

DESCRIPTION

DEVICE FOR MEASURING AN OBJECT TO BE MEASURED, PROCESSING
METHOD THEREOF, AND PROGRAM

5

Technical Field

[0001]

The present invention relates to a device for measuring an object to be measured which measures a length of the object to be measured, a processing method thereof, and a
10 program.

Priority is claimed on Japanese Patent Application No. 2011-215482, filed September 29, 2011, the content of which is incorporated herein by reference.

Background Art

15

[0002]

On toll roads, tolls are set based on the sizes of vehicles passing through the roads of predetermined sections. In addition, for example, an ERP system, an ETC system and the like determine coherence between vehicle type information obtained through communication with an in-vehicle device and a vehicle type specified by
20 measuring an external shape of a vehicle so as to execute a crackdown on illegal resetting of the in-vehicle device. Therefore, it is necessary to accurately determine the size of the vehicle, that is, various factors of the vehicle such as the length, the height, and the width of the vehicle, on the toll road. Further, PTL 1 and PTL 2 disclose technologies to determine the size of the vehicle.

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Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application, First Publication No.

5 H11-203588

[PTL 2] Japanese Unexamined Patent Application, First Publication No.

2000-020876

Summary of Invention

10 Technical Problem

[0004]

Here, PTL 1 and PTL 2 include technologies to measure the size of a vehicle by a laser radiated from a measurement device. However, when measuring the size in a length direction of the vehicle (hereinafter, referred to as a vehicle length), it is necessary to consider the influence of acceleration and deceleration of the vehicle traveling between a plurality of detection devices which are installed spaced apart. This requires the measurement accuracy of the vehicle length of the vehicle to be improved. For example, in PTL 1, the velocity of a vehicle is specified in response to a change point of a vehicle height so as to improve the measurement accuracy of the vehicle length.

20 However, in a case of considering only the change point of the vehicle height, there is a problem in that the velocity of the vehicle cannot be measured accurately using the change point of the vehicle height in a box-shaped vehicle such as a bus with little characteristic change in the vehicle height.

[0005]

25 Therefore, an object of the present invention is to provide a device for

measuring an object to be measured, a processing method thereof, and a program which are capable of solving the above problems.

Solution to Problem

5 [0006]

To achieve the above object, the present invention provides a device for measuring an object to be measured, including: an input unit that receives a strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured from each of a plurality of detection devices, the detection devices
10 being located in respective installation positions which are provided spaced apart in a traveling direction of the object to be measured; a signal strength corresponding relationship determination unit that classifies signal strengths of a plurality of light reflection signals which are respectively detected by the detection devices depending on a time elapsed, for each corresponding relationship of a signal strength indicating the
15 same portion of the object to be measured; and a first velocity calculation unit that calculates a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating the same portion, for each corresponding relationship of the classified signal strength, and
20 calculates a velocity of the object to be measured at the signal strength detection time in any one or all of the plurality of detection devices for each corresponding relationship of the classified signal strength, based on the time difference between the signal strength detection times and an installation interval between the plurality of detection devices.

[0007]

25 Further, in the device for measuring an object to be measured described above

according to the present invention may further include a length calculation unit that calculates a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection times in any one or all of the plurality of detection devices.

[0008]

Further, in the device for measuring an object to be measured described above according to the present invention, it may be so that the input unit receives height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height information of the object to be measured using a radiation-reception interval between a radiation time of a light radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal, each of the detection devices includes a height corresponding relationship determination unit that classifies a plurality of pieces of height information of the object to be measured which are respectively calculated by the detection devices depending on time elapsed for each corresponding relationship of height information indicating the same portion of the object to be measured, and a second velocity calculation unit that calculates a time difference between height detection times of respective pieces of height information in the plurality of detection devices that calculate respective pieces of height information included in the corresponding relationship of height information indicating the same portion, for each corresponding relationship of the classified height information, and calculates a velocity of the object to be measured at the height detection time in any one or all of the plurality of detection devices, for each corresponding relationship of the classified height

information, based on the time difference between the height detection times and an installation interval in the traveling direction between the plurality of detection devices, and the length calculation unit calculates a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified height information, at the height detection time in any one or all of the plurality of detection devices and the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection time in any one or all of the plurality of detection devices.

[0009]

Further, the present invention is a processing method of a device for measuring an object to be measured, the method including: receiving a strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured from each of a plurality of detection devices by an input unit, the detection devices being located in respective installation positions which are provided spaced apart in a traveling direction of the object to be measured; classifying signal strengths of a plurality of light reflection signals which are respectively detected by the detection devices depending on time elapsed, for each corresponding relationship of a signal strength indicating the same portion of the object to be measured, by a signal strength corresponding relationship determination unit; calculating a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating the same portion, for each corresponding relationship of the classified signal strength, by a first velocity calculation unit; and calculating a velocity of the object to be measured at the signal strength detection time in any one or

all of the plurality of detection devices, for each corresponding relationship of the classified signal strength, based on the time difference between the signal strength detection times and an installation interval between the plurality of detection devices.

[0010]

5 Further, the processing method described above according to the present invention may further include calculating a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection times in any one or all of the
10 plurality of detection devices, by a length calculation unit.

[0011]

Further, the processing method described above according to the present invention may further include receiving height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height
15 information of the object to be measured using a radiation-reception interval between a radiation time of a light radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal, by the input unit; classifying a plurality of pieces of height information of the object to be measured which are respectively calculated by the detection devices depending on time
20 elapsed for each corresponding relationship of height information indicating the same portion of the object to be measured by a height corresponding relationship determination unit; calculating a time difference between height detection times of respective pieces of height information in the plurality of detection devices that calculate respective pieces of height information included in the corresponding relationship of height information
25 indicating the same portion, for each corresponding relationship of the classified height

information, and to calculate a velocity of the object to be measured at the height
 detection time in any one or all of the plurality of detection devices, for each
 corresponding relationship of the classified height information, based on the time
 difference between the height detection times and an installation interval in the traveling
 5 direction between the plurality of detection devices, by a second velocity calculation unit;
 and calculating a length in the traveling direction of the object to be measured moving
 between the plurality of detection devices, based on the velocity of the object to be
 measured, which is calculated for each corresponding relationship of the classified height
 information, at the height detection time in any one or all of the plurality of detection
 10 devices and the velocity of the object to be measured, which is calculated for each
 corresponding relationship of the classified signal strength, at the signal strength
 detection time in any one or all of the plurality of detection devices, by the length
 calculation unit.

[0012]

15 Further, the present invention relates to a program of a computer of a device for
 measuring an object to be measured, to function as:

input portion for receiving a strength of a light reflection signal corresponding to
 a light radiation signal which is radiated to the object to be measured from each of a
 plurality of detection devices, the detection devices being located in respective
 20 installation positions which are provided spaced apart in a traveling direction of the
 object to be measured;

signal strength corresponding relationship determination portion for classifying
 signal strengths of a plurality of light reflection signals which are respectively detected
 by the detection devices depending on a time elapsed, for each corresponding
 25 relationship of a signal strength indicating the same portion of the object to be measured;

and

first velocity calculation portion for calculating a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating the same portion, for each corresponding relationship of the classified signal strength, and for calculating a velocity of the object to be measured at the signal strength detection time in any one or all of the plurality of detection devices, for each corresponding relationship of the classified signal strength, based on the time difference between the signal strength detection times and an installation interval between the plurality of detection devices.

[0013]

Further, the present invention relates to a program that further causes the computer to function as length calculation portion for calculating a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection times in any one or all of the plurality of detection devices.

[0014]

Further, the present invention relates to a program in which the input portion receives height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height information of the object to be measured using a radiation-reception interval between a radiation time of a light radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal, in which the program causes the computer to function as height corresponding relationship determination

portion for classifying a plurality of pieces of height information of the object to be measured which are respectively calculated by the detection devices depending on a time elapsed, for each corresponding relationship of height information indicating the same portion of the object to be measured, and second velocity calculation portion for

5 calculating a time difference between height detection times of respective pieces of height information in the plurality of detection devices that calculate respective pieces of height information included in the corresponding relationship of height information indicating the same portion, for each corresponding relationship of the classified height information, and for calculating a velocity of the object to be measured at the height

10 detection time in any one or all of the plurality of detection devices, for each corresponding relationship of the classified height information, based on the time difference between the height detection times and an installation interval in the traveling direction between the plurality of detection devices, and in which the length calculation portion calculates a length in the traveling direction of the object to be measured moving

15 between the plurality of detection devices, based on the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified height information, at the height detection time in any one or all of the plurality of detection devices and the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength

20 detection time in any one or all of the plurality of detection devices.

Advantageous Effects of Invention

[0015]

According to the process of the device for measuring an object to be measured

25 of the present invention, it is possible to detect a length in a traveling direction of an

object to be measured accurately.

Brief Description of Drawings

[0016]

5 FIG. 1 is a diagram showing a configuration of a measurement system.

FIG. 2 is a functional block diagram of the device for measuring an object to be measured.

FIG. 3 is a diagram showing an example of data which is received by an input unit.

10 FIG. 4 is a diagram showing measurement result data based on information which is received by the input unit.

FIG. 5 is a diagram showing a data example of information which is received by the device for measuring an object to be measured.

15 FIG. 6 is a diagram showing a relationship between each characteristic detection time and a velocity calculated using the characteristic detection time.

FIG. 7 is a diagram showing a process flow of the device for measuring an object to be measured.

Description of Embodiments

20 [0017]

Hereinafter, a measurement system including a device for measuring an object to be measured according to an embodiment of the present invention will be described with reference to drawings.

25 FIG. 1 is a diagram showing a configuration of a measurement system of the same embodiment.

In FIG. 1, the reference numeral 10 is a device for measuring an object to be measured which measures a size of the object to be measured. In the present embodiment, the device 10 for measuring an object to be measured is intended to measure the length of a vehicle 30 as the size of the object to be measured. The vehicle 30 travels on a road in a traveling direction (direction from right to left in the FIG. 1).

