constructs a provisional three-dimensional shape using the calculated provisional three-dimensional coordinates. Furthermore, the display unit 20 displays the constructed provisional three-dimensional shape on the screen of the display device 21 (step A4).

[0001~~0096~~] When step A4 is executed, and the provisional three-dimensional shape is displayed on the screen of the display device 21, the user designates line segments or points corresponding to each other between the images, via an input device (not illustrated in FIG. 2). Accordingly, the input accepting unit 19 ~~16~~ accepts input of the designated line segments or points (step A5). The input accepting unit 19 ~~16~~ also notifies the matrix calculation unit 12 of information regarding the designated line segments or points.

[0002~~0097~~] Next, when step A5 is executed, the matrix calculation unit 12 specifies a geometric relation between the line segments or points based on the information regarding the line segments or the points, and calculates a numerical matrix that represents the specified geometric relation (step A6).

[0003~~0098~~] Next, the unnecessary-feature-point specifying unit 13 specifies a combination of feature points between which the geometric relation is inconsistent from among the combinations of feature points that have been subjected to step A3, using the numerical matrix (fundamental matrix) calculated in step A6 (step A7).

[0004~~0099~~] Next, the three-dimensional coordinate calculation unit 14 calculates three-dimensional coordinates for constructing a three-dimensional shape, using combinations of feature points that were not specified in step A7 (step A8).

[0005~~0100~~] Next, the suitability determination unit 15 applies, for each of the combinations of feature points whose three-dimensional coordinates were calculated in step A8, a camera matrix corresponding to an image from which one feature point in the combination was extracted to the three-dimensional coordinates of this combination. The suitability determination unit 15 then calculates two-dimensional coordinates that are obtained by projecting the three-dimensional coordinates of this combination onto the image from which the above-described one feature point was extracted, by applying this camera matrix. Furthermore, the suitability determination unit 15 compares the calculated two-dimensional coordinates with the two-dimensional coordinates of the one feature point (two-dimensional coordinates on the image from which the feature point was extracted), and determines whether or not the above-described one feature point is appropriate based on the comparison result (step A9).

[0006~~0101~~] Next, in step A6, the three-dimensional shape constructing unit 16 constructs a three-dimensional shape of the target object using three-dimensional coordinates of the target object that correspond to feature points of combinations determined as being appropriate (step A10). The

CLAIMS

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

a feature point extraction means for extracting a combination of corresponding feature points from each of the plurality of images;

a matrix calculation means for, when 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 relation between the two or more line segments corresponding to each other or a geometric relation between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relation;

an unnecessary-feature-point specifying means for specifying a combination of feature points between which the geometric relation is inconsistent from among the extracted combinations of feature points, using the numerical matrix;

a three-dimensional coordinate calculation means for calculating, for each combination of feature points excluding the specified combination of feature points, a camera matrix for each feature point constituting the combination, and further calculating three-dimensional coordinates of the target object that correspond to the feature points of the combination using the calculated camera matrices;

a suitability determination means for calculating two-dimensional coordinates obtained by applying, for each combination of the feature points whose three-dimensional coordinates were calculated, a camera matrix corresponding to the image from which one feature point in the combination was extracted to the three-dimensional coordinates of the combination and thereby projecting the three-dimensional coordinates of the combination onto the image from which the one feature point was extracted, and determining whether or not the one feature point is appropriate based on a result of comparison between the calculated two-dimensional coordinates and two-dimensional coordinates of the one feature point; and

a three-dimensional shape constructing means for constructing a three-dimensional shape of the target object using the three-dimensional coordinates of the target object that correspond to feature points determined as being appropriate.

2. The image processing apparatus according to claim 1,

wherein the suitability determination means calculates a difference between the calculated two-dimensional coordinates and the two-dimensional coordinates of the one feature point, as the

comparison result, and determines that the one feature point is appropriate if the calculated difference is smaller than or equal to a threshold value, and that the one feature point is not appropriate if the calculated difference exceeds the threshold value.

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

wherein the suitability determination means selects, from each combination of feature points whose three-dimensional coordinates were calculated, all or one of the feature points constituting the combination, and determines, for each selected feature point, whether or not the selected feature point is appropriate.

4. The image processing apparatus according to any one of claims 1 to 3,

wherein the unnecessary-feature-point specifying means further specifies a feature point that overlaps two or more designated line segments or points corresponding to each other, from among the feature points in the extracted combinations of feature points.

5. The image processing apparatus according to any one of claims 1 to 4, further comprising:

a display means for displaying, on a screen, the three-dimensional shape constructed by the three-dimensional shape constructing means.

6. The image processing apparatus according to claim 5,

wherein the three-dimensional coordinate calculation means calculates provisional three-dimensional coordinates of the target object using the combination of feature points extracted by the feature point extraction means,

the three-dimensional shape constructing means constructs a provisional three-dimensional shape of the target object using the calculated provisional three-dimensional coordinates, and

the display means further displays the provisional three-dimensional shape on the screen.

