

DESCRIPTION

TITLE:

LOADING SPACE RECOGNITION APPARATUS, SYSTEM, METHOD,
AND PROGRAM

5 TECHNICAL FIELD

[0001]

[Description of related applications]

The present invention is based on a priority claim of Japanese Patent Application: Japanese Patent Application No. 2021-030741 (filed on
10 February 26, 2021), and the entire contents of the present application shall be incorporated and stated in the present application by reference. The present invention relates to a loading space recognition apparatus, system, method, and program.

BACKGROUND ART

15 [0002]

In a logistics industry, baggage (luggage, cargo) loaded in truck containers is damaged by load collapse such as falling during transportation, and deterioration of transportation quality occurs. Therefore, techniques are proposed for generating information for
20 arranging baggage so as to prevent baggage from collapsing, and for promptly discovering load collapse when actually occurring (for example, see Patent Literatures (PTLs) 1 to 6).

[0003]

As a technique for suppressing load collapse, PTLs 1 and 2
25 disclose a shape information generation apparatus, including: a first information acquisition part acquiring three-dimensional information of a first area (region) on a surface of a plurality of articles, obtained by imaging or scanning the plurality of articles stacked from a first point; a second information acquisition part acquiring three-dimensional
30 information of a second area of the surfaces of the plurality of articles, obtained by imaging or scanning the plurality of articles from a second point; and a synthesis part generating information showing a three-dimensional shape of at least part of the surfaces of the plurality of articles based on the three-dimensional information of the first area

acquired by the first information acquisition part and the three-dimensional information of the second area acquired by the second information acquisition part, wherein positions of the first point and the second point are different from each other; and the synthesis part
5 complements one of the three-dimensional information of the first area and the three-dimensional information of the second area by the other to generate information showing the three-dimensional shape of at least part of the surfaces of the plurality of articles.

[0004]

10 As a technique for preventing load collapse, PTL 3 discloses a stacking method for stacking a plurality of objects to be stacked in a predetermined baggage attitude and so as to become a predetermined weight, including: measuring a weight and baggage attitude of each of the objects to be stacked; calculating a density of each of these objects
15 to be stacked from the weight and baggage attitude of each of these objects to be stacked; and integrating the density information of each of these objects to be stacked to calculate a stack position of each of these objects to be stacked.

[0005]

20 As a technology that it is possible for a driver to check a state of baggage in a baggage room at any time (whether or not the baggage is collapsed) by a monitor, PTL 4 discloses a baggage room monitoring apparatus of a vehicle, including: monitoring cameras installed at a middle position in a vehicle width direction on an upper surface of the
25 baggage room and at two places that divide the total length of the baggage room into three equal parts; an information processing apparatus inputting image data in the baggage room by the monitoring camera; a monitor inputting and displaying an image data in the baggage room from the information processing apparatus; and a communication
30 apparatus inputting the image data of the baggage room from the information processing apparatus and transmitting the image data towards a base station, wherein the baggage room monitoring apparatus is configured so that availability of a loading space can be grasped by the image of the monitoring camera.

[0006]

As a technology that enables a driver and a management center to easily know a load collapse in a transportation vehicle and to correspond quickly to a treatment of the load collapse, PTL 5 discloses a load collapse monitoring system of a transportation vehicle, including: an in-vehicle terminal monitoring load collapse of baggage to be stacked by a sensor installed in a loading platform of the transportation vehicle and issuing a warning indicating that load collapse occurs to a driver when load collapse is detected; and a management center receiving a load collapse monitoring signal indicating that a load collapse of the baggage to be stacked occurs, the load collapse monitoring signal being transmitted from the in-vehicle terminal when the in-vehicle terminal issues the warning to the driver, and collecting and managing load collapse information of the baggage to be stacked on the transportation vehicle.

[0007]

As a technology capable of detecting load collapse that occurs during and after transfer work, PTL 6 discloses a load collapse detection method of articles, including: acquiring a first image before a transfer of the article and a second image after the transfer by imaging an article group stacked on a pallet before and after the transfer from upper direction at each time an individual article is transferred; comparing the first image and the second image; and determining whether or not a load collapse occurs based on a change degree in an article area other than an area at which the transferred article existed.

CITATION LIST

PATENT LITERATURE

[0008]

[PTL 1] JP6511681B

[PTL 2] JP6577687B

[PTL 3] JP2002-29631A

[PTL 4] JP2018-199489A

[PTL 5] JP2005-018472A

[PTL 6] JP2007-179301A

SUMMARY

TECHNICAL PROBLEM

[0009]

5 The following analysis is given by the inventors of the present application.

[0010]

10 However, in the technologies for suppressing and preventing load collapse described in PTLs 1 to 3, load collapse cannot be completely eliminated by simply loading baggage so that load collapse does not occur, since there are movements of baggage in all directions by acceleration, braking, vibration of the vehicle, etc., movements of baggage leading to load collapse, it is impossible to determine a possibility of occurrence of load collapse by the movements of baggage.

[0011]

15 Also, in the technology for checking a baggage described in PTL 4, since the driver checks the status of baggage in the baggage room by looking at the monitor and knows load collapse, it is difficult for safety to determine a possibility of load collapse due to movement of baggage while the driver is driving the vehicle.

20 [0012]

25 Further, in the technology for detecting a load collapse described in PTL 5, since the load collapse is determined based on the presence or absence of reception of signals such as infrared rays and ultrasonic waves by a sensor, it is impossible to detect movement of baggage within a range at which there is not a change in a signal reception by the sensor, and there is a possibility that it is impossible to determine a possibility of load collapse by movement of baggage.

[0013]

30 Furthermore, in the technology that can detect load collapse that occurs during transfer and after transfer work is completed in PTL 6, each of edge images of the first image taken before transfer and the second image taken after transfer is generated and both images are compared, thereby the presence or absence of load collapse is determined based on a degree of change of the articles other than the

transferred articles. However, by comparing edge images, it is impossible to detect movements of baggage (movement of baggage in the far and near direction to the imaging position) and there is a possibility that it is impossible to determine a possibility that load collapse occurs by the movements of baggage.

[0014]

It is a main object of the present invention to provide a loading space recognition apparatus, system, method, and program that can contribute to determining a possibility that load collapse occurs by movements of baggage.

SOLUTION TO PROBLEM

[0015]

A loading space recognition apparatus according to a first aspect comprises: a baggage overall image estimation part configured to estimate an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data; a voxelization part configured to voxelize the estimation result data to output the voxelized estimation result data as voxel data; and a determination part configured to estimate a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determine whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.

[0016]

A loading space recognition system according to a second aspect comprises: a sensor outputting three-dimensional data imaged by sensing a surface of baggage in a loading space; and a loading space recognition apparatus according to the first aspect.

[0017]

A loading space recognition method according to a third aspect comprises: estimating an overall image of baggage loaded in a loading

space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data; voxelizing the estimation result data to output the voxelized estimation result data as voxel data; and
5 estimating a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determining whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or
10 movement amount, as estimated, with a threshold.

[0018]

A program according to a fourth aspect is a program causing hardware resources to execute processing that recognizes a loading space of baggage, wherein the program causes the hardware resources
15 to execute processings: estimating an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data; voxelizing the estimation result data to output the voxelized estimation result data as
20 voxel data; and estimating a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determining whether or not there is a possibility of load collapse by comparing the fluctuation
25 volume amount or movement amount, as estimated, with a threshold.

[0019]

The program can be recorded on a computer-readable storage medium. The storage medium can be non-transient such as semiconductor memory, hard disk, magnetic recording medium, optical
30 recording medium, and the like. Also, the present disclosure can also be embodied as a computer program product. The program is input from an input apparatus or an outside to a computer apparatus via communication interface, is stored in a storage device, drives a processor in accordance with predetermined steps or processings, can cause to display results of

processing including intermediate states as necessary in stages via a display apparatus, or can cause to communicate with the outside via a communication interface. A computer apparatus for this purpose, as an example, typically comprises a processor, a storage device, an input
5 apparatus, a communication interface, and a display apparatus as necessary, which are connectable to each other by a bus.

ADVANTAGEOUS EFFECTS OF INVENTION

[0020]

According to the first to fourth aspects, it is possible to
10 contribute to determining a possibility that load collapse occurs by movements of baggage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

[Fig. 1] FIG. 1 is an image diagram schematically showing an example
15 of a configuration and use mode of a loading space recognition system according to a first example embodiment.

[FIG. 2] FIG. 2 is a block diagram schematically showing a configuration of a loading space recognition apparatus in the loading space recognition system according to the first example embodiment.

20 [FIG. 3] FIG. 3 is a flowchart schematically showing operations of the loading space recognition apparatus in the loading space recognition system according to the first example embodiment;

[FIG. 4] FIG. 4 is an image diagram schematically showing some examples in case that there is a fluctuation volume amount when
25 extracting a difference between a reference voxel and a comparison voxel.

[FIG. 5] FIG. 5 is an image diagram schematically showing some examples in case that there is no fluctuation volume amount and there is a movement amount, when extracting a difference between the
30 reference voxel and the comparison voxel.