In FIG. 1, the reference numeral 21 is an entrance-side detection device, and the reference numeral 22 is an exit-side detection device. The entrance-side detection device 21 and the exit-side detection device 22 have laser sensors, and receive reflection signals (light reflection signals) corresponding to radiation signals (light radiation signals) of the laser sensors. Thus, the entrance-side detection device 21 and the exit-side detection device 22 detect a distance to the object to be measured, from a difference between the radiation time of the radiation signal and the reception time of the reflection signal to be received corresponding to the radiation signal and a velocity of the optical signal, or detect the strength of the reflection signal (the amount of reflected light).

[0018]

In addition, FIG. 1 shows a situation in which the entrance-side detection device 21 and the exit-side detection device 22 are installed in installation positions which are spaced apart in the traveling direction of the vehicle 30, above the vehicle 30 traveling on the road. It is assumed that the distance D between the entrance-side detection device 21 and the exit-side detection device 22 is, for example, approximately 0.4 m to 0.6 m. Hereinafter, it is assumed that respective points parallel to each other in the width direction on the road at a point to be detected by the entrance-side detection device 21 are referred to as a point A, and respective points parallel to each other in the width direction on the road at a point to be detected by the exit-side detection device 22 are referred to as

a point B. Although not shown, a plurality of the entrance-side detection devices 21 and a plurality of the exit-side detection devices 22 may be provided above the vehicle 30 in the width direction which is perpendicular to the traveling direction of the vehicle 30, at respective installation positions.

5 Alternatively, the entrance-side detection device 21 and the exit-side detection device 22 are provided above the vehicle 30 at the approximate center in the width direction which is perpendicular to the traveling direction of the vehicle 30 at respective installation positions, and the entrance-side detection device 21 and the exit-side detection device 22 may each radiate radiation signals in a wide-angle range in the width
10 direction of the road, the center of the wide-angle range being lower vertical direction.

In addition, a laser sensor may be disposed above the sides of the road so as to radiate signals to the vehicles traveling in whole lanes. At this time, the laser sensors may be provided in a plurality of positions such as both sides of the road.

[0019]

15 The device 10 for measuring an object to be measured is connected to the entrance-side detection device 21 and the exit-side detection device 22 through a communication network, and receives from the entrance-side detection device 21 and the exit-side detection device 22, the detection time and strength of the reflected signal (the amount of reflected light) which are detected by the devices and the height information
20 of the vehicle 30 which is calculated by the devices. The height information is information indicating any one of "a difference between the height of the entrance-side detection device 21 and the height of the measured portion of the object to be measured", or "height of the measured portion of the object to be measured from the road". If the height information to be output by the entrance-side detection device 21 (or the exit-side
25 detection device 22) to the device 10 for measuring an object to be measured is

information indicating the “height of the measured portion of the object to be measured from the road”, the value of the height is obtained by the entrance-side detection device 21 (or the exit-side detection device 22) subtracting “the distance in the vertical direction from the entrance-side detection device 21 (or the exit-side detection device 22) to the measured portion of the object to be measured” from “the distance in the vertical direction from the entrance-side detection device 21 (or the exit-side detection device 22) to the road”. If the height information to be output by the entrance-side detection device 21 (or the exit-side detection device 22) to the device 10 for measuring an object to be measured is information indicating “a difference between the height of the entrance-side detection device 21 (or the exit-side detection device 22) and the height of the measured portion of the object to be measured”, the device 10 for measuring an object to be measured obtains the value of the height as “the distance in the vertical direction from the entrance-side detection device 21 (or the exit-side detection device 22) to the measured portion of the object to be measured”, based on the detection result by the entrance-side detection device 21 (or the exit-side detection device 22).

[0020]

Then, the device 10 for measuring an object to be measured measures the vehicle length of the vehicle 30 which is an object to be measured, using information which is received from the entrance-side detection device 21 and the exit-side detection device 22.

In addition, although it is described that the device 10 for measuring an object to be measured according to the present embodiment measures the vehicle length of the vehicle 30 travelling on the road, the device 10 may be applied to measure the lengths of other moving objects.

[0021]

FIG. 2 is a functional block diagram of the device 10 for measuring an object to be measured.

As shown in the drawing, the device 10 for measuring an object to be measured includes processing units and storage units: an input unit 11, a storage unit 12, a height
5 corresponding relationship determination unit 13, a signal strength corresponding relationship determination unit 14, a second velocity calculation unit 15, a first velocity calculation unit 16, and a length calculation unit 17.

[0022]

The input unit 11 is a processing unit that respectively receives height
10 information of the vehicle 30 and the strength of the reflection signal from the entrance-side detection device 21 and the exit-side detection device 22.

Further, the height corresponding relationship determination unit 13 is a processing unit that classifies a plurality of pieces of height information of the vehicle 30 which are detected respectively by the entrance-side detection device 21 and the exit-side
15 detection device 22 depending on a time elapsed, for each corresponding relationship of height information indicating the same portion of the vehicle 30.

Further, the second velocity calculation unit 15 is a processing unit that calculates a time difference between height detection times of respective pieces of height information by the entrance-side detection device 21 and the exit-side detection device
20 22 that calculate respective pieces of height information included in the corresponding relationship of height information indicating the same portion of the vehicle 30, for each corresponding relationship of the classified height information, and calculates a velocity of the object to be measured at the height detection times in any one or both of the entrance-side detection device 21 and the exit-side detection device 22 for each
25 corresponding relationship of the classified height information, based on the time

difference between the height detection times and the installation interval D in the traveling direction between the entrance-side detection device 21 and the exit-side detection device 22.

[0023]

5 Further, the signal strength corresponding relationship determination unit 14 is a processing unit that classifies the signal strengths of a plurality of light reflection signals which are detected by the entrance-side detection device 21 and the exit-side detection device 22 depending on a time elapsed, for each corresponding relationship of the signal strength indicating the same portion of the vehicle 30.

10 Further, the first velocity calculation unit 16 is a processing unit that calculates a time difference between signal strength detection times of respective signal strengths by the entrance-side detection device 21 and the exit-side detection device 22 that detect respective signal strengths included in the corresponding relationship of the signal strength indicating the same portion of the vehicle 30, for each corresponding
15 relationship of the classified signal strength, and calculates a velocity of the vehicle 30 at the signal strength detection times in any one or both of the entrance-side detection device 21 and the exit-side detection device 22, based on the time difference between the signal strength detection times and an installation interval D, for each corresponding relationship of the classified signal strength.

20 [0024]

Further, the length calculation unit 17 is a processing unit that calculates a length in the traveling direction of the vehicle 30, based on the velocity of the vehicle 30, which is calculated for each corresponding relationship of the classified height information, at the height detection time in any one or both of the entrance-side detection
25 device 21 and the exit-side detection device 22 and the velocity of the object to be

measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection time in any one or both of the entrance-side detection device 21 and the exit-side detection device 22.

[0025]

5 FIG. 3 is a diagram showing an example of data which is received by the input unit 11.

 The input unit 11 receives height information showing the height of the vehicle 30, an amount of reflected light which is the strength of a reflection signal, and a information on detection time thereof respectively from the entrance-side detection
10 device 21 and the exit-side detection device 22, at a predetermined time interval. The predetermined time interval is, for example, 10 msec, and FIG. 3 shows a data table in a case where each piece of information which is received at respective times t1, t2, t3, t4, t5, ... having an interval of 10 msec therebetween is stored. FIG. 3 shows height information, an amount of reflected light, and information on a detection time which are
15 detected by the entrance-side detection device 21 for a point on the road. The input unit 11 receives respective pieces of information shown in FIG. 3 for a plurality of points in the width direction of the road perpendicular to the traveling direction of the vehicle 30. The interval in the width direction is, for example, 10cm. Further, the input unit 11 receives height information, an amount of reflected light, and information on a detection
20 time for a plurality of points on the road in the width direction of the road at a predetermined time interval also from the exit-side detection device 22.

[0026]

 FIG. 4 is a diagram showing measurement result data based on the information which is received by the input unit.

25 FIG. 4 shows measurement result data based on the information which is

received by the device 10 for measuring an object to be measured from the entrance-side detection device 21 or the exit-side detection device 22. The measurement result data indicates height information at measurement points $x_1, x_2, x_3, x_4, \dots$, and x_n at respective detection times $t_1, t_2, t_3, t_4, \dots$, and t_n . The measurement result data may be prepared from any one of information which is received from the entrance-side detection device 21 and information which is received from the exit-side detection device 22. For example, if the measurement result data shown in FIG. 4 is prepared by reading the height information which is received from the entrance-side detection device 21 from the data table shown in FIG. 3, it indicates height information which is detected by the entrance-side detection device 21 for the measurement points $x_1, x_2, x_3, x_4, \dots$, and x_n at respective detection times $t_1, t_2, t_3, t_4, \dots$, and t_n . In addition, if the measurement result data shown in FIG. 4 is prepared from the height information which is received from the entrance-side detection device 21, the measurement point indicates a respective plurality of measurement points which are parallel to the width direction on the road (direction perpendicular to the traveling direction of the road) at the point A at which the entrance-side detection device 21 measures.

[0027]

Each piece of information received by the device 10 for measuring an object to be measured, as information corresponding to each measurement point, may be information measured by each of a plurality of entrance-side detection devices 21 installed corresponding to each measurement point. Otherwise, each piece of information received by the device 10 for measuring an object to be measured, as information corresponding to each measurement point, may be information measured by one or a plurality of the entrance-side detection devices 21 installed above the road

radiating a radiation signal at respective angles in the wide-angle range centered on the lower vertical direction in the width direction of the road.

