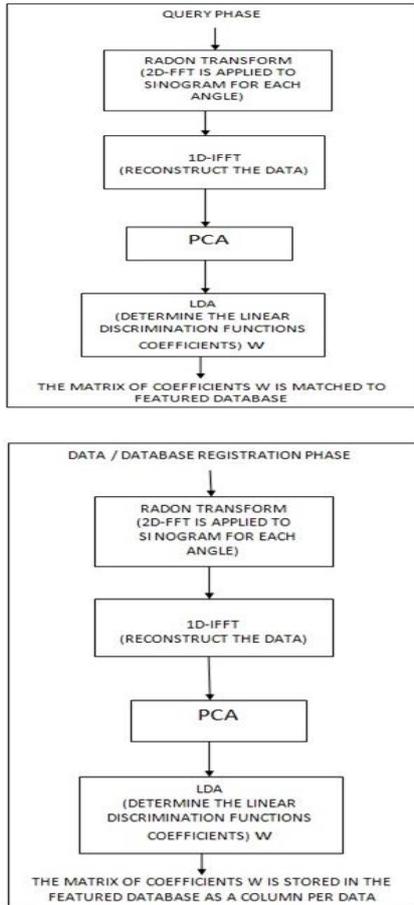


Fig (1). Proposed Method Overview Diagram (CRSFS)

Radon Transform

The radon transform is used in many applications like categories the visual objects /12/, rotation invariants in objects identification /13/,/14/, face recognitions /15/, image recognitions /16/. The radon transform is the projection of the image intensity along a radial line oriented at a specific angle. The radial coordinates are the values along the x'-axis , which is oriented at Θ degree counter clockwise from the x-axis. The origin of the both axis is the center pixel of the image. Radon transform of an image representation as a matrix, called sinogram.

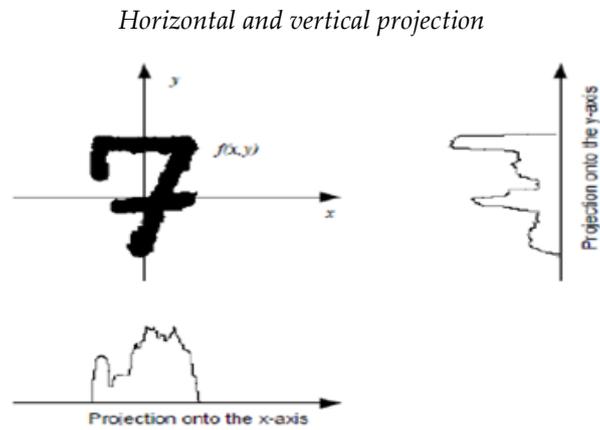


Fig 2. Radon Transform Horizontal & Vertical Projection View

The popular form expresses lines is

$$t = x * \cos(\theta) + y * \sin(\theta) \tag{1}$$

θ – angle & t – smallest distance to the origin of the coordinate system

Projection can be computed along any angle θ , by use general equation of the radon transform

$$g(t, \theta) = \iint_{-\infty}^{+\infty} f(x, y) \delta(t - x(\cos(\theta)) - y(\sin(\theta))) dx dy \tag{2}$$

The very strong property of the radon transform is the ability to extract lines (curves in general) from very noisy images.

Rotation Invariance

The radon transform of a two variable function x is defined as

$$R_{\theta}x(t) = \int_{-\infty}^{\infty} x(t \cos \theta - s \sin \theta, t \sin \theta + s \cos \theta) ds$$

where $(t, \theta) \in (-\infty, \infty) \times (0, \pi) \quad \forall s \in R$ (3)

To compute the value at any given point (t, θ) in the radon domain by integrating along the line:

$$(u, v) = (t \cos \theta - s \sin \theta + s \cos \theta) \tag{4}$$

If x' is a rotated copy of x by on angle θ

Simple proof shows $R_{\theta} \bar{x}(t) = R_{\theta+\hat{\theta}} x(t) \quad \forall t, \theta$

Let $\sigma_{\theta} \Delta \underline{\underline{Var}}_t [R_{\theta} x(t)]$ denotes the variance with respect to t of the RT at θ .

