Pattern Classification and Retrieval of Content-Based Images—a Step Towards Amelioration

Hemjot and Amitabh Sharma

Abstract The progressive web and computerized advancements have forced endless increment in the measure of visual data accessible to users. This trend prompted the advancement of exploration area where retrieval of images is done through the content of information which became familiar as CBIR (content-based image retrieval). CBIR frameworks are to a great extent utilized as a part of medicinal picture annotation, face recognition systems, security frameworks and so on. In this paper, we will discuss about an efficient system for retrieving images faster since speed and precision are important as well as techniques to obtain better classification of images. To conquer the issue of extensive number of features extracted which obliges vast measure of memory and processing force, we need to build a blend of 3 techniques (SURF, SVM and LDA) which best portray the information with adequate precision. Hence, we are using dimensionality reduction algorithm LDA in combination with SVM for the classification purpose and SURF which is quick and robust interest point detector.

Keywords Content-based image retrieval (CBIR) · Pattern recognition · Classification · Support vector machine (SVM) · Colour histogram · Speeded up robust features (SURF) · Linear discriminant analysis (LDA)

1 Introduction

A significant expansion has been done in the digital field for more than many years. This particular development has motivated research in image databases, which were virtually dismissed simply by conventional systems due to the enormous level of

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S. Urooj and J. Virmani (eds.), *Sensors and Image Processing*, Advances in Intelligent Systems and Computing 651, https://doi.org/10.1007/978-981-10-6614-6_2

information important to represent images as well as the problems connected with an automatic analysis of images. In order to make use of this kind of huge number of information, efficient as well as effective approaches to get back multimedia details according to their written content ought to be formulated. It was henceforth proposed to build a system which can retrieve images through content information called as content-based image retrieval.

Many techniques were used for building an efficient CBIR system such as SIFT and SVM but the results were not up to the mark. Considering all the drawbacks of previous work done SURF and SVM, implemented in combination could achieve accuracy over 96%. The main focus now became the computation time and the accuracy of image retrieval. An enhancement should be done to achieve the desired results. Therefore, LDA in combination to SURF and SVM was proposed and implemented which came out to be more promising than the existing works. Basic steps included in proposed CBIR system which are necessary for effective and accurate image retrieval are as follows:

1. Image Acquisition is the method of getting digital image information that consists of n range of pictures.
2. The pre-processing level consists of filtering, segmentation and object identification to urge a collection of serious regions and objects.
3. In the stage of Feature extraction, visual data like colour is extracted from the pictures and saves them as feature vectors in a database of feature vectors. One in every of the most important issues with content primarily based image retrieval system is that the sizable amount of options extracted which needs great deal of memory and computation power. To beat this drawback, different algorithms have been proposed. Most promising algorithm for detection, description and matching of the images used is SURF.

   Improved SURF with k-d tree algorithm makes use of integral images in a very efficient way which results into fast detection of interest points and ultimately less time consumption. SURF is used to extract relevant features and descriptors from images, and k-d tree algorithm makes the matching process faster.
4. Next, dimensionality reduction and classification are done. The necessary features are extracted from the database of feature vectors and are stored as reduced feature vector database. Hence, the result of feature extraction phase is a set of features that are reduced to information which is essential to describe an image, and classification is done.

   LDA (Linear Discriminant Analysis) is one of the most popular statistical techniques of pattern recognition and dimensionality reduction. It calculates the linear combination of all the features of the image which separates the class of image. One of the main advantages that LDA provide is to draw a separation line between the different categories and their classification without losing any data.

   Support vector machines (SVMs) are the models which make use of efficient algorithms to analyse data and pattern for the purpose of efficient classification

and analysis. It is a representation of points in space mapped in such a way that the samples belonging to different categories are divided wider by a distinguishing gap further after the dimensionality reduction process.

5. The stage of similarity matching consists of the matching of the reduced feature vectors of input image with the feature vectors of reduced feature vector database and the best matching image is displayed.

