[0040] Rref(i), Gref(i), and Bref(i) denote R-, G-, and B-components of an i-th (i=1~n) representative color, respectively. Rvref(i), Gvref(i), and Bvref(i) denote normalized R-, G-, and B-components, respectively. In the equation (1a), three color components Rref(i), Gref(i), and Bref(i) are summed together to obtain a value Lref(i) that is to be used for the normalization, and each color component is then normalized by the normalization value Lref(i) in equations (1b)-(1c).

[0041] **FIG. 6A and 6B** show a color normalization process according to the equations (1a)-(1d). There are plotted an open circle representing a representative color, and black dots representing individual colors in the two-dimensional color space of R and B components. The equations (1a)-(1d) means that the representative color vectors are normalized onto a plane PL defined by the equation: R+G+B=1. However, if the representative color is perfectly black (if Lref(i)=0), each of the normalized color components Rvref(i), Gvref(i), and Bvref(i) is set to ⅓ instead of using the equations (1b) -(1d). This is to prevent the right sides of the equations (1b)-(1d) from reaching infinite.

[0042] Similar to the representative colors, the individual color vectors of pixels are also normalized according to the following equations (2a)-(2d).

$$L(j)=R(j)+G(j)+B(j) \tag{2a}$$

$$Rv(j)=R(j)/L(j) \tag{2b}$$

$$Gv(j)=G(j)/L(j) \tag{2c}$$

$$Bv(j)=B(j)/L(j) \tag{2d}$$

[0043] However, if L(j)=0,

$$Rv(j)=Gv(j)=Bv(j)=1/3$$

[0044] In these equations, j denotes an ordinal number for identifying each pixel in a color image.

[0045] In **FIG. 6**B, the individual colors seem to be dispersing around the plane PL even after the normalization, but this is because of the three-dimensional space is observed from a two-dimensional view. In fact all the normalized individual colors sit on the plane PL.

[0046] At step **S12** of **FIG. 5**, an angle index V(i, j) for i-th representative color vector and j-th individual color vector is calculated according to the following equation (3a) or (3b), with respect to N representative color vectors and individual color vectors of individual pixels.

$$V(i,j)=k1*\{|Rvref(i)-Rv(j)|+|Gvref(i)-Gv(j)|+|Bvref(i)-Bv(j)|\} \tag{3a}$$

$$V(i,j)=k1*[\{Rvref(i)-Rv(j)\}^2+\{Gvref(i)-Gv(j)\}^2+\{Bvref(i)-Bv(j)\}^2] \tag{3b}$$

[0047] The first term in the parenthesis on the right hand side of the equation (3a) denotes an absolute value of a difference between the normalized R component Rvref(i) of an i-th representative color and the normalized R component Rv(j) of an individual color of a j-th pixel. The second term and the third term denote corresponding G component and B component, respectively. Furthermore, kl is a predetermined non-zero coefficient. Accordingly, the right hand side of the equation (3a) correlates closely with a distance between the normalized representative color and the normalized individual color on the plain PL. The equation (3b) employs squares of the differences instead of absolute values of the differences, and directly provides a distance between the normalized representative color and the normalized individual color. An angle between a representative color vector and an individual color vector tends to get smaller as the distance between the corresponding representative color and the individual color on the plane PL gets shorter. The value V(i, j) given by the equation (3a) or (3b) depends on the distance between the representative color and the individual color on the plane PL, and correlates closely with the angle between the corresponding representative color vector and individual color vector. Therefore in the present embodiment, the value V(i, j) given by the equation (3a) or (3b) is used as an angle index substantially representing an angle between a representative color vector and an individual color vector.

[0048] As can be appreciated from the equations (3a), (3b), the angle index V(i ,j) may be a value given by another equation other than (3a), (3b), as long as it substantially represents an angle between a representative color vector and an individual color vector in the color space.

[0049] If the coefficient k1 is 1, the angle index V(i ,j) takes a value from 0 to 2. The angle index V(i ,j) is calculated for every combination of the individual color vector of each pixel and N representative color vectors.

[0050] At step **S13**, a distance index D(i, j) for i-th representative color vector and j-th individual color vector is calculated according to the following equation (4a) or (4b).

$$D(i,j)=\frac{|Rref(i)-R(j)|+|Gref(i)-G(j)|+|Bref(i)-B(j)|}{k2} \tag{4a}$$

$$D(i,j)=\frac{\sqrt{\{Rref(i)-R(j)\}^2+\{Gref(i)-G(j)\}^2+\{Bref(i)-B(j)\}^2}}{k2} \tag{4b}$$

[0051] The first term in the parenthesis on the right hand side of the equation (4a) is an absolute value of a difference between an R component Rref(i) of an i-th representative color before normalization and an R component R(j) of an individual color of a j-th pixel before normalization. The second term and the third term are the corresponding G component and B component, respectively. Additionally, k2 is a predetermined non-zero coefficient. The equation (4b) employs square roots of a sum of squares of differences instead of absolute values of the differences. Unlike the above equations (3a), (3b), the un-normalized values Rref(i), R(j) are used in the equations (4a), (4b). The right hand side of the equation (4a) or (4b) accordingly provides a value corresponding to a distance between a representative color and an individual color that are not normalized. Accordingly, in the present embodiment, the value D(i, j) provided by the equation (4a) or (4b) is used as a distance index that substantially represents a distance between a representative color and an individual color.

[0052] As can be appreciated from the equations (4a), (4b), the distance index D(i ,j) may be any value given by another equation other than (4a), (4b), as long as it substantially represents a distance between a representative color and an individual color in the color space.

[0053] If each color component is 8 bit data and the coefficient k2 is 1, the distance index D(i ,j) takes a value from 0 to 765. The distance index D(i ,j) is calculated for every combination of the individual color vector of each pixel and N representative color vectors.