

DESCRIPTION

MEASURING DEVICE, MEASUREMENT METHOD AND PROGRAM

5

TECHNICAL FIELD

[0001]

The present invention relates to a measuring device, a measurement method, and a program by which the height of an object on a road surface is measured.

Priority is claimed on Japanese Patent Application No. 2011-178875, filed
10 August 18, 2011, the content of which is incorporated herein by reference.

BACKGROUND ART

[0002]

In road pricing in the passage of a toll road and the like, a collected fee differs
15 according to each type of vehicle. Thus, a roadside device installed in the passage needs to measure a height of the vehicle in order to determine the type of vehicle. For the measurement of the height of the vehicle, for example, a measurement method using a laser sensor is used.

[0003]

20 As a method of measuring the vehicle height using a laser, there is a method in which the laser sensor provided above a road surface scans laser light toward the road surface and measures the strength of reflected light of the scanned laser and a time from radiation of the laser light to reception of the reflected light (for example, see Patent Document 1). Specifically, the vehicle height is calculated by measuring the length
25 from the laser sensor to the vehicle and subtracting the measured length from an

installation height of the laser sensor.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

5 [0004]

[Patent Document 1]

Japanese Unexamined Patent Application, First Publication No. 2002-008188

DISCLOSURE OF INVENTION

10 PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

However, because a water gradient through which rainwater and the like flow to a road side is provided on the road surface or a wheel rut is formed by the passage of vehicles, the road surface may not necessarily be flat. Thus, the installation height of
15 the laser sensor is likely to differ according to each point on the road surface and it may be difficult to accurately calculate the vehicle height when the above-described method is used.

The present invention is aimed at providing a measuring device, a measurement method, and a program by which the height of an object on an uneven road surface is
20 accurately calculated.

MEANS FOR SOLVING THE PROBLEMS

[0006]

According to a first embodiment of a measuring device of the present invention,
25 there is provided a measuring device which measures a height of an object on a road

surface, the measuring device including: a distance measuring unit configured to emit laser light from a reference position above the road surface toward a plurality of points on the road surface and measure a distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light; a storage unit configured to store road surface height information representing a relationship between a point on the road surface and a road surface height which is the distance from the reference position to the point; a road surface height specifying unit configured to specify the road surface height at each of the reflection points based on the road surface height information stored by the storage unit; and a height calculating unit configured to calculate a length from the road surface to the reflection point as the height of the object based on each distance calculated by the distance measuring unit and the road surface height specified by the road surface height specifying unit.

[0007]

According to a second embodiment of the measuring device of the present invention, in the first embodiment, the measuring device includes: an object determining unit configured to determine whether a difference between the distance measured by the distance measuring unit and the road surface height specified by the road surface height specifying unit is less than or equal to a predetermined threshold value for each reflection point; and an updating unit configured to update the road surface height information stored by the storage unit based on the road surface height of a reflection point when there is a reflection point at which the object determining unit determines that the difference between the distance measured by the distance measuring unit and the road surface height specified by the road surface height specifying unit is less than or equal to the predetermined threshold value.

[0008]

According to a third embodiment of the measuring device of the present invention, in the second embodiment, the measuring device includes: a road surface state determining unit configured to determine whether a road surface state is good, wherein,
5 only when there is a reflection point at which the object determining unit determines that the difference between the distance measured by the distance measuring unit and the road surface height specified by the road surface height specifying unit is less than or equal to the predetermined threshold value and the road surface state determining unit determines that the road surface state is good, the updating unit updates the road surface height
10 information stored by the storage unit based on the road surface height of the reflection point.

[0009]

According to a fourth embodiment of the measuring device of the present invention, in the third embodiment, when there is a reflection point at which the object
15 determining unit determines that the difference between the distance measured by the distance measuring unit and the distance specified by the road surface height specifying unit is less than or equal to the predetermined threshold value, the road surface state determining unit determines that a road surface state is good when a scattering degree of distances measured by the distance measuring unit at the reflection points is less than or
20 equal to a predetermined value for each reflection point.

