An Integrated Approach for Image Retrieval based on Content

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Abstract

The difficulties faced in an image retrieval system used for browsing, searching and retrieving of image in an image databases cannot be underestimated also the efficient management of the rapidly expanding visual information has become an urgent problem in science and technology. This requirement formed the driving force behind the emergence of image retrieval techniques. Image retrieval based on content also called content based image retrieval, is a technique which uses the visual contents to search an image in the scale database. This Image retrieval technique integrate both low-level visual features, addressing the more detailed perceptual aspects, and high-level semantic features underlying the more general conceptual aspects of visual data. In connection with this Content Based Image Retrieval is a technology that is being developed to address different application areas, remote sensing, geographic information systems, and weather forecasting, architectural and engineering design, multimedia documents for digital libraries. In this paper we present an approach that significantly automates the retrieving process by relying on image analysis techniques that are based on image visual features like color with spatial information, texture and shape.

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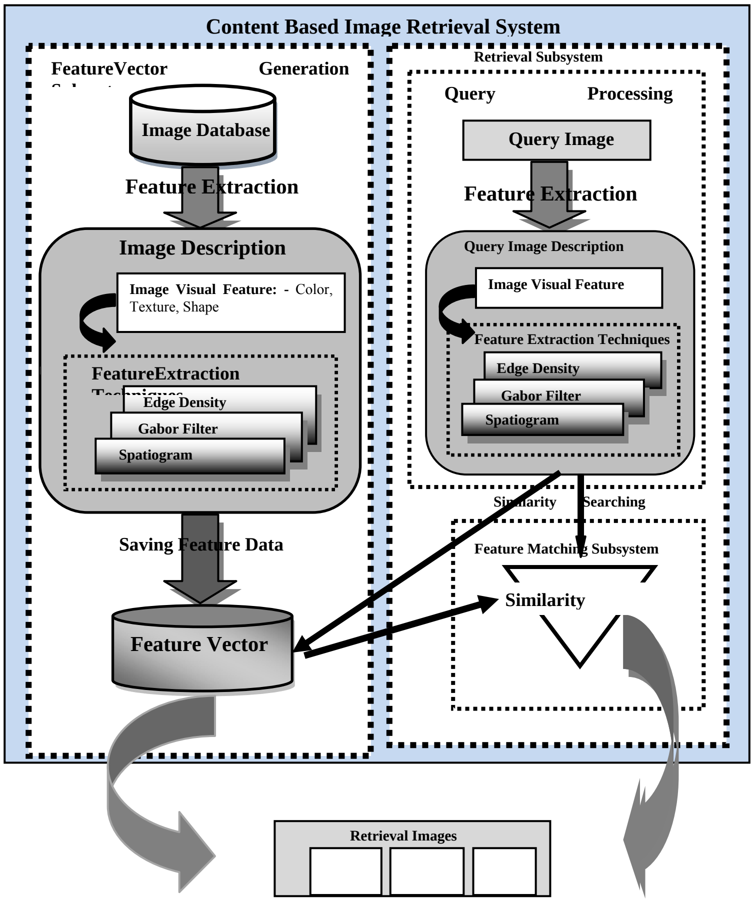
Keywords: *CBIR, semiconductor manufacturing, spatial information.*

