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(58) Field of Search

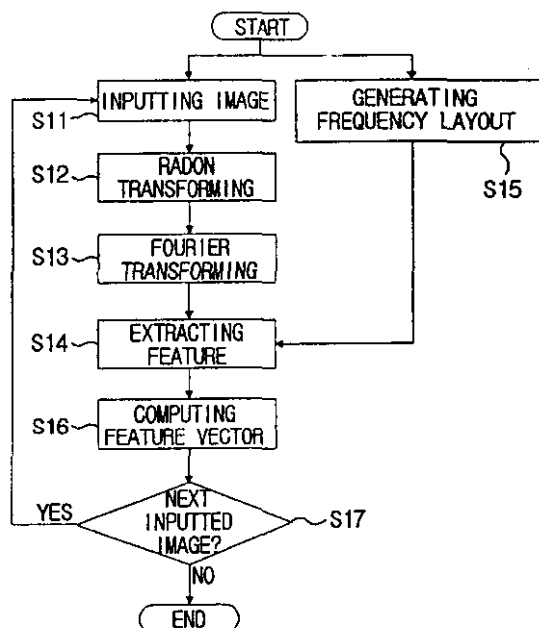
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(54) Abstract Title

**Texture description and texture-based retrieval method in frequency domain.**

(57) A texture description method in frequency domains and a texture-based retrieval method using the same, in which image signals are converted into those in a frequency domain of Polar coordinate system (Figure 4). The texture description method in the frequency domain comprises: a first step of generating a frequency layout (S15) by partitioning the frequency domain into a set of feature channels; a second step of extracting the texture feature values of the image from the respective feature channels (S12-S14); and a third step of constituting a texture descriptor of the image in a vector form (S16) using the texture feature values extracted from the respective feature channels of the frequency layout. According to the present invention, in a texture-based retrieval described in the frequency domain, a retrieval method capable of satisfying respective or all the retrieval conditions such as scale-, rotation- and intensity-invariant retrieval of relevant texture images is provided. Also, a retrieval method of computing the rough scheme of texture to provide a browsing functionality in retrieving is provided.