[Fig. 6] FIG. 6 is an image diagram schematically showing a transition from unity extraction to longest movement amount extraction in example 2-1 of FIG. 5.

[Fig. 7] FIG. 7 is an image diagram schematically showing a transition

from unity extraction to longest movement amount extraction in Example 2-2 of FIG. 5.

[Fig. 8] FIG. 8 is an image diagram schematically showing a transition from unity extraction to longest movement amount extraction in Example 2-3 of FIG. 5.

[Fig. 9] FIG. 9 is an image diagram schematically showing a transition from unity extraction to longest movement amount extraction in Example 2-4 of FIG. 5.

[Fig. 10] FIG. 10 is an image diagram schematically showing a modification of the configuration and use mode of the loading space recognition system according to the first example embodiment.

[Fig. 11] FIG. 11 is a block diagram schematically showing a configuration of a loading space recognition apparatus according to a second example embodiment.

[Fig. 12] FIG. 12 is a block diagram schematically showing a configuration of hardware resources.

EXAMPLE EMBODIMENTS

[0022]

Hereinafter, example embodiments will be described with reference to drawings. It should be noted that when reference numerals are attached to the drawings in the present application, they are solely for a purpose of helping understanding, and are not intended to limit the modes shown in the drawings. Also, the following example embodiments are only examples, and do not limit the present invention. Further, connection lines between blocks in the drawings and the like referred to in the following description include both bidirectional and unidirectional connections. The unidirectional arrows schematically show flows of main signals (data) and do not exclude bidirectionality. Furthermore, in circuit diagrams, block diagrams, internal configuration diagrams, connection diagrams, etc. disclosed in the present application, an input port and an output port exist at the input end and the output end of each connection line, respectively, although not explicitly shown. The same is applied to input/output interface. The program is executed via a computer apparatus, and the computer apparatus comprises, for

example, a processor, a storage device, an input apparatus, a communication interface, and a display apparatus as necessary. The computer apparatus is configured to be able to communicate with an internal or external apparatus (including computer) via the communication interface, regardless of wired or wireless.

[0023]

[FIRST EXAMPLE EMBODIMENT]

A loading space recognition system according to a first example embodiment will be described with reference to the drawings. FIG. 1 is an image diagram schematically showing an example of a configuration and use mode of the loading space recognition system according to the first example embodiment. FIG. 2 is a block diagram schematically showing a configuration of a loading space recognition apparatus in the loading space recognition system according to the first example embodiment. Here, baggage of a container on a truck will be described as an example.

[0024]

The loading space recognition system 1 is a system that recognizes a fluctuation (volume fluctuation, distance fluctuation) of an object in a loading space (in FIG. 1, a loading space 5 in a container 3 on truck 2) at which the object (in FIG. 1, baggage 4) is loaded by using a sensor 10 (see Fig. 1). The loading space recognition system 1 is configured to connect the sensor 10 and the loading space recognition apparatus 200 so as to be communicable (wired communication or wireless communication). The loading space recognition system 1 can be mounted on a truck 2. In the loading space recognition system 1, the loading space recognition apparatus 200 recognizes a fluctuation of the object in the loading space 5 based on image data (100 in FIG. 2) imaged by the sensor 10. Here, the image data 100 is three-dimensional data imaged by the sensor 10 (data obtained by imaging three-dimensional elements such as point group data and depth data, data reconstructed into a three-dimensional space from a plurality of images, etc.).

[0025]

The sensor 10 is a sensor that senses and images a surface of the

baggage 4 in the loading space 5 being an imaging area (see FIG. 1). The sensor 10 is communicably connected to the loading space recognition apparatus 200. The sensor 10 outputs image data (100 in FIG. 2) created from three-dimensional data obtained by imaging the loading space 5 towards the loading space recognition apparatus 200. The sensor 10 can be selected according to an imaging condition and customer's request such as a imaging distance, an angle of view, and a size of the container 3 necessary for detecting the baggage 4. As to the sensor 10, products sold by various manufacturers can be used. As the sensor 10, for example, stereo camera, ToF (Time of Flight) camera, 3D-lidar (Three Dimensions-light detection and ranging), 2D-lidar (Two Dimensions-light detection and ranging), LIDAR (Laser Imaging Detection And Ranging) etc. can be used. The sensor 10 may be mounted at a position where the loading space 5 being an imaging area can be imaged, for example, it may be mounted near an upper part of the container 3 on the loading entrance side. The sensor 10 may image the baggage 4 in the loading space 5 from the upper part of the baggage entrance side of the container 3. There may be at least one sensor 10 in the loading space 5, and there may be a plurality of sensors. Also, a plurality of sensors 10 may be used if the loading space 5 is so large that it is difficult to image by one sensor. In case there is a plurality of sensors 10 in the loading space 5, the types and manufacturers may differ. Further, in case there is a plurality of sensors 10 in the loading space 5, each of image data imaged by each of the sensors 10 may be synthesized by the loading space recognition apparatus 200.

[0026]

The loading space recognition apparatus 200 is an apparatus recognizing a fluctuation (volume fluctuation, distance fluctuation) of the baggage 4 in the loading space 5 in which the baggage 4 is loaded, based on the image data 100 from the sensor 10 (see FIGS. 1 and 2). As the loading space recognition apparatus 200, an apparatus (computer apparatus) comprising function parts (eg, a processor, a storage apparatus, an input apparatus, a communication interface, and a display apparatus) configuring a computer can be used, for example, a notebook

personal computer, a smart phone, a tablet terminal, or the like can be used. The loading space recognition apparatus 200 comprises a function of determining whether or not there is a possibility of load collapse of the baggage 4. The loading space recognition apparatus 200 can also be used when a certain amount of accumulated (or a unity of) volume change is expected in case that load collapse occurs under conditions such as pallet stacking. The loading space recognition apparatus 200 implements a preprocessing part 210, a baggage attitude grasping part 220, a determination part 230, and a user interface part 240 by executing a predetermined program.

[0027]

The preprocessing part 210 is a function part performing preprocessing for performing loading space recognition processing to the image data 100 (see FIG. 2). The preprocessing part 210 outputs preprocessing data 101 obtained by preprocessing the image data 100 towards the baggage attitude grasping part 220 and the user interface part 240. The preprocessing part 210 comprises a format conversion part 211 and a noise reduction part 212.

[0028]

The format conversion part 211 is a function part converting a format of the image data 100 into a common format that can be commonly used in the loading space recognition apparatus 200 as preprocessing (see FIG. 2). The format conversion part 211 outputs the common format of image data 100 to the noise reduction part 212. In case the format of the image data 100 is originally a common format, a process of the format conversion part 211 can be omitted (skipped).

[0029]

The noise reduction (or removal) part 212 is a function part reducing (or removing) noise (for example, point group unnecessary for loading space recognition) from the image data 100 from the format conversion part 211 as preprocessing (see FIG. 2). The noise reduction part 212 outputs the preprocessing data 101 obtained by the noise in the image data 100 being reduced towards the baggage overall image estimation part 222 of the baggage attitude grasping part 220, and if

necessary, outputs it towards the display part 241 of the user interface part 240. As a noise reduction method, for example, a smoothing processing, a filtering (eg, moving average filter processing, median filter processing, etc.), outlier removal processing (eg, outlier removal processing by chi-square test), and the like can be mentioned. The processing of the noise reduction part 212 may be omitted (skipped) in case there is almost no noise.

[0030]

The preprocessing data 101 is output to the display part 241 and can be viewed by the user. Also, since the image data 100 and the preprocessing data 101 provide the basis of all processing, it is possible to ensure them by making them storable.

[0031]

The baggage attitude grasping part 220 is a function part grasping a current baggage attitude from the preprocessing data 101 (see FIG. 2). The baggage attitude grasping part 220 outputs voxel data 102 related to the grasped current baggage attitude towards the determination part 230. The baggage attitude grasping part 220 includes an area designation part 221, a baggage overall image estimation part 222, and a voxelization part 223. The baggage attitude grasping part 220 measures information about the shape of the loaded baggage or empty space from the preprocessing data 101 and provides quantitative information.

[0032]

The area designation part 221 is a function part designating an area (loading area) in which the baggage 4 can be loaded within the container 3 (see FIG. 2). For example, in case that there is an area in which the baggage 4 cannot be loaded in the container 3, or the like, the area designation part 221 designates an area by excluding that area. The area designation part 221 can designate a stacking area via the operation part 242 by user's operation and can automatically designate an area in combination with a system that automatically acquires an edge of an area.

[0033]

Also, the area designation part 221 may designate a determination

exclusion area to be excluded from determination by the determination part 230 via the operation part 242 by user's operation. As a result, it is possible to prevent from determining excessive change of baggage attitude by excluding determination of the baggage attitude change of the baggage 4 that cannot maintain a constant shape. The change determination exclusion area may be determined not only in units of areas but also in units of voxels, or in units of single/individual baggage (in units of objects).