[0010]

According to a fifth embodiment of the measuring device of the present invention, in any one of the first to fourth embodiments, the measuring device includes: a vehicle determining unit configured to determine whether there is a vehicle at the
25 reflection point; and a wheel position specifying unit configured to specify a position at

which there is a wheel of the vehicle when the vehicle determining unit determines that there is a vehicle, wherein the road surface height specifying unit specifies a road surface height of a point at which there is a vehicle based on the wheel position specified by the wheel position specifying unit.

5 [0011]

According to a sixth embodiment of the measuring device of the present invention, in the fifth embodiment, when reflection points at which the object determining unit determines that a difference between the distance measured by the distance measuring unit and the distance specified by the road surface height specifying
10 unit exceeds a predetermined threshold value among the reflection points are continuously present across a predetermined width, the vehicle determining unit determines that there is a vehicle at a position of the continuous reflection points.

[0012]

According to an embodiment of a measurement method of the present invention,
15 there is provided a measurement method using a measuring device, which includes a storage unit configured to store road surface height information representing a relationship between a point on a road surface and a road surface height which is a distance from a reference position above the road surface to the point and measures a height of an object on the road surface, the method including: a distance measuring
20 process of emitting laser light from the reference position toward a plurality of points on the road surface and measuring a distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light; a road surface height specifying process of specifying the road surface height at each of the reflection points based on the road surface height
25 information stored by the storage unit; and a height calculating process of calculating a

length from the road surface to the reflection point as the height of the object based on each distance calculated in the distance measuring process and the road surface height specified in the road surface height specifying process.

[0013]

5 According to the present invention, there is provided a program used to cause a measuring device, which includes a storage unit configured to store road surface height information representing a relationship between a point on a road surface and a road surface height which is the distance from a reference position above the road surface to the point and measures the height of an object on the road surface, to function as: a

10 distance measuring unit configured to emit laser light from the reference position above the road surface toward a plurality of points on the road surface and measure the distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light; a road surface height specifying unit configured to specify the road surface height at each of the reflection

15 points based on the road surface height information stored by the storage unit; and a height calculating unit configured to calculate the length from the road surface to the reflection point based on each distance calculated by the distance measuring unit and the road surface height specified by the road surface height specifying unit as the height of the object.

20 [0014]

 According to the present invention, there is provided a recording medium recording a program used to cause a computer of a measuring device, which includes a storage unit configured to store road surface height information representing a relationship between a point on a road surface and a road surface height which is the

25 distance from a reference position above the road surface to the point and measures the

height of an object on the road surface, to perform: a distance measuring process of emitting laser light from the reference position toward a plurality of points on the road surface and measuring the distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light; a road surface height specifying process of specifying the road surface height at each of the reflection points based on the road surface height information stored by the storage unit; and a height calculating process of calculating the length from the road surface to the reflection point as the height of the object based on each distance calculated in the distance measuring process and the road surface height specified in the road surface height specifying process.

EFFECTS OF THE INVENTION

[0015]

According to the present invention, based on the road surface height information stored by the storage unit, the measuring device specifies the road surface height at each reflection point and calculates the height of the object using the road surface height. Thereby, it is possible to accurately calculate the height of an object on an uneven road surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a configuration diagram of a measuring device according to an embodiment of the present invention.

Fig. 2 is a schematic block diagram illustrating a configuration of an information processing device.

Fig. 3 is a diagram illustrating an example of a road surface height table stored by a storage unit.

Fig. 4 is a flowchart illustrating an operation of the information processing device in this embodiment.

5 Fig. 5 is a diagram illustrating an example of a vehicle which runs on a road surface, wherein (A) is a diagram illustrating a relationship between the road surface and the vehicle, (B) is a diagram illustrating a calculation result including the influence of a wheel rut/gradient, and (C) is a diagram illustrating a calculation result from which the influence of the wheel rut/gradient is removed.

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PREFERRED EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0017]

Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings.

15 Fig. 1 is a configuration diagram of a measuring device according to the embodiment of the present invention. The measuring device includes a laser sensor 1 (distance measuring unit) and an information processing device 2.