FIG. 1



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FIG. 1

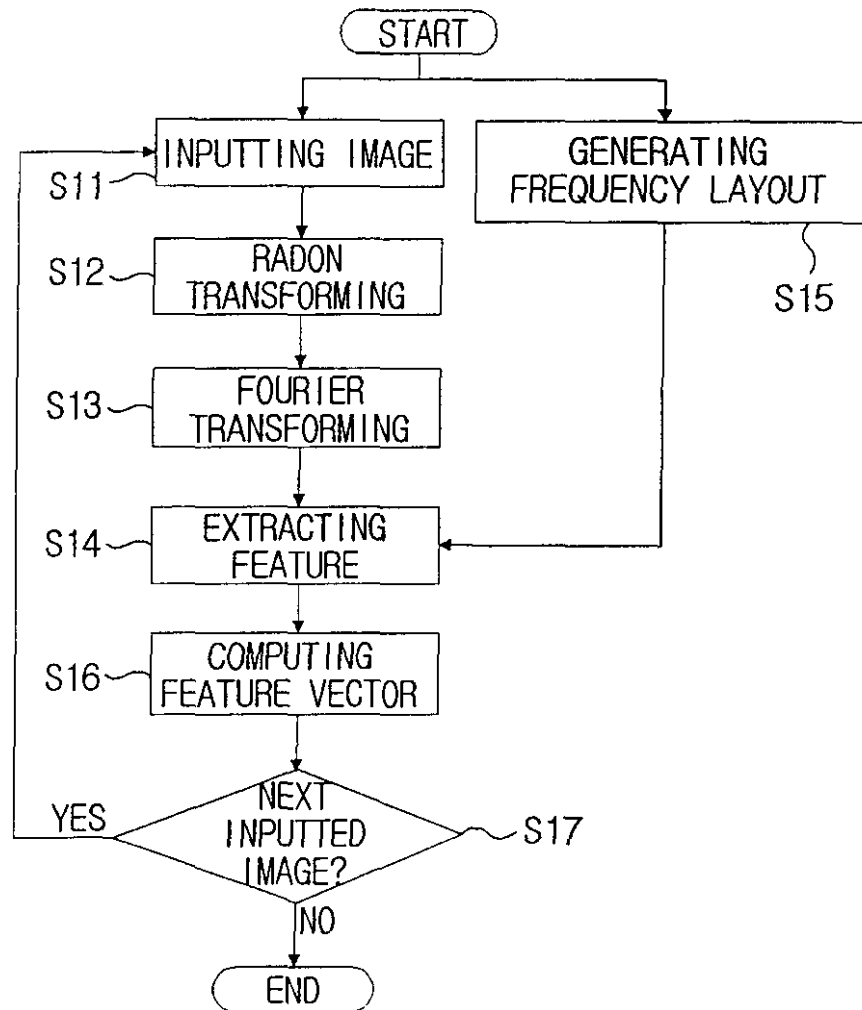


FIG. 2

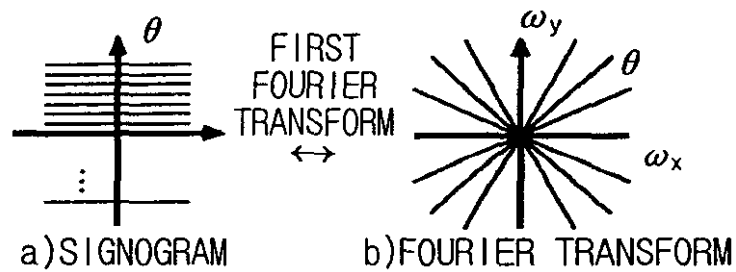


FIG. 3

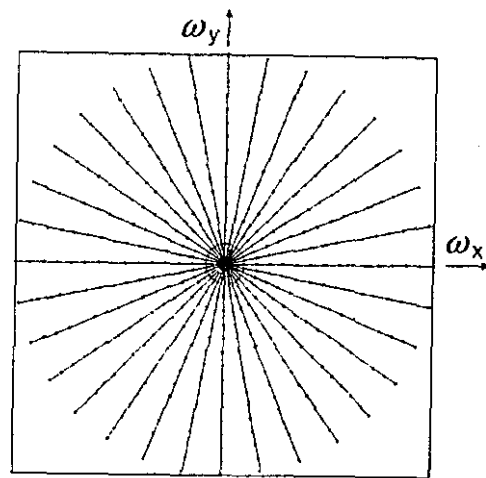
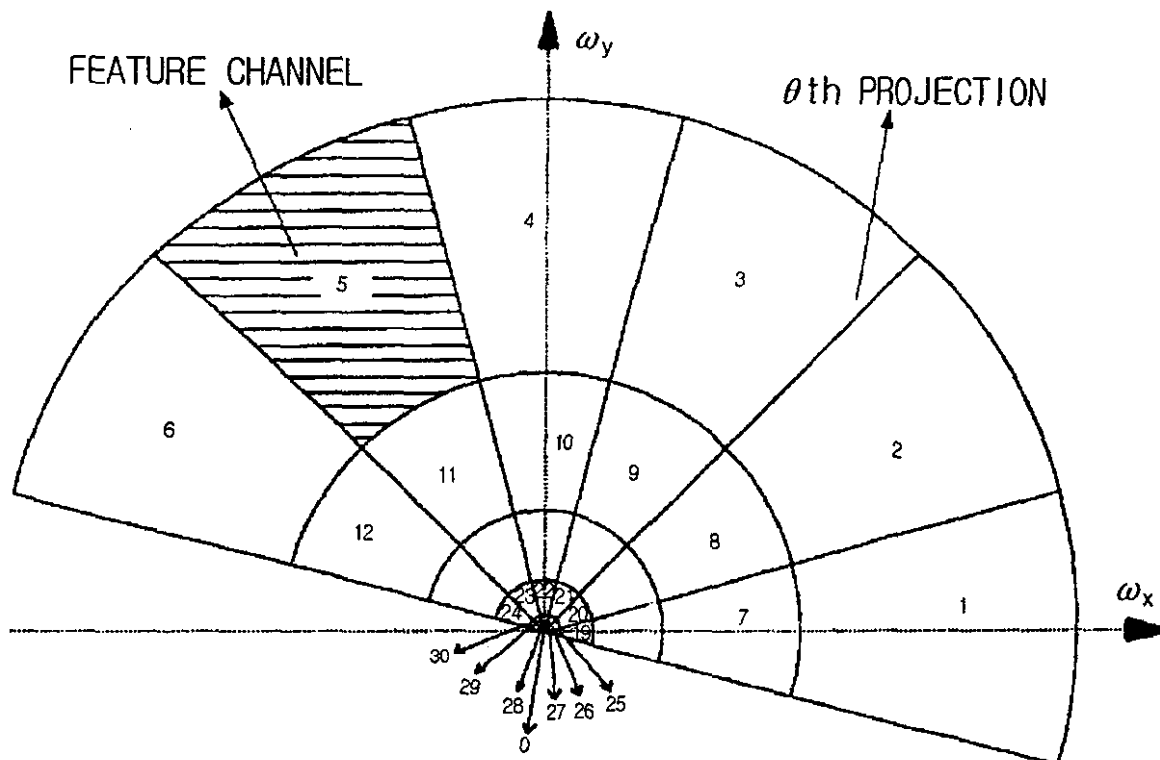
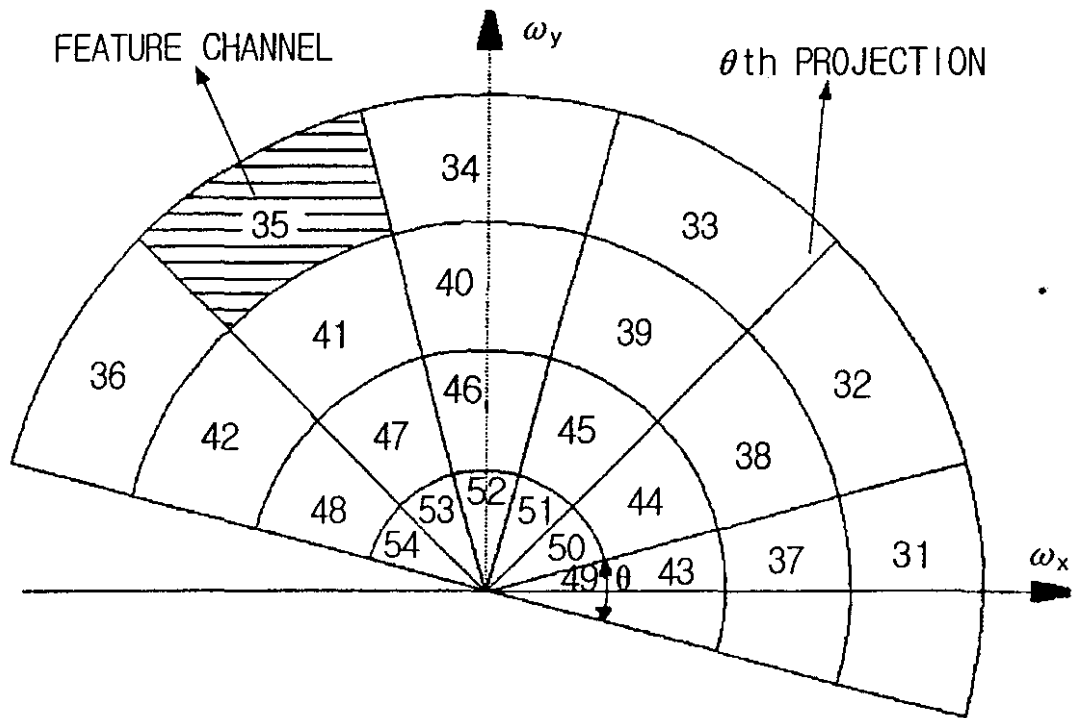


FIG. 4



*FIG. 5*



## TEXTURE DESCRIPTION METHOD AND TEXTURE-BASED RETRIEVAL METHOD IN FREQUENCY DOMAIN

### TECHNICAL FIELD

The present invention relates to a texture description method of an  
5 image, and more particularly, to a method of describing image texture in the frequency  
domain, in which image signals are converted into those in a frequency domain of the  
Polar coordinate system to extract texture features. Also, the present invention relates  
to a texture-based retrieval method of images indexed by the texture description  
method.

### 10 BACKGROUND OF THE INVENTION

The texture information of an image is one of the most important visual  
characteristics of the image and thus, has been studied together with the color  
information for a long time. This texture information of image is usually used as an  
important low-level visual descriptor in content-based indexing and in abstracting  
15 image or video data. Also, Image texture is very important information used for  
retrieval of a special picture in an electronic album or content-based retrieval in tiles or  
textiles database.

Up to now, feature values were mostly computed in time domain or in  
frequency domain to extract a texture feature of the image. More particularly, the  
20 method of extracting the texture features in frequency domain was known to be suitable  
for describing image texture information of various types. Extracting texture features in  
frequency domain can be done in Cartesian or Polar coordinate system.

Conventionally, the Cartesian coordinate system has been widely used in  
extracting a texture feature in frequency domain.

25 A paper entitled "Texture Features For Browsing And Retrieval Of  
Image Data", written by B.S. Manjunath and W.Y. Ma is published in "IEEE  
Transaction on Pattern Analysis and Machine Intelligence", vol.18, no.8, in August of  
1996, in which a method of dividing the frequency domain of the Cartesian coordinate

system based on HVS (Human Visual System), filtering an image in the respective channels by Gabor filters, and then extracting the average and the standard deviation from the respective channels as texture features of the image was disclosed.

However, the method of describing image texture is not suitable in the frequency domain of the Cartesian coordinate system for the HVS and leads to poor performance in relevant texture images.

For solving the problem of the image texture description method in frequency domain of the Cartesian coordinate system, a paper on image texture description method in frequency domain of the Polar coordinate system was published, in which the texture information in the frequency domain is computed in the Cartesian coordinate system.

In the paper entitled "Rotation-invariant Texture Classification using a complete Space Frequency Model", written by B.S. Manjunath and Geoge M. Haley and published in "IEEE Transaction on Pattern Analysis and Machine Intelligence", vol. 8, no.2, in February of 1999, a method of dividing a frequency space of the Polar coordinate system based on HVS (Human Visual System), then extracting 9 feature values using Gabor filter designed to be suitable for respective channels, and describing the image texture using the extracted feature values of all channels was disclosed.

However, in this method, the same design of a set of Gabor filters is used for extracting different kinds of texture features in the frequency domain. .

## SUMMARY OF THE INVENTION

Therefore, the present invention is made in order to solve the aforementioned problems.

An objective of the present invention is to provide a texture description method in a frequency domain, suitable for HVS, in which image texture features are computed and indexed in a frequency domain.

The other objective of the present invention is to provide a texture-based retrieval method by using texture features computed in the frequency domain of the Polar coordinate system, in which similar images in various variations, such as different

rotations or scales or pixel intensity, are retrieved by comparing a query texture descriptor with a data texture descriptor generated by the texture description method by taking account for such variations thereof.

The above objectives can be accomplished by a texture description  
5 method in the frequency domain of the Polar coordinate system according to the present invention. The texture description method comprises a first step of generating a frequency layout by partitioning said frequency domain into a set of feature channels; a second step of extracting texture feature values of said image from said respective feature channels; and a third step of constituting a texture descriptor in a vector form by  
10 using said texture feature values extracted from said respective feature channels in said frequency layout.

It is preferable that said first step is of generating said frequency layout on the basis of HVS (Human Visual System), and that said frequency domain in said first step is that of the Cartesian coordinate system or the Polar coordinate system.