[0034]

The baggage overall image estimation part 222 is a function part estimating an overall image of the baggage 4 loaded in the loading area based on the preprocessing data 101 from the noise reduction part 212 of the preprocessing part 110 [sic., data 101] and the loading area designated by the area designation part 221 (see FIG. 2). The baggage overall image estimation part 222 creates estimation result data relating to an overall image of the loaded baggage 4. The baggage overall image estimation part 222 outputs the created estimation result data towards the voxelization part 223. The baggage overall image estimation part 222 estimates not only the baggage loaded on a surface or frontmost of the baggage, but also baggage (if necessary gap) loaded in the back part (occlusion part) that is shielded by them and cannot be confirmed from the sensor 10. As estimating the baggage loaded on the occlusion part, a complement [or interpolation] by past data stored in chronological order or prior knowledge such as a size and number related to the loaded baggage may be used, a simple algorithm such as assuming that a coordinate point indicating the baggage exists on an extension line of a straight line connecting the frontmost coordinate point and the sensor, or preprocessed data 101 saved in chronological order may be used, and machine learning may be used.

[0035]

As an example of a machine learning teacher data collection method, a method of associating preprocessing data 101 with the actual loading status and recording them in a database can be mentioned. For example, distance sensors are provided at predetermined intervals on a

ceiling surface of the container, and the distance to the loaded baggage is measured by the distance sensors. As a result, it is possible to grasp the loading status of the baggage, such as whether the baggage directly below the sensor is piled up to the ceiling, is piled up to about half of height, or is completely empty. By providing a plurality of sensors on the ceiling surface, it is possible to grasp a loading status of the baggage inside the entire container. In this manner, machine learning can be performed by associating the preprocessing data 101 with the actual loading status. The machine learning method is not limited to this, and other methods may be used. Also, in case machine learning is used, a function of estimating information / attributes other than shape such as "weight" and "strictly forbidden stacking above / strictly forbidden stacking below" may be comprised.

[0036]

The voxelization part 223 is a function part voxelizing the estimation result data of the baggage overall image estimation part 222 (see FIG. 2). The voxelization part 223 creates voxel data 102 relating to an overall image of the baggage 4 based on the estimation result data of the baggage overall image estimation part 222. The voxelization part 223 creates the voxel data 102 by treating a portion where the loaded baggage 4 does not exist as an empty space. The voxelization part 223 outputs the created voxel data 102 towards the reference determination part 231 and the difference extraction part 232 of the determination part 230. In the voxelization process, an estimation of the shielded area that cannot be seen from the 3D sensor, or complement [or interpolation] by data accumulated in chronological order may be performed, and prior knowledge such as the size and number of the loaded baggage may be used.

[0037]

Here, the voxel data 102 is data representing the overall image of the baggage 4 by combining a plurality of voxels (cubes) of a predetermined size. The voxel data 102 includes information related to the dimensions of each voxel and the position of each plane. The voxel data 102 may be stored each time upon creation. The voxel data 102 may

also include information such as the number of baggage in one voxel, information about which multiple voxels are locating across one baggage, information such as weight and shape, or the like.

[0038]

5 The determination part 230 is a function part estimating a fluctuation (varying) volume amount or a movement amount of the baggage by comparing a voxel data 102 (reference voxel data) at a certain reference time point with a voxel data 102 (comparison voxel data) at a time point after a predetermined or arbitrary time has elapsed
10 and determining whether or not there is a possibility of load collapse by comparing the estimated fluctuation volume amount or movement amount with a threshold (see FIG. 2). Thereby, the baggage 4 can be prevented from falling down. Also, the determination part 230 may detect whether or not there is a possibility of load collapse not only by
15 comparing the reference voxel data with the comparison voxel data, but also by comparing one comparison voxel data with another comparison voxel data created one before the one comparison voxel data. As a result, when a change amount between the comparison voxel data per unit time is smaller than a change amount between the reference voxel data and
20 the comparison voxel data, it is possible not to determine that there is a possibility of load collapse. Further, the detection part 20 for detecting vibration and sound is mounted on the truck 2 (a structure body having a loading space) (see FIG. 10), and the determination part 230 may detect whether or not there is a possibility of load collapse by
25 acquiring comparison voxel data from the voxelization part 223 when detecting vibration and sound exceeding a certain level in the detection part 20. Furthermore, in order to supplement or verify a certainty of movement estimation, information acquired from another system, such as information that there are many heavy baggage and many light
30 baggage, may be used. The determination part 230 includes a reference determination part 231, a difference extraction part 232, a fluctuation volume amount estimation part 233, a unity extraction part 234, a combination estimation part 235, a movement amount estimation part 236, and a load collapse determination part 237.

[0039]

The reference determination part 231 is a function part determining the voxel data 102 at a certain reference time point (reference time) from the voxelization part 223 as a change reference point (see FIG. 2). The reference determination part 231 stores the voxel data 102 at the reference time point (instructed time point) from the voxelization part 223 by an instruction from the operation part 242 and holds it as reference data for position fluctuation. The reference determination part 231 outputs the voxel data 102 at the reference time point towards the difference extraction part 232.

[0040]

The difference extraction part 232 is a function part extracting a difference (for example, a difference in positions in a depth direction) between voxels corresponding to a surface of the baggage 4 viewed from a predetermined position (for example, a rear of the truck 2, a position of the sensor 10) by comparing a voxel data 102 at an arbitrary reference time (reference voxel data) with a voxel data 102 (comparison voxel data) at a time point when a predetermined or arbitrary time has passed from the reference time (see FIG. 2). The difference extraction part 232 acquires reference voxel data from the reference determination part 231 and acquires comparison voxel data from the voxelization part 223 in a difference extraction process. In the difference extraction process, for example, when a position of a surface of the voxel when viewing the baggage 4 from a back direction of the truck 2 changes to a front side of the truck 2 in a depth direction (for example, when the baggage 4 at a position of a target voxel moves to left, right, or lower side and a piece of baggage 4 locating at one further rear side of the target voxel appears; when the baggage 4 at a position of the target voxel moves to the rear side; and when the occlusion part decreases), a difference may be extracted so as to indicate that the volume has "decreased". Similarly, when the position of a surface of the voxel changes to a rear side of the truck 2 (for example, when the baggage 4 at a position of the target voxel moves to a rear side; when another baggage 4 moves in front of one baggage 4 at a position of the target voxel; and when the occlusion

part increases), a difference may be extracted so as to indicate that the volume has "increased". Also, in the difference extraction process, for example, a difference may be extracted so as to express a degree of decrease or increase of volume stepwise according to a magnitude of a distance when a position of a surface of the voxel changes forward or backward on the truck 2. The difference extraction part 232 outputs the difference data extracted by the difference extraction process towards the fluctuation volume amount estimation part 233 and the unity extraction part 234.

[0041]

The fluctuation volume amount estimation part 233 is a function part estimating the fluctuated (varied) volume amount (fluctuation volume amount) of the overall image of the baggage 4 based on the difference data from the difference extraction part 232 (see FIG. 2). The fluctuation volume amount can be represented, for example, by a sum of differences in positions of a depth direction of voxels at corresponding positions on a surface of the baggage 4 viewed from a rear of the truck 2. When a certain volume amount increases at a certain position and the same volume amount decreases at another position, there is no change (0) in fluctuation volume amount (see movement examples 2-1 to 2-4 in FIG. 5). Also, when a certain volume amount increases at a certain position and a volume amount decreases greater than the increased volume amount at another position, the fluctuation volume amount becomes a negative value. In addition, when a certain volume amount increases at a certain position and a volume amount decreases smaller than the increased volume decreases at another position, the fluctuation volume amount becomes a positive value (see movement examples 1-1 to 1-3 in FIG. 4). Further, when a certain volume amount increases at a certain position and there is no decrease of a volume amount at another position, the fluctuation volume amount becomes a positive value. Furthermore, when a certain volume amount decreases at a certain position and a volume amount does not increase at another position, the fluctuation volume amount becomes a negative value. The fluctuation volume amount estimation part 233 outputs the estimated fluctuation

volume amount estimation data towards the load collapse determination part 237.

[0042]

5 The unity extraction part 234 is a function part extracting a unity (i.e., a unit sum) of voxels with no increase or decrease in volume existing between voxels with increased volume (volume amount increasing voxels) and voxels with decreased volume (volume amount decreasing voxels) at the same horizontal position based on the difference data from the difference extraction part 232 (see FIG. 2). The
10 unity extraction part 234 may presuppose that a volume amount of the baggage 4 does not fluctuate. When it is possible to extract a unity, the unity extraction part 234 outputs difference data including the extracted unity data towards the combination estimation part 235. When
15 it is impossible to extract a unity, the unity extraction part 234 outputs the difference data from the difference extraction part 232 towards the combination estimation part 235.

