

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. 2011-215483, 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.

25

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, although PTL 1 and PTL 2 include technologies to measure the size of a vehicle by a laser radiated from a measurement device, it is necessary to consider the influence of acceleration and deceleration of the vehicle traveling between a plurality of
15 detection devices which are installed spaced apart, when measuring the size in a length direction of the vehicle (hereinafter, referred to as a vehicle length). This requires the measurement accuracy of the length of the vehicle to be improved. It is necessary to extract an appropriate detection signal of the vehicle among the detection signals received from a plurality of detection devices installed spaced apart, for improving the
20 measurement accuracy of the length of the vehicle.

[0005]

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

[0006]

To achieve the above object, the present invention relates to a device for measuring an object to be measured, including: an input unit that receives a detection
5 signal representing a characteristic of the object to be measured from each of an entrance-side detection device and an exit-side detection device which are installed at a predetermined installation interval in a traveling direction of the object to be measured; a characteristic detection information generation unit that generates characteristic detection information including characteristic increase-decrease information indicating a value of
10 an increase or decrease of the characteristics of the object to be measured and a characteristic detection time included in the detection signal, based on the received detection signal, each time the detection signal is received from the entrance-side detection device and the exit-side detection device; a function-deriving unit that derives a function passing through a point having a first characteristic detection time as a
15 component in each of two detection devices of the entrance-side detection device and the exit-side detection device and a point having a last characteristic detection time for the object to be measured as a component in each of two detection devices, in a two-dimensional coordinate system representing a relationship between the characteristic detection time when the entrance-side detection device detects the object to be measured
20 in a time axis after the entrance-side detection device first detects the detection signal for the object to be measured and the characteristic detection time when the exit-side detection device detects the object to be measured in the time axis, the function representing a traveling time of each characteristic of the object to be measured in the entrance-side detection device and the exit-side detection device at an average
25 acceleration of the object to be measured traveling between the entrance-side detection

device and the exit-side detection device; an assumed time calculation unit that calculates the other component by substituting the characteristic detection time included in the received detection signal as one component for the function, and calculates an assumed time at which a characteristic indicated by the characteristic detection information generated based on the detection signal received from any one detection device of the entrance-side detection device and the exit-side detection device may be detected in the other detection device, in a case of assuming that the object to be measured travels at the average acceleration between the entrance-side detection device and the exit-side detection device; a characteristic detection information candidate specification unit that specifies the characteristic detection information which is generated based on one detection signal received from the one detection device, reads characteristic increase-decrease information from the characteristic detection information, and specifies the characteristic detection information including characteristic increase-decrease information indicating the same value as any value of the increase or decrease indicated by the characteristic increase-decrease information which is read, among the characteristic detection information which is generated based on the detection signal received from the other detection device; a characteristic detection information specification unit that specifies characteristic detection information including a characteristic detection time which is closest to an assumed time obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as one component for the function and calculating the other component, among the specified characteristic detection information; and a detection signal corresponding relationship determination unit that determines one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic detection

information which is specified by the characteristic detection information specification unit, as a corresponding detection signal when a characteristic point of the object to be measured is detected.

[0007]

5 Further, the device for measuring an object to be measured described above according to the present invention further includes a reference detection device specification unit that compares the number of times at which the entrance-side detection device detects the object to be measured between the first characteristic detection time and the last characteristic detection time, with the number of times at which the exit-side
10 detection device detects the object to be measured between the first characteristic detection time and the last characteristic detection time, and specifies the detection device having a smaller number of detection times of the object to be measured out of the entrance-side detection device and the exit-side detection device as one detection device.

[0008]

15 Further, in the device for measuring an object to be measured described above according to the present invention, the input unit respectively receives a detection signal including a characteristic indicating strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured and a characteristic detection time thereof, from the entrance-side detection device and the exit-side detection
20 device, and the characteristic detection information generation unit generates characteristic detection information including characteristic increase-decrease information indicating a value of an increase or decrease of the characteristic of the object to be measured indicating an optical characteristic of the object to be measured and a characteristic detection time included in the detection signal, based on the detection
25 signal.