15 It is more preferable that said first step comprises a sub-step of generating different frequency layouts for different types of texture features, that is, each texture feature type for its respective frequency layout.

It is more preferable that said first step comprises a sub-step of assigning significance or priority to the respective channels.

20 Also, it is preferable that said second step comprises a first sub-step of Radon-transforming said image; a second sub-step of Fourier-transforming said Radon-transformed image; and a third sub-step of extracting said texture feature values of said Fourier-transformed image from said respective feature channels.

It is more preferable that said third sub-step is of extracting at least  
25 energy deviation values and/or energy values in said respective feature channels.

Here, it is still more preferable that a frequency layout for obtaining said energy values and a frequency layout for obtaining said energy deviation value is separately prepared for extracting different types of an image texture, and that said frequency layout for obtaining said energy values partitions said frequency domain at  
30 intervals of  $2^l$  ( $0 \leq l < \log_2(N/2)-1$ ) octave in a radial direction and at intervals of

'180/dividing resolution' in an angular direction. The frequency layout for obtaining said energy deviation values partitions said frequency domain at the same intervals in a radial direction and at intervals of '180/dividing resolution' in an angular direction.

5 It is preferable that said third step is of finding out a rotational reference axis of said image by using said image texture information, rotating said frequency layout with reference to said rotational reference axis, and then extracting said image texture descriptor of said image. Here, the rotational reference axis is set to be an axis in a radial direction, in which energy or entropy or a periodical component is most distributed by Radon-transforming said image.

10 Preferably, the third step is of Fourier-transforming said image to find out a radial reference point, normalizing said Fourier-transformed image with reference to said reference point, and then describing said texture descriptor by using said normalized values of said Fourier-transformed image. Here, the radial reference point is set by finding out an arc in which energy or entropy or a periodical component of  
15 said Fourier-transformed image apart at the same distance from the origin in said frequency domain is most distributed, and setting a radius of said founded arc as said radial reference point.

It is preferable that the method of describing image texture in a frequency domain according to the present invention further comprises a fourth step of  
20 extracting intensity information of said image to add said intensity information to said texture descriptor.

Also, according to the present invention, a computer readable recording media recording a program for realizing a texture description method in a frequency domain is provided. The program performs a first step of generating a frequency layout  
25 by partitioning said frequency domain into a set of feature channels; a second step of extracting texture feature values of said image by Radon-transforming said image in said respective feature channels, Fourier transforming said Radon-transformed image, and extracting texture feature values of said Fourier-transformed image from respective feature channels; and a third step of constituting a texture descriptor of said image in



vector form by using said texture feature values extracted from said respective feature channels.

Also, according to the present invention, a method of populating a database with texture descriptors of images is provided. The method comprises a first step of generating a frequency layout by partitioning the frequency domain into a set of feature channels; a second step of extracting texture feature values of said images in said respective feature channels; a third step of constituting the texture descriptors of said images in vector forms by using said texture feature values extracted in said respective feature channels of said frequency layout; and a fourth step of indexing said respective texture descriptors of said images into said database. The first step comprises a first sub-step of generating the respective frequency layouts for texture feature types by partitioning the frequency domain into the respective sets of feature channels; and a second sub-step of extracting said texture feature values of each type for said images in said feature channels of said respective frequency layouts.

It is preferable that said second-sub step comprises a first step of extracting energy values of a texture feature type for said images in said feature channels of the corresponding frequency layout for said energy feature type; and a second step of extracting energy deviation values of a texture feature type for said images in said feature channels of the corresponding frequency layout for said energy deviation feature type.

Also, it is preferable that said third step comprises a first sub-step of constituting texture descriptors of said images with said energy values and energy deviation values in a vector form; and a second sub-step of adding the mean and standard deviation values of said images into each of said texture descriptors of said images.

More preferably, the second step comprises extracting energy values and energy deviation values as texture features for said images in said feature channels of said frequency layout.

Still more preferably, the first sub-step comprises a step of generating, based on HVS, at least more than one frequency layouts for which each frequency

layout is used for extracting feature values of each feature type; and a step of assigning significance or priority to respective channels of said frequency layouts.

Also, it is preferable that the second sub-step comprises a step of Radon-transforming the inputted images; a step of Fourier-transforming said Radon-transformed image; and a step of extracting feature values from said Fourier-transformed image in said respective feature channels of said frequency layout. The step of extracting feature values from said Fourier-transformed image is of extracting at least energy values or energy deviation values from said respective feature channels of said frequency layout.

Also, a method of retrieving relevant texture images in a database similar to a query image according to the present invention is provided. The method comprises a first step of generating a frequency layout by partitioning frequency domain into a set of feature channels for feature extraction of an input query image; a second step of extracting a query texture descriptor of said query image when said query image is inputted; a third step of reading a texture descriptor from said database; a fourth step of measuring a distance between said texture descriptor of said input texture image and said texture descriptor read from said database; a fifth step of measuring distances for said texture descriptor of said input image to all or parts of texture descriptors in said database; and a sixth step of ordering the similarity for the said texture descriptor to said texture descriptors in said database using said measured distances.

It is preferable that when rotation-invariant matching of said image is considered, said fifth step comprises a first sub-step of measuring distances between a texture descriptor taken from said database and said query texture descriptor by shifting feature values of said query texture descriptor in angular directions into the corresponding positions where the shifted feature values are supposed to be extracted when said query image rotates; a second sub-step of measuring the distances between said texture descriptor of said input texture image to said texture descriptor stored in said database for all rotation angles; and a third sub-step of determining as said distance

the minimum distance between said texture descriptor of said input texture image and said texture descriptor stored in said database for all rotation angles.

Also, it is preferable that when scale-invariant matching of said image is considered, said fifth step comprises a first sub-step of forming at least one zoom-in image and/or zoom-out image from said query image and extracting said query texture descriptors of zoom-in and/or zoom-out images of said query image; a second sub-step of measuring the distances between said query texture descriptors of zoom-in and/or zoom-out query images and said data texture descriptor in said database; and a third sub-step of determining as the distance the minimum distance of said distances between said texture descriptor in said database and said texture descriptor of said query texture descriptors at different scale values. Here, it is preferable that said query texture descriptor and said texture descriptor in said database include a rotational reference axis, a radial reference point, and mean and stand deviation of texture image intensities, respectively.

It is still more preferable that when rotation-invariant of said query texture descriptor is considered, said fifth step is of aligning said texture descriptor of said query image and said texture descriptor in said database with reference to given rotation angles.

Also, it is preferable that said rotational reference axes are set to be radial axes in which an energy, an entropy or a periodical component is most distributed in Fourier transform of said Radon-transformed images.

Preferably, when intensity-invariant matching of said query texture descriptor is considered, said fifth step is of excluding a mean values from said query texture descriptor and said texture descriptor in said database and measuring a distance between said two texture descriptors.

More preferably, when scale-invariant matching of said query texture image is considered, said fifth step comprises a first sub-step of merging said feature values of the adjacent channels in radial directions for said two texture descriptors to be compared or shifting feature values of said two texture descriptors into radial directions according to a radial reference point; and a second sub-step of measuring a distance

between said two texture descriptors with feature values merged in adjacent feature channels or with feature values shifted into adjacent feature channels.

Here, said radial reference point is preferably set by finding out an arc in which energy or entropy or periodical components of said Fourier-transformed image  
5 apart at the same distance from the origin in said frequency domain are most distributed and setting a radius of said found-out arc as said radial reference point.

Still more preferably, when scale-invariant and rotation-invariant matching is considered simultaneously, said fifth step comprises a first sub-step of merging said feature values of the adjacent channels in radial directions for said two  
10 texture descriptors to be compared or shifting feature values of said two texture descriptors into radial directions with reference to a radial reference point; a second sub-step of shifting feature values of said two texture descriptors in angular directions into the corresponding positions where the shifted feature values are supposed to  
• . . extracted with reference to a rotation point; and a third sub-step of measuring a distance  
15 between said two texture descriptors with feature values of adjacent feature channels merged in radial directions and then shifted in angular directions.