[0043]

The combination estimation part 235 is a function part estimating a combination of volume amount increasing voxels and volume amount
20 decreasing voxels based on the difference data (including unity data when a unity can be extracted) from the unity extraction part 234 (see FIG. 2). The combination estimation part 235 may presuppose that a volume amount of the baggage 4 does not fluctuate. In the combination estimation process, for example, in case a plurality of combinations are
25 possible, it is possible to preferentially combine volume amount increasing voxels and volume amount decreasing voxels at the same horizontal position. Also, in case a plurality of combinations are possible, it is possible to preferentially combine the volume amount increasing voxel and the volume amount decreasing voxel that are
30 farthest apart from each other. In addition, in case a plurality of combinations are possible, it is possible to preferentially combine volume amount increasing voxels and volume amount decreasing voxels so as to maximize a sum of distances. Further, a volume amount decreasing voxel can be prevented from being combined with a volume

amount increasing voxel that exists one level above it, since it is impossible for the baggage 4 to move upward when the baggage 4 falls down. A volume amount increasing voxel may not be combined with a volume amount decreasing voxel one level below it, since it is impossible for the baggage 4 to move upward when the baggage 4 falls down. When a combination can be estimated, the combination estimation part 235 outputs difference data including the extracted combination data towards the movement amount estimation part 236. When the combination cannot be estimated, the combination estimation part 235 outputs the difference data from the unity extraction part 234 towards the movement amount estimation part 236.

[0044]

The movement amount estimation part 236 is a function part estimating a movement amount of the baggage 4 that has occurred between a reference time and a time when a predetermined or arbitrary time has elapsed based on the difference data (which may include unity data and combination data) from the combination estimation part 235 (see FIG. 2). The moving amount estimation part 236 may presuppose that a volume amount of the baggage 4 does not fluctuate. In case the difference data includes the unity data and the combination data, the movement amount estimation part 236 calculates a distance from a volume amount decreasing voxel to a volume amount increasing voxel related to the combination data; calculates a length of voxels without increasing and decreasing of volume amount related to the unity data; and estimates a value obtained by subtracting the calculated length from the calculated distance as a movement amount of the baggage 4. In case a difference data does not include unity data and includes combination data, the movement amount estimation part 236 calculates a distance from a volume amount decreasing voxel to a volume amount increasing voxel related to the combination data and estimates a value of the calculated distance as a movement amount of the baggage 4. In case the difference data does not include combination data (regardless of the presence or absence of unity data), it is a movement of the baggage 4 accompanied by a fluctuation in volume amount and thus the movement

amount estimation part 236 may not estimate a movement amount, and the fluctuation volume amount estimation part 233 may preferentially estimate a fluctuation volume amount. Also, in the movement amount estimation, correction may be made so that different weights are assigned to lateral movement and vertical movement (falling) respectively, for example, a correction may be made to become smaller than the estimated movement amount so as not to warn even when a lateral movement occurs and is large, and a correction may be made to become larger than the estimated movement amount so as to warn even when vertical or oblique movement occurs and is small. When the difference data includes a plurality of combination data, the movement amount estimation part 236 estimates a movement amount for each combination data.

[0045]

Also, the movement amount estimation part 236 selects a longest movement amount from among the estimated movement amounts and estimates the selected movement amount as the longest movement amount. When the estimated movement amount is one, this movement amount is estimated as the longest movement amount. The movement amount estimation part 236 outputs the estimated longest movement amount estimation data towards the load collapse determination part 237.

[0046]

Examples of operations of the unity extraction part 234, the combination estimation part 235, and the movement amount estimation part 236 will be described later.

[0047]

The load collapse determination part 237 is a function part that determines whether or not there is a possibility of load collapse of the baggage 4 by comparing the fluctuation volume amount estimation data from the fluctuation volume amount estimation part 233 or the longest movement amount estimation data from the movement amount estimation part 236 with a preset threshold (a first threshold for the fluctuation volume amount or a second threshold for the longest movement amount) (see FIG. 2). When the fluctuation volume amount estimation data is

greater than the first threshold (even when the first threshold or more is possible), the load collapse determination part 237 determines that there is a possibility of load collapse of the baggage 4. When the fluctuation volume amount estimation data is equal to or less than the first threshold (even when less than the first threshold is possible), the load collapse determination part 237 determines that there is no possibility of load collapse of the baggage 4. When the longest movement amount is larger than the second threshold (even when the second threshold or more is possible), the load collapse determination part 237 determines that there is a possibility of load collapse of the baggage 4. When the longest movement amount is equal to or less than the second threshold (even when less than the second threshold is possible), the load collapse determination part 237 determines that there is no possibility of load collapse of the baggage 4. Although it is arbitrary for the load collapse determination part 237 to determine whether or not there is a possibility of load collapse of the baggage 4 by preferentially using either the fluctuation volume amount or the longest movement amount, considering the data processing load, the determination may be made by preferentially using a fluctuation volume amount with a relatively small load. In case it is determined that there is a possibility of load collapse of the baggage 4, the load collapse determination part 237 outputs warning output instruction information towards the warning output part 243 to warn the occurrence of an abnormality to the user.

[0048]

The user interface part 240 is a function part including a user interface (function for exchanging information with the user) (see FIG. 2). The user interface part 240 performs an interface between the user and the loading space recognition apparatus 200 and is configured so that each process can be operated and the result of each process can be confirmed. The user interface part 240 includes a display part 241, an operation part 242 and a warning output part 243.

[0049]

The display part 241 is a function part displaying the

preprocessing data 101 and the like from the noise reduction part 212 (see FIG. 2). As the display part 241, for example, a liquid crystal display, an organic EL (Electroluminescence) display, an AR (Augmented Reality) glass, or the like can be used.

5 [0050]

The operation part 242 is a function part performing an area designation and a determination instruction to the area designation part 221 and the reference determination part 231 based on a user's operation (see FIG. 2). As the operation part 242, for example, a touch panel, a
10 mouse, a camera and software for recognizing gestures and eye movements can be used.

[0051]

The warning output part 243 is a function part outputting a warning to the user based on the warning output instruction information from the load collapse determination part 237 (see FIG. 2). As the
15 warning output part 243, for example, a display displaying characters and images related to the warning, a speaker outputting an alarm sound, a lamp lighting up an alarm, a communication part transmitting warning output instruction information to another system, etc. can be used.

20 [0052]

Next, operations of the loading space recognition apparatus in the loading space recognition system according to the first example embodiment will be described with reference to the drawings. FIG. 3 is a flow chart schematically showing operations of the loading space
25 recognition apparatus in the loading space recognition system according to the first example embodiment. Regarding the configuration parts and details of the loading space recognition apparatus, please refer to FIG. 1 and 2 and their descriptions.

[0053]

30 First, the format conversion part 211 of the preprocessing part 210 acquires image data (reference image data; three-dimensional data) 100 for reference obtained by imaging the baggage 4 in the loading space 5 being the image area, from the sensor 10 (step A1).

[0054]

Next, the format conversion part 211 of the preprocessing part 210 converts a format of the image data 100 for reference into a common format (step A2).

[0055]

5 Next, the noise reduction part 212 of the preprocessing part 210 reduces noise from the image data 100 for reference converted into the common format to create preprocessing data 101 for reference (step A3).

[0056]

10 Next, the baggage overall image estimation part 222 of the baggage attitude grasping part 220 estimates an overall image of the loaded baggage 4 on the loading area based on the preprocessing data 101 for reference and the loading area designated by the area designation part 221 (step A4).

[0057]

15 Next, the voxelization part 223 of the baggage attitude grasping part 220 creates voxel data 102 for reference (reference voxel data) relating to the overall image of the baggage 4 based on the estimation result data estimated in step A4 (step A5).

[0058]

20 Next, the reference determination part 231 of the determination part 230 saves the reference voxel data created by the voxelization part 223 as a value of a reference time for the load collapse determination process by an operation of the operation part 242 by the user (step A6). The operation of the operation part 242 by the user may be performed,
25 for example, after the loading of the baggage 4 into the container 3 is completed and before delivery is started.

[0059]

30 Next, the format conversion part 211 of the preprocessing part 210 acquires image data 100 for comparison (comparison image data; three-dimensional data) obtained by imaging the baggage 4 in the loading space 5 being the image area from the sensor 10 at a time when a predetermined or arbitrary time has elapsed from a time the image data 100 for reference (reference image data) was acquired (step A7).

[0060]

Next, the format conversion part 211 of the preprocessing part 210 converts a format of the comparison image data 100 into a common format (step A8).

[0061]

Next, the noise reduction part 212 of the preprocessing part 210 reduces noise from the comparison imaging data 100 converted into the common format to create preprocessing data 101 for comparison (step A9).

[0062]

Next, the baggage overall image estimation part 222 of the baggage attitude grasping part 220 estimates an overall image of the loaded baggage 4 on the loading area based on the preprocessing data 101 for comparison and the loading area designated by the area designation part 221 (step A10).

[0063]

Next, the voxelization part 223 of the baggage attitude grasping part 220 creates voxel data 102 for comparison (comparison voxel data) relating to the overall image of the baggage 4 based on the estimation result data estimated in step A10 (step A11).