[0009]

Further, in the device for measuring an object to be measured described above according to the present invention, the input unit respectively receives a detection signal including a characteristic indicating height information of the object to be measured
5 which is detected using a radiation-transmission interval between a radiation time of the light radiation signal and a reception time of the light reflection signal and a characteristic detection time thereof, from the entrance-side detection device and the exit-side detection device, and the characteristic detection information generation unit generates characteristic detection information including characteristic increase-decrease
10 information indicating a value of an increase or decrease of the characteristic of the object to be measured indicating a geometric characteristic of the object to be measured and a characteristic detection time included in the detection signal, based on the detection signal.

[0010]

15 Further, in the device for measuring an object to be measured described above according to the present invention, the detection signal corresponding relationship determination unit determines one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic detection information which is specified by the characteristic
20 detection information specification unit, as the corresponding detection signal when the characteristic point of the object to be measured is detected, only if the characteristic detection time which is closest to the assumed time is within a predetermined time difference from the assumed time, the assumed time being obtained by substituting the characteristic detection time included in the one detection signal which is received from
25 the one detection device as one component for the function and calculating the other

component, among characteristic detection times included in the characteristic detection information which is specified by the characteristic detection information candidate specification unit.

[0011]

5 Further, the device for measuring an object to be measured described above according to the present invention further includes a corresponding relationship determination stop unit that compares a time relationship between the characteristic detection time included in the detection signal which is first received for the object to be measured from the entrance-side detection device and the characteristic detection time
10 included in the detection signal which is first received for the object to be measured from the exit-side detection device, with the time relationship between the characteristic detection time included in the detection signal which is last received for the object to be measured from the entrance-side detection device and the characteristic detection time included in the detection signal which is last received for the object to be measured from
15 the exit-side detection device, and stops the determination of the corresponding relationship of the detection signals which are received from the entrance-side detection device and the exit-side detection device, if the time relationships are different.

[0012]

 Further, the device for measuring an object to be measured described above
20 according to the present invention further includes a velocity calculation unit that calculates a velocity for each of the characteristic points of the object to be measured, based on combined information of one detection signal received from the one detection device which is determined as the corresponding detection signal when the characteristic point of the object to be measured is detected and characteristic detection times included
25 in each of detection signals received from the other detection device, and the installation

interval.

[0013]

Further, the device for measuring an object to be measured described above according to the present invention further includes a length calculation unit that
5 calculates a length in the traveling direction of the object to be measured, based on a velocity for each of the characteristic points and any one or both of a characteristic detection time included in the detection signal received from the entrance-side detection device and a characteristic detection time included in the detection signal received from the exit-side detection device.

10 [0014]

Further, the present invention relates to a processing method of a device for measuring an object to be measured causing: an input unit to receive a detection signal representing a characteristic of the object to be measured from each of an entrance-side detection device and an exit-side detection device which are installed at a predetermined
15 installation interval in a traveling direction of the object to be measured; a characteristic detection information generation unit to generate characteristic detection information including characteristic increase-decrease information indicating a value of an increase or decrease of the characteristic of the object to be measured and a characteristic detection time included in the detection signal, based on the received detection signal, each time
20 the detection signal is received from the entrance-side detection device and the exit-side detection device; a function-deriving unit to derive a function passing through a point having a first characteristic detection time as a component in each of two detection devices of the entrance-side detection device and the exit-side detection device and a point having a last characteristic detection time for the object to be measured as a
25 component in each of two detection devices, in a two-dimensional coordinate system

representing a relationship between the characteristic detection time when the entrance-side detection device detects the object to be measured in a time axis after the entrance-side detection device first detects the detection signal for the object to be measured and the characteristic detection time when the exit-side detection device detects the object to be measured in the time axis, the function representing a traveling time of each characteristic of the object to be measured in the entrance-side detection device and the exit-side detection device at an average acceleration of the object to be measured traveling between the entrance-side detection device and the exit-side detection device; an assumed time calculation unit to calculate the other component by substituting the characteristic detection time included in the received detection signal as one component for the function, and to calculate an assumed time at which a characteristic indicated by the characteristic detection information generated based on the detection signal received from any one detection device of the entrance-side detection device and the exit-side detection device may be detected in the other detection device, in a case of assuming that the object to be measured travels at the average acceleration between the entrance-side detection device and the exit-side detection device; a characteristic detection information candidate specification unit to specify the characteristic detection information which is generated based on one detection signal received from the one detection device, to read characteristic increase-decrease information from the characteristic detection information, and to specify the characteristic detection information including characteristic increase-decrease information indicating the same value as any value of an increase or decrease indicated by the characteristic increase-decrease information which is read, among the characteristic detection information which is generated based on the detection signal received from the other detection device; a characteristic detection information specification unit to specify characteristic detection information including a characteristic

detection time which is closest to an assumed time obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as one component for the function and calculating the other component, among the specified characteristic detection information; and a detection
5 signal corresponding relationship determination unit to determine one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic detection information which is specified by the characteristic detection information specification unit, as a corresponding detection signal when a characteristic point of the object to be measured is
10 detected.