A computer readable recording media recording a program retrieving a data image similar to any query image in a computer according to the present invention is provided. The program performs the following steps; a first step of generating a  
20 frequency layout by partitioning the frequency domain into a set of feature channels; a second step of, when images to be stored in a database is given, extracting texture feature values of said data image in said respective feature channels, and then extracting and storing a data texture descriptor of said data image by using said extracted texture feature values; a third step of, when said query image is inputted, extracting texture  
25 feature values of said query image in said respective feature channels, and extracting a query texture descriptor of said query image by using said extracted texture feature values; a fourth step of matching said data texture descriptor with said query texture descriptor and measuring a distance between two texture descriptors; and a fifth step of determining a similarity between said two images by means of said distance between  
30 said two texture descriptors.

Also, a texture-based retrieval method of a data image similar to a query image in a frequency domain according to the present invention is provided. The method comprises a first step of extracting and storing a texture descriptor including texture feature values and the rotation information of images to be stored in a database; 5 a second step of extracting a query texture descriptor including texture feature values and the rotation information of said query image when said query image is inputted; a third step of aligning the rotating angle between said data texture descriptor and said query texture descriptor according to said rotation information of said two texture descriptors; a fourth step of matching said two texture descriptors and measuring a 10 distance between said two texture descriptors with rotation angles aligned between said two texture descriptors; and a fifth step of determining a similarity between said two images by means of said distance between said two texture descriptors.

It is preferable that said step of extracting said texture descriptor in said first and second steps comprises a first sub-step of generating a frequency layout by 15 partitioning the frequency domain into a set of feature channels so as to extract respective feature value; a second sub-step of extracting texture feature values of said images in said respective divided frequency domains; and a third sub-step of constituting a texture descriptor of said image in a vector form by using said feature values extracted in said respective frequency channels of said frequency layout.

20 It is more preferable that said step of extracting said rotation information of said images in said first and second steps comprises a first sub-step of finding out a direction in which energy is much distributed in the Fourier transform of said inputted image; a second sub-step of generating a frequency layout by using said direction as a reference axis; and a third sub-step of adding said rotation information of said 25 frequency layout to said texture descriptor of said image.

It is still more preferable that said first sub-step in said step of extracting said texture descriptor comprises a step of generating at least one frequency layout in consideration of HVS; and a step of giving significance or priority to respective feature channels of said frequency layouts.

Preferably, said second sub-step in said step of extracting said texture descriptor comprises a step of Radon-transforming said inputted image; a step of Fourier-transforming said Radon-transformed image; and a step of extracting said texture feature values from said Fourier-transformed image with respect to said  
5 respective frequency layout, and it is preferable that the step of extracting texture feature values from said Fourier-transformed image is of extracting at least energy values or energy deviation values in said respective feature channels.

A computer readable recording media recording a program retrieving a data image similar to a query image in a computer according to the present invention is  
10 provided. The program performs a first step of generating a frequency layout by partitioning a frequency domain into a set of feature channels; a second step of generating and storing a data texture descriptor by extracting texture feature values and the rotation information of said data image from said respective feature channels when an image to be stored in a database is given; a third step of generating a query texture  
15 descriptor by extracting texture feature values and the rotation information of said query image from said respective feature channels when said query image is inputted; a fourth step of aligning the rotating angles between said two data texture descriptors by using said rotation information of said data texture descriptor and said rotation information of said query texture descriptor; a fifth step of matching said two texture descriptors and  
20 measuring a distance between said two texture descriptors with said rotating angles aligned between said two texture descriptors; and a sixth step of determining a similarity between said two images by means of said distance between said two texture descriptors.

## BRIEF DESCRIPTION OF THE DRAWINGS

25 The embodiments of the present invention will be explained with reference to the accompanying drawings, in which:

Fig.1 is a flow chart for illustrating a texture description method in a frequency domain according to an embodiment of the present invention;

Fig.2 is a drawing for illustrating general Central Slice theorem;

Fig.3 is a drawing for illustrating a frequency sampling structure in frequency domain using Radon transformation;

Fig.4 is a drawing for showing a frequency layout used to extracting average values in respective frequency channels in the present invention; and

5 Fig.5 is a drawing for showing a frequency layout used to extracting energy deviation values in respective frequency channels in the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

The above objectives, other objectives, features and advantages of the present invention will be better understood from the following description in  
10 conjunction with the attached drawings.

Now, an embodiment of the present invention will be described in detail with reference to the drawings.

Fig.1 shows a flow chart for illustrating a texture description method in a frequency domain according to the present invention, using Radon transformation.

15 The texture description method is used both in texture information-based indexing of the image and in texture information-based retrieval of the image, in which the input image is processed to prepare a texture descriptor. When images to be stored in a database are given, the corresponding data texture descriptors are generated and the generated texture descriptors are stored in the database. Also, when a query image is  
20 inputted, a query texture descriptor is generated and compared with the data texture descriptors stored in the database to perform retrieval.

With reference to Fig. 1, the texture description method according to the present invention will be described as follows.

First, when any image is inputted (S11), the inputted image is Radon-  
25 transformed at step S12. Here, Radon-transformation means a serial procedure of performing line integral of 2-dimensional (2-D) image or multi-dimensional multimedia data along a light axis to obtain 1-dimensional projection data. That is, an object appears different according to viewing angles, and when viewing the object from all

angles, profiles of the object can be guessed, the Radon transformation is using such principle.

The Radon transformation equation of the 2-dimensional image is expressed as follows.

5 [Equation 1]

$$p_{\theta}(R) = \int_{L(R,\theta)} f(x,y) dl = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x,y) \delta(x \cos \theta + y \sin \theta - s) dx dy$$

Here,  $f(x,y)$  is an image in the Cartesian coordinate system, and  $p_{\theta}(R)$  is an 1-D projection obtained by the line integration of the image along a light axis of which the angle with respect to a positive  $x$ - axis is  $\theta$  and which passes through the origin in the Cartesian coordinate system. That is,  $p_{\theta}(R)$  is an 1-D projection of the  
10 image by Radon transformation.

A function  $\delta(x)$  is a function which becomes 1 when  $x$  value is 0. The 2-dimensional image has the range of ' $-\infty < x,y < \infty$ ' in the Cartesian coordinate system and a range of ' $0 < s < \infty, 0 < \theta < \pi$ ' in a Radon coordinate system. That is, when  $x \cos \theta + y \sin \theta$  is  $s$ ,  $\delta(x \cos \theta + y \sin \theta - s)$  becomes 1 .

15 A set of the first Radon transform functions  $p_{\theta}(R)$  is referred to as Signogram, and in next step S13, the Signogram is Fourier transformed. As a result of Fourier transforming the Signogram, relationships between the Fourier transform of the Signogram and the Fourier transform of the image in the Cartesian coordinate system is expressed as following Equation 2.

20 [Equation 2]

$$G_{\theta}(\lambda) = F(\lambda \cos \theta, \lambda \sin \theta) = F(\omega_x, \omega_y) \Big|_{\omega_x = \lambda \cos \theta, \omega_y = \lambda \sin \theta}$$

Here,  $G_{\theta}(\lambda)$  is a function to which  $p_{\theta}(R)$  is Fourier transformed. And  $\lambda$  is  $\sqrt{\omega_x^2 + \omega_y^2}$  and  $\theta$  is  $\tan^{-1}(\omega_y/\omega_x)$ .

Fig.2 shows a Central Slice theorem and is a drawing for illustrating a relationship between an 1-dimensional Fourier transform of the Signogram and the Signogram. The Fourier transform of the Signogram is a function value taken by  
25 cutting the Fourier transform function of the 2-dimensional image along  $\theta$ -axis.