1. Introduction

Advances in data storage and image acquisition technologies have enabled the creation of large image datasets. In order to deal with these data, it is necessary to develop appropriate information systems to efficiently manage these collections. Image searching is one of the most important services that need to be supported by such systems developing effective methods for automated annotation of digital images continues to challenge for computer scientist. Image retrieval algorithms are dividing into two categories. Conventional information retrieval is based solely on text, and these approaches to textual information retrieval have been transplanted into image retrieval in a variety of ways, including the representation of an image as a vector of feature values. However, “a picture is worth a thousand words.” .Text based image retrieval is non standardized because different users use different keywords for annotation. Text descriptions are subjective and incomplete because it cannot depict complicated image feature very well. Another method is content based. Image contents are much more versatile compared with text, and the amount of visual data is already enormous and still expanding very rapidly. It has been widely recognized that the family of image retrieval techniques should become an integration of both low-level visual features, addressing the more detailed perceptual aspects, and high-level semantic features underlying the more general conceptual aspects of visual data. The emergence of multimedia technology and the rapid growth in the number and type of multimedia assets controlled by public and private entities, as well as the expanding range of image and video documents appearing on the web, have attracted significant research efforts in providing tools for effective retrieval and management of visual data. Image retrieval is based on the availability of a representation scheme of image content. Image content descriptors may be visual features such as color, texture, shape, and spatial relationships, or semantic primitives. In this paper, we describe the approach for image retrieval that is based on its visual content as well as present an architectural framework that describing actual process.Content based image retrieval means that images can be searched by their visual content such as color, texture, shape etc. Content-Based Image Retrieval (CBIR) systems are in the focus of attention of all visual information systems investigators. Content based image retrieval (CBIR) is a two phase process: first images are analyzed and inserted to the image database and after that they can be queried. Query is issued by giving an example image or by starting with random images from current images in database. Query continues so that images can be marked as positive or negative samples to refine search and to get better results.

Proposed Model

The system extract the visual attributes of the query image in the same mode as it does for each database image, and then identifies images in the database whose feature vectors match those of the query image, and sorts the best similar objects according to their similarity value. In this system we use approaches that are Spatiogram[1] that is used on color, Gabor filter[2] that is used for texture retrieval and for Edge we use Edge Histogram because Edges convey essential information to a picture and therefore can be applied to image retrieval. The edge histogram descriptor captures the spatial distribution of edges [6].Sample Architecture shown in given fig below.



(a) Spatiogram

Spatiograms are a generalization of the common histogram and contain the exact same information as histograms but also include additional spatial information for each bin we can say that it is histogram with spatial information. Histogram discarding all spatial information. spatiogram, which augments the histogram bins with the spatial means and covariance of the pixels. Spatiogram combining the distribution information of a histogram with spatial moment information. Specifically, 2*nd*-order spatiograms include the spatial mean and covariance of each bin. For 2*nd*-order spatiograms the spatial mean μ_b, and covariance, Σ_b, also need to be computed for eachbin:

$$\mu_b = \frac{1}{\sum_{j=1}^{N} \delta_{jb}} \sum_{i=1}^{N} x_i \delta_{ib} \qquad \Sigma_b = \frac{1}{\sum_{j=1}^{N} \delta_{jb}} \sum_{i=1}^{N} (x_i - \mu_b)(x_i - \mu_b)^T \delta_{ib}$$

Where $x_i = [x, y]^T$ the spatial is position of pixel *i*. To compare regions of different sizes, it is necessary to map the spatial coordinates to the same scale; for example, by mapping coordinates into the [-1; +1] range. Additionally, in order to ensure that each Σ_b is invertible, we force them to be diagonal, and set a minimum variance value to one pixel. After computed histogram, spatial mean and covariance for each database image we also compute for query image.

Spatiogram Comparison

To derive our similarity measure, we leverage the fact that we can convert the 2*nd* order spatiogram back to a histogram, adding an extra dimension of space. For bin *b*, we divide its contents, n_b, over an infinite number of spatial bins, $n_{b,k}$, where *k* is an integer ranging from -∞ to +∞ .We express this as:

$$n_{b,k} = \frac{n_b \, \emptyset_b(k\Delta w)\Delta w}{\sum_{l=-\infty}^{+\infty} \emptyset_b(l\Delta w)\Delta w}$$