[0015]

Further, the present invention is a program causing a computer of a device for measuring an object to be measured to function as: input portion for receiving a detection signal representing a characteristic of the object to be measured from each of an
15 entrance-side detection device and an exit-side detection device which are installed at a predetermined installation interval in a traveling direction of the object to be measured; characteristic detection information generation portion for generating characteristic detection information including characteristic increase-decrease information indicating a value of an increase or decrease of the characteristic of the object to be measured and a
20 characteristic detection time included in the detection signal, based on the received detection signal, each time the detection signal is received from the entrance-side detection device and the exit-side detection device; function-deriving portion for deriving a function passing through a point having a first characteristic detection time as a component in each of two detection devices of the entrance-side detection device and the
25 exit-side detection device and a point having a last characteristic detection time for the

object to be measured as a component in each of two detection devices, in a two-dimensional coordinate system representing a relationship between the characteristic detection time when the entrance-side detection device detects the object to be measured in a time axis after the entrance-side detection device first detects the detection signal for the object to be measured and the characteristic detection time when the exit-side detection device detects the object to be measured in the time axis, the function representing a traveling time of each characteristic of the object to be measured in the entrance-side detection device and the exit-side detection device at an average acceleration of the object to be measured traveling between the entrance-side detection device and the exit-side detection device; assumed time calculation portion for calculating the other component by substituting the characteristic detection time included in the received detection signal as one component for the function, and for calculating an assumed time at which a characteristic indicated by the characteristic detection information generated based on the detection signal received from any one detection device of the entrance-side detection device and the exit-side detection device may be detected in the other detection device, in a case of assuming that the object to be measured travels at the average acceleration between the entrance-side detection device and the exit-side detection device; characteristic detection information candidate specification portion for specifying the characteristic detection information which is generated based on one detection signal received from the one detection device, for reading characteristic increase-decrease information from the characteristic detection information, and for specifying the characteristic detection information including characteristic increase-decrease information indicating the same value as any value of an increase or decrease indicated by the characteristic increase-decrease information which is read, among the characteristic detection information which is generated based on the

detection signal received from the other detection device; characteristic detection information specification portion for specifying characteristic detection information including a characteristic detection time which is closest to an assumed time obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as one component for the function and calculating the other component, among the specified characteristic detection information; and detection signal corresponding relationship determination portion for determining one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic detection information which is specified by the characteristic detection information specification unit, as a corresponding detection signal when a characteristic point of the object to be measured is detected.

Advantageous Effects of Invention

[0016]

According to the process of the device for measuring an object to be measured of the present invention, it is possible to extract an appropriate detection signal of a vehicle among the detection signals received from a plurality of detection devices installed spaced apart, in the measurement of a length of the vehicle.

Brief Description of Drawings

[0017]

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.

FIG. 4 is a diagram showing an outline of an extraction process of a detection signal used in a process.

5 FIG. 5 is a block diagram showing a functional configuration of a detection signal extraction unit.

FIG. 6 is a diagram showing a process flow of the detection signal extraction unit.

10 FIG. 7 is a diagram showing measurement result data based on information which is received by the input unit.

FIG. 8 is a diagram showing a data example of information which is output from a detection signal extraction unit.

FIG. 9 is a diagram showing a relationship between each characteristic detection time and a velocity calculated using the characteristic detection time.

15 FIG. 10 is a diagram showing a process flow of the device for measuring an object to be measured.

Description of Embodiments

[0018]

20 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.

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

25 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).

5 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
10 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).

15 [0019]

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 (installation interval) between the
20 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
25 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.

[0020]

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).

[0021]

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.

[0022]

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, a length calculation unit 17, and a detection signal extraction unit 18.

[0023]

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.

[0024]

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 [0025]

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.

