[0043]

The following section outlines a solution to the PnP problem.

[0044]

In order to solve the PnP problem, information about a view angle and a distortion of a camera which captured image data is required. In more detail, data called "camera matrix" and "distortion coefficient vector" are required.

[0045]

The camera matrix is a three-dimensional square matrix (matrix A below) including focal length fx and fy each expressed in a pixel unit, and a principal point (cx ,cy) which is usually an image center.

$$A = \begin{bmatrix} fx & 0 & cx \\ 0 & fy & cy \\ 0 & 0 & 1 \end{bmatrix}$$

[0046]

In the above matrix A, a camera view angle is represented by fx and fy. For example, consider a case of a typical camera (pinhole camera model) where an image width is 2000 pixels and a horizontal angle of view is 60 degrees. In this case, "cx = 2000/2 = 1000" and "fx = 1/tan(60/2)*(2000/2) = around 1732".

[0047]

The camera matrix is a matrix necessary to find r11 to r33 and t1 to t3 that minimize an error in equation representing perspective projection transformation shown below in order to solve the PnP problem.

$$s \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

where (X,Y,Z) is a point coordinate in the 3D world coordinate system, (u, v) is a projection point coordinate in the 2D normalized image

coordinate system, r11 to r33 are elements of a rotation matrix, t1 to t3 are elements of a translation vector, and s is a constant factor.

[0048]

R11 to r33 and t1 to t3 obtained as a solution of the above equation (equation representing perspective projection transformation), correspond to an orientation of a camera (rotation matrix) and a position of the camera (translation vector).

CLAIMS:

1. An article position management apparatus that manages a position of an article in a field in which a plurality of articles, a plurality of reference point markers, coordinate information of each reference point marker in an absolute coordinate system in the field being set in advance, a plurality of camera apparatuses for capturing image data in the field, including one or more fixed camera apparatuses and one or more mobile camera apparatuses are provided, the article position management apparatus comprising:

a camera related information table including ID (identifier) information of each camera apparatus and a type of the each camera apparatus indicating whether the each camera apparatus is a mobile or fixed camera apparatus;

an article marker information table including a marker ID of a marker attached to the article and a marker size;

a reference point marker information table including the coordinate information of the reference point marker and a marker size;

an input part that receives image data and the ID information of the camera apparatus from ~~a~~the camera apparatus that captured the image data; and

an identification part that determines, based on the ID information of the camera apparatus with reference to the camera related information table, whether the camera apparatus that captured the image data is the mobile camera apparatus or the fixed camera apparatus,

identifies a position of ~~an~~the article, based on an article marker attached to the article and ~~a~~the reference point marker, with reference to the article marker information table and the reference point marker information table, the article marker and the reference point marker being included in the image data, when the camera apparatus is determined to be ~~a~~the mobile camera apparatus, and

identifies the position of the article, based on the article marker included in the image data with reference to the article marker information table, when the camera apparatus is determined to be ~~a~~the fixed camera apparatus.

2. The article position management apparatus according to claim 1, wherein when the camera apparatus is determined to be the mobile camera apparatus, the identification part calculates, based on information on an angle of view and distortion of the mobile camera apparatus which are included in the camera related information table, and the marker size included in each of the reference point marker information table and the article marker information table, a relative position of the reference point marker to the mobile camera apparatus at a time when the image data is captured, and a relative position of the article marker to the mobile camera apparatus at the time when the image data is captured, and

identifies the position of the article using at least coordinate information of the reference point marker, the relative position of the reference point marker and the relative position of the article marker.

3. The article position management apparatus according to claim 1 or 2, wherein when the camera apparatus is determined to be a fixed camera apparatus, the identification part calculates based on information on an angle of view and distortion and absolute position of the fixed camera apparatus which are included in the camera related information table and the marker size included in the article marker information table, a relative position of the article marker to the fixed camera apparatus at a time when the image data is captured, and

identifies the position of the article using at least coordinate information of the fixed camera apparatus and the relative position of the article marker.

4. The article position management apparatus according to claim 1 or 2, wherein the input part receives image data from each of at least a first camera and a second camera both being the mobile camera apparatus, and

wherein the identification part calculates a relative position of the reference point maker to the first camera at a time when first image data is captured, based on the reference point marker included in the first image data captured by the first camera, and a relative position of the article marker to the second camera at a time when second image data is captured, based on the article marker included in the second image data captured by the second camera, and

identifies the position of the article using the relative position of the reference point marker, the relative position of the article marker and position and orientation differences with respect to the first camera and the second camera.