σ_{θ} - Useful in estimating the principal orientation in an image.

Estimate $\hat{\theta}$

$$\hat{\theta} = \arg \min_{\theta} \left(\frac{d^2 \sigma \theta}{d \theta^2} \right) \tag{5}$$

Scale Invariance

Let x' is the scaled copy of x with scaling factor ϵ such that

$$\bar{x}(u, v) = x(\xi u, \xi v) \tag{6}$$

Relate this to RT ,

$$R_{\theta} \bar{x}(t) = \int_{-\infty}^{\infty} \bar{x}(t \cos \theta - s \sin \theta + s \cos \theta) ds$$

$$= \int_{-\infty}^{\infty} x(\xi t \cos \theta - \xi s \sin \theta, \xi t \sin \theta + \xi s \cos \theta) ds$$

$$= \frac{1}{\xi} R_{\theta} x(\xi t)$$

From this observation, scale invariance can be achieved through the normalization in the RT.

Principal Component Analysis (PCA)

Principal Components Analysis (PCA) is one of several statistical tools available for reducing the dimensionality of a data set /17/, /18/, /21/. Its relative simplicity and both computational and in terms of understanding what's happening and make it a particularly popular tool. The major goal of principal components analysis is to reveal hidden structure in a data set. In so doing, we may be able to

- identify how different variables work together to create the dynamics of the system
- reduce the dimensionality of the data
- decrease redundancy in the data
- compress the data

The training set D and testing set Q on basic vectors:

Step 1: calculate mean value m for training set and subtract it from the training set

$$m = \frac{1}{n} \sum_{i=1}^n D_i \tag{7}$$

All training set $D_i = D_i - m$

Step 2: calculate the eigenvectors and eigenvalues of the training set covariance matrix C_t

$$C_t = D \cdot D^T \tag{8}$$

the eigenvectors corresponding N largest eigenvalues of C_t . These construct the principal component matrix (V) .

Step 3: the basic vector matrix (E) is defined by:

$$E = V \cdot D^Q \tag{9}$$

Step 4: the reduced feature vectors for training and testing data calculated by:

$$WD = D \cdot E \tag{10}$$

$$WQ = Q \cdot E \tag{11}$$

Linear Discriminant Analysis (LDA)

The LDA is used to find the set of basic vectors which maximizes the ratio between between-class scatter and within-class scatter /17/, /19/, /20/.

The between class scatter matrix is defined by :

$$S_B = \sum_{i=1}^c N_i (m_i - m_t) (m_i - m_t)^Q \tag{12}$$

Here , C – Classes , Ci- ith Class , Ni – number of samples , Mt – mean of the hole dataset , Mi – mean of the ith class.

The within- class scatter matrix is defined by:

$$S_W = \sum_{i=1}^c \sum_{mk \in ci} (mk - m_i) (mk - m_i)^Q \tag{13}$$

The basic vector is defined by :

$$W = \arg \max \left(\frac{|W^Q S_B W|}{|W^Q S_W W|} \right) \tag{14}$$

Solving Equations (11) to produces a matrix W whose columns are the eigenvectors corresponding to the largest eigenvalues are calculated. These columns are the linear discriminant function related with classes as one of the function for each data. These functions are stored in the database to perform the classification.

Distance Measures

L1& L2 Norm:

L2 Norm measures the Euclidian distance between the weight vector values of the query and the database images. Formula for the L2 norm is:

$$W1 = ((img_query_ (w) - img_database_ (w))^2)$$

L1 Norm measures the absolute distance between the weight vector values of the query and the database images. Formula for the L1 norm is:

$$W2 = (abs (img_query_ (w) - img_database_ (w)))$$

Performance Measure

In the CBIR performance measure is calculated in this work was universal methods Precision & Recall.

$$\begin{aligned} \text{Precision} &= \frac{\text{No of relevant images retrieved}}{\text{Total no of images retrieved}} \\ \text{Recall} &= \frac{\text{No of relevant images retrieved}}{\text{Total no of images in the database}} \end{aligned}$$

Experiments

The proposed image retrieval method (CRSFS) was applied Caltech 101 database datasets images in the size 120x120 pixel resolution. Totally four experiments conducted. Each with different query environments like normal, rotated, scaled and performance was evaluated and represent in Tables (1, 2, 3, 4).