Further, the detection signal extraction unit 18 is a processing unit that extracts a
 5 detection signal used in the process of the device 10 for measuring an object to be measured, among the detection signals received from the input unit 11.

[0026]

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

10 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 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
 15 case where each piece of information which is received at respective times t_1 , t_2 , t_3 , t_4 , t_5 , ... 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 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
 20 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 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.

25 [0027]

FIG. 4 is a diagram showing an outline of an extraction process of a detection signal used for the processing.

The device 10 for measuring an object to be measured sequentially receives detection signals depending on a time elapsed from each of the entrance-side detection device 21 and the exit-side detection device 22. The detection signal includes height information, an amount of reflected light, a characteristic detection time (time at which any one characteristic of the height information and the amount of reflected light is detected), identification information of a detection device, and the like. The height information is a height of the vehicle 30, and the amount of reflected light is an amount of reflected light (signal strength) radiated to the vehicle 30. Here, in order to accurately calculate the velocity and the length of the vehicle 30 based on the detection signal, it is necessary to specify a pair of the detection signals indicating the same characteristic (the height and the amount of reflected light) for the vehicle 30, among the detection signals received from the entrance-side detection device 21 and the detection signal received from the exit-side detection device 22.

[0028]

However, for example, if the traveling velocity of the vehicle 30 is extremely slow (including a case where vehicles are stopped due to traffic congestion, or the like) and the entrance-side detection device 21 or the exit-side detection device 22 shakes under the influence of wind, or the like, there is a possibility that the entrance-side detection device 21 or the exit-side detection device 22 sends the detection signal for the same characteristic of the vehicle 30 more than once to the device 10 for measuring an object to be measured. In this case, the device 10 for measuring an object to be measured cannot obtain the pair of the detection signals for the same characteristic of the vehicle 30 only by associating a pair of the detection signal received from the

entrance-side detection device 21 and the detection signal received from the exit-side detection device 22 in time order in which they are received. Accordingly, the device 10 for measuring an object to be measured determines the pair of the detection signals indicating the same characteristic among the detection signals received from the entrance-side detection device 21 and the detection signals received from the exit-side detection device 22, based on an extraction processing shown in FIG. 4.

[0029]

The extraction processing of the detection signal will be described more specifically using FIG. 4.

First, the horizontal axis in FIG. 4 represents a characteristic detection time t_E included in the detection signals received from the entrance-side detection device 21. The vertical axis in FIG. 4 represents a characteristic detection time t_P included in the detection signals received from the exit-side detection device 22. FIG. 4 shows a case in which characteristic detection times t_{E1} , t_{E2} , t_{E3} , and t_{E4} are respectively included in four detection signals of E1 to E4 which are received from the entrance-side detection device 21. Further, FIG. 4 shows a case in which characteristic detection times t_{P1} , t_{P2} , t_{P3} , t_{P4} , t_{P5} , t_{P6} , t_{P7} , and t_{P8} are respectively included in eight detection signals of P1 to P8 which are received from the exit-side detection device 22.

[0030]

Here, the detection signal E1 is a detection signal that detects the characteristic of a single vehicle 30 first in the entrance-side detection device 21. In addition, the detection signal P1 is a detection signal that detects the characteristic of a single vehicle 30 first in the exit-side detection device 22. In a state where the detection signal including the height information indicating the road surface height is received, if the detection signal including the height information higher than the road surface height is

received, it is possible to determine that the vehicle 30 which is an object to be measured is measured. Therefore, the detection signal extraction unit 18 can determine detection signals that respectively detect the characteristic of the vehicle 30 first in the entrance-side detection device 21 and the exit-side detection device 22, from the height information included in the detection signals.

[0031]

Further, the detection signal E4 is a detection signal that detects the characteristic of a single vehicle 30 last in the entrance-side detection device 21. In addition, the detection signal P8 is a detection signal that detects the characteristic of a single vehicle 30 last in the exit-side detection device 22. In a state where the height information higher than the road surface height continues, if the detection signal including the height information indicating the road surface height is received, it is possible to determine that the vehicle 30 which is an object to be measured has passed. Therefore, the detection signal extraction unit 18 can determine detection signals that respectively detect the characteristic of the vehicle 30 last in the entrance-side detection device 21 and the exit-side detection device 22, from the height information included in the detection signals.