5. The article position management apparatus according to claim 1, wherein the input part receives first image data and second image data from a first mobile camera apparatus and a second mobile camera apparatus, respectively,

wherein at least the second mobile camera apparatus is attached with a mobile body marker, and

wherein the identification part identifies a position of the second mobile camera apparatus, based on the reference point marker and the mobile body marker attached to the second mobile camera apparatus included in the first image data, and

identifies the position of the article, based on the article marker included in the second image data and the position of the second mobile camera apparatus.

6. The article position management apparatus according to any one of claims 1 to 5, wherein the identification part uses the article marker attached to the article with a position thereof being identified as a new reference point marker.

7. The article position management apparatus according to claim 2, wherein the input part receives the first image data and the second image data from the mobile camera apparatus,

wherein the identification part calculates a relative position of the reference point marker to the mobile camera apparatus at a time when the first image data is captured, based on the reference point marker included in the first image data,

calculates a relative position of the article marker to the mobile camera apparatus at a time when the second image data is captured, based on the article marker included in the second image data, and

identifies a position of the article using the relative position of the reference point marker, the relative position of the article marker and movement history of the mobile camera apparatus from a time when the first image data is captured to a time when the second image data is captured.

8. The article position management apparatus according to claim 2, wherein an orientation of a camera installed in the mobile camera apparatus is configured to be variable,

wherein the input part receives first and second image data from the mobile camera apparatus whose orientation of the camera is configured to be variable,

wherein the identification part calculates a relative position of the reference point marker to the mobile camera apparatus at a time when the first image data is captured, based on the reference point marker included in the first image data captured by the camera at a first orientation, and

calculates a relative position of the article marker to the mobile camera apparatus at a time the second image data is captured, based on the article marker included in the second image data captured by the camera at a second orientation, and

identifies a position of the article using the relative position of the reference point marker, the relative position of article marker, and difference in orientations between the first and second orientations of the camera.

9. The article position management apparatus according to claim 2, wherein a focal length of a camera installed in the mobile camera apparatus is configured to be variable,

wherein the input part receives first and second image data from the mobile camera apparatus whose focal length of the camera is configured to be variable,

wherein the identification part calculates a relative position of the reference point marker to the mobile camera apparatus at a time when the first image data is captured, based on the reference point marker included in the first image data captured by the camera with a first focal length,

calculates a relative position of the article marker to the mobile camera apparatus at a time the second image data is captured, based on the article marker included in the second image data captured by the camera with a second focal length, and

identifies a position of the article using the relative position of the reference point marker and the relative position of the article marker.

10. The article position management apparatus according to claim 2, wherein the mobile camera apparatus is configured to measure at least a distance between the article marker and the mobile camera apparatus itself, and

wherein the identification part calculates a relative position of the article marker, based on the measured distance.

11. The article position management apparatus according to any one of claims 1 to 10, wherein each relative position of the reference point marker and the article marker is calculated as a solution of PnP (Perspective-n-Point) problem or by a modification of a solution of PnP problem.

12. The article position management apparatus according to any one of claims 1 to 11, wherein the reference point marker and/or the article marker are/is an AR (Augmented Reality) marker(s).

13. The article position management apparatus according to any one of claims 1 to 12, wherein the identification part determines whether a sender of the image data is the mobile camera apparatus or the fixed camera apparatus, based on an identifier of the camera apparatus assigned to the image data.

14. An article position management system, comprising:

a plurality of articles;

a plurality of reference point markers, coordinate information of each reference point marker in an absolute coordinate system in a field being set in advance;

a plurality of camera apparatuses for capturing image data in the field, including a plurality of fixed camera apparatuses and a plurality of mobile camera apparatuses, the camera apparatus capturing the reference point marker and an article marker attached to the article in the field to generate image data; and

an article position management apparatus for managing a position of the article in the field, including:

a camera related information table including ID (identifier) information of each camera apparatus and a type of the each camera apparatus indicating whether the each camera apparatus is a mobile or fixed camera apparatus ~~a means that shoots a reference point marker whose coordinate information in an absolute coordinate system in a field and an article marker attached to an article to generate image data~~;

an article marker information table including a marker ID of a marker attached to the article and a marker size;

a reference point marker information table including the coordinate information of the reference point marker and a marker size;

an input part that receives image data and the ID information of the camera apparatus from the

camera apparatus that captured the image data;

an identification part that determines, based on the ID information of the camera apparatus with reference to the camera related information table, whether the camera apparatus that captured the image data is the mobile camera apparatus or the fixed camera apparatus,