[0028]

In addition, the device 10 for measuring an object to be measured stores
5 measurement result data indicating a detection time and an amount of reflected light at each measurement point which is detected by the entrance-side detection device 21, measurement result data indicating a detection time and height information at each measurement point which is detected by the exit-side detection device 22, and measurement result data indicating a detection time and an amount of reflected light at
10 each measurement point which is detected by the exit-side detection device 22, based on the information received from the entrance-side detection device 21 or the exit-side detection device 22, in addition to the measurement result data shown in FIG. 4.

[0029]

The measurement result data of FIG. 4 shows that the entrance-side detection
15 device 21 measures the height information at each measurement point in the range of x4 to x20 from time t3 to time t29. In addition, the measurement result data shows that the device 10 for measuring an object to be measured receives substantially the same height information A1 which is measured from time t3 to time t10 for each measurement point between x4 and x20 by the entrance-side detection device 21, substantially the same
20 height information B1 which is measured from time t11 to time t22 for each measurement point between x4 and x20 by the entrance-side detection device 21, and substantially the same height information C1 which is measured from time t23 to time t29 for each measurement point between x4 and x20 by the entrance-side detection device 21.

25 [0030]

Further, the measurement result data of FIG. 4 indicates respective pieces of height information: height information A1, B1, and C1, and thus it can be recognized that the vehicle 30 has three characteristics: the height information A1, the height information B1, and the height information C1.

5 Further, in the same manner, the device 10 for measuring an object to be measured can recognize that the vehicle 30 has a plurality of characteristics being optically different, of a color of a body and a portion of a body (such as a sunroof or a trunk bed), based on the information of the amount of reflected light that is received from the entrance-side detection device 21 and that is shown in the measurement result data.

10 [0031]

Further, in the same manner, the device 10 for measuring an object to be measured can recognize that the vehicle 30 has a plurality of geometric characteristics of a hood or other portions (such as a roof or a trunk bed), based on the height information which is received from the exit-side detection device 22 and that is shown in the
15 measurement result data.

Further, in the same manner, the device 10 for measuring an object to be measured can recognize that the vehicle 30 has a plurality of characteristics being optically different, of a color of a body and a portion of a body, based on the information of the amount of reflected light that is received from the exit-side detection device 22 and
20 that is shown in the measurement result data.

[0032]

Then, the device 10 for measuring an object to be measured calculates the length of the vehicle 30, using a geometric characteristic based on the height information of the vehicle 30 and an optical characteristic based on the amount of reflected light which are
25 received from the entrance-side detection device 21 or a geometric characteristic based

on the height information of the vehicle 30 and an optical characteristic based on the amount of reflected light which are received from the exit-side detection device 22.

[0033]

FIG. 5 is a diagram showing a data example of information that is received by the device for measuring an object to be measured.

Next, a specific calculation method of the vehicle length of the vehicle 30 will be described.

The device 10 for measuring an object to be measured determines that the height information A1 is detected at time t3 based on the height information which is received from the entrance-side detection device 21. Further, the device 10 for measuring an object to be measured determines that the height information B1 having a height different from that of height information A1 by a predetermined threshold or more is measured at time t11.

Furthermore, the device 10 for measuring an object to be measured determines that the height information C1 having a height different from that of height information B1 by a predetermined threshold or more is measured at time t23. Thus, the device 10 for measuring an object to be measured specifies respective times at which respective characteristics of height information A1, B1, and C1 are respectively detected first as the characteristic detection time t3, the characteristic detection time t11, and the characteristic detection time t23, based on the height information which is received from the entrance-side detection device 21. In addition, after detecting the height of the vehicle 30 based on the height information which is received from the entrance-side detection device 21, the device 10 for measuring an object to be measured detects a time at which the road surface is determined to be detected, and determines the time as the characteristic detection time t30.

[0034]

Further, the device 10 for measuring an object to be measured determines that the amount of reflected light $m1$ changed by a predetermined threshold or more from the amount of reflected light of the road is detected at time $t3$, based on the amount of reflected light that is received from the entrance-side detection device 21. Further, the device 10 for measuring an object to be measured determines that the amount of reflected light $n1$ changed by a predetermined threshold or more from the amount of reflected light $m1$ is detected at time tn_1 . Further, the device 10 for measuring an object to be measured determines that the amount of reflected light $o1$ changed by a predetermined threshold or more from the amount of reflected light $n1$ is detected at time tn_2 . Thus, the device 10 for measuring an object to be measured specifies respective times at which respective characteristics of the amounts of reflected light $m1$, $n1$, and $o1$ are detected first, each of which is changed by the predetermined threshold or more from the amount of reflected light which has been previously detected, as the characteristic detection time $t3$, the characteristic detection time tn_1 , and the characteristic detection time tn_2 , based on the amount of reflected light which is received from the entrance-side detection device 21.

In addition, it is assumed that the following time relationship is established when the characteristic detection time $t3 < \text{the characteristic detection time } tn_1 < \text{the characteristic detection time } tn_2 < \text{the characteristic detection time } t11 < \text{the characteristic detection time } t23 < \text{the characteristic detection time } t30$.

[0035]

The device 10 for measuring an object to be measured determines that the height information $A1$ is detected at time tn_3 based on the height information which is received from the exit-side detection device 22. The device 10 for measuring an object to be

measured determines that the height information B1 having a height different from that of the height information A1 by a predetermined threshold or more is detected at time tn_6 .

The device 10 for measuring an object to be measured determines that the height information C1 having a height different from that of the height information B1 by a

5 predetermined threshold or more is detected at time tn_7 . Thus, the device 10 for measuring an object to be measured specifies respective times at which respective characteristics of the height information A1, B1, and C1 are detected first, as the characteristic detection time tn_3 , the characteristic detection time tn_6 , and the characteristic detection time tn_7 , based on the height information which is received from the exit-side detection device 22. After detecting the height of the vehicle 30 based on the height information which is received from the exit-side detection device 22, the device 10 for measuring an object to be measured detects a time at which a road surface is determined to be detected, and then determines the time as the characteristic detection time tn_8 .

15 [0036]

The device 10 for measuring an object to be measured determines that the amount of reflected light $m1$ changed from the amount of reflected light of the road by a predetermined threshold or more is detected at time tn_3 , based on the amount of reflected light that is received from the exit-side detection device 22. The device 10 for

20 measuring an object to be measured determines that the amount of reflected light $n1$ changed from the amount of reflected light $m1$ by a predetermined threshold or more is detected at time tn_4 . The device 10 for measuring an object to be measured determines that the amount of reflected light $o1$ changed from the amount of reflected light $n1$ by a predetermined threshold or more is detected at time tn_5 . Thus the device 10 for

25 measuring an object to be measured specifies respective times at which respective

characteristics of the amounts of reflected light $m1$, $n1$, and $o1$ are detected first, each of which is changed by the predetermined threshold or more from the amount of reflected light which has been previously detected, as the characteristic detection time tn_3 , the characteristic detection time tn_4 , and the characteristic detection time tn_5 , based on the
 5 amount of reflected light which is received from the exit-side detection device 22.

In addition, it is assumed that the following time relationship is established when the characteristic detection time $tn_3 < \text{the characteristic detection time } tn_4 < \text{the characteristic detection time } tn_5 < \text{the characteristic detection time } tn_6 < \text{the characteristic detection time } tn_7 < \text{the characteristic detection time } tn_8$.

10 [0037]

The device 10 for measuring an object to be measured calculates, based on the characteristic detection time which is specified by the height information which is received from the entrance-side detection device 21 and the exit-side detection device 22 and the installation interval D between the entrance-side detection device 21 and the
 15 exit-side detection device 22, the velocity of the vehicle 30 at the characteristic detection time in any one or both of the entrance-side detection device 21 and the exit-side detection device 22 for each corresponding relationship of height information. In other words, the device 10 for measuring an object to be measured calculates the velocity $V1$ by the equation of “velocity $V1$ of the vehicle 30 = $D \div (tn_3 - t3)$ ” using the difference
 20 $(tn_3 - t3)$ between the characteristic detection times and the installation interval D for the height information $A1$. The device 10 for measuring an object to be measured calculates the velocity $V2$ by the equation of “velocity $V2$ of the vehicle 30 = $D \div (tn_6 - t11)$ ” using the difference $(tn_6 - t11)$ between the characteristic detection times and the installation interval D for the height information $B1$. The device 10 for measuring
 25 an object to be measured calculates the velocity $V3$ by the equation of “velocity $V3$ of

the vehicle 30 = $D \div (tn_7 - t_{23})$ ” using the difference ($tn_7 - t_{23}$) between the characteristic detection times and the installation interval D for the height information C1. The device 10 for measuring an object to be measured calculates the velocity V7 by the equation of “velocity V7 of the vehicle 30 = $D \div (tn_8 - t_{30})$ ” using the difference ($tn_8 - t_{30}$) between the
 5 characteristic detection times at which the road surface is detected in the entrance-side detection device 21 and the exit-side detection device 22 and the installation interval D.

[0038]

The device 10 for measuring an object to be measured calculates, based on the characteristic detection time which is specified by the amount of reflected light that is
 10 received from the entrance-side detection device 21 and the exit-side detection device 22 and the installation interval D between the entrance-side detection device 21 and the exit-side detection device 22, the velocity of the vehicle 30 at the characteristic detection time in any one or both of the entrance-side detection device 21 and the exit-side detection device 22 for each corresponding relationship of the change in the amount of
 15 reflected light. In other words, the device 10 for measuring an object to be measured calculates the velocity V4 by the equation of “velocity V4 of the vehicle 30 = $D \div (tn_3 - t_3)$ ” using the difference ($tn_3 - t_3$) between the characteristic detection times and the installation interval D for the amount of reflected light m1. The device 10 for measuring an object to be measured calculates the velocity V5 by the equation of “velocity V5 of the vehicle
 20 30 = $D \div (tn_4 - tn_1)$ ” using the difference ($tn_4 - tn_1$) between the characteristic detection times and the installation interval D for the amount of reflected light n1. The device 10 for measuring an object to be measured calculates the velocity V6 by the equation of “velocity V6 of the vehicle 30 = $D \div (tn_5 - tn_2)$ ” using the difference ($tn_5 - tn_2$) between the characteristic detection times and the installation interval D for the amount of reflected

light o1.

