[0017] **FIG. 3** is a flow chart showing the procedures of region segmentation employed in the embodiments.

[0018] **FIG. 4** shows the setting of representative colors.

[0019] **FIG. 5** is a flowchart showing the detailed procedures of step S4 in **FIG. 3**.

[0020] **FIG. 6A and 6B** show a color normalization process employed in the first embodiment.

[0021] **FIG. 7** shows the distribution of individual colors that are grouped into four representative color clusters.

[0022] **FIG. 8** shows plural divided regions.

[0023] **FIG. 9A and 9B** show a color normalization process employed in a second embodiment.

[0024] **FIG. 10A and 10B** show the result of conventional region segmentation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] Modes of implementation of the present invention are described below based on embodiments in the following order.

[0026] A. First embodiment

[0027] B. Second embodiment

[0028] C. Modifications

[0029] A. First embodiment

[0030] **FIG. 1** shows the structure of a printed circuit board inspection apparatus as one embodiment of the present invention. The apparatus **100** comprises a light source **20** for illuminating a printed circuit board PCB, a camera unit for capturing an image of the printed circuit board PCB, and a computer **40** for controlling the entire apparatus. The computer **40** is connected with an external storage device **50** for storing various data and computer programs.

[0031] The computer **40** has functions of a representative color setter **110**, a pre-processor **120**, a composite distance processor **130**, a color region divider **140**, a post-processor **150**, and an inspection processor **160**. These various functions are implemented with the computer **40** by executing computer programs stored in the external storage device **50**. As can be appreciated from the following description, the composite distance processor **130** also functions as an angle index calculator and a distance index calculator.

[0032] **FIG. 2** shows a color image of a printed circuit board PCB. The surface of the PCB contains a first green region GI of a board base coated with resist, a second green region **G2** of copper wirings coated with resist, a gold region GL plated with gold, a brown region BR of a board base, and a white region WH of a board base printed with white characters. Since the board base underlying the first green region GI is brown, and the copper wirings underlying the second green region **G2** is of copper color, the colors of these two regions **G1**, **G2** are both green but slightly different from each other. Accordingly, these two green regions **G1**, **G2** are referred to as "a green region GR" altogether in this embodiment. In the process described in the following, the two green regions **G1**, **G2** are both considered as a green region GR.

[0033] **FIG. 3** is a flowchart showing the procedures of region segmentation in a first embodiment. At step **S1**, a color image (**FIG. 2**) of the printed circuit board PCB is captured by the camera unit **30**. If the image data has been captured in advance, the image data is read from the external storage device **50** at step **S1**.

[0034] At step **S2**, a user observes the color image displayed on a display of the computer **40**, and sets a plurality of representative colors by using a pointing device such as mouse. At this time, the representative color setter **110** displays on the display of the computer **40**, a predetermined dialog box for the setting process of representative colors, thereby allowing the user to set representative colors.

[0035] **FIG. 4** shows the process of setting representative colors. The user inputs the names of the four regions GR(**G1**+**G2**), GL, BR, WH (e.g., "resist region", "gold plate region" and such) into the dialog box on the display, and specifies sample points (indicated by asterisks) on the color image for obtaining representative colors of each region. At least one sample point is specified for each region. If more than one sample points are specified for one region, the average color of the sample points is employed as the representative color of the region.

[0036] The user further specifies whether or not each region is to be united with other region. In the example shown in **FIG. 4, a** green region GR is specified to make up a first divided region DR**1** by itself. A gold region GL and a brown region BR are specified to unite together to make up a divided region DR**2**, and a white region WH is specified to make up a third divided region DR**3** by itself. The representative color setter **110** obtains and registers RGB components of the representative colors of the four regions GR, GL, BR, and WH. Generally, N representative colors are registered where N is an integer of 2 or more.

[0037] At step **S3** (**FIG. 3**), the pre-processor **120** (**FIG. 1**) performs smoothing process (blurring process) on a color image targeted for processing. Various smoothing filters such as median filter, gauss filter, moving average may be used in the smoothing process. By performing the smoothing process, anomalous pixels can be removed from the image data, thereby obtaining an image data with less noise. The pre-processing may be omitted.

[0038] At step **S4**, the composite distance processor **130** calculates composite distance indices for each pixel color in the color image (referred to as "individual color") with respect to the plural representative colors, and classifies each individual color into one of the representative color clusters. **FIG. 5** is a flowchart showing the detailed procedures of step **S4**. At step **S11**, representative color vectors of N representative colors (n is an integer of 2 or more) and individual color vectors of individual colors in the color image are normalized. The normalization of the representative color vectors is performed according to the following equations (1a)-(1d).

$$Lref(i)=Rref(i)+Gref(i)+Bref(i) \tag{1a}$$

$$Rvref(i)=Rref(i)/Lref(i) \tag{1b}$$

$$Gvref(i)=Gref(i)/Lref(i) \tag{1c}$$

$$Bvref(i)=Bref(i)/Lref(i) \tag{1d}$$

[0039] However, if Lref(i)=0,

$$Rvref(i)=Gvref(i)=Bvref(i)=1/3$$