That is, the image function is Fourier-transformed after Radon transforming it, as shown in Fig. 2(b), the resulting Fourier transform of the image is represented in the Polar coordinate system, and frequency sampling in the Polar coordinate system is shown as in Fig. 3.

5                    Fig. 3 is a drawing for illustrating a frequency sampling structure in frequency domain using Radon transformation. The Fourier transform using the Radon transform converts the image signal into that in a frequency domain in the Polar coordinate system. This frequency sampling is described such that the density of the frequency sampling is high in low frequency regions and becomes lower from low to  
10    high frequency regions.

This sampling structure is well suited for the characteristics that information of general image texture is gathered in the low-to-mid frequency region, and features extracted from this frequency sampling structure represent well the characteristics of image texture.

15                    Next, in step S14, the image texture features are extracted in the frequency domain of the Polar coordinate system having such frequency sampling structure as shown in Fig. 3. At that time, a frequency layout of the Polar coordinate system generated in step S15 is used. The respective partitioned frequency domains are referred to as a feature channel.

20                    The frequency layout is partition of the frequency domain on the basis of HVS (Human Visual System). That is, HVS is shown to be insensitive to the high frequency components and sensitive to the low frequency components of images and the frequency layout is designed by using such characteristics. The details thereof will be described later.

25                    The present invention employs respective frequency layouts, that is, energy values and energy deviation values of Fourier transform of the image in respective channels, as an image texture feature. For this reason, a frequency layout of the Polar coordinate system for extracting the energy values and a frequency layout of the Polar coordinate system for extracting the energy deviation values are separately  
30    generated.

Fig. 4 is a drawing showing a frequency layout of the Polar coordinate system used to extracting the energy values of respective channels on the basis of HVS.

As shown in Fig. 4, the frequency domain of the Polar coordinate system is partitioned in a radial direction and in an angular direction. The frequency domain is partitioned at intervals of  $2^l$  ( $0 \leq l < \log_2(N/2)-1$ ) octave in the radial direction and  $\theta$  is partitioned at intervals of '180/dividing resolution' in the angular direction. By this partition, a frequency layout of the Polar coordinate system for extracting the energy values is dense at low frequency regions and sparse at high frequency regions. The respective partitioned frequency regions indicate feature channels and the slashed part is a 5-th channel.

From the above description, a primary characteristic of the present invention is known, in which the sampling density at low frequency region is high and the sampling density at high frequency region is low due to the Radon transform. When partitioning the frequency domain on the basis of HVS, the low frequency region is partitioned densely and the high frequency region is partitioned sparsely. That is, the feature values extracted from the respective partitioned frequency regions, that is, the respective channels, reflect well the global texture features all together.

Fig. 5 is a drawing for showing a frequency layout used to extract energy deviation values on the basis of HVS.

Unlike the frequency layout of the Polar coordinate system for extracting the energy values, the frequency layout of the Polar coordinate system for extracting the energy deviation values uniformly partitions the frequency domain in a radial direction. However,  $\theta$  is partitioned by  $180/P$  (here,  $P$  is a dividing resolution of  $\theta$ ) in the angular direction as in the frequency layout of Fig. 4. The respective partitioned frequency regions constitute feature channels, and the 35-th channel is slashed.

In the present invention, the respective frequency layouts are designed for means of the extracted feature values. This provides a flexibility, so that the optimal frequency layout is allowed to provide high retrieval rate of relevant texture images to the respective features.

When the energy values and the energy deviation values are obtained in the respective channels, the image texture descriptor describing the image texture from the feature values, that is, a feature vector, is computed in step S16.

The texture descriptor is expressed as following Equation 3.

[Equation 3]

$$TD = \{e_0, e_1, \dots, e_{P \times Q}, d_{P \times Q + 1}, d_{P \times Q + 2}, \dots, d_{P \times Q + Q}\}$$

Here,  $e_i$  is the energy value of the  $i$ -th channel in the frequency layout shown in Fig. 4 and  $d_j$  is the energy deviation value of the  $j$ -th channel in the frequency layout shown in Fig. 5. Specifically,  $e_0$  represents the energy of a DC channel.  $P$  is the number of the frequency regions partitioned in the angular direction and  $Q$  is the number of the frequency regions partitioned in the radial direction, in the frequency domain of the Polar coordinate system.

The respective feature values of equation 3 can be first described according to the priority of the channels, and the size of texture descriptor decreases with excluding the feature values of the channels having low significance according to the significance of channels.

The energy value  $e_i$  and the energy deviation value  $d_j$  are obtained by means of Equation 5 and Equation 7, respectively. In Equation 4,  $p_i$  is obtained by using  $G_\theta(\lambda)$  which is the Fourier transform of  $p_\theta(R)$ , and in equation 6,  $q_j$  is obtained by using  $G_\theta(\lambda)$  and  $p_i$  obtained in Equation 4.

[Equation 4]

$$p_i = \sum_{\lambda_i} \sum_{\theta_i} C(\lambda_i, \theta_i) G_\theta^2(\lambda)$$

[Equation 5]

$$e_i = \log(1 + p_i)$$

[Equation 6]

$$q_j = \sqrt{\sum_{\lambda_j} \sum_{\theta_j} D_j(\lambda_j, \theta_j) [G_\theta^2(\lambda) - p_j]^2}$$

[Equation 7]

$$d_j = \log(1 + q_j)$$

As described above, a texture descriptor constituted with the energy values and the energy deviation values of respective feature channels is obtained.

With respect to all the inputted images, step S11 through step S16 are repeatedly performed and the respective data texture descriptors are stored in the  
5 database.

The data texture descriptors stored in the database are matched with the query texture descriptor obtained from the query image to be used for retrieval the image similar to the query image.

Hereinafter, the texture-based retrieval method in the Polar coordinate  
10 frequency domain will be described.

In order to retrieve the image similar to the query image, 3 elements are considered in the present invention. First, the intensity-invariant matching is considered. That is, there are two cases, the one that the images similar in texture are retrieved without considering the changes in intensity of image and with considering the  
15 intensity changes. Second, rotation-invariant matching is considered. That is, the retrieval in consideration of rotation of image and the retrieval without consideration of rotation of image is classified. Third, scale-invariant matching is considered. That is, the original image is zoomed in/zoomed out to be retrieved in cases of abridgement/enlargement of the image.

20 First, the intensity-invariant retrieval method of texture images is explained. The intensity of image is represented by means of energy value  $e_0$  of the DC channel of the texture descriptor (TD) vector. That is,  $e_0$  is large when the image is bright and indicates small values when the image is dark. Therefore, in the intensity-invariant retrieval,  $e_0$  is excluded from TD vector of the data texture descriptor vector  
25 and then the TD vector is matched with the query texture descriptor during the similarity matching. However, when the retrieval in consideration of intensity-invariant matching is intended to perform, the TD vector containing  $e_0$  is matched with the query texture descriptor.

Next, a first embodiment of the retrieval method with invariability in rotation is explained. When the image is rotated with respect to the same image, the conventional texture-based retrieval method did not retrieve the image as the same image. However, in the present invention, by performing matching of the images with  
 5 invariability in rotation of image, the retrieval may be performed without consideration of rotation. The rotation-invariant retrieval method is as follows.. It is known that a rotated image in time domain results in the rotated Fourier transform of the original image.

In a state that the data texture descriptors  $TD_m$  are stored in the database,  
 10 the query image is processed by means of the texture description method of Fig.1 to obtain the query texture descriptor  $TD_{query}$ . Then, a similarity between any  $TD_m$  and  $TD_{query}$  is computed to measure the matching degree.

The similarity is in inverse proportion to  $D_m$  obtained by means of Equation 8.

15 [Equation 8]

$$D_m = \text{distance}(TD_m, TD_{query})$$

A distance between the data texture descriptor and the query texture descriptor is obtained by comparing the texture descriptor having energy and energy deviation values. As explained above, the result that any image has been rotated and then Fourier transformed is equal to the result that the image has been Fourier  
 20 transformed and then rotated in the frequency domain. When two images are compared while rotating them in the frequency domain, two similar images can be found out.