2 Literature Review

Anna Wojnar, Antonio M. G. pinheiro [1] depict the medical images retrieval and annotation using a fast descriptor and a classifier. SURF algorithm is used for the extraction of features as it acts as a fast-hessian detector. SVM is used for the feature matching process in combination with the quadratic kernel. **Dong Hui, Han Dian Yuan** [3] explained the more efficient SURF algorithm. The effective image matching method was introduced where the extraction of features is done effectively in the presence of scale rotation in the images. Efficiency is achieved with the introduction of k-d tree algorithm in addition to SURF algorithm. K-d tree helps to search similar points more effectively and quickly. **Herbert Bay, Andreas Ess, Tinne Tuytelaars and Luc Van Gool** [6] demonstrated a combination of detector and descriptor which is invariant towards rotation and scale named as Speeded Up Robust Features. It is best in every aspect as compared to previous schemes and is much faster. **S. Balakrishnama, A. Ganapathiraju** [12] explained the concept of classification technique LDA and its two approaches, class dependent and class independent. Selection of type of LDA is based on the data set and classification problem.

3 Proposed Work

3.1 Loading of Image

In proposed work, three different categories of images are stored in the database that is medical images, face images and random images. Image is loaded after selecting from one category. In Fig. 1(a) different categories are displayed to choose from for the image retrieval process and Fig. 1(b) shows the loading of the selected image.

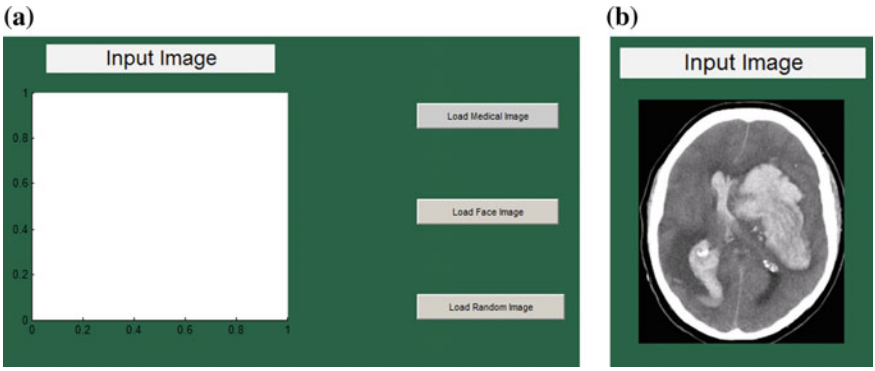

Fig. 1 (**a**) Different categories of images (**b**) loading of image

3.2 Pre-Processing and Feature Extraction

Colour Histogram. A histogram is defined as a graph that represents the level of incidence of all the colours present in a picture regardless of the sort of the image. This method portrays the proportion of pixels of every colour in a picture. It's been used as an attribute for feature extraction with the positive aspects like strength with relevance to geometric changes of the objects within the image. More formally, the colour histogram is defined by,

$$h_{A,B,C}(a, b, c) = N.\text{Prob}(A = a, B = b, C = c) \tag{1}$$

Where

A, B and C = R, G, B or H, S, V (three colour channels)

N = number of pixels in the image

The colour histogram is made by separating the colours in an image and keeping a record of pixels of each and every colour. In image retrieval, the colour histogram features from query image are extracted for the process of adding in the feature set matching with all the images in database.

Speeded Up Robust Features (SURF) SURF Descriptor will be used for detection, description and matching of image features.