In the present embodiment, since the velocity V1 which is calculated using the characteristic detection time specified by the height information A1 and the velocity V4 which is calculated using the characteristic detection time specified by the amount of reflected light m1 are calculated using the same characteristic detection time, they are consistent with each other. Accordingly, it is assumed that the velocity V4 is not used in the following processes.

[0039]

Through the above processes, the device 10 for measuring an object to be measured calculates the velocity V1 which is calculated using the characteristic detection time at which the height information A1 is detected, the velocity V2 which is calculated using the characteristic detection time at which the height information B1 is detected, the velocity V3 which is calculated using the characteristic detection time at which the height information C1 is detected, the velocity V5 which is calculated using the characteristic detection time at which the amount of reflected light n1 is detected, the velocity V6 which is calculated using the characteristic detection time at which the amount of reflected light o1 is detected, and the velocity V7 which is calculated using the characteristic detection time at which the road surface is detected.

[0040]

FIG. 6 is a diagram showing a relationship between each characteristic detection time and a velocity calculated using the characteristic detection time.

FIG. 6 shows the following relationships:

a relationship between the characteristic detection time t3 at which the height information A1 is detected and the velocity V1 calculated by the device 10 for measuring an object to be measured using the characteristic detection time t3;

a relationship between the characteristic detection time tn_1 at which the amount of reflected light $n1$ is detected and the velocity $V5$ calculated by the device 10 for measuring an object to be measured using the characteristic detection time tn_1 ;

5 a relationship between the characteristic detection time tn_2 at which the amount of reflected light $o1$ is detected and the velocity $V6$ calculated by the device 10 for measuring an object to be measured using the characteristic detection time tn_2 ;

a relationship between the characteristic detection time $t11$ at which the height information $B1$ is detected and the velocity $V2$ calculated by the device 10 for measuring an object to be measured using the characteristic detection time $t11$;

10 a relationship between the characteristic detection time $t23$ at which the height information $C1$ is detected and the velocity $V3$ calculated by the device 10 for measuring an object to be measured using the characteristic detection time $t23$; and

a relationship between the characteristic detection time $t30$ at which the road surface is detected and the velocity $V7$ calculated by the device 10 for measuring an
15 object to be measured using the characteristic detection time $t30$.

[0041]

The device 10 for measuring an object to be measured integrates expressions indicating relationships between the characteristic detection times shown in FIG. 5 and velocities calculated by the device 10 for measuring an object to be measured using the
20 characteristic detection times from $t3$ to $t30$, thereby calculating the vehicle length of the vehicle 30.

In this manner, the device 10 for measuring an object to be measured calculates the vehicle length L of the vehicle 30 using each velocity at the characteristic detection time at which each characteristic of geometric characteristics (characteristics by height
25 information) and optical characteristics (the amount of reflected light) of the vehicle 30

which is an object to be measured is detected.

[0042]

Here, usually, in a case of calculating the length of the vehicle 30, if using the detection time T1 of the vehicle 30 in the entrance-side detection device 21, the traveling
5 time (detection end time) T2 of the vehicle 30 in the entrance-side detection device 21, a time interval t from when the vehicle 30 is detected in the entrance-side detection device 21 to when the vehicle 30 is detected in the exit-side detection device 22, and the installation interval D between the entrance-side detection device 21 and the exit-side detection device 22, the velocity v of the vehicle 30 = $D \div t$ is calculated,

10 and thus it is possible to calculate the vehicle length L of the vehicle 30 using the expression

$$L = (D \div t) \cdot (T2 - T1).$$

However, although the vehicle length L which is calculated by the above expression is a substantially correct value if the vehicle 30 moves at a constant velocity
15 of the velocity v, the velocity does not become a correct value if the vehicle 30 passes between the entrance-side detection device 21 and the exit-side detection device 22 while changing the velocity.

[0043]

Therefore, the device 10 for measuring an object to be measured according to
20 the present embodiment calculates the vehicle length L in view of the change in the velocity depending on time elapsed using the velocities V of the vehicle 30 at plural characteristic detection times, thereby calculating the vehicle length L of the vehicle 30 with high accuracy. In addition, the larger number of characteristics of the vehicle 30, the more accurate the vehicle length L. Therefore, not only the geometric characteristic
25 but also the optical characteristic is used. Since the optical characteristic is used, it is

possible to detect the changes in more characteristic points and to measure more accurately the velocity or the vehicle length L of the vehicle 30 based on the change in the amount of reflected light according to the change in the materials or the like forming the portions of the vehicle, even in the box-shaped vehicle 30 such as a bus with less
 5 amount of change in the geometric characteristic, for example, the vehicle height.

[0044]

Then, the process flow of the device 10 for measuring an object to be measured according to the present embodiment will be described.

FIG. 7 is a diagram showing a process flow of the device for measuring an
 10 object to be measured according to the present embodiment.

First, the input unit 11 of the device 10 for measuring an object to be measured sequentially receives the detection signal including height information, an amount of reflected light, detection times from each of the entrance-side detection device 21 and the exit-side detection device 22 at a predetermined time interval depending on time elapsed
 15 (step S101). Then the input unit 11 reads the height information, the amount of reflected light, the detection times from the detection signal which is received from the entrance-side detection device 21 or the exit-side detection device 22, and outputs combination information of the height information, the detection times and an identification number (identification number for identifying any one of the entrance-side
 20 detection device 21 and the exit-side detection device 22) of the detection device which detects them to the height corresponding relationship determination unit 13. Further, the input unit 11 reads the height information, the amount of reflected light, and the detection times from the input detection signal, and outputs combination information of the amount of reflected light, the detection times and an identification number
 25 (identification number for identifying any one of the entrance-side detection device 21

and the exit-side detection device 22) of the detection device which detects them to the signal strength corresponding relationship determination unit 14.

[0045]

Thus, the height corresponding relationship determination unit 13 receives each
5 piece of information corresponding to the height information and the detection time in the examples of data of “information input from the entrance-side detection device 21” shown in FIG. 5 and each piece of information corresponding to the height information and the detection time in the examples of data of “information received from the exit-side detection device 22”.

10 Further, the signal strength corresponding relationship determination unit 14 receives each information corresponding to the amount of reflected light and the detection time in the examples of data of “information input from the entrance-side detection device 21” shown in FIG. 5 and each information corresponding to the amount of reflected light and the detection time in the examples of data of “information input
15 from the exit-side detection device 22”.

[0046]

Each time receiving the height information included in the detection signal that is transmitted from the entrance-side detection device 21, the height corresponding relationship determination unit 13 compares the received height information with, for
20 example, the height information which has been received one time previously (height information included in the detection signal transmitted from the entrance-side detection device 21) to determine whether the received height information changes by a threshold or more. Then, if the height information, in which the change is within the threshold, is received in a row a predetermined number of times or more, the height corresponding
25 relationship determination unit 13 determines the detection time corresponding to the

height information which is received at the earliest time among respective pieces of height information falling within the threshold, as a characteristic detection time at which the height information is detected first in the entrance-side detection device 21 (step S102). In the example of FIG. 5, a time at which the height information A1 is detected first by the entrance-side detection device 21 is determined as the characteristic detection time t3.

In a similar manner, a time at which the height information B1 is detected first by the entrance-side detection device 21 is determined as the characteristic detection time t11, a time at which the height information C1 is detected first by the entrance-side detection device 21 is determined as the characteristic detection time t23, and then a time at which the height information of a road surface is detected first by the entrance-side detection device 21 is determined as the characteristic detection time t30. In addition, it is assumed that a characteristic detection time at which the height of the road surface is detected first is coincident with a time at which the height information of the end of the vehicle 30 is detected at the last time.

[0047]

In a similar manner, each time receiving the height information included in the detection signal that is transmitted from the exit-side detection device 22, the height corresponding relationship determination unit 13 compares the received height information with, for example, the height information which has been received one time previously (height information included in the detection signal transmitted from the exit-side detection device 22) to determine whether the received height information changes by a threshold or more. Then, if the height information, in which the change is within the threshold, is received in a row a predetermined number of times or more, the height corresponding relationship determination unit 13 determines the detection time

corresponding to the height information which is received at the earliest time among respective pieces of height information falling within the threshold as a characteristic detection time that is detected first in the exit-side detection device 22 (step S103). In the example of FIG. 5, a time at which the height information A1 is detected first by the exit-side detection device 22 is determined as the characteristic detection time tn_3 . In a similar manner, a time at which the height information B1 is detected first by the exit-side detection device 22 is determined as the characteristic detection time tn_6 , a time at which the height information C1 is detected first by the exit-side detection device 22 is determined as the characteristic detection time tn_7 , and then a time at which the height information of a road surface is detected first by the exit-side detection device 22 is determined as the characteristic detection time tn_8 .

[0048]

Then, the height corresponding relationship determination unit 13 classifies the characteristic detection time $t3$, the characteristic detection time $t11$, the characteristic detection time $t23$, the characteristic detection time $t30$ which are determined for the entrance-side detection device 21, and the characteristic detection time tn_3 , the characteristic detection time tn_6 , the characteristic detection time tn_7 , and the characteristic detection time tn_8 which are determined for the exit-side detection device 22 for each corresponding relationship of height information indicating the same portion of the vehicle 30, based on the value of the height information corresponding to the detection times (step S104). In other words, since the difference between the value of height information that is detected by the entrance-side detection device 21 at the characteristic detection time $t3$ and the value of height information that is detected by the exit-side detection device 22 at the characteristic detection time tn_3 is a threshold or less, the height corresponding relationship determination unit 13 determines that they belong

to the same classification. Then, the height corresponding relationship determination unit 13 associates the height information A1 that is detected by the entrance-side detection device 21 at the characteristic detection time t_3 with the characteristic detection time t_3 , and associates the height information A1 that is detected by the exit-side
 5 detection device 22 at the characteristic detection time tn_3 with the characteristic detection time tn_3 , as the classification information belonging to the same classification, so as to be written into the queue provided in the second velocity calculation unit 15.