[0064]

Next, the difference extraction part 232 of the determination part 230 extracts a difference (for example, the difference in the position in the depth direction) between the voxels at the corresponding positions on a surface at which the baggage 4 are viewed from a predetermined position (for example, a rear of the truck 2, a position of the sensor 10) by comparing the reference voxel data stored in the reference determination part 231 with the comparison voxel data created by the voxelization part 223 (step A12).

[0065]

Next, the fluctuation volume amount estimation part 233 of the determination part 230 estimates a fluctuated volume amount (fluctuation volume amount) of the overall image of the baggage 4 based on the difference data from the difference extraction part 232 (step A13).

[0066]

Next, the load collapse determination part 237 of the determination part 230 determines whether or not the fluctuation volume amount estimation data from the fluctuation volume amount estimation part 233 is greater than a preset first threshold for the fluctuation volume amount (step A14). When the fluctuation volume amount estimation [sic., fluctuation volume amount estimation data] is greater than the first threshold (YES in step A14), the load collapse determination part 237 determines that there is a possibility of load collapse of the baggage 4; outputs warning output instruction information to the warning output part 243; and proceeds to step A20. [0067]

When the fluctuation volume amount estimation [sic., fluctuation volume amount estimation data] is equal to or less than the first threshold (NO in step A14), the unity extraction part 234 of the determination part 230 extracts a unity of voxels without increase or decrease in volume amount between the volume amount increasing voxel and the volume amount decreasing voxel at positions (level) in a same horizontal direction based on the difference data from the difference extraction part 232 (step A15). When a unity can not be extracted, step A15 is skipped. [0068]

Next, the combination estimation part 235 of the determination part 230 estimates a combination of the volume amount increasing voxels and the volume amount decreasing voxels based on the difference data from the unity extraction part 234 (including the unity data when the unity can be extracted) (step A16). [0069]

Next, the movement amount estimation part 236 of the determination part 230 estimates a movement amount of the baggage 4 that occurred from the reference time to a time that a predetermined or arbitrary time has elapsed based on the difference data (which may include unity data and combination data) from the combination estimation part 235 (step A17). [0070]

Here, in estimating the movement amount, in case the difference data includes unity data and combination data, a distance from the volume amount decreasing voxel to the volume amount increasing voxel related to the combined data is calculated; a length of voxels without increasing and decreasing of volume amount related to the unity data is calculated; and a value obtained by subtracting the calculated length from the calculated distance is estimated as a movement amount of the baggage 4. Also, in estimating the movement amount, in case the difference data does not include unity data and includes combination data, a distance from the volume amount decreasing voxel to the volume amount increasing voxel related to the combination data is calculated and a value of the calculated distance is estimated as a movement amount of the baggage 4. Further, in estimating the movement amount, in case the difference data includes a plurality of combination data, the movement amount is estimated for each combination data.

[0071]

Next, the movement amount estimation part 236 of the determination part 230 selects a longest movement amount from among the estimated movement amounts and estimates the selected movement amount as a longest movement amount (step A18).

[0072]

Next, the load collapse determination part 237 of the determination part 230 determines whether or not the longest movement amount estimation data from the movement amount estimation part 236 is larger than a preset second threshold for a longest movement amount (step A19). In case the longest movement amount estimation data is greater than the second threshold (YES in step A19), the load collapse determination part 237 determines that there is a possibility of load collapse of the baggage 4; outputs warning output instruction information towards the warning output part 243; and proceeds to step A20. In case the longest movement amount estimation data is equal to or less than the second threshold (NO in step A19), the load collapse determination part 237 determines that there is no possibility of load collapse of the baggage 4, terminates one cycle; and steps A7 to A20

are repeated until the user instructs termination.

[0073]

5 In case the fluctuation volume amount estimation [sic., fluctuation volume amount estimation data] is greater than the first threshold (YES in step A14), or in case the longest movement amount estimation data is greater than the second threshold (YES in step A19), the warning output part 243 of the user interface part 240 outputs a warning to the user based on the warning output instruction information from the load collapse determination part 237 (step A20). After that,
10 one cycle is terminated, and steps A7 to A20 are repeated until the user instructs termination.

[0074]

15 Next, operations of the difference extraction part, the fluctuation volume amount estimation part, and the load collapse determination part of the loading space recognition apparatus in the loading space recognition system according to the first example embodiment will be described using some examples and drawings. FIG. 4 is an image diagram schematically showing some examples in which there is a fluctuation volume amount when extracting the difference between the
20 reference voxel and the comparison voxel.

[0075]

25 In case that the reference voxel data when the overall image of the package (4 in FIG. 1) is viewed from the rear side of the truck (2 in FIG. 1) is in a state like the reference voxel data in FIG. 4, when changing from the reference voxel data in FIG. 4 to the comparison voxel data related to the movement example 1-1, the difference extraction data extracted by the difference extraction part (232 in FIG. 2) becomes like the difference extraction data related to the movement example 1-1 in FIG. 4. In the difference extraction data related to the
30 movement example 1-1, the volume amounts of only four voxels at the upper left increase by one step, respectively, and there is no change of increasing or decreasing of the other voxels. That is, since the voxels whose volume amounts increasing by one step are only four, the reference voxel data and the comparison voxel data differ in total

volume. In this case, it is thought that the occlusion part (gap or space) has increased on the back side of the voxel whose volume has increased, and thus by assuming that the distance from a surface position of the reference voxel data to the increased surface position of the comparison voxel data has moved, the fluctuation volume amount estimation part (233 in FIG. 2) estimates a fluctuation volume amount, and the load collapse determination part (237 in FIG. 2) can perform threshold determination of the fluctuation volume amount.

[0076]

When the reference voxel data in FIG. 4 changes to the comparison voxel data related to the movement example 1-2, the difference extraction data extracted by the difference extraction part (232 in FIG. 2) becomes like the difference extraction data related to the movement example 1-2 in FIG. 2. In the differential extraction data related to the movement example 1-2, the volume amounts of four voxels decrease by one step respectively; the volume amounts of other eight voxels increase by one step respectively; and the remaining voxels do not change in increase or decrease respectively. In other words, although there are voxels increasing and decreasing in volume, even if the voxels increasing and decreasing in volume are canceled out each other, there are four voxels increasing in volume by one stage, so that a total volume of the reference voxel data is different from that of the comparison voxel data. In this case, since the baggage have moved as a whole, it is impossible to accurately calculate a movement amount. Also, in this case, assuming that there are movements of the baggage 4 between the 4 voxels increasing in volume and the 4 voxels decreasing in volume and a distance from a surface position of the reference voxel data to a surface position of the comparison voxel data increased about the increase of 4 voxels remaining in volume has been moved, the fluctuation volume amount estimation part (233 in FIG. 2) estimates a fluctuation volume amount and the load collapse determination part (237 in FIG. 2) performs threshold determination of the fluctuation volume amount.

[0077]

When the reference voxel data in FIG. 4 changes to the comparison voxel data related to the movement example 1-3, the difference extraction data extracted by the difference extraction part (232 in FIG. 2) becomes like the difference extraction data related to the movement example 1-3 in FIG. 4. In the differential extraction data related to the movement example 1-3, the volume amounts of 8 voxels decrease by one step respectively; the volume amounts of other 12 voxels increase by one step respectively; the volume amounts of yet other four voxels increase by two steps respectively; and the volume amounts of the remaining voxels do not change in increase or decrease respectively. In other words, although there are voxels increasing and decreasing in volume, even if the voxels increasing and decreasing in volume are canceled out each other, there are 4 more voxels increasing in volume by one step, and there are 4 voxels increasing in volume by 2 steps. So a total volume of the reference voxel data is different from that of comparison voxel data. In this case, assuming that there are movements of the baggage 4 between the 4 voxels increasing in volume by one step and the 8 voxels decreasing in volume by one step and a distance from the surface position of the reference voxel data to the increased surface position of the comparison voxel data has been moved, the fluctuation volume amount estimation part (233 in FIG. 2) estimates a fluctuation volume amount, and the load collapse determination part (237 in FIG. 2)) performs the threshold determination of the fluctuation volume amount.

[0078]

Next, operations of the difference extraction part, the unity extraction part, the combination estimation part, the movement amount estimation part, and the load collapse determination part of the loading space recognition apparatus in the loading space recognition system according to the first example embodiment will be described using some examples and drawings. FIG. 5 is an image diagram schematically showing some examples in case that there is no fluctuation volume amount and there is a movement amount, when extracting a difference between the reference voxel and the comparison voxel. FIG. 6 is an

image diagram schematically showing a transition from unity extraction to longest movement amount extraction in example 2-1 of FIG. 5. FIG. 7 is an image diagram schematically showing a transition from unity extraction to longest movement amount extraction in Example 2-2 of FIG. 5. FIG. 8 is an image diagram schematically showing a transition from unity extraction to longest movement amount extraction in Example 2-3 of FIG. 5. FIG. 9 is an image diagram schematically showing a transition from unity extraction to longest movement amount extraction in Example 2-4 of FIG. 5.