The laser sensor 1 is installed above a road surface D via a cantilever or a gantry, and laser light Z is scanned from its installation position S to the road surface D. The
20 laser sensor 1 emits the laser light Z toward a plurality of points E on the road surface D by scanning the laser light Z toward the road surface D. In addition, the laser sensor 1 measures the distance (measurement distance H) from a predetermined reference position T to a reflection point R which is a point at which the laser light Z is reflected based on reflected light of the scanned laser light Z.

25 In this embodiment, the reference position T is a position of the same height as

that of the installation position S of the laser sensor 1 and a position immediately above the reflection point R. That is, in this embodiment, the measurement distance H is equivalent to the difference between the height of the installation position S of the laser sensor 1 and the height of the reflection point R.

5 [0018]

As examples of a relationship between the reflection point R and the measurement distance H output by the laser sensor 1 to the information processing device 2, there is a relationship of a polar coordinate system indicated by a scanning angle θ from the origin of the laser sensor 1 and a straight line distance L to the reflection point R at the scanning angle θ , a relationship of an orthogonal coordinate system indicated by a position X of a horizontal direction in which the installation position S of the laser sensor 1 is the origin and a distance Y of a vertical direction from the position X to the reflection point R, and so on.

When the laser sensor 1 outputs the relationship of the orthogonal coordinate system to the information processing device 2, the laser sensor 1 calculates $X = L\sin\theta$ and $Y = L\cos\theta$ using the scanning angle θ and the straight line distance L, and outputs a relationship between the position X and the distance Y to the information processing device 2.

The information processing device 2 calculates a height of a vehicle O (object) on the road surface D based on the distance measured by the laser sensor 1.

[0019]

Fig. 2 is a schematic block diagram illustrating a configuration of the information processing device 2.

The information processing device 2 includes a sensor information acquiring unit 21, a storage unit 22, a road surface height specifying unit 23, an object determining

unit 24, a road surface state determining unit 25, an updating unit 26, a vehicle
determining unit 27, a wheel position specifying unit 28, and a height calculating unit 29.
[0020]

5 The sensor information acquiring unit 21 acquires the measurement distance H
in association with coordinates (for example, a distance from a road side) representing a
position of a road surface width direction of the reflection point R at each reflection point
R from the laser sensor 1.

[0021]

Fig. 3 is a diagram illustrating an example of a road surface height table stored
10 by the storage unit 22.

The storage unit 22 stores the road surface height table (road surface height
information) in which a point E on the road surface D and a road surface height I which
is the distance from the reference position T corresponding to the point E to the point E
are associated and stored. As an example of the road surface height table, as illustrated
15 in Fig. 3, there is a road surface height table in which the height of each division point is
stored in association with the division point when the road surface D is divided every 10
centimeters in a width direction.

The road surface height table is created by measuring the road surface height I
using the laser sensor 1 in advance when there is no object and recording the measured
20 value in association with the point E on the road surface D.

In the laser sensor 1, drift may generally occur in the measurement result due to
temperature. Thus, the updating unit 26 updates a value of the road surface height table
stored by the storage unit 22 to a value including an offset due to an influence of
temperature drift.

25 [0022]

Based on the road surface height information stored by the storage unit 22, the road surface height specifying unit 23 reads the road surface height I corresponding to the reflection point R acquired by the sensor information acquiring unit 21 and outputs the road surface height I to the object determining unit 24.

5 In addition, after the determination by the object determining unit 24, the road surface height specifying unit 23 specifies the road surface height I corresponding to the point E at which there is a vehicle O based on the road surface height information and a wheel position specified by the wheel position specifying unit 28, and outputs the road surface height I to the height calculating unit 29.

10 [0023]

 The object determining unit 24 determines whether there is an object serving as a height measurement target at the reflection point R by determining whether a difference between the measurement distance H acquired by the sensor information acquiring unit 21 and the road surface height I acquired from the road surface height specifying unit 23
15 is less than or equal to a predetermined threshold value for each reflection point R.

