that a processing technique called “Bundle Adjustment” may be adopted as an error adjustment method at this time.

[0001] Incidentally, in the above-described SfM, there are cases where matching is incorrect, and, in these cases, a pair of different feature points is extracted, decreasing the accuracy of a three-dimensional shape that is regenerated. Moreover, as a result of the number of extracted pairs of feature points being small, and matching having not been entirely successful, there may be a region in which the number of pairs of feature points is small. Also in this case, the accuracy of a three-dimensional shape that is regenerated decreases.

[0002] In contrast, Patent Document 1 discloses a system for correcting the positions of corresponding feature points. Specifically, the system disclosed in Patent Document 1 first arranges two images such that the epipolar lines thereof extend in parallel with scanning lines, and extracts corresponding feature points from the images for each of the scanning lines.

[0003] Next, this system accepts user input of a line segment for designating corresponding locations, on the images. This system then determines whether or not corresponding feature points on a scanning line coincide with the intersection between this scanning line and the input line segment, and if not, corrects the positions of the feature points to the position of the intersection. Thereafter, the system regenerates a three-dimensional shape using feature points whose positions have been corrected.

[0004] As described above, according to the system disclosed in Patent Document 1, the issue of incorrect pairs of feature points being extracted and the issue of a region having a small number of pairs of feature points are solved, and thus the issue of a decrease in the accuracy of three-dimensional shape that is regenerated is solved.

LIST OF RELATED ART DOCUMENTS

PATENT DOCUMENT

[0005] Patent document 1: Japanese Patent Laid-Open Publication No. 5311465

SUMMARY

[0006] However, in the system disclosed in Patent Document 1, the positions of feature points are only corrected on scanning lines that extend along the epipolar lines of two images, and thus incorrect pairs of feature points that are not on the same scanning line are not corrected. Therefore, in the system disclosed in Patent Document 1, incorrect pairs of feature points are not sufficiently corrected, and it is difficult to suppress a decrease in the accuracy of a three-dimensional shape that is regenerated.

[0007] An example object of the disclosure is to solve the foregoing issues by providing an image processing apparatus, an image processing method, and a computer-readable recording medium that can suppress extraction of incorrect combinations of feature points when extracting combinations of corresponding feature points from a plurality of images.

[0008] In a first aspect, the present disclosure provides an image processing appratus for building a three-dimensional shape from a plurality of images, the apparatus comprising:

a feature point extraction unit configured to extract combinations of corresponding feature points from the plurality of images;

a matrix calculation unit configured to, if two or more line segments or two or more points corresponding to each other are designated in at least two images out of the plurality of images, specify a geometric relationship between the two or more line segments corresponding to each other or a geometric relationship between the two or more points corresponding to each other, and calculate a numerical matrix that represents the specified geometric relationship; and

a shape building unit configured to specify a combination of feature points with a conflicting geometric relationship, from among the extracted combinations of feature points, using the numerical matrix, and build the three-dimensional shape using the combinations of feature points other than the specified combination of feature

points.

[0009] In addition, in a second aspect, the present disclosure provides an image processing

method for building a three-dimensional shape from a plurality of images, the method comprising:

(a) a step of extracting combinations of corresponding feature points from the plurality of images;

(b) a step of, if two or more line segments or two or more points corresponding to each other are designated in at least two images out of the plurality of images, specifying a geometric relationship between the two or more line segments corresponding to each other or a geometric relationship between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relationship; and

(c) a step of specifying a combination of feature points with a conflicting geometric relationship, from among the extracted combinations of feature points, using the numerical matrix, and building the three-dimensional shape using the combinations of feature points other than the specified combination of feature points.

[0010] Furthermore, in a third aspect, the present disclosure provides a computer-readable recording medium that includes a program recorded thereon for building a three-dimensional shape from a plurality of images, the program including instructions that cause a computer to carry out:

(a) a step of extracting combinations of corresponding feature points from the plurality of images;

(b) a step of, if two or more line segments or two or more points corresponding to each other are designated in at least two images out of the plurality of images, specifying a geometric relationship between the two or more line segments corresponding to each other or a geometric relationship between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relationship; and

(c) a step of specifying a combination of feature points with a conflicting geometric relationship, from among the extracted combinations of feature points, using

the numerical matrix, and building the three-dimensional shape using the combinations of feature points other than the specified combination of feature points.

[0011] As described above, according to the present disclosure, it is possible to suppress extraction of an incorrect combination of feature points when extracting combinations of corresponding feature points from a plurality of images.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a block diagram illustrating a schematic configuration of an image processing apparatus according to an example embodiment of the invention.