Therefore, in the present invention, in comparing the distance between two texture descriptors by comparing the texture descriptors, the matching is performed in consideration of possibility of rotation. By that consideration, all the rotated similar  
 25 images can be retrieved. The matching is represented as following Equation 9.

[Equation 9]

$$D_m^{k_i} = \text{distance}(TD_m|_{k_i}, TD_{query})$$

Here,  $\phi$  is  $180/P$ , and  $k$  is any integer between 1 and  $P$ . That is, Equation 9 is the equation for obtaining the distance between the rotated data texture descriptor and the query texture descriptor, with the data texture descriptor rotated by the angle  $\phi$  in the frequency domain.

5 By applying the distances in respective rotational angle ranges obtained in Equation 9 to following Equation 10, the minimum distance is found out.

[Equation 10]

$$D_m = \min(D_m^{k*})_{k \in \{1, \dots, P\}}$$

By comparing the data texture descriptor with the query texture descriptor with the data texture descriptor rotated by a minute angle and selecting the  
10 minimum distance between two texture descriptors as a distance between two texture descriptors, the similar image can be retrieved regardless of rotation of image. On the contrary, when the retrieval without considering invariability in rotation of image is performed, the similarity is retrieved by means of Equation 8.

In retrieval in consideration of invariability in rotation of image, as  
15 described above,  $e_0$  is contained in the texture descriptor vector when the intensity of image is considered, and  $e_0$  is excluded from the texture descriptor vector when the intensity of image is not considered. Thereafter, texture-based retrieval in consideration of invariability in rotation is performed.

Now, a second embodiment of the retrieval method with invariability in  
20 rotation of image is explained. As described above, Fourier transform of the rotated image is equal to the result of rotating Fourier transform of the non-rotated image in the frequency domain. Therefore, in matching the texture descriptors, when the matching is performed in consideration of possibility of rotation, all images having equal texture and being rotated can be retrieved. For this performance, in the first embodiment of the  
25 retrieval method with invariability in rotation, the method of matching the data texture descriptors with the query texture descriptor is provided, with the data texture descriptor rotated by a minute angle.

On the contrary, in the second embodiment of the present invention, a method of adding the rotation information to the texture descriptor is provided. That is, if the image is Radon transformed, a reference angular direction which is most periodical or in which energy is most distributed is known. The Polar coordinate  
5 frequency layout (transformed layout) is generated using the direction as a reference axis, and then the texture descriptor of Fig. 1 is computed. At that time, the transformed layout is rotated with respect to the Polar coordinate layout of Fig. 5, and the reference axis of the transformed layout and the reference axis of the original Polar coordinate frequency layout are added to the texture descriptor as rotation information.

10 When a retrieval is required while the query texture descriptor containing the rotation information is provide together with the database storing the data texture descriptors containing the rotation information, two texture descriptors are matched in the rotational angles by using the rotation information of the data texture descriptor and the rotation of the query texture descriptor.

15 That is, the reference angular directions of two images are matched and in this state, the distance between two images is obtained by comparing two texture descriptors. Unlike the first embodiment, the second embodiment has an advantage that similarity between two images can be obtained without the procedure of obtaining the distance between two texture descriptors by comparing the data texture descriptor with  
20 the query texture descriptor while the data texture descriptor is rotated. However, because the procedure of obtaining and adding the rotation information to the texture descriptor is added to the step of describing the texture, computing the texture descriptor become complex.

Here, the rotation information is represented using Radon transform of  
25 image, in which the reference direction is the direction in which energy is most periodic or in which energy is most distributed. However, a method of finding out the reference axis of rotational direction using the texture information of image and describing the texture by matching the frequency layout with the reference axis, or a texture description method using the frequency layout without the reference axis may be  
30 employed, and the present invention is not limited to those method.

Third, in the texture-based retrieval method of an embodiment according to the present invention, as described above, invariability in abridgement/enlargement of image is considered, and is explained in detailed.

When image is obtained as varying zoom of a camera, the obtained  
5 image is abridged or enlarged according to the zoom magnification of the camera. When such effect is analyzed in the frequency domain, the frequency spectrum distribution of an image enlarged from the original image shrinks toward the origin of the frequency domain than the original spectrum. Also, the frequency spectrum distribution of an image abridged from the original image spreads out from the origin of  
10 the frequency domain than the original spectrum.

By Radon transformation of image, scale reference is found out with reference to energy of the projection data. When the texture-based retrieval with invariability in abridgement/enlargement of image is performed with respect to such image, by adding feature value of adjacent channel with reference to the scale reference  
15 in a radial direction to be overlapped by one channel, or by finding out a channel enlarged/abridged from the origin due to abridgement/enlargement, the similarity is computed as in Equation 11. The added channel is referred to as an merged channel or a matching channel and in a word, as a modified channel.

[Equation 11]

$$D_k = \text{distance}(\text{modified channel feature}_k^{\text{texture}}, \text{modified channel feature}_{\text{unknown}}^{\text{texture}})$$

20 When the texture descriptor is obtained by finding out a reference point in the radial direction by using texture information of image, normalizing Fourier transform of the image with reference to the reference point, and then extracting feature value of the normalized Fourier transform, similarity retrieval can be performed using Equation 8.

25 Here, a radius of the found-out arc as follows is set as the reference point in the radial direction. The arc is found out in which energy or entropy or periodical component of said Fourier-transformed image apart at the same distance from the origin in the frequency domain is most distributed is found out.



Another embodiment of the retrieval method with invariability in abridgement/enlargement is described. By making one inputted image at least one enlarged image or at least one abridged image, the texture descriptor is represented by means of respective enlarged/abridged query images. Then, the texture descriptors of the respective enlarged/abridged query images are extracted and a distance to the data texture descriptor is measured by means of Equation 8. The minimum distance of the distances between the data descriptor and the data descriptors of the respective enlarged/abridged query image is determined as an original distance between the query texture descriptor and the data texture descriptor.

When the retrieval without invariability in abridgement/enlargement of image is performed, the similarity is computed by means of Equation 8.

When the retrieval with both invariability in abridgement/enlargement and invariability in rotation is performed, in the retrieval with invariability in abridgement/enlargement of image, adjacent channels are merged and modified, and then feature values of the modified channels are retrieved invariantly in rotation. At that time, the similarity retrieval is performed by means of Equations 11, 9 and 10.

The texture descriptor TD vector expressed in equation 3 makes the texture structure information be inferred from the arranged pattern of feature values of the texture descriptor. This can supports for the functionality of roughly finding out a special structure of the texture to browse. In order to support the simple browsing, in the present invention, the simple structure information of texture is computed using feature values extracted from the energy channel as show in Fig. 4. Computing the texture structure is performed by obtaining entropy of feature values of 30 energy channels, or by computing the angular difference or radial difference between two maximum energies in energy channel layout.

According to the above-described present invention, by using a method of partitioning the frequency domain in the Polar coordinate system, with a frequency layout in the Polar coordinate system suitable for extracting the respective feature values, a method of extracting feature values in respective frequency domains, assigning significance and priority to respective frequency channels, a texture indexing

method supporting rotation-, scale-, intensity-invariant retrieval, a texture descriptor matching method, and the like, the image texture can be described more accurately and the effective indexing and retrieval is possible.

5 The image texture descriptor extracted by means of the texture description method according to the present invention can be used as a useful searching clue in finding out an image having a special feature in an aerial photograph on a grand scale, a military radar image and the like.

10 Although preferred embodiments of the present invention has been disclosed with reference to the appended drawings, descriptions in the present specification are only for illustrative purpose, not for limiting the present invention.