 The road surface state determining unit 25 acquires the measurement distance H acquired by the sensor information acquiring unit 21 and the determination result of the object determining unit 24, and determines whether the state of the road surface D is good based on a scattering degree of measurement distances H of reflection points R at
20 which it is determined that there is no object.

 When the road surface state determining unit 25 determines that the state of the road surface D is good, the updating unit 26 updates the road surface height table stored by the storage unit 22 based on a difference between the measurement distance H and the road surface height I at each reflection point R at which it is determined that there is no
25 object.

[0024]

The vehicle determining unit 27 determines whether there is a vehicle O at the reflection point R at which the object determining unit 24 determines that there is an object.

5 When the vehicle determining unit 27 determines that there is a vehicle O, the wheel position specifying unit 28 specifies the position of its wheel.

The height calculating unit 29 calculates the height of the object by calculating a difference between the measurement distance H acquired by the sensor information acquiring unit 21 and the road surface height I specified by the road surface height specifying unit 23 for each reflection point R.

[0025]

In this embodiment, the laser sensor 1 performs scanning of the laser light Z at predetermined time intervals, and outputs coordinates representing a position of a road surface width direction of the reflection point R and the measurement distance H to the information processing device 2 for each reflection point R as the measurement result.

Hereinafter, an operation of the information processing device 2 to be executed every time the measurement result is received from the laser sensor 1 will be described.

[0026]

Fig. 4 is a flowchart illustrating an operation of the information processing device 2 in this embodiment.

When the measurement result is output from the laser sensor 1, the sensor information acquiring unit 21 acquires the measurement result (step S1).

Next, the sensor information acquiring unit 21 outputs the acquired measurement result to the object determining unit 24. In addition, the sensor information acquiring unit 21 outputs coordinates of the reflection point R among the

acquired measurement results to the road surface height specifying unit 23.

[0027]

Next, the road surface height specifying unit 23 reads the road surface height I corresponding to coordinates of each reflection point R acquired from the sensor

5 information acquiring unit 21 by referring to the road surface height table stored by the storage unit 22, and outputs the read road surface height I to the object determining unit 24 (step S2). At this time, the road surface height specifying unit 23 outputs the road surface height I associated with a division point (see Fig. 3) closest to coordinates of the reflection point R as the road surface height I corresponding to the coordinates of the

10 reflection point R.

[0028]

Next, the object determining unit 24 calculates a difference between the measurement distance H acquired from the sensor information acquiring unit 21 and the road surface height I acquired from the road surface height specifying unit 23 for each

15 reflection point R (step S3).

Next, based on the calculated difference, the object determining unit 24 determines whether there is an object at the reflection point R for each reflection point R (step S4). Specifically, the object determining unit 24 determines that there is an object at the reflection point R at which the calculated difference is greater than or equal to a

20 predetermined threshold value (for example, 1 meter), and determines that there is no object at the reflection point R at which the calculated difference is less than the predetermined threshold value. When there is no object at the reflection point R, the laser light Z emitted by the laser sensor 1 is reflected by the road surface D and the reflection point R is the point E on the road surface D.

25 [0029]

Next, the road surface state determining unit 25 acquires the distance at the reflection point R at which the object determining unit 24 determines that there is no object among the measurement results acquired by the sensor information acquiring unit 21 in step S1. Then, the road surface state determining unit 25 calculates a standard deviation of measurement distances H at reflection points R at which it is determined that there is continuously no object in a predetermined number of most recent measurements (step S5).

Next, the road surface state determining unit 25 determines whether the road surface state is good by determining whether the calculated standard deviation is greater than or equal to a predetermined threshold value (step S6). Specifically, when the calculated standard deviation is greater than or equal to the predetermined threshold value, the road surface state determining unit 25 determines that the road surface state is bad. When the road surface D is wet due to rainy weather or the like, variation in the measurement distance H increases because the laser light Z radiated by the laser sensor 1 is irregularly reflected. That is, when the road surface state is bad, the reliability of the measured results by the laser sensor 1 is low.