~~a means that extracts the reference point marker and the article marker from the image data;~~

~~a means that~~ identifies ~~a~~the position of the article, based on the reference point marker and ~~the~~an article marker attached to the article, with reference to the reference point marker information table and the article marker information table, the article marker and the reference point marker being included in the image data, when ~~the image data is generated by~~ the camera apparatus is determined to be ~~a~~the mobile camera apparatus~~;~~, and

~~a means that~~ identifies ~~a~~the position of the article, based on the article marker included in the image data with reference to the article marker information table, when ~~the image data is generated by~~ the camera apparatus is determined to be ~~a~~the fixed camera apparatus.

15. An article position management method for an article position management apparatus that manages a position of an article in a field in which a plurality of articles, a plurality of reference point markers, coordinate information of each reference point marker in an absolute coordinate system in the field being set in advance, a plurality of camera apparatuses for capturing image data in the field, including one or more fixed camera apparatuses and one or more mobile camera apparatuses are provided,

the method comprising:

storing in a storage a camera related information table including ID (identifier) information of each camera apparatus and a type of the each camera apparatus indicating whether the each camera apparatus is a mobile or fixed camera apparatus;

storing in the storage an article marker information table including a marker ID of a marker attached to the article and a marker size;

storing in the storage a reference point marker information table including the coordinate information of the reference point marker and a marker size;

receiving image data and the ID information of the camera apparatus from ~~a~~the camera apparatus that captured the image data;

determining, based on the ID information of the camera apparatus with reference to the camera related information table, whether the camera apparatus that captured the image data is the mobile camera apparatus or the fixed camera apparatus;

identifying the position of ~~an~~the article ~~position~~, based on an article marker attached to the article and ~~a~~the reference point marker ~~whose coordinate information in an absolute coordinate system in a field is set in advance~~, with reference to the article marker information table and the reference

point marker information table, the article marker and the reference point marker being included in the image data, when the camera apparatus is determined to be ~~a~~the mobile camera apparatus; and

identifying the position of the article, based on the article marker included in the image with reference to the article marker information table, when the camera apparatus is determined to be ~~a~~the fixed camera apparatus.

16. A program causing a computer installed on an article position management apparatus that manages a position of an article in a field in which a plurality of articles, a plurality of reference point markers, coordinate information of each reference point marker in an absolute coordinate system in the field being set in advance, a plurality of camera apparatuses for capturing image data in the field, including one or more fixed camera apparatuses and one or more mobile camera apparatuses are provided to perform processing comprising:

storing in a storage a camera related information table including ID (identifier) information of each camera apparatus and a type of the each camera apparatus indicating whether the each camera apparatus is a mobile or fixed camera apparatus;

storing in the storage an article marker information table including a marker ID of a marker attached to the article and a marker size;

storing in the storage a reference point marker information table including the coordinate information of the reference point marker and a marker size;

receiving image data and the ID information of the camera apparatus from ~~a~~the camera apparatus that captured the image data;

determining, based on the ID information of the camera apparatus with reference to the camera related information table, whether the camera apparatus that captured the image data is the mobile camera apparatus or the fixed camera apparatus;

identifying a position of ~~an~~the article ~~position~~, based on an article marker attached to the article and ~~a~~the reference point marker ~~whose coordinate information in an absolute coordinate system in a field is set in advance~~, with reference to the article marker information table and the reference point marker information table, the article marker and the reference point marker being included in the image data, when the camera apparatus is determined to be ~~a~~the mobile camera apparatus; and

identifying the position of the article, based on the article marker included in the image with reference to the article marker information table, when the camera apparatus is determined to be ~~a~~the fixed camera apparatus.

17. The article position management apparatus according to claim 2, wherein when the camera apparatus is determined to be the mobile camera apparatus, the identification part calculates a direction vector from the reference point marker to the article marker based on the difference between the relative position of the reference point marker and the relative position of the article marker and determines the

position of the article marker relative to the reference point marker from the direction vector and the coordinate information of the reference point marker to identify the position of the article.

18. The article position management apparatus according to claim 3, wherein at least, based on the coordinate information of the fixed camera apparatus, the identification part calculates the relative position of the object marker, calculate a direction vector from the fixed camera apparatus to the object marker, and using the direction vector and the coordinate information of the fixed camera apparatus, determine the position of the object marker relative to the reference point marker to identify the position of the article.