[0032]

In addition, although the road surface height is not the characteristic indicating the vehicle 30, it is possible to determine a time at which the road surface is first detected after the height of the vehicle 30 is continuously detected, as a time at which the height information of the vehicle 30 becomes "0", that is, a time at which the vehicle 30 has passed. In the present embodiment, the time at which the road surface is first detected after the height of the vehicle 30 is continuously detected is determined as the time at which the height information which is the characteristic of the vehicle 30 becomes "0" (a

time at which the characteristic of the vehicle is last detected) is detected, for the sake of convenience.

[0033]

Then, if the detection signal E1 that detects the characteristic of the vehicle 30
 5 first and the detection signal E4 that detects the characteristic of the vehicle 30 last in the
 entrance-side detection device 21 are determined among respective detection signals
 which are received, the detection signal extraction unit 18 of the device 10 for measuring
 an object to be measured extracts other detection signals including a characteristic
 detection time between characteristic detection times included in two detection signals
 10 E1 and E4, among the detection signals which are received from the entrance-side
 detection device 21. Through this processing, the detection signal extraction unit 18
 extracts the detection signal E2 including the characteristic detection time t_{E2} and the
 detection signal E3 including the characteristic detection time t_{E3} .

[0034]

15 Further, if the detection signal P1 that detects the characteristic of the vehicle 30
 first and the detection signal P8 that detects the characteristic of the vehicle 30 last in the
 exit-side detection device 22 are determined among respective detection signals which
 are received, the detection signal extraction unit 18 extracts other detection signals
 including a characteristic detection time between characteristic detection times included
 20 in two detection signals P1 and P8, among the detection signals which are received from
 the exit-side detection device 22. Through this processing, the detection signal
 extraction unit 18 extracts the detection signal P2 including the characteristic detection
 time t_{P2} , the detection signal P3 including the characteristic detection time t_{P3} , the
 detection signal P4 including the characteristic detection time t_{P4} , the detection signal P5
 25 including the characteristic detection time t_{P5} , the detection signal P6 including the

characteristic detection time t_{p6} and the detection signal P7 including the characteristic detection time t_{p7} .

[0035]

Then, the detection signal extraction unit 18 extracts a pair of corresponding
 5 detection signals indicating the characteristic of the same vehicle 30, using the detection signals E2 and E3 which are extracted among the detection signals which are received from the entrance-side detection device 21 and the detection signals P2, P3, P4, P5, P6, and P7 which are extracted among the detection signals which are received from the exit-side detection device 22.

[0036]

FIG. 5 is a block diagram showing a functional configuration of a detection signal extraction unit.

As shown in FIG. 5, the detection signal extraction unit 18 is configured to include a characteristic detection information generation unit 181, a function-deriving
 15 unit 182, a reference detection device specification unit 183, an assumed time calculation unit 184, a characteristic detection information candidate specification unit 185, a characteristic detection information specification unit 186, a detection signal corresponding relationship determination unit 187, a corresponding relationship determination stop unit 188, and a processing result output unit 189.

Here, the characteristic detection information generation unit 181 is a processing
 20 unit that generates characteristic detection information including characteristic increase-decrease information indicating a value of an increase or decrease of the characteristic of the vehicle 30 and the characteristic detection time included in the detection signal, based on the received detection signal, each time receiving the detection
 25 signal from the entrance-side detection device 21 and the exit-side detection device 22.

[0037]

The function-deriving unit 182 is a processing unit that derives a function passing through a point having the first characteristic detection time as a component in each of two detection devices of the entrance-side detection device 21 and the exit-side
5 detection device 22 and a point having the last characteristic detection time for the vehicle 30 as a component in two detection devices, in a two-dimensional coordinate system representing a relationship between the characteristic detection time when the entrance-side detection device 21 detects the vehicle 30 in a time axis after the entrance-side detection device 21 detects the detection signal for the vehicle 30 first, and
10 the characteristic detection time when the exit-side detection device 22 detects the vehicle 30 in the time axis. Further, the function represents the traveling time of each characteristic of the vehicle 30 in each of the entrance-side detection device 21 and the exit-side detection device 22, at an average acceleration of the vehicle 30 traveling between the entrance-side detection device 21 and the exit-side detection device 22.