[0030]

When the road surface state determining unit 25 determines that the road surface state is good (step S6: YES), the updating unit 26 acquires a difference associated with the reflection point R at which the object determining unit 24 determines that there is no object among differences calculated in step S3. Then, the updating unit 26 updates the road surface height table stored by the storage unit 22 based on a value of the acquired difference (step S7). As a method of updating the road surface height table, for example, there is a method of calculating an average value between acquired differences and adding the average value to each road surface height I of the road surface height table.

In addition, a method of deriving a function representing an influence of temperature drift in the laser sensor 1 from a relationship between the reflection point R and the value of the acquired difference and adding the influence of temperature drift to each road surface height I of the road surface height table based on the function may be used.

5 [0031]

When the road surface state determining unit 25 determines that the road surface state is bad in step S6 (step S6: NO) or when the updating unit 26 updates the road surface height table in step S7, the road surface height specifying unit 23 reads the road surface height I of each reflection point R from the road surface height table stored by the storage unit 22 (step S8). When it is determined that the road surface state is good in step S6, the road surface height I read by the road surface height specifying unit 23 is set as the road surface height I of the road surface height table updated in step S7.

Next, the height calculating unit 29 calculates the height of each reflection point R by subtracting the measurement distance H acquired by the sensor information acquiring unit 21 in step S1 from the road surface height I read by the road surface height specifying unit 23 (step S9).

[0032]

Next, for each reflection point R at which the object determining unit 24 determines that there is an object, the vehicle determining unit 27 determines whether there is a vehicle O at the reflection point R (step S10). Specifically, when there are reflection points R at which the object determining unit 24 determines that there is continuously an object across a predetermined width (for example, 40 centimeters), the vehicle determining unit 27 determines that there is a vehicle O at a position of a group of the continuous reflection points R.

25 [0033]

When the vehicle determining unit 27 determines that there is no group of the reflection points R at which there is a vehicle O (step S10: NO), the information processing device 2 outputs the height of the reflection point R calculated in step S9 as the height of the object on the road surface D and ends the process.

5 On the other hand, upon determining that there is a group of the reflection points R at which there is a vehicle O (step S10: YES), the vehicle determining unit 27 determines whether the vehicle O is a four-wheeled vehicle O1 (step S11). Specifically, when the width of the vehicle O is greater than or equal to a predetermined width (for example, 70 centimeters), the vehicle determining unit 27 determines that the vehicle O
10 is a four-wheeled vehicle. Otherwise, the vehicle determining unit 27 determines that the vehicle O is a two-wheeled vehicle O2.

[0034]

When the vehicle determining unit 27 determines that the vehicle O is the four-wheeled vehicle (step S11: YES), the wheel position specifying unit 28 specifies
15 that each of points R at a predetermined length (for example, 10 centimeters) inward from both ends of the group of the reflection points R at which the vehicle determining unit 27 determines that there is a four-wheeled vehicle is the position of a wheel of the four-wheeled vehicle (step S12).

On the other hand, when the vehicle determining unit 27 determines that the
20 vehicle O is a two-wheeled vehicle (step S11: NO), the wheel position specifying unit 28 specifies that the center point R of the group of the reflection points R at which the vehicle determining unit 27 determines that there is a two-wheeled vehicle is a position of a wheel of the two-wheeled vehicle (step S13).

[0035]

25 When the wheel position specifying unit 28 specifies a wheel position in step

S12 or S13, the road surface height specifying unit 23 specifies the road surface height I corresponding to the group of the reflection points R at which the vehicle determining unit 27 determines that there is a vehicle O based on the road surface height I corresponding to the specified wheel position among road surface heights I read in step S8 (step S14). Specifically, because the wheel position is specified by two reflection points R in step S12 when the vehicle O is a four-wheeled vehicle, the road surface height I corresponding to the group of the reflection point R is calculated by linearly complementing two road surface heights I corresponding to the wheel position.

On the other hand, because the wheel position is specified by one reflection point R in step S13 when the vehicle O is a two-wheeled vehicle, the road surface height I corresponding to the wheel position is set as a road surface height I corresponding to the group of the reflection points R.