[0079]

In case that the reference voxel data when the overall image of the baggage (4 in FIG. 1) is viewed from a rear side of the truck (2 in FIG. 1) is in a state like the reference voxel data in FIG. 5, if changing from the reference voxel data in FIG. 5 to the comparison voxel data related to the movement example 2-1, a difference extraction data extracted by the difference extraction part (232 in FIG. 2) become like the difference extraction data related to the movement example 2-1 in FIG. 5. In the difference extraction data related to the movement example 2-1, the volume amounts of six voxels increase by one step respectively; the volume amounts of other six voxels decrease by one step respectively; and the remaining voxels do not change in increase or decrease respectively. In other words, there are voxels increasing and decreasing in volume, and the voxels increasing and decreasing in volume are canceled out each other by the same number and step number, so that a total volume of the reference voxel data and that of the comparison voxel data are the same. In this case, the unity extraction part (234 in FIG. 2) extracts two unities of voxels without increase or decrease in volume amount that exist between the volume amount increasing voxels and the volume amount decreasing voxels at the same horizontal position as shown in FIG. 6(A); the combination estimation part (235 in FIG. 2) estimates two combinations of the unity of the volume amount increasing voxels and the unity of the volume amount decreasing voxels that are linked as shown in FIG. 6(B); the movement amount estimation part (236 in FIG. 2) calculates a distance (see the

two arrows in FIG. 6(C)) from the volume amount decreasing voxels to the volume amount increasing voxels related to the combination as shown in FIG. 6(C), calculates a length (not shown) of voxels without increase or decrease in volume amount related to the unity data, and estimates a value obtained by subtracting the calculated length from the distance calculated as shown in FIG. 6(D) as a movement amount (see two arrows in FIG. 6(D)) of the baggage 4; the movement amount estimation part (236 in FIG. 2) estimates the movement amount being a longest from among the movement amounts as a longest movement amount (see the circled arrow in FIG. 6(D)); and the load collapse determination part (237 in FIG. 2) performs threshold determination of the longest movement amount.

[0080]

When the reference voxel data in FIG. 5 changes to the comparison voxel data related to the movement example 2-2, the difference extraction data extracted by the difference extraction part (232 in FIG. 2) becomes like the difference extraction data related to the movement example 2-2 in FIG. 5. In the differential extraction data related to the movement example 2-2, the volume amounts of 8 voxels increase by one step respectively; the volume amounts of other 8 voxels decrease by one step respectively; and the remaining voxels do not change in increase or decrease respectively. In other words, there are voxels increasing and decreasing in volume, and the voxels increasing and decreasing in volume are canceled out each other by the same number and step number, so that a total volume of the reference voxel data and that of the comparison voxel data are the same. In this case, the unity extraction part (234 in FIG. 2) extracts one unity of voxels without increase or decrease in volume amount that exist between the volume amount increasing voxels and the volume amount decreasing voxels at the same horizontal position as shown in FIG. 7(A); the combination estimation part (235 in FIG. 2) estimates two combinations of the unity of the volume amount increasing voxels and the unity of the volume amount decreasing voxels that are linked as shown in FIG. 7(B); the movement amount estimation part (236 in FIG. 2) calculates a

distance (see the two arrows in FIG. 7(C)) from the volume amount decreasing voxels to the volume amount increasing voxels related to the combination as shown in FIG. 7(C), calculates a length (not shown; one) of voxels without increase or decrease in volume amount related to the unity data, and estimates a value obtained by subtracting the calculated length from the distance calculated as shown in FIG. 7(D) as a movement amount (see two arrows in FIG. 7(D); one with subtraction, the other without subtraction) of the baggage 4; the movement amount estimation part (236 in FIG. 2) estimates the movement amount being a longest from among the movement amounts as a longest movement amount (see the circled arrow in FIG. 7(D)); and the load collapse determination part (237 in FIG. 2) performs threshold determination of the longest movement amount.

[0081]

When the reference voxel data in FIG. 5 changes to the comparison voxel data related to the movement example 2-3, the difference extraction data extracted by the difference extraction part (232 in FIG. 2) becomes like the difference extraction data related to the movement example 2-3 in FIG. 5. In the differential extraction data related to the movement example 2-3, the volume amounts of 8 voxels increase by one step respectively; the volume amounts of other 8 voxels decrease by one step respectively; and the remaining voxels do not change in increase or decrease respectively. In other words, there are voxels increasing and decreasing in volume and the voxels increasing and decreasing in volume are canceled out each other by the same number and step number, so that a total volume of the reference voxel data and that of the comparison voxel data are the same. In this case, the unity extraction part (234 in FIG. 2) skips since it is impossible to extract a unity of voxels without increase or decrease in volume amount that exist between the volume amount increasing voxels and the volume amount decreasing voxels at the same horizontal position as shown in FIG. 8(A); the combination estimation part (235 in FIG. 2) estimates two combinations of the unity of the volume amount increasing voxels and the unity of the volume amount decreasing voxels that are linked as

shown in FIG. 8(B); the movement amount estimation part (236 in FIG. 2) calculates a distance (see the two arrows in FIG. 8(C)) from the volume amount decreasing voxels to the volume amount increasing voxels related to the combination as shown in FIG. 8(C), and estimates the distance calculated as shown in FIG. 8(D) as a movement amount (see two arrows in FIG. 8(D)) of the baggage 4; the movement amount estimation part (236 in FIG. 2) estimates the movement amount being a longest from among the movement amounts as a longest movement amount (see the circled arrow in FIG. 8(D)); and the load collapse determination part (237 in FIG. 2) performs threshold determination of the longest movement amount.

[0082]

When the reference voxel data in FIG. 5 changes to the comparison voxel data related to the movement example 2-4, the difference extraction data extracted by the difference extraction part (232 in FIG. 2) becomes like the difference extraction data related to the movement example 2-4 in FIG. 5. In the differential extraction data related to the movement example 2-4, the volume amounts of 12 voxels increase by one step respectively; the volume amounts of other 12 voxels decrease by one step respectively; and the remaining voxels do not change in increase or decrease. In other words, there are voxels increasing and decreasing in volume, and the voxels increasing and decreasing in volume are canceled out each other by the same number and step number, so that a total volume of the reference voxel data and that of the comparison voxel data are the same. In this case, the unity extraction part (234 in FIG. 2) skips since it is impossible to extract a unity of voxels without increase or decrease in volume amount that exist between the volume amount increasing voxels and the volume amount decreasing voxels at the same horizontal position as shown in FIG. 9(A); the combination estimation part (235 in FIG. 2) estimates 3 combinations of the unity of the volume amount increasing voxels and the unity of the volume amount decreasing voxels that are linked as shown in FIG. 9(B); the movement amount estimation part (236 in FIG. 2) calculates a distance (see the 3 arrows in FIG. 9(C)) from the volume

amount decreasing voxels to the volume amount increasing voxels related to the combination as shown in FIG. 9(C), and estimates the distance calculated as shown in FIG. 9(D) as a movement amount (see 3 arrows in FIG. 9(D)) of the baggage 4; the movement amount estimation part (236 in FIG. 2) estimates the movement amount being a longest from among the movement amounts as a longest movement amount (see the circled arrow in FIG. 9(D)); and the load collapse determination part (237 in FIG. 2) performs threshold determination of the longest movement amount.

10 [0083]

Regarding the unity extraction processing reference (criteria) of the unity extraction part 234, the combination estimation processing reference (criteria) of the combination estimation part 235, and the movement amount estimation processing reference (criteria) of the movement amount estimation part 236 in the movement examples 1-1 to 1-3 and 2-1 to 2-4 above, please see the detailed description of FIG. 2.
[0084]

According to the first example embodiment, the difference between the voxels at the corresponding positions between the reference voxel data and the comparison voxel data is extracted to estimate the fluctuation volume amount or the longest movement amount of the overall image of the baggage 4 and perform threshold determination, it is possible to contribute to determining a possibility of occurrence of load collapse by a movement of baggage.

25 [0085]

Also, according to the first example embodiment, even if an occlusion portion hidden by the baggage 4 occurs, since the occlusion portion is estimated and the baggage attitude of the baggage 4 is grasped, it is possible to consider a change of the baggage 4 in the occlusion portion.

30 [0086]

Further, according to the first example embodiment, by holding the reference voxel data of the baggage attitude at a specific time, such as before a start of movement of the truck 2 and comparing the

comparative voxel data of the baggage attitude after a predetermined or arbitrary time has elapsed from the reference time with the reference voxel data, since it is possible to detect that whether or not there is a possibility of load collapse, even if an arrangement of baggage by loading and unloading work, etc. becomes unstable, and there is a danger of falling down, it can be detected and notified to a driver. As a result, a possibility of load collapse of the baggage 4 can be detected at an early stage, the damage of the baggage 4 can be prevented before it happens; and it is possible to contribute to preventing deterioration of transport quality.

[0087]

[Second example embodiment]

A loading space recognition apparatus according to a second example embodiment will be described with reference to drawings. FIG. 11 is a block diagram schematically showing a configuration of the loading space recognition apparatus according to the second example embodiment.