Also, those who are skilled in the art will appreciate that various modifications, additions and substitutions are possible without departing from the scope and spirit of the present invention. Therefore, it should be understood that the present invention is not limited only to the accompanying claims and the equivalents thereof,  
15 and includes the aforementioned modifications, additions and substitutions.

## CLAIMS

What is claimed is:

1. A method of describing an image texture information in a frequency domain, comprising the steps of:
  - a first step of generating a frequency layout by partitioning said frequency domain into a set of feature channels;
  - a second step of extracting texture feature values of said image from said respective feature channels; and
  - a third step of constituting a texture descriptor of said image in a vector form by using said texture feature values extracted from said respective feature channels in said frequency layout.
2. The method of describing the image texture information in a frequency domain according to claim 1, wherein said first step is of generating said frequency layout on the basis of HVS (Human Visual System).
3. The method of describing the image texture information in a frequency domain according to claim 1, wherein said frequency domain in said first step is that of an Cartesian coordinate system or a Polar coordinate system.
4. The method of describing the image texture information in a frequency domain according to claim 2, wherein said first step comprises a sub-step of assigning significance or priority to respective feature channels.
5. The method of describing the image texture information in a frequency domain according to claim 1, wherein said second step comprises:
  - a first sub-step of Radon transforming said image;
  - a second sub-step of Fourier-transforming said Radon-transformed image; and

a third sub-step of extracting said texture feature values of said Fourier-transformed image from said respective feature channels.

6. The method of describing the image texture information in a frequency domain according to claim 5, wherein said third sub-step is of extracting at least energy deviation values and/or energy values in said respective feature channels.

7. The method of describing the image texture information in a frequency domain according to claim 6, wherein a frequency layout for obtaining said energy values and a frequency layout for obtaining said energy deviation values is separately prepared for extracting different types of an image texture.

8. The method of describing the image texture information in a frequency domain according to claim 7, wherein said frequency layout for obtaining said energy values partitions said frequency domain at intervals of  $2^l$  ( $0 \leq l < \log_2(N/2)-1$ ) octave in a radial direction and at intervals of '180/dividing resolution' in an angular direction.

9. The method of describing the image texture information in a frequency domain according to claim 7, wherein said frequency layout for obtaining said energy deviation values partitions said frequency domain at the same intervals in a radial direction and at intervals of '180/dividing resolution' in an angular direction.

10. The method of describing the image texture information in a frequency domain according to claim 1, wherein said third step is of finding out a rotational reference axis of said image by using said image texture information, rotating said frequency layout with reference to said rotational reference axis, and then extracting said texture descriptor of said image.

11. The method of describing the image texture information in a frequency domain according to claim 10, wherein said rotational reference axis is set to be an axis in a

radial direction, in which an energy, an entropy or a periodical component is most distributed by radon transforming said image.

12. The method of describing the image texture information in a frequency domain according to claim 1, wherein said third step is of Fourier transforming said image to find out a radial reference point, normalizing said Fourier-transformed image with reference to said radial reference point, and then describing said texture descriptor by using normalized values of said Fourier-transformed image.

13. The method of describing the image texture information in a frequency domain according to claim 12, wherein said radial reference point is set by finding out an arc in which an energy, an entropy or a periodical component of said Fourier-transformed image apart at the same distance from the origin in said frequency domain is most distributed, and setting a radius of said founded arc as said radial reference point.

14. The method of describing the image texture information in a frequency domain according to claim 1, further comprising a fourth step of extracting intensity information of said image to add said intensity information to said texture descriptor.

15. A computer readable recording media recording a program describing a texture information of an image in a computer, the program performing the steps of:

- a first step of generating a frequency layout by partitioning said frequency domain into a set of feature channels;

- a second step of extracting texture feature values of said image by Radon transforming said image in said respective feature channels, Fourier transforming said Radon-transformed image, and extracting feature values of said Fourier-transformed image from said respective feature channels; and

- a third step of constituting a texture descriptor of said image in a vector form by using said texture feature values extracted from said respective feature channels.

16. A method of populating a database with texture descriptors of images, comprising the steps of:

a first step of generating a frequency layout by partitioning the frequency domain into a set of feature channels;

a second step of extracting texture feature values of said images in said respective feature channels;

a third step of constituting the texture descriptors of said images in vector forms by using said texture feature values extracted in said respective feature channels of said frequency layout; and

a fourth step of indexing said respective texture descriptors of said images into said database.

17. The method of populating a database with texture descriptors of images according to claim 16, wherein said first step comprises:

a first sub-step of generating the respective frequency layouts for texture feature types by partitioning the frequency domain into the respective sets of feature channels; and

a second sub-step of extracting said texture feature values of each type for said images in said feature channels of said respective frequency layouts.

18. The method of populating a database with texture descriptors of images according to claim 17, wherein said second-sub step comprises:

extracting energy values of a texture feature type for said images in said feature channels of the corresponding frequency layout for said energy feature type; and

extracting energy deviation values of a texture feature type for said images in said feature channels of the corresponding frequency layout for said energy deviation feature type.

19. The method of populating a database with texture descriptors of images according to claim 18, wherein said third step comprises:

a first sub-step of constituting texture descriptors of said images with said energy values and energy deviation values in a vector form; and

a second sub-step of adding the mean and standard deviation values of said images into each of said texture descriptors of said images.

20. The method of populating a database with texture descriptors of images according to claim 16, wherein said second step comprises:

extracting energy values and energy deviation values as texture features for said images in said feature channels of said frequency layout.

21. The method of populating a database with texture descriptors of images according to claim 17, wherein said first sub-step comprises:

generating, based on HVS, at least more than one frequency layouts for which each frequency layout is used for extracting feature values of each feature type; and

assigning significance or priority to respective channels of said frequency layouts.

22. The method of populating a database with texture descriptors of images according to claim 17, wherein said second sub-step comprises:

Radon-transforming the inputted images;

Fourier-transforming said Radon-transformed image; and

extracting feature values from said Fourier-transformed image in said respective feature channels of said frequency layout.

23. The method of populating a database with texture descriptors of images according to claim 22, wherein said step of extracting feature values from said Fourier-transformed image is of extracting at least energy values or energy deviation values from said respective feature channels of said frequency layout.

24. A method of retrieving relevant texture images in a database similar to a query image, comprising the steps of:

- a first step of generating a frequency layout by partitioning frequency domain into a set of feature channels for feature extraction of an input query image;
- a second step of extracting a query texture descriptor of said query image when said query image is inputted;
- a third step of reading a texture descriptor from said database;
- a fourth step of measuring a distance between said texture descriptor of said input texture image and said texture descriptor read from said database;
- a fifth step of measuring distances for said texture descriptor of said input image to all or parts of texture descriptors in said database; and
- a sixth step of ordering the similarity for the said texture descriptor to said texture descriptors in said database using said measured distances.

25. The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein when rotation-invariant matching of said image is considered, said fifth step comprises:

- a first sub-step of measuring distances between a texture descriptor taken from said database and said query texture descriptor by shifting feature values of said query texture descriptor in angular directions into the corresponding positions where the shifted feature values are supposed to be extracted when said query image rotates;
- a second sub-step of measuring the distances between said texture descriptor of said input texture image to said texture descriptor stored in said database for all rotation angles; and
- a third sub-step of determining as said distance the minimum distance between said texture descriptor of said input texture image and said texture descriptor stored in said database for all rotation angles.



26. The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein when scale-invariant matching of said image is considered, said fifth step comprises:

a first sub-step of forming at least one zoom-in image and/or zoom-out image from said query image and extracting said query texture descriptors of zoom-in and/or zoom-out images of said query image;

a second sub-step of measuring the distances between said query texture descriptors of zoom-in and/or zoom-out query images and said data texture descriptor in said database; and

a third sub-step of determining as the distance the minimum distance of said distances between said texture descriptor in said database and said texture descriptor of said query texture descriptors at different scale values.

27. The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein said query texture descriptor and said texture descriptor in said database include a rotational reference axis, a radial reference point, and mean and stand deviation of texture image intensities, respectively.