15 [0038]

The reference detection device specification unit 183 is a processing unit that compares the number of times at which the entrance-side detection device 21 detects the vehicle 30 between the first characteristic detection time of the vehicle 30 and the last characteristic detection time with the number of times at which the exit-side detection
20 device 22 detects the vehicle 30 between the first characteristic detection time of the vehicle 30 and the last characteristic detection time. Further, the reference detection device specification unit 183 is a processing unit that specifies the detection device having a smaller number of detection times of the vehicle 30 out of the entrance-side detection device 21 and the exit-side detection device 22 as one detection device.

25 [0039]

The assumed time calculation unit 184 substitutes the characteristic detection time included in the detection signal received from the one detection device that has been specified as one component for the function so as to calculate the other component.

Through such a process, the assumed time calculation unit 184 is a processing unit that

5 calculates the assumed time at which the same characteristic as the characteristic indicating the characteristic detection information which is generated based on the detection signal received from the one detection device may be detected from the other detection device, in a case of assuming that the vehicle 30 travels at the acceleration indicated by the function between the entrance-side detection device 21 and the exit-side
10 detection device 22.

The characteristic detection information candidate specification unit 185 is a processing unit that specifies the characteristic detection information which is generated based on one detection signal received from the one detection device, reads characteristic increase-decrease information from the characteristic detection information, and specifies
15 the characteristic detection information including the characteristic increase-decrease information indicating the same value as any value of an increase or decrease indicating the characteristic increase-decrease information which is read, among a plurality of pieces of the characteristic detection information which is generated based on the detection signal received from the other detection device.

20 [0040]

The characteristic detection information specification unit 186 is a processing unit that specifies characteristic detection information including a characteristic detection time which is closest to the assumed time obtained by substituting the characteristic detection time included in one detection signal that is received from the one detection
25 device as one component for the function and calculating the other component among the

specified characteristic detection information.

Further, the detection signal corresponding relationship determination unit 187 is a processing unit that determines one detection signal received from one detection device and the detection signal received from another detection device used in the generation of the characteristic detection information which is specified by the characteristic detection information specification unit 186, as the corresponding detection signal when the characteristic point of the vehicle 30 is detected.

[0041]

The corresponding relationship determination stop unit 188 is a processing unit that compares a time relationship of the characteristic detection time included in the detection signal which is received for the vehicle 30 first from the entrance-side detection device 21 and the characteristic detection time included in the detection signal which is received for the vehicle 30 first from the exit-side detection device 22, with a time relationship of the characteristic detection time included in the detection signal which is received for the vehicle 30 last from the entrance-side detection device 21 and the characteristic detection time included in the detection signal which is received for the vehicle 30 last from the exit-side detection device 22. Then, the corresponding relationship determination stop unit 188 is a processing unit that determines to stop the determination of the corresponding relationships of the detection signals which are received from the entrance-side detection device 21 and the exit-side detection device 22, if the time relationships are different.

The processing result output unit 189 is a processing unit that outputs the processing result of the detection signal extraction unit 18.

[0042]

Then, through the processing of the detection signal extraction unit 18 having

the function of each processing unit, a pair of the corresponding detection signals from the entrance-side detection device 21 and the exit-side detection device 22, indicating the same characteristic of the vehicle 30, is extracted, among the detection signals which are received respectively from the entrance-side detection device 21 and the exit-side
5 detection device 22.

[0043]

FIG. 6 is a diagram showing a process flow of the detection signal extraction unit.

Next, the process flow of the detection signal extraction unit will be described
10 sequentially using FIG. 6.

First, the input unit 11 of the device 10 for measuring an object to be measured receives the detection signals which are received from the entrance-side detection device 21 and the exit-side detection device 22 through a communication network. The detection signal includes the signal strength such as the amount of reflected light (first
15 characteristic of the vehicle 30) of the light reflection signal corresponding to the light radiation signal which is radiated to the vehicle 30, and the height information (second characteristic of the vehicle 30) of the object to be measured which is detected using a radiation-transmission interval between the radiation time of the light radiation signal and the reception time of the light reflection signal. Further, the detection signal includes
20 the characteristic detection times and the identification numbers of the detection devices representing the entrance-side detection device 21 or the exit-side detection device 22 which detects the signal strength (amount of reflected light) and the height information. The input unit 11 outputs the detection signal which is input to the detection signal extraction unit 18.