[0049]

Further, in the same manner, since the difference between the value of height
 10 information that is detected by the entrance-side detection device 21 at the characteristic detection time t_{11} and the value of height information that is detected by the exit-side detection device 22 at the characteristic detection time tn_6 is a threshold or less, the height corresponding relationship determination unit 13 determines that they belong to
 15 the same classification. Then, the height corresponding relationship determination unit 13 associates the height information B1 that is detected by the entrance-side detection device 21 at the characteristic detection time t_{11} with the characteristic detection time t_{11} , and the height information B1 that is detected by the exit-side detection device 22 at the characteristic detection time tn_6 with the characteristic detection time tn_6 , as the classification information belonging to the same classification, so as to be written into the
 20 queue provided in the second velocity calculation unit 15.

Further, in the same manner, since the difference between the value of height
 information that is detected by the entrance-side detection device 21 at the characteristic
 detection time t_{23} and the value of height information that is detected by the exit-side
 detection device 22 at the characteristic detection time tn_7 is a threshold or less, the
 25 height corresponding relationship determination unit 13 determines that they belong to

the same classification. Then, the height corresponding relationship determination unit 13 associates the height information C1 that is detected by the entrance-side detection device 21 at the characteristic detection time t_{23} with the characteristic detection time t_{23} , and the height information C1 that is detected by the exit-side detection device 22 at the characteristic detection time t_{n7} with the characteristic detection time t_{n7} , as the classification information belonging to the same classification, so as to be written into the queue provided in the second velocity calculation unit 15.

[0050]

Further, in the same manner, since the difference between the value of height information (road surface) that is detected by the entrance-side detection device 21 at the characteristic detection time t_{30} and the value of height information (road surface) that is detected by the exit-side detection device 22 at the characteristic detection time t_{n8} is a threshold or less, the height corresponding relationship determination unit 13 determines that they belong to the same classification. Then, the height corresponding relationship determination unit 13 associates the road surface height that is detected by the entrance-side detection device 21 at the characteristic detection time t_{30} with the characteristic detection time t_{30} , and the road surface height that is detected by the exit-side detection device 22 at the characteristic detection time t_{n8} with the characteristic detection time t_{n8} , as the classification information belonging to the same classification, so as to be written into the queue provided in the second velocity calculation unit 15.

[0051]

Then, as described above, the height corresponding relationship determination unit 13 repeats the determination of the characteristic detection time based on the height information detected by the entrance-side detection device 21 and the exit-side detection device 22, and the classification of the characteristic detection time. The height

corresponding relationship determination unit 13 compares the height information which is received with the height of a road which is stored in advance, and if it is determined that the height information which is received is the height of a road, the height corresponding relationship determination unit 13 writes vehicle traveling information indicating that the vehicle 30 passes through the entrance-side detection device 21 and the exit-side detection device 22 into the queues provided in the second velocity calculation unit 15 and the first velocity calculation unit 16.

[0052]

Subsequently, the second velocity calculation unit 15 reads first classification information from the queue. The classification information includes a pair of the characteristic detection time t_3 and the height information A1 detected by the entrance-side detection device 21 at the characteristic detection time t_3 , or a pair of the characteristic detection time tn_3 and the height information A1 detected by the exit-side detection device 22 at the characteristic detection time tn_3 . The second velocity calculation unit 15 acquires the characteristic detection time t_3 and the characteristic detection time tn_3 included in the classification information which is read, calculates the velocity V1 of the vehicle 30 at the characteristic detection time t_3 or the characteristic detection time tn_3 by the equation of $V1 = D \div (tn_3 - t_3)$ (step S105) using the acquired times and the installation interval D, and writes the velocity V1 into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection time t_3 and the characteristic detection time tn_3 . In the present embodiment, it is assumed that the velocity V1 and the characteristic detection time t_3 are associated and written into the queue provided in the length calculation unit 17.

[0053]

Here, the second velocity calculation unit 15 determines whether the information

which is subsequently read from the queue is vehicle traveling information (step S106).

Then, if the information is not the vehicle traveling information, the second velocity

calculation unit 15 repeats the calculation of the velocity of the vehicle 30 using the

characteristic detection time included in the classification information. In other words,

5 the second velocity calculation unit 15 reads the subsequent classification information

from the queue. The classification information includes a pair of the characteristic

detection time $t11$ and the height information B1 detected by the entrance-side detection

device 21 at the characteristic detection time $t11$, or a pair of the characteristic detection

time tn_6 and the height information B1 detected by the exit-side detection device 22 at the

10 characteristic detection time tn_6 . The second velocity calculation unit 15 acquires the

characteristic detection time $t11$ and the characteristic detection time tn_6 included in the

classification information which is read, calculates the velocity V2 of the vehicle 30 at

the characteristic detection time $t11$ or the characteristic detection time tn_6 by the

equation of $V2 = D \div (tn_6 - t11)$ using the acquired times and the installation interval D, and

15 writes the velocity V2 into the queue provided in the length calculation unit 17 in

association with any one of the characteristic detection time $t11$ and the characteristic

detection time tn_6 . In the present embodiment, it is assumed that the velocity V2 and

the characteristic detection time $t11$ are associated and written into the queue provided in

the length calculation unit 17.

20 [0054]

Further, in the same manner, the second velocity calculation unit 15 reads the

subsequent classification information from the queue. The classification information

includes a pair of the characteristic detection time $t23$ and the height information C1

detected by the entrance-side detection device 21 at the characteristic detection time $t23$,

25 or a pair of the characteristic detection time tn_7 and the height information C1 detected by

the exit-side detection device 22 at the characteristic detection time tn_7 . The second velocity calculation unit 15 acquires the characteristic detection time $t23$ and the characteristic detection time tn_7 included in the classification information which is read, calculates the velocity $V3$ of the vehicle 30 at the characteristic detection time $t23$ or the characteristic detection time tn_7 by the equation of $V3=D/(tn_7-t23)$ using the acquired times and the installation interval D , and writes the velocity $V3$ into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection time $t23$ and the characteristic detection time tn_7 . In the present embodiment, it is assumed that the velocity $V3$ and the characteristic detection time $t23$ are associated and written into the queue provided in the length calculation unit 17.

[0055]

Further, in the same manner, the second velocity calculation unit 15 reads the subsequent classification information from the queue. The classification information includes a pair of the characteristic detection time $t30$ and the height information (road surface height) detected by the entrance-side detection device 21 at the characteristic detection time $t30$, or a pair of the characteristic detection time tn_8 and the height information (road surface height) detected by the exit-side detection device 22 at the characteristic detection time tn_8 . The second velocity calculation unit 15 acquires the characteristic detection time $t30$ and the characteristic detection time tn_8 included in the classification information which is read, calculates the velocity $V7$ of the vehicle 30 at the characteristic detection time $t30$ or the characteristic detection time tn_8 by the equation of $V7=D/(tn_8-t30)$ using the acquired times and the installation interval D , and writes the velocity $V7$ into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection time $t23$ and the characteristic detection time tn_8 . In the present embodiment, it is assumed that the velocity $V7$ and

the characteristic detection time t_{30} are associated and written into the queue provided in the length calculation unit 17.

[0056]

Then, if the vehicle traveling information is read from the queue, the second
 5 velocity calculation unit 15 stops the calculation of the velocity using each characteristic detection time for one vehicle 30 and writes the vehicle traveling information into the queue provided in the length calculation unit 17.

[0057]

In contrast, each time receiving the amount of reflected light included in the
 10 detection signal transmitted from the entrance-side detection device 21, the signal strength corresponding relationship determination unit 14 determines whether the amount of reflected light that is received is changed by a threshold or more from, for example, the amount of reflected light (the amount of reflected light included in the detection signal transmitted from the entrance-side detection device 21) that has been received one
 15 time previously by comparing them. Then, if the amount of reflected light, in which the change is within the threshold, is received in a row a predetermined number of times or more, the signal strength corresponding relationship determination unit 14 determines the detection time corresponding to the amount of reflected light that is received at the earliest time among respective amounts of reflected light falling within the threshold as a
 20 characteristic detection time at which the amount of reflected light is detected first in the entrance-side detection device 21 (step S107). In the example of FIG. 5, a time at which the amount of reflected light m_1 is detected first in the entrance-side detection device 21 is determined as the characteristic detection time t_3 . Further, in the same manner, a time at which the amount of reflected light n_1 is detected first in the
 25 entrance-side detection device 21 is determined as the characteristic detection time t_{n1} .

and a time at which the amount of reflected light o1 is detected first in the entrance-side detection device 21 is determined as the characteristic detection time tn_2 .

[0058]

Further, in the same manner, each time receiving the amount of reflected light
 5 included in the detection signal transmitted from the exit-side detection device 22, the signal strength corresponding relationship determination unit 14 determines whether the amount of reflected light that is received is changed by a threshold or more from, for example, the amount of reflected light (the amount of reflected light included in the detection signal transmitted from the exit-side detection device 22) that has been received
 10 one time previously by comparing them. Then, if the amount of reflected light, in which the change is within the threshold, is received in a row a predetermined number of times or more, the signal strength corresponding relationship determination unit 14 determines the detection time corresponding to the amount of reflected light that is received at the earliest time among respective amounts of reflected light falling within
 15 the threshold as a characteristic detection time at which the amount of reflected light is detected first in the exit-side detection device 22 (step S108). In the example of FIG. 5, a time at which the amount of reflected light m1 is detected first in the exit-side detection device 22 is determined as the characteristic detection time tn_3 . Further, in the same manner, a time at which the amount of reflected light n1 is detected first in the exit-side
 20 detection device 22 is determined as the characteristic detection time tn_4 , and a time at which the amount of reflected light o1 is detected first in the exit-side detection device 22 is determined as the characteristic detection time tn_5 .

