Claims

[Claim 1]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image,

wherein the estimation unit estimates, for each of a plurality of regions formed by dividing a scanning range of the laser beam, the position of the industrial vehicle by using the valid point cloud data in a case where a number of pieces of the valid point cloud data belonging to each region is equal to or greater than the predetermined number.

[Claim 2]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the

position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image,

wherein

the extraction unit excludes point cloud data derived from an object that is only temporarily present from the point cloud data, and extracts remaining point cloud data as the valid point cloud data.

[Claim 3]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image,

wherein

in a case where a number of pieces of the valid point cloud data is less than the predetermined number and a previous estimated position belongs to a predefined camera-usable region, the estimation unit estimates the position of the industrial vehicle by using the image.

[Claim 4]

The position estimation device according to claim 3, wherein

the estimation unit changes the camera-usable region depending on a time of day.

[Claim 5]

The position estimation device according to claim 3 or 4, wherein in a case where a number of pieces of the valid point cloud data is less than the predetermined number and the previous estimated position does not belong to the predefined camera-usable region, the estimation unit estimates the position of the industrial vehicle by using a detection value of an internal field sensor mounted in the industrial vehicle.

[Claim 6]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image,

wherein

in a case where a number of pieces of the valid point cloud data is less than the predetermined number and characteristic points extracted from the image are evenly distributed, the estimation unit estimates the position of the industrial vehicle by using the image.

[Claim 7]

The position estimation device according to claim 6, wherein in a case where a number of pieces of the valid point cloud data is less than the predetermined number and the characteristic points extracted from the image are not evenly distributed, the estimation unit estimates the position of the industrial vehicle by using a detection value of an internal field sensor mounted in the industrial vehicle.

[Claim 8]

The position estimation device according to claim 6 or 7, wherein the estimation unit determines whether the characteristic points are evenly distributed based on the number of divided image regions including the characteristic points, the divided image regions being formed by dividing the image into a predetermined number.

[Claim 9]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image,

wherein

in a case where position estimation based on the valid point cloud data and position estimation based on the image are switched, the estimation unit performs a process of smoothly transitioning a position estimation result.

[Claim 10]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image,

wherein

the estimation unit estimates the position of the industrial vehicle by using the result of mixing, at a predetermined ratio, the position estimation result based on the valid point cloud data and the position estimation result based on the image.

[Claim 11]

A position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

the estimation unit estimates the position of the industrial vehicle by using a result of mixing, at a predetermined ratio, a position estimation result based on the valid point cloud data and a position estimation result based on the image.

[Claim 12]

The position estimation device according to claim 10 or 11, wherein the estimation unit dynamically changes the ratio in accordance with a situation.

[Claim 13]

The position estimation device according to claim 12, wherein the estimation unit performs mixing such that a weight of the position estimation result based on the valid point cloud data relatively increases when a

previous self-position is not included in a predetermined camera-usable region, and performs mixing such that a weight of the position estimation result based on the image relatively increases when the previous self-position is included in the camera-usable region.

[Claim 14]

A control device for controlling autonomous travel of an industrial vehicle, the control device comprising:

the position estimation device of any one of claims 1 to 13; and

a steering unit configured to cause the industrial vehicle to travel along a predetermined path based on an estimation result of the position.

[Claim 15]

The control device according to claim 14, wherein

the steering unit stops autonomous travel of the industrial vehicle in a case where an obstacle is detected in the travel direction based on the point cloud data.

[Claim 16]

An industrial vehicle comprising:

the control device of claim 14 or 15.

[Claim 17]

The industrial vehicle according to claim 16, wherein

the laser scanner is attached to a lower side of a vehicle main body.

[Claim 18]

An industrial vehicle comprising:

a control device for controlling autonomous travel of an industrial vehicle, the control device comprising:

a position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the position estimation device comprising:

an acquisition unit configured to acquire the point cloud data and the image;

an estimation unit configured to estimate the position of the industrial vehicle based on at least one of the point cloud data and the image; and

an extraction unit configured to extract, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, the estimation unit estimates the position of the industrial vehicle by using the valid point cloud data and in a case where a number of pieces of the valid point cloud data is less than the predetermined number, the estimation unit estimates the position of the industrial vehicle by using the image; and

a steering unit configured to cause the industrial vehicle to travel along a predetermined path based on an estimation result of the position,

wherein the camera is attached to be capable of imaging an area above the vehicle main body.

[Claim 19]

A logistics support system comprising:

the industrial vehicle of any one of claims 16 to 18; and

a host device configured to hold management information indicating a location of each industrial vehicle and a placement position of goods at a current time.

[Claim 20]

A position estimation method for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, the method comprising:

a step of acquiring the point cloud data and the image;

a step of estimating the position of the industrial vehicle based on at least one of the point cloud data and the image; and

a step of extracting, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in the step of estimating the position, the position of the industrial vehicle is estimated by using the valid point cloud data in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, and the position of the industrial vehicle is estimated by

using the image in a case where a number of pieces of the valid point cloud data is less than the predetermined number,

wherein, in the step of estimating the position, for each of a plurality of regions formed by dividing a scanning range of the laser beam, the position of the industrial vehicle by using the valid point cloud data in a case where a number of pieces of the valid point cloud data belonging to each region is equal to or greater than the predetermined number.

[Claim 21]

A program that causes a computer in a position estimation device for estimating a position of an industrial vehicle equipped with a laser scanner capable of acquiring point cloud data by scanning a laser beam and a camera capable of acquiring an image in a predetermined direction, to execute:

a step of acquiring the point cloud data and the image,

a step of estimating the position of the industrial vehicle based on at least one of the point cloud data and the image, and

a step of extracting, from the point cloud data, valid point cloud data that is usable for estimating the position, wherein

in the step of estimating the position, the position of the industrial vehicle is estimated by using the valid point cloud data in a case where a number of pieces of the valid point cloud data is equal to or greater than a predetermined number, and the position of the industrial vehicle is estimated by using the image in a case where a number of pieces of the valid point cloud data is less than the predetermined number,

wherein, in the step of estimating the position, for each of a plurality of regions formed by dividing a scanning range of the laser beam, the position of the industrial vehicle by using the valid point cloud data in a case where a number of pieces of the valid point cloud data belonging to each region is equal to or greater than the predetermined number.