28. The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein when rotation-invariant of said query texture descriptor is considered, said fifth step is of aligning said texture descriptor of said query image and said texture descriptor in said database with reference to given rotation angles.

29. The method of retrieving relevant texture images in a database similar to a query image according to claim 27, wherein said rotational reference axes are set to be radial axes in which an energy, an entropy or a periodical component is most distributed in Fourier transform of said Radon-transformed images.

30. The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein when intensity-invariant matching of said query texture descriptor is considered, said fifth step is of excluding a mean values from said query

texture descriptor and said texture descriptor in said database and measuring a distance between said two texture descriptors.

31. The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein when scale-invariant matching of said query texture image is considered, said fifth step comprises:

a first sub-step of merging said feature values of the adjacent channels in radial directions for said two texture descriptors to be compared or shifting feature values of said two texture descriptors into radial directions according to a radial reference point; and

a second sub-step of measuring a distance between said two texture descriptors with feature values merged in adjacent feature channels or with feature values shifted into adjacent feature channels.

32. The method of retrieving relevant texture images in a database similar to a query image according to claim 31, wherein said radial reference point is set by finding out an arc in which energy or entropy or periodical components of said Fourier-transformed image apart at the same distance from the origin in said frequency domain are most distributed and setting a radius of said found-out arc as said radial reference point.

33. *The method of retrieving relevant texture images in a database similar to a query image according to claim 24, wherein when scale-invariant and rotation-invariant matching is considered simultaneously, said fifth step comprises:*

a first sub-step of merging said feature values of the adjacent channels in radial directions for said two texture descriptors to be compared or shifting feature values of said two texture descriptors into radial directions with reference to a radial reference point;

a second sub-step of shifting feature values of said two texture descriptors in angular directions into the corresponding positions where the shifted feature values are supposed to be extracted with reference to a rotation point; and

a third sub-step of measuring a distance between said two texture descriptors with feature values of adjacent feature channels merged in radial directions and then shifted in angular directions.

34. A computer readable recording media recording a program retrieving a data image similar to any query image in a computer, the program performing the steps of:

a first step of generating a frequency layout by partitioning the frequency domain into a set of feature channels;

a second step of, when images to be stored in a database is given, extracting texture feature values of said data image in said respective feature channels, and then extracting and storing a data texture descriptor of said data image by using said extracted texture feature values;

a third step of, when said query image is inputted, extracting texture feature values of said query image in said respective feature channels, and extracting a query texture descriptor of said query image by using said extracted texture feature values;

a fourth step of matching said data texture descriptor with said query texture descriptor and measuring a distance between two texture descriptors; and

a fifth step of determining a similarity between said two images by means of said distance between said two texture descriptors.

35. A texture-based retrieval method of a data image similar to a query image in a frequency domain, comprising the steps of:

a first step of extracting and storing a texture descriptor including texture feature values and the rotation information of images to be stored in a database;

a second step of extracting a query texture descriptor including texture feature values and the rotation information of said query image when said query image is inputted;

a third step of aligning the rotating angle between said data texture descriptor and said query texture descriptor according to said rotation information of said two texture descriptors;

a fourth step of matching said two texture descriptors and measuring a distance between said two texture descriptors with rotation angles aligned between said two texture descriptors; and

a fifth step of determining a similarity between said two images by means of said distance between said two texture descriptors.

36. The texture-based retrieval method of a data image similar to a query image in a frequency domain according to claim 35, wherein said step of extracting said texture descriptor in said first and second steps comprises:

- a first sub-step of generating a frequency layout by partitioning the frequency domain into a set of feature channels so as to extract respective feature value;

- a second sub-step of extracting texture feature values of said images in said respective divided frequency domains; and

- a third sub-step of constituting a texture descriptor of said image in a vector form by using said feature values extracted in said respective frequency channels of said frequency layout.

37. The texture-based retrieval method of a data image similar to a query image in a frequency domain according to claim 36, wherein said step of extracting said rotation information of said images in said first and second steps comprises:

- a first sub-step of finding out a direction in which energy is much distributed in the Fourier transform of said inputted image;

- a second sub-step of generating a frequency layout by using said direction as a reference axis; and

- a third sub-step of adding said rotation information of said frequency layout to said texture descriptor of said image.

38. The texture-based retrieval method of a data image similar to a query image in a frequency domain according to claim 36, wherein said first sub-step in said step of extracting said texture descriptor comprises:

- generating at least one frequency layout in consideration of HVS; and

- giving significance or priority to respective feature channels of said frequency layouts.

39. The texture-based retrieval method of a data image similar to a query image in a frequency domain according to claim 36, wherein said second sub-step in said step of extracting said texture descriptor comprises:

Radon-transforming said inputted image;  
Fourier-transforming said Radon-transformed image; and  
extracting said texture feature values from said Fourier-transformed image with respect to said respective frequency layout.

40. The texture-based retrieval method of a data image similar to a query image in a frequency domain according to claim 39, wherein said step of extracting texture feature values from said Fourier-transformed image is of extracting at least energy values or energy deviation values in said respective feature channels.

41. A computer readable recording media recording a program retrieving a data image similar to a query image in a computer, the program performing steps of:

a first step of generating a frequency layout by partitioning a frequency domain into a set of feature channels;

a second step of generating and storing a data texture descriptor by extracting texture feature values and the rotation information of said data image from said respective feature channels when an image to be stored in a database is given;

a third step of generating a query texture descriptor by extracting texture feature values and the rotation information of said query image from said respective feature channels when said query image is inputted;

a fourth step of aligning the rotating angles between said two data texture descriptors by using said rotation information of said data texture descriptor and said rotation information of said query texture descriptor;

a fifth step of matching said two texture descriptors and measuring a distance between said two texture descriptors with said rotating angles aligned between said two texture descriptors; and

a sixth step of determining a similarity between said two images by means of said distance between said two texture descriptors.

42. A method of describing an image texture information in a frequency domain substantially as described herein with reference to the accompanying drawings.

43. Apparatus substantially as described herein with reference to the accompanying drawings.



INVESTOR IN PEOPLE

**Application No:** GB 0016488.9  
**Claims searched:** 1, 15, 16

**Examiner:** Matthew Males  
**Date of search:** 30 January 2001

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4T TBEC

Int Cl (Ed.7): G06F 17/30 G06T 7/40

Other: Online databases: WPI EPODOC JAPIO INSPEC

### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X E	WO 00/46750 A1 SAMSUNG - whole document but see abstract and page 1, line 22-page 2, line 10.	1, 15, 16 at least
X	"IEEE Transactions on Image Processing", published February 1999, IEEE, Vol.8, No. 2, pp. 255-269, Haley G M & Manjunath B S, "Rotation invariant texture classification using a complete space-frequency model".	1, 15, 16 at least
X	"IEEE Transactions on Pattern Analysis and Machine Intelligence", published August 1996, IEEE, Vol. 18, No. 8, pp. 837-842, B S Manjunath & W Y Ma, "Texture features for browsing and retrieval of image data".	1, 15, 16 at least

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

發明名稱：組織描述及在頻率域中以組織為基礎之擷取方法

發明摘要：一種頻率域中之組織描述方法及使用該方法且以組織為基礎之擷取方法，其中影像信號係被轉換成極座標系統(圖 4)之頻率域信號。該頻率域組織描述方法包含藉由分割頻率域為一組特徵通道而產生一頻率配置之第一步驟(S15)；使用擷取自頻率配置之個別特徵通道之組織特徵值並以向量方式擷取影像之組織描述之第二步驟(S16)。根據本發明，在頻率域中以組織為基礎所擷取之方法可提供滿足個別或全部之擷取條件(例如縮放，旋轉及強度常數(invariant))之相關之組織影像之擷取。此外，本發明亦可提供計算組織之概略架構而提供瀏覽功能之擷取方法。