[0059]

Then, the signal strength corresponding relationship determination unit 14
 25 classifies the characteristic detection time $t3$, the characteristic detection time tn_1 , the

characteristic detection time tn_2 which are determined for the entrance-side detection device 21 and the characteristic detection time tn_3 , the characteristic detection time tn_4 , and the characteristic detection time tn_5 which are determined for the exit-side detection device 22, for each corresponding relationship of the amount of reflected light indicating

5 the same portion of the vehicle 30, based on the value of the amounts of reflected light corresponding to the detection times (step S109). In other words, since the difference between the value of the amount of reflected light that is detected by the entrance-side detection device 21 at the characteristic detection time $t3$ and the value of the amount of reflected light that is detected by the exit-side detection device 22 at the characteristic

10 detection time tn_3 is a threshold or less, the signal strength corresponding relationship determination unit 14 determines that they belong to the same classification. Then, the signal strength corresponding relationship determination unit 14 associates the amount of reflected light $m1$ that is detected by the entrance-side detection device 21 at the characteristic detection time $t3$ with the characteristic detection time $t3$, and the amount

15 of reflected light $m1$ that is detected by the exit-side detection device 22 at the characteristic detection time tn_3 with the characteristic detection time tn_3 , as the classification information belonging to the same classification, so as to be written into the queue provided in the first velocity calculation unit 16.

[0060]

20 Further, in the same manner, since the difference between the value of the amount of reflected light that is detected by the entrance-side detection device 21 at the characteristic detection time tn_1 and the value of the amount of reflected light that is detected by the exit-side detection device 22 at the characteristic detection time tn_4 is a threshold or less, the signal strength corresponding relationship determination unit 14

25 determines that they belong to the same classification. Then, the signal strength

corresponding relationship determination unit 14 associates the amount of reflected light n_1 that is detected by the entrance-side detection device 21 at the characteristic detection time tn_1 with the characteristic detection time tn_1 , and the amount of reflected light n_1 that is detected by the exit-side detection device 22 at the characteristic detection time tn_4 with the characteristic detection time tn_4 , as the classification information belonging to the same classification, so as to be written into the queue provided in the first velocity calculation unit 16.

Further, in the same manner, since the difference between the value of the amount of reflected light that is detected by the entrance-side detection device 21 at the characteristic detection time tn_2 and the value of the amount of reflected light that is detected by the exit-side detection device 22 at the characteristic detection time tn_5 is a threshold or less, the signal strength corresponding relationship determination unit 14 determines that they belong to the same classification. Then, the signal strength corresponding relationship determination unit 14 associates the amount of reflected light o_1 that is detected by the entrance-side detection device 21 at the characteristic detection time tn_2 with the characteristic detection time tn_2 , and the amount of reflected light o_1 that is detected by the exit-side detection device 22 at the characteristic detection time tn_5 with the characteristic detection time tn_5 , as the classification information belonging to the same classification, so as to be written into the queue provided in the first velocity calculation unit 16.

[0061]

Then, as described above, the signal strength corresponding relationship determination unit 14 repeats the determination of the characteristic detection time based on the amount of reflected light detected by the entrance-side detection device 21 and the exit-side detection device 22, and the classification of the characteristic detection time.

When the processing of the repeat for one vehicle 30 is completed, the vehicle traveling information which is output from the height corresponding relationship determination unit 13 described above is written into the queue provided in the first velocity calculation unit 16.

5 [0062]

Subsequently, the first velocity calculation unit 16 reads the first classification information from the queue. The classification information includes a pair of the characteristic detection time t_3 and the amount of reflected light m_1 detected by the entrance-side detection device 21 at the characteristic detection time t_3 , or a pair of the
 10 characteristic detection time tn_3 and the amount of reflected light m_1 detected by the exit-side detection device 22 at the characteristic detection time tn_3 . Then, the first velocity calculation unit 16 acquires the characteristic detection time t_3 and the characteristic detection time tn_3 included in the classification information which is read, calculates the velocity V_4 of the vehicle 30 at the characteristic detection time t_3 or the
 15 characteristic detection time tn_3 by the equation of $V_4 = D \div (tn_3 - t_3)$ using the acquired times and the installation interval D (step S110), and writes the velocity V_4 into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection time t_3 and the characteristic detection time tn_3 . In the present embodiment, it is assumed that the velocity V_4 and the characteristic detection time t_3
 20 are associated and written into the queue provided in the length calculation unit 17.

[0063]

Here, the first velocity calculation unit 16 determines whether the information which is subsequently read from the queue is vehicle traveling information (step S111). Then, if the information is not the vehicle traveling information, the first velocity
 25 calculation unit 16 repeats the calculation of the velocity of the vehicle 30 using the

characteristic detection time included in the classification information. In other words, the first velocity calculation unit 16 reads the subsequent classification information from the queue. The classification information includes a pair of the characteristic detection time tn_1 and the amount of reflected light $n1$ detected by the entrance-side detection device 21 at the characteristic detection time tn_1 , or a pair of the characteristic detection time tn_4 and the amount of reflected light $n1$ detected by the exit-side detection device 22 at the characteristic detection time tn_4 . Then, the first velocity calculation unit 16 acquires the characteristic detection time tn_1 and the characteristic detection time tn_4 included in the classification information which is read, calculates the velocity $V5$ of the vehicle 30 at the characteristic detection time tn_1 or the characteristic detection time tn_4 by the equation of $V5=D÷(tn_4-tn_1)$ using the acquired times and the installation interval D , and writes the velocity $V5$ into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection time tn_1 and the characteristic detection time tn_4 . In the present embodiment, it is assumed that the velocity $V5$ and the characteristic detection time tn_1 are associated and written into the queue provided in the length calculation unit 17.

[0064]

Further, the first velocity calculation unit 16 reads the subsequent classification information from the queue. The classification information includes a pair of the characteristic detection time tn_2 and the amount of reflected light $o1$ detected by the entrance-side detection device 21 at the characteristic detection time tn_2 , or a pair of the characteristic detection time tn_5 and the amount of reflected light $o1$ detected by the exit-side detection device 22 at the characteristic detection time tn_5 . Then, the first velocity calculation unit 16 acquires the characteristic detection time tn_2 and the characteristic detection time tn_5 included in the classification information which is read,

calculates the velocity $V6$ of the vehicle 30 at the characteristic detection time tn_2 or the characteristic detection time tn_5 by the equation of $V6=D÷(tn_5-tn_2)$ using the acquired times and the installation interval D , and writes the velocity $V6$ into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection

5 time tn_2 and the characteristic detection time tn_5 . In the present embodiment, it is assumed that the velocity $V6$ and the characteristic detection time tn_2 are associated and written into the queue provided in the length calculation unit 17.

[0065]

Then, if the vehicle traveling information is read from the queue, the first

10 velocity calculation unit 16 stops the calculation of the velocity using each characteristic detection time for one vehicle 30 and writes the vehicle traveling information into the queue provided in the length calculation unit 17.

[0066]

In this case, the information stored into the queue provided in the length

15 calculation unit 17 is as follows:

Information in which the velocity $V1$ and the characteristic detection time $t3$ are associated;

Information in which the velocity $V2$ and the characteristic detection time $t11$ are associated;

20 Information in which the velocity $V3$ and the characteristic detection time $t23$ are associated;

Information in which the velocity $V4$ and the characteristic detection time $t3$ are associated;

Information in which the velocity $V5$ and the characteristic detection time tn_1

25 are associated;

Information in which the velocity $V6$ and the characteristic detection time tn_2 are associated;

Information in which the velocity $V7$ and the traveling time $t30$ are associated;
and

5 Vehicle traveling information.

Then, the length calculation unit 17 reads, from the queues, the combination information of the velocity $V1$ and the characteristic detection time $t3$, the combination information of the velocity $V2$ and the characteristic detection time $t11$, the combination information of the velocity $V3$ and the characteristic detection time $t23$, the combination
10 information of the velocity $V4$ and the characteristic detection time $t3$, the combination information of the velocity $V5$ and the characteristic detection time tn_1 , the combination information of the velocity $V6$ and the characteristic detection time tn_2 , the combination information of the velocity $V7$ and the traveling time $t30$, and vehicle traveling information in order. Then, if the vehicle traveling information is read, the length
15 calculation unit 17 stops the reading of information from the queue, and reads the characteristic detection time among respective pieces of combination information so as to determine whether there exists a coincident characteristic detection time. Then, if there exists the coincident characteristic detection time, the length calculation unit 17 determines to exclude the combination information including the characteristic detection
20 times which are late, from information used for the processing. In the present embodiment, in the combination information of the velocity $V1$ and the characteristic detection time $t3$ and the combination information of the velocity $V4$ and the characteristic detection time $t3$, the characteristic detection times are coincident with each other. Accordingly, the length calculation unit 17 determines to exclude the
25 combination information of the velocity $V4$ and the characteristic detection time $t3$ from

information used for the processing. In addition, it is possible to remove information that has been determined to be excluded from the information used for processing.

[0067]

Then, the length calculation unit 17 calculates the vehicle length L of the vehicle
 5 30 using the combination information of the velocity $V1$ and the characteristic detection time $t3$, the combination information of velocity $V2$ and the characteristic detection time $t11$, the combination information of the velocity $V3$ and the characteristic detection time $t23$, the combination information of the velocity $V5$ and the characteristic detection time tn_1 , and the combination information of the velocity $V6$ and the characteristic detection
 10 time tn_2 (step S112). More specifically, two pieces of combination information are specified in the order from the earliest characteristic detection time. Here, the combination information of the velocity $V1$ and the characteristic detection time $t3$, and the combination information of the velocity $V5$ and the characteristic detection time tn_1 are specified. Then, the length calculation unit 17 calculates an integral value from the
 15 characteristic detection time $t3$ to the characteristic detection time tn_1 , using an equation indicated by a function taking the characteristic detection time as x-axis and the velocity as y-axis and traveling through (velocity $V1$, characteristic detection time $t3$) and (velocity $V5$, characteristic detection time tn_1). The combination information including the earliest characteristic detection time is excluded from the information used for
 20 processing. The combination information that has been excluded is the combination information of the velocity $V1$ and the characteristic detection time $t3$.