[0088]

The loading space recognition apparatus 200 is an apparatus that recognizes fluctuations (volume fluctuations, distance fluctuations) of baggage in a loading space at which the baggage are loaded, based on image data. The loading space recognition apparatus 200 includes a baggage overall image estimation part 222, a voxelization part 223 and a determination part 230.

[0089]

The baggage overall image estimation part 222 is configured to estimate an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data.

[0090]

The voxelization part 223 is configured to voxelize the estimation result data to output the voxelized estimation result data as voxel data.

[0091]

The determination part 230 is configured to estimate a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from a reference time and
5 determine whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.

[0092]

According to the second example embodiment, since the
10 difference of voxels between the voxel data at a corresponding position between a voxel data at a reference time and a voxel data at a time other than the reference time is extracted; a fluctuation volume amount or a longest movement amount of an overall image of the baggage are estimated; and threshold determination is performed, it is possible to
15 contribute to determining a possibility that load collapse occurs by movements of baggage.

[0093]

It should be noted that the loading space recognition apparatus according to the first and second example embodiments can be
20 configured by so-called hardware resources (information processing apparatus, computer), and can use one including a configuration exemplarily shown in FIG. 12. For example, hardware resources 1000 include a processor 1001, a memory 1002, a network interface 1003, etc., which are interconnected by an internal bus 1004.

25 [0094]

It should be noted that the configuration shown in FIG. 12 is not intended to limit a hardware configuration of the hardware resources 1000. The hardware resources 1000 may comprise a hardware not shown (for example, an input/output interface). Alternatively, it is not
30 intended to limit the number of units such as the processors 1001 included in the apparatus to the example shown in FIG. 12 as well. For example, multiple processors 1001 may be included in the hardware resources 1000. As the processor 1001, for example, a CPU (Central Processing Unit), MPU (Micro Processor Unit), GPU (Graphics

Processing Unit), or the like can be used.

[0095]

As the memory 1002, for example, RAM (Random Access Memory), ROM (Read Only Memory), HDD (Hard Disk Drive), SSD (Solid State Drive), etc. can be used.

[0096]

As the network interface 1003, for example, a LAN (Local Area Network) card, network adapter, network interface card, etc. can be used.

[0097]

The functions of the hardware resources 1000 are realized by the above processing modules. The processing module is realized by the processor 1001 executing a program stored in the memory 1002, for example. Also, the program can be downloaded via a network or updated using a storage medium storing the program. Further, the above processing module may be realized by a semiconductor chip. In other words, the functions performed by the above processing module may be realized by executing software in some kind of hardware.

[0098]

Part or all of the above example embodiments can be described as the following MODES but are not limited to the following.

[0099]

[MODE 1]

A loading space recognition apparatus, comprising:

a baggage overall image estimation part configured to estimate an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data;

a voxelization part configured to voxelize the estimation result data to output the voxelized estimation result data as voxel data; and

a determination part configured to estimate a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determine

whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.

[MODE 2]

- 5 The loading space recognition apparatus according to MODE 1, wherein the determination part comprises:
- a reference determination part configured to determine the voxel data at the reference time from the voxelization part as a change reference point;
- 10 a difference extraction part configured to extract a difference of voxels at corresponding positions on a surface of the baggage viewed from a predetermined position by comparing the voxel data at the reference time with a voxel data at the time when a predetermined or arbitrary time has elapsed from the reference time and output the difference as
- 15 difference data;
- a fluctuation volume amount estimation part configured to estimate a fluctuation volume amount of the overall image of the baggage based on the difference data to output the fluctuation volume amount as fluctuation volume amount estimation data; and
- 20 a load collapse determination part configured to determine whether or not there is a possibility of load collapse by comparing the fluctuation volume amount estimation data with a threshold for a fluctuation volume amount as the threshold.

[MODE 3]

- 25 The loading space recognition apparatus according to MODE 2, wherein the determination part further comprises:
- a unity extraction part configured to extract a unity of voxels without an increase or decrease in volume amount existing between a volume amount increasing voxel having a volume amount increased and a
- 30 volume amount decreasing voxel having a volume amount decreased, at positions in a same horizontal direction, based on the difference data, and output the unity as unity data;
- a combination estimation part configured to estimate a combination of the volume amount increasing voxel and the volume amount decreasing

voxel based on the difference data and output the combination as combination data; and

a movement amount estimation part configured to estimate at least one movement amount of the baggage occurred during a period from the reference time to a time when a predetermined or arbitrary time has elapsed based on the difference data, the unity data, and the combination data, select a longest movement amount from among the movement amounts estimated, estimate the selected movement amount as a longest movement amount, and output the longest movement amount as longest movement amount estimation data,

wherein the load collapse determination part is configured to determine whether or not there is a possibility of load collapse by comparing the fluctuation volume amount estimation data with a threshold for a fluctuation volume amount as the threshold, and determine whether or not there is a possibility of load collapse by comparing the longest movement amount estimation data with a threshold for a longest movement amount as the threshold when it is determined that there is the possibility of load collapse.

[MODE 4]

The loading space recognition apparatus according to MODE 1, wherein the determination part comprises:

a reference determination part configured to determine the voxel data at the reference time from the voxelization part as a change reference point;

a difference extraction part configured to extract a difference of voxels at corresponding positions on a surface of the baggage viewed from a predetermined position by comparing the voxel data at the reference time with the voxel data at the time when a predetermined or arbitrary time has elapsed from the reference time and output the difference as difference data;

a unity extraction part configured to extract a unity of voxels without an increase or decrease in volume amount existing between a volume amount increasing voxel having a volume amount increased and a volume amount decreasing voxel having a volume amount decreased, at

positions in a same horizontal direction, based on the difference data, and output the unity as unity data;

a combination estimation part configured to estimate a combination of the volume amount increasing voxel and the volume amount decreasing voxel based on the difference data and output the combination as combination data;

a movement amount estimation part configured to estimate at least one movement amount of the baggage occurred during a period from the reference time to a time when a predetermined or arbitrary time has elapsed based on the difference data, the unity data, and the combination data, select a longest movement amount from among the movement amounts estimated, estimate the selected movement amount as a longest movement amount, and output the longest movement amount as longest movement amount estimation data; and

a load collapse determination part configured to determine whether or not there is a possibility of load collapse by comparing the longest movement amount estimation data with a threshold for a longest movement amount as the threshold.

[MODE 5]

The loading space recognition apparatus according to any one of MODES 1 to 4, further comprising an area designation part configured to designate a loading area of the baggage in the loading space by user's operation,

wherein the baggage overall image estimation part is configured to estimate an overall image of the baggage loaded in the loading area.

[MODE 6]

The loading space recognition apparatus according to MODE 5, wherein the area designation part is configured to designate a determination exclusion area to be excluded from the determination of the determination part by user's operation, and

wherein the baggage overall image estimation part is configured to exclude the baggage loaded at the determination exclusion area and estimate the overall image of baggage loaded in the loading area.

[MODE 7]

The loading space recognition apparatus according to any one of MODES 1 to 6, further comprising a detection part being mounted on a structure body having the loading space and detecting shaking or sound, wherein the detection part is configured to acquire the voxel data from the voxelization part when the detection part detects shaking or sound of a predetermined level or more and estimate a fluctuation volume amount or a movement amount of the baggage by comparing the voxel data at the reference time with the acquired voxel data.

[MODE 8]

The loading space recognition apparatus according to MODE 3 or 4, wherein the movement amount estimation part is configured to correct the movement amount to be smaller than the estimated movement amount when a movement direction of the baggage is in a lateral direction, or correct the movement amount to be larger than the estimated movement amount when the movement direction of the baggage is in a vertical direction or an oblique direction and select a longest movement amount from among the corrected movement amounts.

[MODE 9]

The loading space recognition apparatus according to any one of MODES 1 to 8, wherein the determination part is configured to further determine whether or not there is a possibility of load collapse by comparing a change amount between one voxel data at a time other than the reference time and other voxel data that is one before the one voxel data with a change amount between a voxel data at the reference time and the voxel data at a time other than the reference time.

[MODE 10]

The loading space recognition apparatus according to any one of MODES 1 to 9,

wherein the determination part is configured to output warning output instruction information when it is determined that there is a possibility of load collapse, and

wherein the loading space recognition apparatus further comprises a warning output part configured to output a warning based on the warning output instruction information.

[MODE 11]

A loading space recognition system, comprising:

a sensor outputting three-dimensional data imaged by sensing a surface of baggage in a loading space; and

5 a loading space recognition apparatus according to any one of MODES 1 to 10.

[MODE 12]

A loading space recognition system, comprising:

10 estimating an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data;

voxelizing the estimation result data to output the voxelized estimation result data as voxel data; and

15 estimating a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determining whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or
20 movement amount, as estimated, with a threshold.

[MODE 13]

A program causing hardware resources to execute processing that recognizes a loading space of baggage, wherein the program causes the hardware resources to execute processings:

25 estimating an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data;

30 voxelizing the estimation result data to output the voxelized estimation result data as voxel data; and

estimating a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determining whether or not there is a possibility

of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.