7. An image processing method for constructing a three-dimensional shape of a target object from a plurality of images of the target object, the method comprising:

extracting a combination of corresponding feature points from each of the plurality of images;

when 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 relation

between the two or more line segments corresponding to each other or a geometric relation between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relation;

specifying a combination of feature points between which the geometric relation is inconsistent from among the extracted combinations of feature points, using the numerical matrix;

calculating, for each combination of feature points excluding the specified combination of feature points, a camera matrix for each feature point constituting the combination, and further calculating three-dimensional coordinates of the target object that correspond to the feature points of the combination using the calculated camera matrices;

calculating two-dimensional coordinates obtained by applying, for each combination of the feature points whose three-dimensional coordinates were calculated, a camera matrix corresponding to the image from which one feature point in the combination was extracted to the three-dimensional coordinates of the combination and thereby projecting the three-dimensional coordinates of the combination onto the image from which the one feature point was extracted, and determining whether or not the one feature point is appropriate based on a result of comparison between the calculated two-dimensional coordinates and two-dimensional coordinates of the one feature point; and

constructing a three-dimensional shape of the target object using the three-dimensional coordinates of the target object that correspond to feature points determined as being appropriate.

8. The image processing method according to claim 7,

wherein, in the determining of whether or not the one feature point is appropriate, a difference between the calculated two-dimensional coordinates and the two-dimensional coordinates of the one feature point is calculated as the comparison result, and it is determined that the one feature point is appropriate if the calculated difference is smaller than or equal to a threshold value, and that the one feature point is not appropriate if the calculated difference exceeds the threshold value.

9. The image processing method according to claim 7 or 8,

wherein, in the determining of whether or not the one feature point is appropriate, from each combination of feature points whose three-dimensional coordinates were calculated, all or one of the feature points constituting the combination is selected, and determination is performed as to, for each selected feature point, whether or not the selected feature point is appropriate.

10. The image processing method according to any one of claims 7 to 9, wherein, in the specifying of a combination of feature points, a feature point that overlaps two or more designated line segments or points corresponding to each other is further specified from among the feature points in the extracted combinations of feature points.

11. The image processing method according to any one of claims 7 to 10, further comprising: displaying, on a screen, the three-dimensional shape constructed in the constructing the three-dimensional shape.

12. The image processing method according to claim 11, further comprising: calculating provisional three-dimensional coordinates of the target object using the combination of feature points extracted in the extracting the combinations of corresponding feature points, constructing a provisional three-dimensional shape of the target object using the calculated provisional three-dimensional coordinates, and further displaying the provisional three-dimensional shape on the screen.

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

extracting a combination of corresponding feature points from each of the plurality of images;

when 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 relation between the two or more line segments corresponding to each other or a geometric relation between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relation;

specifying a combination of feature points between which the geometric relation is inconsistent from among the extracted combinations of feature points, using the numerical matrix;

calculating, for each combination of feature points excluding the specified combination of feature points, a camera matrix for each feature point constituting the combination, and further calculating three-dimensional coordinates of the target object that correspond to the feature points of the combination using the calculated camera matrices;

calculating two-dimensional coordinates obtained by applying, for each combination of the feature points whose three-dimensional coordinates were calculated, a camera matrix

~~corresponding to the image from which one feature point in the combination was extracted to the three-dimensional coordinates of the combination and thereby projecting the three-dimensional coordinates of the combination onto the image from which the one feature point was extracted, and determining whether or not the one feature point is appropriate based on a result of comparison between the calculated two-dimensional coordinates and two-dimensional coordinates of the one feature point; and~~

~~constructing a three-dimensional shape of the target object using the three-dimensional coordinates of the target object that correspond to feature points determined as being appropriate.~~

~~14. The computer-readable recording medium according to claim 13,~~

~~wherein, in the determining of whether or not the one feature point is appropriate, a difference between the calculated two-dimensional coordinates and the two-dimensional coordinates of the one feature point is calculated as a comparison result, and it is determined that the one feature point is appropriate if the calculated difference is smaller than or equal to a threshold value, and that the one feature point is not appropriate if the calculated difference exceeds the threshold value.~~

~~15. The computer-readable recording medium according to claim 13 or 14,~~

~~wherein, in the determining of whether or not the one feature point is appropriate, from each combination of feature points whose three-dimensional coordinates were calculated, all or one of the feature points constituting the combination is selected, and determination is performed as to, for each selected feature point, whether or not the selected feature point is appropriate.~~

~~16. The computer-readable recording medium according to any one of claims 13 to 15,~~

~~wherein, in the specifying of a combination of feature points, a feature point that overlaps two or more designated line segments or points corresponding to each other is further specified from among the feature points in the extracted combinations of feature points.~~

~~17. The computer-readable recording medium according to any one of claims 13 to 16, the program further including instructions that cause the computer to carry out:~~

~~displaying, on a screen, the three-dimensional shape constructed in the constructing the three-dimensional shape.~~

~~18. The computer-readable recording medium according to claim 17, the program further~~

~~including instructions that cause the computer to carry out:~~

~~calculating provisional three-dimensional coordinates of the target object using the combination of feature points extracted in the extracting of the combination of corresponding feature points, constructing a provisional three-dimensional shape of the target object using the calculated provisional three-dimensional coordinates, and further displaying the provisional three-dimensional shape on the screen.~~