[0068]

Subsequently, the length calculation unit 17 specifies two pieces of combination
 information in order from the earliest characteristic detection time among pieces of
 25 combination information which currently remain and are not being excluded. Here, the

combination information of the velocity $V5$ and the characteristic detection time tn_1 and the combination information of the velocity $V6$ and the characteristic detection time tn_2 are specified.

Then, the length calculation unit 17 calculates an integral value from the
 5 characteristic detection time tn_1 to the characteristic detection time tn_2 , using an equation indicated by a function taking the characteristic detection time as x-axis and the velocity as y-axis and traveling through (velocity $V5$, characteristic detection time tn_1) and (velocity $V6$, characteristic detection time tn_2). The combination information including the earliest characteristic detection time is excluded from the information used for
 10 processing.

The combination information that has been excluded is the combination information of the velocity $V5$ and the characteristic detection time tn_1 .

[0069]

Subsequently, the length calculation unit 17 specifies two pieces of combination
 15 information in order from the earliest characteristic detection time among pieces of combination information which currently remain and are not being excluded. Here, the combination information of the velocity $V6$ and the characteristic detection time tn_2 and the combination information of the velocity $V2$ and the characteristic detection time $t11$ are specified.

20 Then, the length calculation unit 17 calculates an integral value from the characteristic detection time tn_2 to the characteristic detection time $t11$, using an equation indicated by a function taking the characteristic detection time as x-axis and the velocity as y-axis and traveling through (velocity $V6$, characteristic detection time tn_2) and (velocity $V2$, characteristic detection time $t11$). The combination information including
 25 the earliest characteristic detection time is excluded from the information used for

processing.

The combination information that has been excluded is the combination information of the velocity V_6 and the characteristic detection time t_{n2} .

[0070]

Subsequently, the length calculation unit 17 specifies two pieces of combination information in order from the earliest characteristic detection time among pieces of combination information which currently remain and are not being excluded. Here, the combination information of the velocity V_2 and the characteristic detection time t_{11} and the combination information of the velocity V_3 and the characteristic detection time t_{23} are specified.

Then, the length calculation unit 17 calculates an integral value from the characteristic detection time t_{11} to the characteristic detection time t_{23} , using an equation indicated by a function taking the characteristic detection time as x-axis and the velocity as y-axis and traveling through (velocity V_2 , characteristic detection time t_{11}) and (velocity V_3 , characteristic detection time t_{23}). The combination information including the earliest characteristic detection time is excluded from the information used for processing.

The combination information that has been excluded is the combination information of the velocity V_2 and the characteristic detection time t_{11} .

[0071]

Subsequently, the length calculation unit 17 specifies two pieces of combination information in order from the earliest characteristic detection time among pieces of combination information which currently remain and are not being excluded. Here, the combination information of the velocity V_3 and the characteristic detection time t_{23} and the combination information of the velocity V_7 and the characteristic detection time t_{30}

are specified.

Then, the length calculation unit 17 calculates an integral value from the characteristic detection time t_{23} to the characteristic detection time t_{30} , using an equation indicated by a function taking the characteristic detection time as x-axis and the velocity as y-axis and traveling through (velocity V_3 , characteristic detection time t_{23}) and (velocity V_7 , characteristic detection time t_{30}). The combination information including the earliest characteristic detection time is excluded from the information used for processing.

The combination information that has been excluded is the combination information of the velocity V_3 and the characteristic detection time t_{23} .

[0072]

Then, if only one piece of combination information of the velocity V_7 and the characteristic detection time t_{30} remains at the end, the process of integration is ended. Then, the length calculation unit 17 sums the results calculated by the integration so as to be output as the length L of the vehicle 30.

[0073]

In addition, the length calculation unit 17 may obtain a smooth approximation equation taking the characteristic detection time as an x-axis and the velocity as a y-axis and traveling through each point of (velocity V_1 , characteristic detection time t_3), (velocity V_5 , characteristic detection time t_{n1}), (velocity V_6 , characteristic detection time t_{n2}), (velocity V_2 , characteristic detection time t_{11}), (velocity V_3 , characteristic detection time t_{23}), and (velocity V_7 , characteristic detection time t_{30}), calculate an integral value from the characteristic detection time t_3 which is earliest in the detection time to the characteristic detection time t_{30} which is latest in the detection time, using the approximation equation, and output the integral value as the length L of the vehicle 30.

[0074]

Hitherto, the embodiments of the present invention has been described,
according to the process of the device 10 for measuring an object to be measured
described above, it is possible to detect the length in the traveling direction of the object
5 to be measured accurately.

[0075]

In addition, in the process of step S102 and step S103 described above, if the
height information, in which the change is within the threshold, is received in a row a
predetermined number of times or more, the height corresponding relationship
10 determination unit 13 determines the detection time corresponding to the height
information which is received at the earliest time among respective pieces of height
information falling within the threshold as a characteristic detection time at which the
height information is detected first. However, if the height information, in which the
change is within the threshold, is received in a row a predetermined number of times or
15 more, the height information which is received at the earliest time among respective
pieces of height information falling within the threshold is a portion in which the height
of the object to be measured changes, and thus the reliability of the value of the height
information to be detected is low. Therefore, if the height information, in which the
change is within the threshold, is received in a row a predetermined number of times or
20 more, the detection time of the height information other than the height information
which is received at the earliest time among respective pieces of height information
falling within the threshold may be determined as the characteristic detection time.

In other words, in this case, if a description is made using FIG. 4, for example,
the detection time t_4 is determined as the characteristic detection time of the height
25 information A1, the detection time t_{12} is determined as the characteristic detection time

of the height information B1, and the detection time t_{24} is determined as the characteristic detection time of the height information C1.

[0076]

In addition, in the process of step S107 and step S108 described above, if the
 5 amount of reflected light, in which the change is within the threshold, is received in a row a predetermined number of times or more, the signal strength corresponding relationship determination unit 14 determines the detection time corresponding to the amount of reflected light that is received at the earliest time among respective amounts of reflected light falling within the threshold as a characteristic detection time at which the
 10 amount of reflected light falling within the threshold is detected first. However, if the amount of reflected light, in which the change is within the threshold, is received in a row a predetermined number of times or more, the amount of reflected light that is received at the earliest time among respective amounts of reflected light falling within the threshold is a portion in which the amount of reflected light of the object to be
 15 measured changes, and thus the reliability of the value of the amount of reflected light to be detected is low. Therefore, if the amount of reflected light, in which the change is within the threshold, is received in a row a predetermined number of times or more, the detection time of the amount of reflected light other than the amount of reflected light that is received at the earliest time among respective amounts of reflected light falling
 20 within the threshold may be determined as the characteristic detection time.

In other words, in this case, if describing using FIG. 5, for example, the detection time subsequent to the detection time tn_1 is determined as the characteristic detection time of the amount of reflected light $n1$, and the detection time subsequent to the detection time tn_2 is determined as the characteristic detection time of the amount of
 25 reflected light $o1$.

[0077]

In addition, in the present embodiment, an example is described in which each detection device provided in the traveling direction calculates the length of the object to be measured, using the detection time of the geometric characteristic and the detection
5 time of the optical characteristic of the object to be measured. However, without being limited thereto, each detection device provided in the traveling direction may calculate the length of the object to be measured, not by using the detection time of the geometric characteristic of the object to be measured, but by using the detection time of the optical characteristic of the object to be measured. If there is no geometric characteristic in the
10 object to be measured, it is possible to perform the measurement of the length of the object to be measured, using an optical characteristic (characteristic of the amount of reflected light such as characteristic of the glass surface and the color of the body of the vehicle 30 being greatly changed) of the object to be measured.

[0078]

15 In addition, the device 10 for measuring an object to be measured described above has a computer system inside thereof.

The procedure of each process described above is stored in a computer-readable recording medium in the form of a program, and the computer reads and executes the program so as to perform the process. Here, the computer readable recording medium
20 refers to magnetic disks, magneto optical disks, CD-ROMs, DVD-ROMs, semiconductor memories, and the like. Further, the computer program may be distributed to a computer through a communication line to cause the computer which receives this distribution to execute the program.

[0079]

25 Further, the program may be intended to implement a part of the functions

described above.

Furthermore, the program may be a so-called differential file (differential program) in which the functions described above can be implemented in combination with the program that has been recorded already in a computer system.

5

Industrial Applicability

[0080]

According to the process of the device for measuring an object to be measured of the present invention, it is possible to measure a length in a traveling direction of an
10 object to be measured accurately.

Reference Signs List

[0081]

- 10 ... Device for measuring an object to be measured
- 15 11 ... Input unit
- 12 ... Storage unit
- 13 ... Height corresponding relationship determination unit
- 14 ... Signal strength corresponding relationship determination unit
- 15 ... Second velocity calculation unit
- 20 16 ... First velocity calculation unit
- 17 ... Length calculation unit
- 21 ... Entrance-side detection device
- 22 ... Exit-side detection device
- 30 ... Vehicle

25

CLAIMS

1. A device for measuring an object to be measured, comprising:
 - an input unit that receives a strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured from each of a plurality of detection devices, the detection devices being located in respective installation positions which are provided spaced apart in a traveling direction of the object to be measured;
 - a signal strength corresponding relationship determination unit that classifies signal strengths of a plurality of light reflection signals which are respectively detected by the detection devices depending on time elapsed into at least one or more corresponding relationship of a signal strength with respect to the object to be measured, for each corresponding relationship of a signal strength indicating the same portion of the object to be measured; and
 - a first velocity calculation unit that calculates a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating the same portion, for each corresponding relationship of the signal strength classified into at least one or more corresponding relationship with respect to the object to be measured, and calculates a velocity of the object to be measured at the time of at least one or more signal strength detection time of the object to be measured in any one or all of the plurality of detection devices, for each corresponding relationship of the classified signal strength, based on the calculated time difference of at least one or more signal strength detection time of the object to be measured and an installation interval between the plurality of detection devices.