[0100]

It should be noted that each disclosure of the above PTLs is incorporated herein by reference and can be used as the basis or part of the present invention as necessary. Within the framework of the entire disclosure of the present invention (including claims and drawings), modifications and adjustments of the example embodiments or examples are possible based on the basic technical concept thereof further. Also, within the framework of the entire disclosure of the present invention, various combinations or selections (if necessary not selection) of various disclosure elements (including each element of each claim, each element of each example embodiment or example, each element of each drawing, etc.) is possible. That is, the present invention naturally includes various variations and modifications that can be made by one skilled in the art according to the entire disclosure including the claims and drawings, and the technical idea. Further, with regard to numerical values and numerical ranges described in the present application, it is assumed that any intermediate values, sub-numerical values and sub-ranges thereof are described even if not explicitly mentioned. Furthermore, it is assumed that each disclosure matter of the above-cited document(s) is included in (belong to) the disclosure matter of the present application as a part of the disclosure of the present invention in accordance with the meaning of the present invention if necessary and a part or all of each disclosure matter of the above-cited document can be used in combination with the matters described in the present document.

REFERENCE SIGNS LIST

[0101]

- 1 Loading space recognition system
- 2 Truck
- 3 Container
- 4 Baggage
- 5 Loading space

- 10 Sensor
- 20 Detection part
- 100 Image data
- 101 Preprocessing data
- 5 102 Voxel data
- 200 Loading space recognition apparatus
- 210 Preprocessing part
- 211 Format conversion part
- 212 Noise reduction part
- 10 220 Baggage attitude grasping part
- 221 Area designation part
- 222 Baggage overall image estimation part
- 223 Voxelization part
- 230 Determination part
- 15 231 Reference determination part
- 232 Difference extraction part
- 233 Fluctuation volume amount estimation part
- 234 Unity extraction part
- 235 Combination estimation part
- 20 236 Movement amount estimation part
- 237 Load collapse determination part
- 240 User interface part
- 241 Display part
- 242 Operation part
- 25 243 Warning output part
- 1000 Hardware resources
- 1001 Processor
- 1002 Memory
- 1003 Network interface
- 30 1004 Internal bus

CLAIMS:

[Claim 1]

A loading space recognition apparatus, comprising:

5 a baggage overall image estimation part configured to estimate an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data;

10 a voxelization part configured to voxelize the estimation result data to output the voxelized estimation result data as voxel data; and

a determination part configured to estimate a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determine
15 whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.

[Claim 2]

20 The loading space recognition apparatus according to claim 1, wherein the determination part comprises:

a reference determination part configured to determine the voxel data at the reference time from the voxelization part as a change reference point;

25 a difference extraction part configured to extract a difference of voxels at corresponding positions on a surface of the baggage viewed from a predetermined position by comparing the voxel data at the reference time with a voxel data at the time when a predetermined or arbitrary time has elapsed from the reference time and output the difference as difference data;

30 a fluctuation volume amount estimation part configured to estimate a fluctuation volume amount of the overall image of the baggage based on the difference data to output the fluctuation volume amount as fluctuation volume amount estimation data; and

a load collapse determination part configured to determine

whether or not there is a possibility of load collapse by comparing the fluctuation volume amount estimation data with a threshold for a fluctuation volume amount as the threshold.

[Claim 3]

5 The loading space recognition apparatus according to claim 2, wherein the determination part further comprises:

10 a unity extraction part configured to extract a unity of voxels without an increase or decrease in volume amount existing between a volume amount increasing voxel having a volume amount increased and a volume amount decreasing voxel having a volume amount decreased, at positions in a same horizontal direction, based on the difference data, and output the unity as unity data;

15 a combination estimation part configured to estimate a combination of the volume amount increasing voxel and the volume amount decreasing voxel based on the difference data and output the combination as combination data; and

20 a movement amount estimation part configured to estimate at least one movement amount of the baggage occurred during a period from the reference time to a time when a predetermined or arbitrary time has elapsed based on the difference data, the unity data, and the combination data, select a longest movement amount from among the movement amounts estimated, estimate the selected movement amount as a longest movement amount, and output the longest movement amount as longest movement amount estimation data,

25 wherein the load collapse determination part is configured to determine whether or not there is a possibility of load collapse by comparing the fluctuation volume amount estimation data with a threshold for a fluctuation volume amount as the threshold, and determine whether or not there is a possibility of load collapse by comparing the longest movement amount estimation data with a threshold for a longest movement amount as the threshold when it is determined that there is the possibility of load collapse.

30 [Claim 4]

 The loading space recognition apparatus according to claim 1,

wherein the determination part comprises:

a reference determination part configured to determine the voxel data at the reference time from the voxelization part as a change reference point;

5 a difference extraction part configured to extract a difference of voxels at corresponding positions on a surface of the baggage viewed from a predetermined position by comparing the voxel data at the reference time with the voxel data at the time when a predetermined or arbitrary time has elapsed from the reference time and output the
10 difference as difference data;

a unity extraction part configured to extract a unity of voxels without an increase or decrease in volume amount existing between a volume amount increasing voxel having a volume amount increased and a volume amount decreasing voxel having a volume amount decreased,
15 at positions in a same horizontal direction, based on the difference data, and output the unity as unity data;

a combination estimation part configured to estimate a combination of the volume amount increasing voxel and the volume amount decreasing voxel based on the difference data and output the
20 combination as combination data;

a movement amount estimation part configured to estimate at least one movement amount of the baggage occurred during a period from the reference time to a time when a predetermined or arbitrary time has elapsed based on the difference data, the unity data, and the combination
25 data, select a longest movement amount from among the movement amounts estimated, estimate the selected movement amount as a longest movement amount, and output the longest movement amount as longest movement amount estimation data; and

a load collapse determination part configured to determine
30 whether or not there is a possibility of load collapse by comparing the longest movement amount estimation data with a threshold for a longest movement amount as the threshold.

[Claim 5]

The loading space recognition apparatus according to any one of

claims 1 to 4, further comprising an area designation part configured to designate a loading area of the baggage in the loading space by user's operation,

wherein the baggage overall image estimation part is configured to estimate an overall image of the baggage loaded in the loading area.

[Claim 6]

The loading space recognition apparatus according to claim 5,

wherein the area designation part is configured to designate a determination exclusion area to be excluded from the determination of the determination part by user's operation, and

wherein the baggage overall image estimation part is configured to exclude the baggage loaded at the determination exclusion area and estimate the overall image of baggage loaded in the loading area.

[Claim 7]

The loading space recognition apparatus according to any one of claims 1 to 6, further comprising a detection part being mounted on a structure body having the loading space and detecting shaking or sound,

wherein the detection part is configured to acquire the voxel data from the voxelization part when the detection part detects shaking or sound of a predetermined level or more and estimate a fluctuation volume amount or a movement amount of the baggage by comparing the voxel data at the reference time with the acquired voxel data.

[Claim 8]

The loading space recognition apparatus according to claim 3 or 4, wherein the movement amount estimation part is configured to correct the movement amount to be smaller than the estimated movement amount when a movement direction of the baggage is in a lateral direction or correct the movement amount to be larger than the estimated movement amount when the movement direction of the baggage is in a vertical direction or an oblique direction and select a longest movement amount from among the corrected movement amounts.

[Claim 9]

The loading space recognition apparatus according to any one of claims 1 to 8, wherein the determination part is configured to further

determine whether or not there is a possibility of load collapse by comparing a change amount between one voxel data at a time other than the reference time and other voxel data that is one before the one voxel data with a change amount between the voxel data at the reference time and a voxel data at a time other than the reference time.

[Claim 10]

The loading space recognition apparatus according to any one of claims 1 to 9,

wherein the determination part is configured to output warning output instruction information when it is determined that there is a possibility of load collapse, and

wherein the loading space recognition apparatus further comprises a warning output part configured to output a warning based on the warning output instruction information.

[Claim 11]

A loading space recognition system, comprising:

a sensor outputting three-dimensional data imaged by sensing a surface of baggage in a loading space; and

a loading space recognition apparatus according to any one of claims 1 to 10.

[Claim 12]

A loading space recognition method, comprising:

estimating an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data;

voxelizing the estimation result data to output the voxelized estimation result data as voxel data; and

estimating a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determining whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.

[Claim 13]

A program causing hardware resource(s) to execute processing that recognizes a loading space of baggage, wherein the program causes the hardware resources to execute processings:

5 estimating an overall image of baggage loaded in a loading space based on three-dimensional data obtained by imaging the loading space of the baggage from a predetermined direction to output the overall image as estimation result data;

10 voxelizing the estimation result data to output the voxelized estimation result data as voxel data; and

15 estimating a fluctuation volume amount or a movement amount of the baggage by comparing a voxel data at an arbitrary reference time with a voxel data after a predetermined or arbitrary time has elapsed from the reference time and determining whether or not there is a possibility of load collapse by comparing the fluctuation volume amount or movement amount, as estimated, with a threshold.