[0036]

A reason for which the road surface height I is specified in step S14 will be described.

Fig. 5 is a diagram illustrating an example of a vehicle which runs on a road surface, wherein (A) is a diagram illustrating a relationship between the road surface and the vehicle, (B) is a graphic diagram illustrating a calculation result including the influence of a wheel rut/gradient, and (C) is a graphic diagram illustrating a calculation result from which the influence of the wheel rut/gradient is removed.

[0037]

As illustrated in Fig. 5(A), a wheel rut W may be formed on the road surface D according to the passage of vehicles O.

If the height of the vehicle O is calculated based on only the road surface height table stored by the storage unit 22 when there is a four-wheeled vehicle on the wheel rut

W as illustrated in Fig. 5(A), the calculation result of the height of the vehicle O includes the influence of unevenness due to the wheel rut W as illustrated in Fig. 5(B).

On the other hand, when the road surface height I is specified in the process of step S14, it is possible to remove the influence of a wheel rut from the calculation result of the height of the vehicle O as illustrated in Fig. 5(C) (see a reference line P of the height of the vehicle O of Fig. 5(A)).

[0038]

Because the number of wheels of the two-wheeled vehicle is one, a posture does not depend upon a gradient. Thus, when the height of the vehicle O is calculated based on only a road surface height table stored by the storage unit 22, the calculation result of the height of the vehicle O includes the influence of the gradient as illustrated in Fig. 5(B).

On the other hand, when the road surface height I is specified in the process of step S14, it is possible to remove the influence of the gradient from the calculation result of the height of the vehicle O as illustrated in Fig. 5(C) (see the reference line P of the height of the vehicle O of Fig. 5(A)).

[0039]

When the road surface height specifying unit 23 specifies the road surface height I in step S14, the height calculating unit 29 calculates the height of the vehicle O by subtracting the measurement distance H acquired by the sensor information acquiring unit 21 in step S1 from the road surface height I specified by the road surface height specifying unit 23 (step S15). Then, the height calculating unit 29 replaces the height of the reflection point R at which the vehicle O is present with the height of the vehicle O calculated in step S15. Thereby, it is possible to calculate the height of the object for each reflection point R of the laser light Z.

[0040]

Although the exemplary embodiments of the present invention have been described above with reference to the drawings, specific configurations are not limited to the above-described exemplary embodiments. Various design changes and the like are possible within the scope without departing from the scope of the present invention.

[0041]

Although the case in which the laser sensor 1 outputs the distance H from the reference position T to the reflection point R to the information processing device 2 has been described in this embodiment, the present invention is limited thereto. That is, the present invention is not limited to the case in which the measurement result of the laser sensor 1 is a value of the orthogonal coordinate system. For example, the laser sensor 1 can perform a similar process even when a scanning angle θ of a laser R1 and a distance L to a reflection point R are output to the information processing device 2. That is, the measurement result of the laser sensor 1 may be a value of the polar coordinate system.

In this case, the reference position T is the installation position S, and the road surface height table needs to store the relationship between the scanning angle θ and the road surface height I.

[0042]

Although the case in which the scanning type laser sensor 1 is used as a distance measuring unit has been described in this embodiment, the present invention is not limited thereto. A laser sensor based on another sensing scheme such as a multi-optical axis may be used.

[0043]

Although the case in which the road surface height specifying unit 23 outputs the road surface height I associated with a division point closest to coordinates of the

reflection point R as the road surface height I corresponding to the coordinates of the reflection point R has been described in this embodiment, the present invention is not limited thereto. For example, the road surface height specifying unit 23 may obtain the road surface height I corresponding to the coordinates of the reflection point R through the interpolation calculation of the road surface height I associated with two division points in the vicinity of the coordinates of the reflection point R.

[0044]

Although the case in which the storage unit 22 stores a relationship between the point E on the road surface D and the road surface height I which is the distance from the reference position T to the point E as the road surface height table has been described in this embodiment, the present invention is not limited thereto. For example, when there is no wheel rut W on the road surface D or when the wheel rut W is negligibly small, the storage unit 22 may store a function representing a relationship between the point E on the road surface D and the road surface height I which is the distance from the reference position T to the point E as the road surface height information.