FIG. 2 is a block diagram illustrating a specific configuration of an image processing apparatus according to an example embodiment of the invention.

FIG. 3 is a diagram illustrating an example of a plurality of images to be processed according to an example embodiment of the invention.

FIG. 4 is a diagram illustrating processing performed by a matrix calculation unit according to an example embodiment of the invention.

FIG. 5 is a diagram illustrating processing performed by a shape building unit according to an example embodiment of the invention.

FIG. 6 is a flowchart illustrating operations of an image processing apparatus according to an example embodiment of the invention.

FIG. 7 is a block diagram illustrating an example of a computer that realizes an image processing apparatus according to an example embodiment of the invention.

EXAMPLE EMBODIMENT

[0013] (Example Embodiment)

The following describes an image processing apparatus, an image processing method, and a program according to an example embodiment of the invention with reference to FIGS. 1 to 7.

[0014] [Apparatus Configuration]

CLAIMS

1. An image processing apparatus for building a three-dimensional shape from a plurality of images, the apparatus comprising:

a feature point extraction unit configured to extract combinations of corresponding feature points from the plurality of images;

a matrix calculation unit configured to, if two or more line segments or two or more points corresponding to each other are designated in at least two images out of the plurality of images, specify a geometric relationship between the two or more line segments corresponding to each other or a geometric relationship between the two or more points corresponding to each other, and calculate a numerical matrix that represents the specified geometric relationship; and

a shape building unit configured to specify a combination of feature points with a conflicting geometric relationship, from among the extracted combinations of feature points, using the numerical matrix, and build the three-dimensional shape using the combinations of feature points other than the specified combination of feature points.

2. The image processing apparatus according to claim 1,

wherein the shape building unit specifies feature points that overlap the two or more designated line segments or points corresponding to each other, from among feature points included in the extracted combinations of feature points, removes a combination of feature points that includes the specified feature points, and builds the three-dimensional shape.

3. The image processing apparatus according to claim 1 or 2, further comprising

a display unit configured to display the three-dimensional shape built by the shape building unit, on a screen.

4. The image processing apparatus according to claim 3,

wherein the shape building unit builds a temporary three-dimensional shape

using the combinations of feature points extracted by the feature point extraction unit, and

the display unit further displays the temporary three-dimensional shape on a screen.

5. An image processing method for building a three-dimensional shape from a plurality of images, the method comprising:

(a) a step of extracting combinations of corresponding feature points from the plurality of images;

(b) a step of, if two or more line segments or two or more points corresponding to each other are designated in at least two images out of the plurality of images, specifying a geometric relationship between the two or more line segments corresponding to each other or a geometric relationship between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relationship; and

(c) a step of specifying a combination of feature points with a conflicting geometric relationship, from among the extracted combinations of feature points, using the numerical matrix, and building the three-dimensional shape using the combinations of feature points other than the specified combination of feature points.

6. The image processing method according to claim 5,

wherein, in the (c) step,

feature points that overlap the two or more designated line segments or points corresponding to each other are specified from among feature points included in the combinations of feature points extracted in the (a) step, a combination of feature points that includes the specified feature points is removed, and the three-dimensional shape is built.

7. The image processing method according to claim 5 or 6, further comprising

(d) a step of displaying the three-dimensional shape built in the (c) step, on a

screen.

8. The image processing method according to claim 7, further comprising:

(e) a step of building a temporary three-dimensional shape using the combinations of feature points extracted in the (a) step; and

(f) a step of displaying the temporary three-dimensional shape built in the (e) step, on a screen.

9. A computer-readable recording medium that includes a program recorded thereon for building a three-dimensional shape from a plurality of images, the program including instructions that cause a computer to carry out:

(a) a step of extracting combinations of corresponding feature points from the plurality of images;

(b) a step of, if two or more line segments or two or more points corresponding to each other are designated in at least two images out of the plurality of images, specifying a geometric relationship between the two or more line segments corresponding to each other or a geometric relationship between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relationship; and

(c) a step of specifying a combination of feature points with a conflicting geometric relationship, from among the extracted combinations of feature points, using the numerical matrix, and building the three-dimensional shape using the combinations of feature points other than the specified combination of feature points.

10. The computer-readable recording medium according to claim 9,

wherein, in the (c) step,

feature points that overlap the two or more designated line segments or points corresponding to each other are specified from among feature points included in the combinations of feature points extracted in the (a) step, a combination of feature points that includes the specified feature points is removed, and the three-dimensional shape is

built.