CLAIMS:

[Claim 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.

[Claim 2]

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;

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;

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]

The loading space recognition apparatus according to claim 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 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.

[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;

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.

[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 non-transitory computer-readable recording medium storing thereon 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:

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.