[0045]

Although the case in which the road surface state determining unit 25 determines whether the road surface state is good based on a standard deviation of measurement information of each time for reflection points R at which there is continuously no object has been described in this embodiment, the present invention is not limited thereto. For example, it may be determined whether or not a road surface state is good based on a value representing another scattering degree such as a range based on a magnitude of variance or a difference between a maximum value and a minimum value. In addition, it may be determined whether or not a road surface state is good based on a scattering degree of a plurality of reflection points at which there is no

object at a certain time rather than the standard deviation of measurement information of each time.

[0046]

Although the case in which the road surface state determining unit 25
5 determines whether the road surface state is good based on a scattering degree of measurement information has been described above in this embodiment, the present invention is not limited thereto. For example, when a rainfall sensor or the like is provided and the rainfall sensor detects rainfall, the road surface state determining unit 25 may determine that the road surface state is bad.

10 [0047]

Although the case in which the difference of the road surface height I is overwritten in the processes of steps S10 to S15 after the height of each reflection point R is first calculated in steps S8 and S9 has been described in this embodiment, the present invention is not limited thereto. For example, the height of the reflection point
15 R at which there is no vehicle O may be calculated according to a procedure similar to steps S8 and S9 after the processes of steps S10 to S15 are first executed.

[0048]

Although the case in which the height including the vehicle O and the road surface D is calculated by calculating heights of all reflection points R has been
20 described in this embodiment, the present invention is not limited thereto. For example, the measuring device may merely calculate the height of the vehicle O. In this case, only the height of the vehicle O may be calculated by omitting the processes of steps S8 and S9 and performing the processes of steps S10 to S15.

[0049]

25 The information processing device 2 internally has a computer system. An

operation of each processing unit described above is stored in a computer-readable recording medium in the form of a program and the above-described process is executed by causing a computer to read the program. Here, the computer-readable recording medium is a magnetic disk, a magneto-optical disc, a compact disc-read only memory (ROM) (CD-ROM), a digital versatile disc (DVD)-ROM, a semiconductor memory, or the like. The computer program may be distributed to the computer by a communication line, and the computer receiving the distribution may execute the program.

[0050]

The above-described program may be used to implement some of the above-described functions. Further, the program may be a so-called differential file (differential program) capable of implementing the above-described functions in combination with a program already recorded on the computer system.

DESCRIPTION OF THE REFERENCE SYMBOLS

[0051]

1	Laser sensor (distance measuring unit)
2	Information processing device
21	Sensor information acquiring unit
22	Storage unit
23	Road surface height specifying unit
24	Object determining unit
25	Road surface state determining unit
26	Updating unit
27	Vehicle determining unit

	28	Wheel position specifying unit
	29	Height calculating unit
	A	Measuring device
	Z	Laser light
5	D	Road surface
	W	Wheel rut
	E	Point on road surface
	S	Installation position
	T	Reference position
10	R	Reflection point
	H	Measurement distance
	I	Road surface height
	O	Object

CLAIMS

[Claim 1]

A measuring device which measures a height of an object on a road surface, the measuring device comprising:

5 a distance measuring unit configured to emit laser light from a reference position above the road surface toward a plurality of points on the road surface and measure a distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light;

 a storage unit configured to store road surface height information representing a
10 relationship between a point on the road surface and a road surface height which is the distance from the reference position to the point;

 a road surface height specifying unit configured to specify the road surface height at each of the reflection points based on the road surface height information stored by the storage unit; and

15 a height calculating unit configured to calculate a length from the road surface to the reflection point as the height of the object based on each distance calculated by the distance measuring unit and the road surface height specified by the road surface height specifying unit.

[Claim 2]

20 The measuring device according to claim 1, comprising:

 an object determining unit configured to determine whether a difference between the distance measured by the distance measuring unit and the road surface height specified by the road surface height specifying unit is less than or equal to a predetermined threshold value for each reflection point; and

25 an updating unit configured to update the road surface height information stored

by the storage unit based on the road surface height of a reflection point when there is a reflection point at which the object determining unit determines that the difference between the distance measured by the distance measuring unit and the road surface height specified by the road surface height specifying unit is less than or equal to the predetermined threshold value.