Detection Interest points will be identified and a vector will be constructed to extract the features. Hessian matrix approximation is used here for the detection of interest point.

$$H(x, \sigma) \begin{pmatrix} L_{xx}(x, \sigma) L_{xy}(x, \sigma) \\ L_{xy}(x, \sigma) L_{yy}(x, \sigma) \end{pmatrix} \tag{2}$$

Where

$$L_{xx}(x,\sigma) = I(x) * \frac{\delta^2}{\delta x^2} g(\sigma) \tag{3}$$

$$L_{xy}(x,\sigma) = I(x) * \frac{\delta^2}{\delta xy} g(\sigma) \tag{4}$$

L_{xx} (x,σ) and L_{xy} (x,σ) are the convolutions of the image with the second derivative of the Gaussian. The use of integral images for calculating convolutions has approximated and speeded up the computations which otherwise is very costly. An integral image I(x) is an image where each point x = (x,y) represents the addition of all the points(pixels) in a rectangular area.

$$I(x) = \sum_{i=0}^{i<x} \sum_{j=0}^{j\leq y} I(x,y) \tag{5}$$

Determinants of hessian matrices are calculated to detect the structures which appear as blobs and are detected at the points where determinants are maximized.

$$Det\left(H_{approx}\right) = D_{xx}D_{xy} - \left(wD_{xy}\right)^2 \tag{6}$$

Where

$$D_{xx} = L_{yy}(x,\sigma) \tag{7}$$

$$D_{xy} = L_{xy}(x,\sigma) \tag{8}$$

Description Haar—Wavelet responses are used to compute the orientation in both directions i.e., x and y. The estimation of the final orientation is done by adding the horizontal wavelet and vertical wavelet responses in the space where an angle of π/3 is within a rotating wedge. The orientation of interest point is then described by choosing the maximum resultant. To assess the primary direction of the feature, Haar Transforms are used.

Matching Process In feature matching, SURF finds out features from same positions in two images and matches two images based on these features. It is a 64-dimensional vector which will adopt nearest neighbour search using a k-d tree.

3.3 Pattern Recognition and Classification of Images

Linear Discriminant Analysis (LDA) LDA (Linear Discriminant Analysis) is the frequently used technique for separation of data and reduction of dimensionality.

Linear Discriminant Analysis smoothly manages the occurrence of sloping and inequality within-class frequencies. This process ensures optimum separation between the classes by maximizing the degree of between-class and the within-class variances in data. The biggest advantage of LDA in proposed work is that it provides large separation of classes without changing the location and also provides a separate boundary between the given classes.

Between-Class Scatter Matrix

$$S_b = \sum_{i=1}^{C} (\mu_i - \mu)(\mu_i - \mu)^T \tag{9}$$

$$\mu = {}^1/_C \sum_{i=1}^{C} \mu_i (\text{Mean of entire data set}) \tag{10}$$

Within-Class Scatter Matrix

$$S_w \sum_{i=1}^{C} \sum_{j=1}^{M_i} (y_i - \mu_i)(y_i - \mu_i)^T \tag{11}$$

This transformation is good to retain maximum class separation and thereby reducing the variation caused because of sources other than identity (e.g. illumination).

Support Vector Machine (SVM) Classification and regression of feature points are handled by support vector machine. It is a technique used for binary classification of images but later it was optimized for multi-classification of images and extended for multi-classification.

SVM classifier is trailed by SURF in the whole process. After feature detection, separation is done between matching and non-matching points of the two images. Further, a plane separates the matching and non-matching feature points so as to achieve a clear differentiation between the two images. Therefore, during the matching process, pattern classification is also performed. Arrangement of training examples is done in such a way that SVM training algorithm develops a model that allots new samples into one class or the other according to the training algorithm, making it a non-probabilistic binary linear classifier.

3.4 Similarity Matching of the Images

After the classification of images, next comes out the process of obtaining the best similar image against the query image. The most similar image is displayed with the accuracy rate of similarity which is greater than 98% (Fig. 2).

Fig. 2 Matching process

4 Experimental Results

In our research work, main point of achievement is better classification of images with more accuracy and reduced matching time. Therefore, different parameters are compared and evaluated between the previous used algorithm and our proposed combination of techniques to present our achievement.

Different parameters calculated are:

(a) (PSNR) Peak Signal-To-Noise Ratio
(b) (MSE) Mean Square Error
(c) Feature Points
(d) Matching Time
(e) Accuracy (Table 1, Fig. 3).

