[0066] In the second embodiment, the normalization of individual colors and representative colors is performed by using the following equations (6a)-(6d) and (7a)-(7d) instead of the above equations (1a)-(1d) and (2a)-(2d).

[0067] $Lref(i)=\sqrt{Rref(i)^2+Gref(i)^2+Bref(i)^2}$ (6a)

$Rvref(i)=Rref(i)/Lref(i)$ (6b)

$Gvref(i)=Gref(i)/Lref(i)$ (6c)

$Bvref(i)=Bref(i)/Lref(i)$ (6d)

[0068] However, if Lref(i)=0,

$Rvref(i)=Gvref(i)=Bvref(i)=1\sqrt{3}$

$L(j)=\sqrt{R(j)^2+G(j)^2+B(j)^2}$ (7a)

$Rv(j)=R(j)/L(j)$ (7b)

$Gv(j)=G(j)/L(j)$ (7c)

$Bv(j)=B(j)/L(j)$ (7d)

[0069] However, if L(j)=0,

$Rv(j)=Gv(j)=Bv(j)=1\sqrt{3}$

[0070] **FIG. 9A and 9B** show a color normalization process employed in the second embodiment. The equations (6a)-(6d) and (7a)-(7d) implies that individual colors and representative colors are normalized onto dots on a spherical surface of a radius **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 1√3.

[0071] By normalizing representative colors and individual colors onto dots on a spherical surface SP of radius **1**, the second embodiment can attain substantially the same effects attained as the first embodiment. The color normalization is intended to facilitate the operations for obtaining angles between each individual color vector and the representative color vectors. Accordingly, if other methods are employed to obtain angles between vectors, such as a method using inner products of vectors, such normalization is not required. However, operation speeds can be advantageously improved by performing color normalization stated above.

[0072] C. Modifications

[0073] C1. Modification **1**

[0074] Although the RGB space has been employed as a color space in the above embodiments, other various color spaces are also applicable to the present invention. For example, three-dimensional color space such as L*a*b*, and two-dimensional color space defined by two basic colors are also applicable. In other words, any color space of two or more dimensions is generally applicable to the present invention.

[0075] C2. Modification **2**

[0076] In region dividing process, composite distance indices for the N representative colors may be calculated in advance with respect to arbitrary colors in the color space, and the calculation results may be formed into a lookup table LUT (**FIG. 1**), instead of actually calculating composite distance indices for each individual pixel color in the target color image. Alternatively, the correspondence between arbitrary colors in the color space and plural representative colors may be determined and formed into a lookup table LUT. In these cases, the composite distance processor **130** functions as a lookup table generator. In the actual region dividing process, the composite distance processor **140** makes reference to the lookup table LUT, so that the region dividing or region segmentation can be performed with high speed. This advantage is particularly significant whenthe target color image is of a large size or a plurality of target color images are processed. For example, if a lookup table LUT is employed in the printed circuit board inspection apparatus **100**, not only the reference image but also the target image or inspection image can also be divided into color regions by making reference to the lookup table LUT.

[0077] It is preferable that the lookup table LUT has any arbitrary color in the color space as input and a representative color number representing one of plural representative colors as output. These representative color numbers do not represent color components such as RGB pixel values, but represent identification numbers discriminable from one another, such as 0, 1, and 2.

[0078] In order to reduce the capacity of the lookup table LUT, one or more lower bits may be omitted from plural bits of each input color data (pixel value data). In this case, colors with same bits except for the omitted lower bits will be considered as a same color and will be related with a same representative color. The preparation time of the lookup table LUT and the amount of data can thus be reduced dramatically. For an image supposed to have substantial amount of noise components, such as an image picked up by CCD camera, the region segmentation according to colors may possibly be performed with less errors by employing such lookup table LUT with reduced bit numbers.

[0079] C3. Modification **3**

[0080] If each color component of the image data is expressed in 8 bits, it is preferable to replace the normalization terms 1/Lref(i), 1/(j) in the above equations (1b)-(1d) and (2b)-(2d) with 765/Lref(i), 765/L(j), respectively. This makes the range of each normalized color component to be from 0 to 255, and the subsequent operations may be performed with integers, thereby improving the operation speed of the software. The value of each normalized color component is set to 255 if Lref(i)=0 and L(j)=0.

[0081] C4. Modification **4**

[0082] The result of region segmentation may be output onto a display or a printed medium, or may be used for various applications. For example, an original color image may be displayed on the display device of the computer **40**. When specified an arbitrary location on the display by the user, the apparatus can make reference to the results of the image region segmentation shown in **FIG. 8**, and notify the user of the divided region to which the specified location belongs. Specifically, when the user uses a mouse and clicks a location in a green region GR, a notice "this is resist" can be displayed. The user can thus be notified of the correspondence between the original objects and arbitrary locations on the picture image displayed on the display device.

[0083] At least one representative color region (or divided region) obtained by the region segmentation may be employed as a mask that represents a region targeted or not targeted for some image processing. For example, the first divided region DRI shown in **FIG. 8** may be used as a mask to selectively perform a predetermined image processing in the mask region.