CLAIMS

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

a feature point extraction means for extracting a combination of corresponding feature points from each of the plurality of images;

a matrix calculation means for, when 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 relation between the two or more line segments corresponding to each other or a geometric relation between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relation;

an unnecessary-feature-point specifying means for specifying a combination of feature points between which the geometric relation is inconsistent from among the extracted combinations of feature points, using the numerical matrix;

a three-dimensional coordinate calculation means for calculating, for each combination of feature points excluding the specified combination of feature points, a camera matrix for each feature point constituting the combination, and further calculating three-dimensional coordinates of the target object that correspond to the feature points of the combination using the calculated camera matrices;

a suitability determination means for calculating two-dimensional coordinates obtained by applying, for each combination of the feature points whose three-dimensional coordinates were calculated, a camera matrix corresponding to the image from which one feature point in the combination was extracted to the three-dimensional coordinates of the combination and thereby projecting the three-dimensional coordinates of the combination onto the image from which the one feature point was extracted, and determining whether or not the one feature point is appropriate based on a result of comparison between the calculated two-dimensional coordinates and two-dimensional coordinates of the one feature point; and

a three-dimensional shape constructing means for constructing a three-dimensional shape of the target object using the three-dimensional coordinates of the target object that correspond to feature points determined as being appropriate.

2. The image processing apparatus according to claim 1,

wherein the suitability determination means calculates a difference between the calculated two-dimensional coordinates and the two-dimensional coordinates of the one feature point, as the

comparison result, and determines that the one feature point is appropriate if the calculated difference is smaller than or equal to a threshold value, and that the one feature point is not appropriate if the calculated difference exceeds the threshold value.

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

wherein the suitability determination means selects, from each combination of feature points whose three-dimensional coordinates were calculated, all or one of the feature points constituting the combination, and determines, for each selected feature point, whether or not the selected feature point is appropriate.

4. The image processing apparatus according to any one of claims 1 to 3,

wherein the unnecessary-feature-point specifying means further specifies a feature point that overlaps two or more designated line segments or points corresponding to each other, from among the feature points in the extracted combinations of feature points.

5. The image processing apparatus according to any one of claims 1 to 4, further comprising:

a display means for displaying, on a screen, the three-dimensional shape constructed by the three-dimensional shape constructing means.

6. The image processing apparatus according to claim 5,

wherein the three-dimensional coordinate calculation means calculates provisional three-dimensional coordinates of the target object using the combination of feature points extracted by the feature point extraction means,

the three-dimensional shape constructing means constructs a provisional three-dimensional shape of the target object using the calculated provisional three-dimensional coordinates, and

the display means further displays the provisional three-dimensional shape on the screen.

7. An image processing method for constructing a three-dimensional shape of a target object from a plurality of images of the target object, the method comprising:

extracting a combination of corresponding feature points from each of the plurality of images;

when 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 relation

between the two or more line segments corresponding to each other or a geometric relation between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relation;

specifying a combination of feature points between which the geometric relation is inconsistent from among the extracted combinations of feature points, using the numerical matrix;

calculating, for each combination of feature points excluding the specified combination of feature points, a camera matrix for each feature point constituting the combination, and further calculating three-dimensional coordinates of the target object that correspond to the feature points of the combination using the calculated camera matrices;

calculating two-dimensional coordinates obtained by applying, for each combination of the feature points whose three-dimensional coordinates were calculated, a camera matrix corresponding to the image from which one feature point in the combination was extracted to the three-dimensional coordinates of the combination and thereby projecting the three-dimensional coordinates of the combination onto the image from which the one feature point was extracted, and determining whether or not the one feature point is appropriate based on a result of comparison between the calculated two-dimensional coordinates and two-dimensional coordinates of the one feature point; and

constructing a three-dimensional shape of the target object using the three-dimensional coordinates of the target object that correspond to feature points determined as being appropriate.

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

extracting a combination of corresponding feature points from each of the plurality of images;

when 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 relation between the two or more line segments corresponding to each other or a geometric relation between the two or more points corresponding to each other, and calculating a numerical matrix that represents the specified geometric relation;

specifying a combination of feature points between which the geometric relation is inconsistent from among the extracted combinations of feature points, using the numerical matrix;

calculating, for each combination of feature points excluding the specified combination of feature points, a camera matrix for each feature point constituting the combination, and further

calculating three-dimensional coordinates of the target object that correspond to the feature points of the combination using the calculated camera matrices;

calculating two-dimensional coordinates obtained by applying, for each combination of the feature points whose three-dimensional coordinates were calculated, a camera matrix corresponding to the image from which one feature point in the combination was extracted to the three-dimensional coordinates of the combination and thereby projecting the three-dimensional coordinates of the combination onto the image from which the one feature point was extracted, and determining whether or not the one feature point is appropriate based on a result of comparison between the calculated two-dimensional coordinates and two-dimensional coordinates of the one feature point; and

constructing a three-dimensional shape of the target object using the three-dimensional coordinates of the target object that correspond to feature points determined as being appropriate.