Where Δw is the spatial size of each bin and $\emptyset_b$ is a normalized Gaussian with the mean and covariance of bin b . Now compare spatiograms using the Bhattacharyya coefficient. This has a relationship with the probability of Bayes error. Given two spatigrams $n_{b,k}$ and $n'_{b,k}$, compare them using the Bhattacharyya coefficient as follows [1]:

$$\rho(n, n') = \sum_{b=1}^{B} \sum_{k=-\infty}^{+\infty} \sqrt{n_{b,k}\, n'_{b,k}}$$

$$= \sum_{b=1}^{B} \sum_{k=-\infty}^{+\infty} \sqrt{\left(\frac{n_b \emptyset_b(k\Delta w)\Delta w}{\sum_{l=-\infty}^{+\infty} \emptyset_b(l\Delta w)\Delta w}\right)\left(\frac{n'_b \emptyset'_b(k\Delta w)\Delta w}{\sum_{l=-\infty}^{+\infty} \emptyset'_b(l\Delta w)\Delta w}\right)}$$

(b) Gabor Filter

Next methodology applied on texture that is gabor filter. For texture retrieval we used Gabor filter .Gabor filters are a group of wavelets, with each wavelet capturing energy at a specific frequency and a specific direction. Expanding a signal using this basis provides a localized frequency description, therefore capturing local features/energy of the signal. Texture features can then be extracted from this group of energy distributions. The scale (frequency) and orientation tunable property of Gabor filter makes it especially useful for texture analysis. Gabor filters have the ability to perform multi-resolution decomposition due to its localization both in spatial and spatial frequency domain. Texture segmentation requires simultaneous measurements in both the spatial and the spatial-frequency domains. Filters with smaller bandwidths in the spatial-frequency domain are more desirable because they allow us to make finer distinctions among different textures .for the accurate localization of texture boundaries requires filters that are localized in the spatial domain. However, normally the effective width of a filter in the spatial domain and its bandwidth in the spatial-frequency domain are inversely related according the uncertainty principle A two-dimensional Gabor function consists of a sinusoidal plane wave of some frequency and orientation, modulated by a two-dimensional Gaussian. The Gabor filter in the spatial domain is given by

$$g_{\lambda\theta\Psi\sigma\gamma}(x, y) = \exp\left(\frac{-x'^2 + \gamma^2 y'^2}{2\sigma^2}\right)\cos\left(2\pi \frac{x}{\lambda} + \Psi\right)$$

Where $x' = x\cos(\theta) + y\sin(\theta)$

$y' = y\cos(\theta) - x\sin(\theta)$

In this equation λ represent the wavelength of the cosine factor, θ represents the orientation of the normal to the parallel stripes of a Gabor function in degrees, Ψ is the phase offset in degrees, and γ is the spatial aspect ratio and specifies the elliptically of the support of the Gabor function, and σ is the standard deviation of the Gaussian determines the (linear) size of the receptive field. When an image is processed by a Gabor filter, the output is the convolution of the image I(x, y) with the Gabor function g(x, y) i.e. $r(x,y)= I(x,y) * g(x,y)$ where * denotes the two dimensional convolution. This process can be used at different frequencies and different orientations, and prepared filter bank.Multi-scale representation of a signal is an ordered set of derived signals intended to represent the original signal at different levels of scale and multi scale benefit given by Gabor Filter.

Filter Bank Generation

For generated filter bank we use Gabor function using 3 scales of frequency and 4 orientations we set frequencies and orientations that cover the entire spatial frequency space so as to capture texture information as much as possible in accordance with filter design . The lower and upper frequencies of the filters were set at 0.06 octaves and 0.5 octaves respectively, the orientations were at intervals of 30 degrees, and the half-peak magnitudes of the filter responses in the frequency spectrum are constrained to touch each other . Because we use the symmetric property of the Gabor function as explained in Gabor filter explanation, with center frequencies and orientation covering only half of the frequency spectrum $(0, \frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{4})$. It is assumed that we are interested in images or regions that have homogenous texture, therefore the following mean μ_{mn} and standard deviation σ_{mn} of the magnitude of the transformed coefficients are used to represent the homogenous texture feature of the region:

$$\mu_{mn} = \frac{E(m,n)}{P \times Q}$$

$$\sigma_{mn} = \frac{\sqrt{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^2}}{P \times Q}$$

A feature vector (texture representation) is created using μ_{mn} and σ_{mn} as the feature components, 3 scales and 4 orientations are used in common implementation. The feature vector is given by:
Feature Vector = $[\mu_{00}, \sigma_{00}, \mu_{01}, \sigma_{01}, \ldots, \mu_{23}, \sigma_{23}]$