Image Set		Angle 30°	Angle 60°	Angle 90°	Angle 120°
Classical Image	Set 1	91.5	93.3	97.8	94.7
	Set 2	96.4	90.4	88.5	94.5
	Set 3	95.2	92.4	90.9	96.7
	Set 4	89.6	95.3	92.7	88.3
	Set 5	95.6	91.5	97.2	89.9
Texture	Set 6	97.7	88.4	93.7	95.2
	Set 7	96.8	95.2	92.7	94.1
	Set 8	89.5	96.2	93.8	97.1

TABLE (1) Recognition Rate for Query in Different Angles

Image Set		Scaling Factor	Scaling Factor	Scaling Factor
		30x30	60x60	90x90
Classical Image	Set 1	95.4	91.5	98.1
	Set 2	93.2	97.5	96.3
	Set 3	97.8	88.3	89.4
	Set 4	96.4	92.8	98.2
	Set 5	97.1	91.3	94.7
Texture	Set 6	98.3	95.5	88.9
	Set 7	88.5	96.7	91.9
	Set 8	89.4	87.2	96.2

TABLE (2) Recognition Rate for Query in Different Scaling Factor

Image Sets	Recognition Rate
Set 1	98.3
Set 2	97.8
Set 3	98.1
Set 4	98.6
Set 5	97.3
Set 6	98.8
Set 7	97.4
Set 8	97.8

TABLE (3) Recognition Rate for Query in Normal

Query Type	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8
Normal	98.3	97.8	98.1	98.6	97.3	98.8	97.4	97.8
Rotated	97.8	96.4	96.7	95.3	97.2	97.7	96.8	97.1
Scaled	98.1	97.5	97.8	98.2	97.1	98.3	96.7	96.2

TABLE (5) Recognition Rate for Different Query Types in Different Datasets.

Situation-1 :

In this situation performance measured in different rotated angle in query image. It's applied in 8 datasets combined with classical & texture images. The selected Query rotated angles was 30°, 60°, 90° and 120°. See Table (1). It obtained percentage is around 97.8%.

Situation - 2:

In this situation performance measured in different scaling factor in query image. It's applied in 8 datasets combined with classical & texture images. The selected Query scaling factor was 30x30, 60x60 and 120x120. See Table (2). It obtained percentage is around 98.3%.

Situation – 3:

Image Set		Distance Measures	
		L1	L2
Classical Image	Set 1	0.25	0.87
	Set 2	0.31	0.56
	Set 3	0.18	0.73
	Set 4	0.29	0.66
	Set 5	0.45	0.88
Texture	Set 6	0.13	0.91
	Set 7	0.17	0.93
	Set 8	0.21	0.73

TABLE (4) Recognition Rate for L1 & L2 Distance Measures

The two types of distance measure function was used in our proposed method is L1 & L2 performance was evaluated and represent in Table (5).

In this situation performance measured in standard image used as query image. It's applied in 8 datasets combined with classical & texture images. See Table (4). It obtained percentage is around 98.8%.

Discussion

Image retrieval completed using our proposed method Combined Radon Space Features Set. This proposed methods recognition rate is compared with the mention literatures & references. This represent our proposed combined feature space matrix is very effectively represent the image features. From the different situation conducted in different query en-

vironments it appears that the performance is improved with the increased number of related images retrieved followed by query image. Table [1, 2, 3, and 4] represented the different query types used and achieved the better recognition rate. Table [5] represented the two types of distance measure methods L1 & L2 applied in this datasets and distance measures value is point up.

Conclusion

Image Retrieval method has been described in this work. The main part of this work is PCA and LDA directly apply to the radon space relatively than images. In this work radon transform used in this method was FFT based. The method was verified Caltech 101 database contains 8 image sets. The best recognition rate 98.8% , 97.8%, 98.3% achieved by normal, rotated and scaled query environments. The Radon Transform achieved in this method better than related works stated in the literature review section 2.

Notes

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