from three-dimensional point group information obtained through laser measurement, generates a crack vector from image information obtained through capturing simultaneously with the laser measurement, and compares the crack vector and the step vector to determine the state of the crack represented by the crack vector on the basis of the distance between line segments constituting the respective vectors. As a result, the detection device 20 can eliminate the need for a large amount of work time by human power, and can automatically determine whether a crack generated on the surface of a structure is merely a crack or a crack accompanied by lifting separation without depending on the experience and skill of the investigator. The detection device 20 can thus have an improved accuracy of detecting a cracked state.

[0051] Second Embodiment.

In the first embodiment, the detection device 20 generates a crack vector from image information, generates a step vector from three-dimensional point group information, and compares the two vectors to determine whether the crack is accompanied by lifting separation. In a second embodiment, a description will be given of a case where the state of a crack is determined in a detection device without vectorizing a crack obtained from image information.

[0052] FIG. 18 is a block diagram illustrating an exemplary configuration of a detection device 20a according to the second embodiment. The detection device 20a is configured by replacing the crack detection unit 3 and the determination unit 5 of the detection device 20 with a crack detection unit 3a and a determination unit 5a. The crack detection unit 3a is configured by replacing the crack vector information generation unit 32 of the crack

crack is accompanied by lifting separation without generating a crack vector, the determination method is easier than that of the first embodiment. Therefore, the processing time required for determination can be reduced.

[0067] Third Embodiment.

In the first embodiment, the detection device 20 generates a crack vector from image information, generates a step vector from three-dimensional point group information, and compares the two vectors to determine whether the crack is accompanied by lifting separation. In a third embodiment, a description will be given of a case where the state of a crack is determined in a detection device without vectorizing a step obtained from three-dimensional point group information.

[0068] FIG. 26 is a block diagram illustrating an exemplary configuration of a detection device 20b according to the third embodiment. The detection device 20b is configured by replacing the step detection unit 4 and the determination unit 5 of the detection device 20 with a structure surface position calculation unit 6 and a determination unit 5b.

[0069] The structure surface position calculation unit 6 calculates the position of a structure surface by approximating the surface of a structure as a smooth surface from three-dimensional point group information input from the three-dimensional point group information input unit 2, for example, using smoothing processing.

[0070] The determination unit 5b determines the state of a crack by using crack vector information that is information on a deformation, information on the position of a structure surface, and three-dimensional point group information. Specifically, on the basis of a crack vector generated by the crack vector information generation unit

CLAIMS

1. A detection device comprising:

a deformation detection unit to extract a crack on a surface of a structure from image information on the structure and generate vector information on the extracted crack using three-dimensional point group information on the surface of the structure measured with a laser;

a step detection unit to extract a step on the surface of the structure from the three-dimensional point group information and generate vector information on the extracted step; and

a determination unit to calculate, using the vector information on the crack that is information on the crack and the vector information on the step that is information on the step, an inter-segment distance between each line segment of a vector indicated by the vector information on the crack and a line segment, nearest to the each line segment, of a vector indicated by the vector information on the step, and determine a state of the crack on a basis of a ratio of a point of the vector information on a single crack having the inter-segment distance to the vector information on a corresponding step less than a specified threshold value.

2. A detection device comprising:

a deformation detection unit to extract a crack on a surface of a structure from image information on the structure and generate three-dimensional information for a pixel of the crack and a pixel located within a specified range from the pixel of the crack, using three-dimensional point group information on the surface of the structure measured with a laser;

a step detection unit to extract a step on the surface of the structure from the three-dimensional point group

information and generate vector information on the extracted step; and

a determination unit to generate, using the three-dimensional information on the crack that is information on the crack and the vector information on the step that is information on the step, a three-dimensional space that includes all pixels of the three-dimensional information on the crack and determine a state of the crack on a basis of a ratio of a vector indicated by the vector information on the step existing in the three-dimensional space.

3. The detection device according to claim 1 or 2, comprising

a display unit to display the image information, the information on the crack, the three-dimensional point group information, the information on the step, and a determination result of the state of the crack in the determination unit.

4. A detection device comprising:

a deformation detection unit to extract a crack on a surface of a structure from image information on the structure and generate vector information on the extracted crack using three-dimensional point group information on the surface of the structure measured with a laser;

a structure surface position calculation unit to calculate a position of the surface of the structure from the three-dimensional point group information; and

a determination unit to extract, using the vector information on the crack that is information on the crack, information on the position of the surface of the structure, and the three-dimensional point group information, three-dimensional point group information in a space within a specified range from the crack, classify the extracted three-dimensional point group information into two groups of

points using the crack as a boundary in a direction perpendicular to the position of the surface of the structure, calculate a vertical distance between each point of the classified groups of points and the position of the surface of the structure, calculate an average vertical distance for each of the groups of points, and determine a state of the crack on a basis of a difference between the average vertical distances for the groups of points.

5. The detection device according to claim 1 or 4, comprising:

a display unit to display the image information and the vector information on the crack; and

an editing unit to accept an operation from a user and correct the vector information on the crack, wherein

the determination unit determines the state of the crack using the vector information on the crack corrected by the editing unit.

6. The detection device according to claim 3 or 5, comprising

a similarity determination unit to determine a similarity between the crack and the step using a determination result of the state of the crack in the determination unit and display determination content on the display unit.

7. The detection device according to any one of claims 1 to 6, comprising

an internal deformation detection unit to detect a crack inside the structure from radar information, wherein

the determination unit further determines a state of the crack using information on the crack inside the structure detected by the internal deformation detection unit.

8. A detection method for a detection device to detect a

crack on a surface of a structure, the method comprising:

a deformation detection step of a deformation detection unit extracting a crack on the surface of the structure from image information on the structure and generating vector information on the extracted crack using three-dimensional point group information on the surface of the structure measured with a laser;

a step detection step of a step detection unit extracting a step on the surface of the structure from the three-dimensional point group information and generating vector information on the extracted step; and

a determination step of a determination unit calculating, using the vector information on the crack that is information on the crack and the vector information on the step that is information on the step, an inter-segment distance between each line segment of a vector indicated by the vector information on the crack and a line segment, nearest to the each line segment, of a vector indicated by the vector information on the step, and determining a state of the crack on a basis of a ratio of a point of the vector information on a single crack having the inter-segment distance to the vector information on a corresponding step less than a specified threshold value.

9. A detection method for a detection device to detect a crack on a surface of a structure, the method comprising:

a deformation detection step of a deformation detection unit extracting a crack on the surface of the structure from image information on the structure and generating vector information on the extracted crack using three-dimensional point group information on the surface of the structure measured with a laser;

a structure surface position calculation step of a structure surface position calculation unit calculating a

position of the surface of the structure from the three-dimensional point group information; and

a determination step of a determination unit extracting, using the vector information on the crack that is information on the crack, information on the position of the surface of the structure, and the three-dimensional point group information, three-dimensional point group information in a space within a specified range from the crack, classifying the extracted three-dimensional point group information into two groups of points using the crack as a boundary in a direction perpendicular to the position of the surface of the structure, calculating a vertical distance between each point of the classified groups of points and the position of the surface of the structure, calculating an average vertical distance for each of the groups of points, and determining a state of the crack on a basis of a difference between the average vertical distances for the groups of points.