Texture Comparison

For texture comparison consider query image i and each database image j and let $f^{(i)}$ and $f^{(j)}$ represent the corresponding feature vectors then the distance between two texture pattern in the feature space is defined to be

$$d(i,j) = \sum_m \sum_n d_{mn}(i,j)$$

Where $d_{mn}(i,j) = \left|\frac{\mu_{mn}^{(i)} - \mu_{mn}^{j}}{\alpha(\mu_{mn})}\right| + \left|\frac{\sigma_{mn}^{(i)} - \sigma_{mn}^{j}}{\alpha(\sigma_{mn})}\right|$

$\alpha(\mu_{mn})$ and $\alpha(\sigma_{mn})$ are the standard deviation of the respective feature over the entire database and are used to normalized the individual feature components.

(c) Edge Histogram Descriptor

An edge histogram in the image space represents the frequency and the directionality of the brightness changes in the image**.** The edge histogram descriptor[6] represents the spatial distribution of five types of edges, namely four directional edges and one non-directional edge. Since edges play an important role for image perception, it can retrieve images with similar semantic meaning. Edge histogram is built by applying an edge detector to the image, then going over all pixels that lie on an edge, and histogramming the local tangent orientation. The Edge Histogram Descriptor represents the local edge distribution in the image which is obtained by subdividing the whole image into 4 × 4 sub images. For each of these sub images we compute the histogram. This means a total of 16 ×5 = 80 bins are required. The histograms are categorized into four directional edges called vertical, horizontal, 45 degree, 135 degree, and one non-directional edge. To detect the edge strength, filter coefficients shown in Figure2 were applied. Edges blocks that are greater than a given threshold is selected. Filter coefficients for edge detection are -

$$\begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix} \quad \begin{bmatrix} \sqrt{2} & 0 \\ 0 & -\sqrt{2} \end{bmatrix} \quad \begin{bmatrix} 0 & \sqrt{2} \\ -\sqrt{2} & 0 \end{bmatrix} \quad \begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}$$

For each sub image the edge density can be calculated using equation given below. Let (x1, y1) and (x2, y2) are the top left corner and the bottom right corner of the sub image. Then the edge density f is given by,

$$f = \frac{1}{a_r} \sum_{x=x_1}^{x_2} \sum_{y=y_1}^{y_2} e(x, y)$$

Where $a_r = (x_2 - x_1 + 1)(y_2 - y_1 + 1)$ is the region area and e(x, y) be its edge magnitude .For similarity comparison, we used Euclidean distance the shape comparison measurement of a query image Q and a target image T in the database is defined by Euclidean space according to following equation:

$$D_i = \sqrt{\{T_i\}^2 - \{Q\}^2}$$

Where D =is Euclidean Distance, T= is a database image feature vector, Q =is a query image feature vector, i=1,2,….P,

P=is the number of images in database.

Performance Evolution

Performance Evolution is calculated using average retrieval rate. The average retrieval rate for the query image is measured by counting the number of images from the same category which are found in the top 'N' matches. Retrieval performance of the proposed CBIR system using Spatiogram, Gabor filter and EDH result on the database of 500 images shown in table it is observed that the proposed CBIR system with different method for retrieval (like spatiogram, Gabor,EDH) very effective and give good results.

	No of Top matches			
Methods	1	3	5	8
Spatiogarm Gabor Filter EDH	100	90.81	85.5	77.27
	90.12	88.12	85.05	79.00
	100	90.85	85.25	75.00

Table 1. Retrieval rate (1, 3, 5, 8 are the top 'N' retrieved Images)

Conclusion

This paper has presented a brief overview of content-based image retrieval area. Firstly, we have presented a set of constructs aiming to define precisely the main related concepts. Next, we have described the main issues that need to be taken into account when designing this kind of image retrieving system. Then we describe new methodology that is integration of different approaches that are Spatiogram, Gabor Filter, Edge Histogram.

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