5 Conclusion

In this paper, a comparative study is presented between two image retrieval methods that are SURF + SVM and SURF + SVM + LDA. One of the real issues with content-based image retrieval framework was the less accurate results and the laborious force taken to retrieve the images. Our proposed combination of algorithm has proved to get an accuracy rate greater than 98%. Improved SURF algorithm with k-d tree has proved to reduce the matching time to a greater extent

Table 1 Comparison between different Parameters based on SURF + SVM and SURF + SVM + LDA

Parameter	Description	Mathematic formula	SURF + SVM (Previous work)	SURF + SVM + LDA (Proposed work)
PSNR	It is the calculation of the ratio of peak signal-to-noise between the input and output images Higher PSNR Value = Better Quality	$PSNR = 20\log_{10}\left(\frac{255}{RMSE}\right)$ Where RMSE is the square root of MSE. Unit of PSNR is in decibels.	3.5267	8.9817
MSE	The MSE (mean square error) is the calculation of cumulative squared error between the two images Lesser MSE Value = Less error	$MSE = \frac{\sum [f(i,j) - F(I,J)]^2}{N^2}$	7.8534e + 03	7.8170e + 03
Feature points	Less feature points with more discriminatory data results in less time consumption and more accuracy	————	544.5000	223.5000
Matching time	The total time is taken to get the most similar image	————	1.7077	1.1887
Accuracy	It measures how accurately the query image matches with the similar image. Achieved accuracy with our proposed method > 98%	————	93.4148	98.4149

and SVM with LDA achieved the purpose of extracting less feature points with a large set of discriminatory information without any loss of data. For better evaluation of results PSNR, MSE, Feature points, Matching time and Accuracy of our proposed work were calculated in comparison with the results of previous work. Thus, the results achieved were promising and best in every aspect.

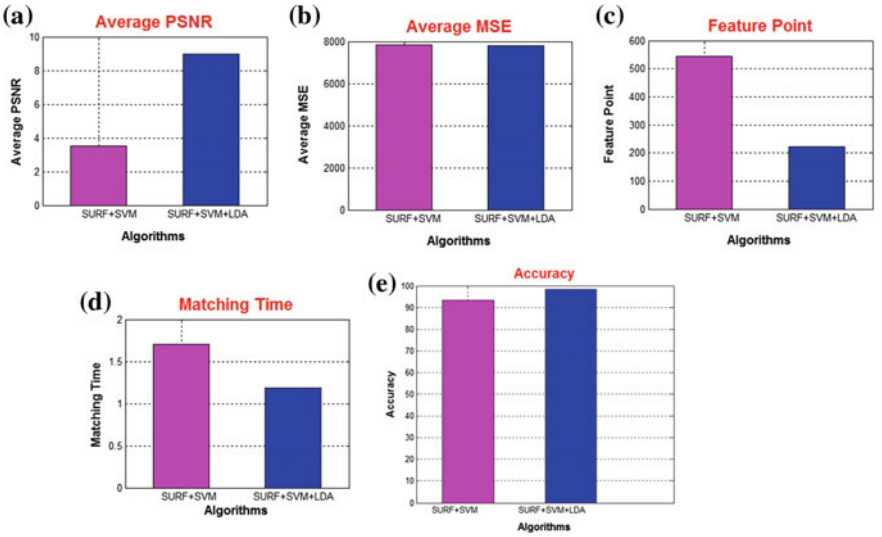

Fig. 3 Comparison between SURF + SVM and SURF + SVM + LDA using different parameters (**a**) PSNR (**b**) MSE (**c**) FEATURE POINTS (**d**) MATCHING TIME (**e**) ACCURACY

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http://www.springer.com/978-981-10-6613-9

Sensors and Image Processing
Proceedings of CSI 2015
Urooj, S.; Virmani, J. (Eds.)
2018, XV, 275 p. 123 illus., 80 illus. in color., Softcover
ISBN: 978-981-10-6613-9