[Claim 3]

The measuring device according to claim 2, comprising:

a road surface state determining unit configured to determine whether a road surface state is good,

wherein, only when there is a reflection point at which the object determining unit determines that the difference between the distance measured by the distance measuring unit and the road surface height specified by the road surface height specifying unit is less than or equal to the predetermined threshold value and the road surface state determining unit determines that the road surface state is good, the updating unit updates the road surface height information stored by the storage unit based on the road surface height of the reflection point.

[Claim 4]

The measuring device according to claim 3, wherein, when there is a reflection point at which the object determining unit determines that the difference between the distance measured by the distance measuring unit and the distance specified by the road surface height specifying unit is less than or equal to the predetermined threshold value, the road surface state determining unit determines that a road surface state is good when a scattering degree of distances measured by the distance measuring unit at the reflection points is less than or equal to a predetermined value for each reflection point.

[Claim 5]

The measuring device according to any one of claims 1 to 4, comprising:

a vehicle determining unit configured to determine whether there is a vehicle at the reflection point; and

a wheel position specifying unit configured to specify a position at which there is a wheel of the vehicle when the vehicle determining unit determines that there is a vehicle,

wherein the road surface height specifying unit specifies a road surface height of a point at which there is a vehicle based on the wheel position specified by the wheel position specifying unit.

10 [Claim 6]

The measuring device according to claim 5, wherein, when reflection points at which the object determining unit determines that a difference between the distance measured by the distance measuring unit and the distance specified by the road surface height specifying unit exceeds a predetermined threshold value among the reflection points are continuously present across a predetermined width, the vehicle determining unit determines that there is a vehicle at the position of the continuous reflection points.

[Claim 7]

A measurement method using a measuring device, which includes a storage unit configured to store road surface height information representing a relationship between a point on a road surface and a road surface height which is a distance from a reference position above the road surface to the point and measures a height of an object on the road surface, the method comprising:

a distance measuring process of emitting laser light from the reference position toward a plurality of points on the road surface and measuring a distance from the reference position to a reflection point which is a point at which the laser light has been

reflected based on the reflected light of the laser light;

a road surface height specifying process of specifying the road surface height at each of the reflection points based on the road surface height information stored by the storage unit; and

- 5 a height calculating process of calculating a length from the road surface to the reflection point as the height of the object based on each distance calculated in the distance measuring process and the road surface height specified in the road surface height specifying process.

[Claim 8]

- 10 A program used to cause a measuring device, which includes a storage unit configured to store road surface height information representing a relationship between a point on a road surface and a road surface height which is a distance from a reference position above the road surface to the point and measures a height of an object on the road surface, to function as:

- 15 a distance measuring unit configured to emit laser light from the reference position above the road surface toward a plurality of points on the road surface and measure a distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light;

- a road surface height specifying unit configured to specify the road surface height at each of the reflection points based on the road surface height information stored by the storage unit; and

- a height calculating unit configured to calculate a length from the road surface to the reflection point based on each distance calculated by the distance measuring unit and the road surface height specified by the road surface height specifying unit as the height of the object.

[Claim 9]

A recording medium recording a program used to cause a computer of a measuring device, which includes a storage unit configured to store road surface height information representing a relationship between a point on a road surface and a road surface height which is a distance from a reference position above the road surface to the point and measures a height of an object on the road surface, to perform:

a distance measuring process of emitting laser light from the reference position toward a plurality of points on the road surface and measuring a distance from the reference position to a reflection point which is a point at which the laser light has been reflected based on the reflected light of the laser light;

a road surface height specifying process of specifying the road surface height at each of the reflection points based on the road surface height information stored by the storage unit; and

a height calculating process of calculating a length from the road surface to the reflection point as the height of the object based on each distance calculated in the distance measuring process and the road surface height specified in the road surface height specifying process.