2. The device for measuring an object to be measured according to Claim 1, further comprising:

a length calculation unit that calculates a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the time of at least one or more signal strength detection time of the object to be measured in any one or all of the plurality of detection devices.

3. The device for measuring an object to be measured according to Claim 2,

wherein the input unit receives height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height information of the object to be measured using a radiation-reception interval between a radiation time of a light radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal,

wherein each of the detection devices includes

a height corresponding relationship determination unit that classifies a plurality of pieces of height information of the object to be measured which are respectively calculated by the detection devices depending on time elapsed for each corresponding relationship of height information indicating the same portion of the object to be measured; and

a second velocity calculation unit that calculates a time difference between height detection times of respective pieces of height information in the plurality of detection devices that calculate respective pieces of height information included in the corresponding relationship of height information indicating the same portion, for each corresponding relationship of the classified height information, and calculates a velocity of the object to be measured at the height detection time in any one or all of the plurality of detection devices,

for each corresponding relationship of the classified height information, based on the time difference between the height detection times and an installation interval in the traveling direction between the plurality of detection devices, and

wherein the length calculation unit calculates a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified height information, at the height detection time in any one or all of the plurality of detection devices and the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection time in any one or all of the plurality of detection devices.

4. The device for measuring an object to be measured according to Claim 3, wherein the length calculation unit calculates a length of the object to be measured in the traveling direction, the object to be measured traveling between the plurality of detection devices, based on each integral value calculated by each equation indicated by each relationship between the plurality of signal strength detection times or the plurality of height detection times of the object to be measured and the velocity of the object to be measured at the time of the plurality of signal strength detection times or the plurality of height detection times.

5. The device for measuring an object to be measured according to any one of Claims 1 to 4, wherein

the signal strength corresponding relationship determination unit determines whether there is a change of the signal strength of the light reflection signal by a predetermined threshold or more as compared with the previous signal strength of the light reflection signal

at each time receiving the signal strength of the light reflection signal included in a detection signal sent from each of the detection devices, and

the signal strength corresponding relationship determination unit determines the detection time corresponding to the signal strength of the light reflection signal that is received at the earliest time or corresponding to the signal strength of the light reflection signal that is received at a time delay for a predetermined time from the light reflection signal that is received at the earliest time among the respective light reflection signals falling within the predetermined threshold as a characteristic detection time at which the signal strength of the light reflection signal is detected first in the detection device when the signal strength of the light reflection signal having the change of the signal strength of the light reflection signal by the predetermined threshold or less is received in a row a predetermined number of times or more.

6. A processing method of a device for measuring an object to be measured, the method comprising:

receiving a strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured from each of a plurality of detection devices by an input unit, the detection devices being located in respective installation positions which are provided spaced apart in a traveling direction of the object to be measured;

classifying signal strengths of a plurality of light reflection signals which are respectively detected by the detection devices depending on time elapsed into at least one or more corresponding relationship of a signal strength with respect to the object to be measured, for each corresponding relationship of a signal strength indicating the same portion of the object to be measured, by a signal strength corresponding relationship determination unit;

calculating a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating the same portion, for each corresponding relationship of the signal strength classified into at least one or more corresponding relationship with respect to the object to be measured, by a first velocity calculation unit; and

calculating a velocity of the object to be measured at the time of at least one or more signal strength detection time of the object to be measured in any one or all of the plurality of detection devices, for each corresponding relationship of the classified signal strength, based on the calculated time difference of at least one or more the signal strength detection time of the object to be measured and an installation interval between the plurality of detection devices, by a first velocity calculation unit.

7. The processing method according to Claim 6, further comprising:

calculating a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the time of at least one or more signal strength detection time of the object to be measured in any one or all of the plurality of detection devices, by a length calculation unit.

8. The processing method according to Claim 7, further comprising:

receiving height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height information of the object to be measured using a radiation-reception interval between a radiation time of a light

radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal, by the input unit;

classifying a plurality of pieces of height information of the object to be measured which are respectively calculated by the detection devices depending on time elapsed for each corresponding relationship of height information indicating the same portion of the object to be measured by a height corresponding relationship determination unit;

calculating a time difference between height detection times of respective pieces of height information in the plurality of detection devices that calculate respective pieces of height information included in the corresponding relationship of height information indicating the same portion, for each corresponding relationship of the classified height information, and to calculate a velocity of the object to be measured at the height detection time in any one or all of the plurality of detection devices, for each corresponding relationship of the classified height information, based on the time difference between the height detection times and an installation interval in the traveling direction between the plurality of detection devices, by a second velocity calculation unit; and

calculating a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified height information, at the height detection time in any one or all of the plurality of detection devices and the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection time in any one or all of the plurality of detection devices, by the length calculation unit.

9. The processing method according to Claim 8, further comprising:

calculating a length of the object to be measured in the traveling direction, the object to be measured traveling between the plurality of detection devices, based on each integral value calculated by each equation indicated by each relationship between the plurality of signal strength detection times or the plurality of height detection times of the object to be measured and the velocity of the object to be measured at the time of the plurality of signal strength detection times or the plurality of height detection times, by the length calculation unit.

10. The processing method according to any one of Claims 6 to 9, further comprising:
determining whether there is a change of the signal strength of the light reflection signal by a predetermined threshold or more as compared with the previous signal strength of the light reflection signal at each time receiving the signal strength of the light reflection signal included in a detection signal sent from each of the detection devices, by the signal strength corresponding relationship determination unit, and

determining the detection time corresponding to the signal strength of the light reflection signal that is received at the earliest time or corresponding to the signal strength of the light reflection signal that is received at a time delay for a predetermined time from the light reflection signal that is received at the earliest time among the respective light reflection signals falling within the predetermined threshold as a characteristic detection time at which the signal strength of the light reflection signal is detected first in the detection device when the signal strength of the light reflection signal having the change of the signal strength of the light reflection signal by the predetermined threshold or less is received in a row a predetermined number of times or more, by the signal strength corresponding relationship determination unit.

11. A program of a computer of a device for measuring an object to be measured, to function as:

input portion for receiving a strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured from each of a plurality of detection devices, the detection devices being located in respective installation positions which are provided spaced apart in a traveling direction of the object to be measured;

signal strength corresponding relationship determination portion for classifying signal strengths of a plurality of light reflection signals which are respectively detected by the detection devices depending on a time elapsed into at least one or more corresponding relationship of a signal strength with respect to the object to be measured, for each corresponding relationship of a signal strength indicating the same portion of the object to be measured; and

first velocity calculation portion for calculating a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating the same portion, for each corresponding relationship of the signal strength classified into at least one or more corresponding relationship with respect to the object to be measured, and for calculating a velocity of the object to be measured at the time of at least one or more signal strength detection time of the object to be measured in any one or all of the plurality of detection devices, for each corresponding relationship of the classified signal strength, based on the calculated time difference of at least one or more signal strength detection time of the object to be measured and an installation interval between the plurality of detection devices.

12. The program according to Claim 11, that further causes the computer to function as

length calculation portion for calculating a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the time of at least one or more signal strength detection time of the object to be measured in any one or all of the plurality of detection devices.

13. The program according to Claim 12,

wherein the input portion receives height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height information of the object to be measured using a radiation-reception interval between a radiation time of a light radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal,

wherein the program further causes the computer to function as:

height corresponding relationship determination portion for classifying a plurality of pieces of height information of the object to be measured which are respectively calculated by the detection devices depending on a time elapsed, for each corresponding relationship of height information indicating the same portion of the object to be measured; and

second velocity calculation portion for calculating a time difference between height detection times of respective pieces of height information in the plurality of detection devices that calculate respective pieces of height information included in the corresponding relationship of height information indicating the same portion, for each corresponding relationship of the classified height information, and for calculating a velocity of the object to be measured at the height detection time in any one or all of the plurality of detection devices, for each corresponding relationship of the classified height information, based on the time

difference between the height detection times and an installation interval in the traveling direction between the plurality of detection devices; and

wherein the length calculation portion calculates a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified height information, at the height detection time in any one or all of the plurality of detection devices and the velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection time in any one or all of the plurality of detection devices.

14. The program according to Claim 13,

wherein the length calculation portion calculates a length of the object to be measured in the traveling direction, the object to be measured traveling between the plurality of detection devices, based on each integral value calculated by each equation indicated by each relationship between the plurality of signal strength detection times or the plurality of height detection times of the object to be measured and the velocity of the object to be measured at the time of the plurality of signal strength detection times or the plurality of height detection times.

15. The program according to any one of Claims 11 to 14,

wherein the signal strength corresponding relationship determination portion determines whether there is a change of the signal strength of the light reflection signal by a predetermined threshold or more as compared with the previous signal strength of the light reflection signal at each time receiving the signal strength of the light reflection signal included in a detection signal sent from each of the detection devices, and

the signal strength corresponding relationship determination portion determines the detection time corresponding to the signal strength of the light reflection signal that is received at the earliest time or corresponding to the signal strength of the light reflection signal that is received at a time delay for a predetermined time from the light reflection signal that is received at the earliest time among the respective light reflection signals falling within the predetermined threshold as a characteristic detection time at which the signal strength of the light reflection signal is detected first in the detection device when the signal strength of the light reflection signal having the change of the signal strength of the light reflection signal by the predetermined threshold or less is received in a row a predetermined number of times or more.