25 [0044]

Next, the characteristic detection information generation unit 181 of the detection signal extraction unit 18 receives the detection signals which are received from the entrance-side detection device 21 or the exit-side detection device 22 by the input unit 11 (step S601). The characteristic detection information generation unit 181
5 compares the signal strength (amount of reflected light) of the light reflection signal and the height information which are included in the detection signal which is received at the present time with the signal strength (amount of reflected light) of the light reflection signal and the height information which are included in the detection signal which is received at the previous time, for the detection signals including the identification
10 number of the same detection device.

[0045]

Then, if the signal strength (amount of reflected light) of the light reflection signal included in the detection signal which is received at the present time is changed by a threshold or more from the signal strength (amount of reflected light) of the light
15 reflection signal included in the detection signal which is received at the previous time, the characteristic detection information generation unit 181 generates characteristic increase-decrease information indicating the value of an increase or decrease of the signal strength (amount of reflected light). Further, if the height information included in the detection signal which is received at the present time is changed by a threshold or
20 more from the height information included in the detection signal which is received at the previous time, the characteristic detection information generation unit 181 generates characteristic increase-decrease information indicating the value of an increase or decrease of the height information. Hereinafter, the characteristic increase-decrease information of the signal strength will be referred to as signal strength increase-decrease
25 information and the characteristic increase-decrease information of the height

information will be referred to as height increase-decrease information.

[0046]

Then, the characteristic detection information generation unit 181 generates the characteristic detection information including signal strength increase-decrease
5 information, height increase-decrease information, a detection time included in the received detection signal, and an identification number of the detection device (step S602). Each time receiving the detection signal, the characteristic detection information generation unit 181 generates the characteristic detection information. Then, the characteristic detection information generation unit 181 sequentially outputs the
10 generated characteristic detection information to the function-deriving unit 182.

[0047]

Next, the function-deriving unit 182 specifies the characteristic detection information indicating that the vehicle 30 is first detected in the entrance-side detection device 21 among the characteristic detection information which is received. In the
15 specification process, the function-deriving unit 182 first classifies the characteristic detection information into characteristic detection information generated by the detection signal of the entrance-side detection device 21 and characteristic detection information generated by the detection signal of the exit-side detection device 22, based on the identification number of the entrance-side detection device 21 and the identification
20 number of the exit-side detection device 22. Then, the function-deriving unit 182 sequentially compares height information included in the characteristic detection information which is generated by the detection signal of the entrance-side detection device 21, and determines whether the characteristic detection information indicating the information of height which is higher by a threshold or more than the road surface height
25 is received in a row a predetermined number of times or more, after the characteristic

detection information indicating the height information indicating the road surface height is received. Then, if the characteristic detection information indicating the information of height which is higher by a threshold or more than the road surface height is received in a row a predetermined number of times or more, the characteristic detection
5 information including the earliest detection time among the characteristic detection information indicating the information of height which is higher by a threshold or more than the road surface height is specified as the characteristic detection information indicating that the entrance-side detection device 21 detects the vehicle 30 first.

[0048]

10 The function-deriving unit 182 compares the height information included in the characteristic detection information which has been received at the previous time with the height information included in the characteristic detection information which is received at the present time, in order from the characteristic detection information which is received from the entrance-side detection device 21, subsequent to the characteristic
15 detection information indicating that the entrance-side detection device 21 detects the vehicle 30 first. Then, if the difference between the height information included in the characteristic detection information which is received at the previous time and the height information included in the characteristic detection information which is received at the present time is the threshold or more, the characteristic detection information which is
20 received at the present time is determined as the characteristic detection information indicating the characteristic point (point at which height information changes) of the vehicle 30 which is detected in the entrance-side detection device 21. Then, the function-deriving unit 182 sequentially specifies the characteristic detection information indicating the characteristic point of the vehicle 30 which is detected in the entrance-side
25 detection device 21.

[0049]

In addition, in the present embodiment, in the method of specifying the characteristic detection information indicating the characteristic point of the vehicle 30, if the difference between the height information included in the characteristic detection information which is received at the previous time and the height information included in the characteristic detection information which is received at the present time is the threshold or more, the characteristic detection information which is received at the present time is determined as the characteristic detection information indicating the characteristic point of the vehicle 30. However, without being limited thereto, the characteristic detection information indicating the characteristic point of the vehicle 30 may be specified by other methods.

[0050]

After the characteristic detection information indicating that the vehicle 30 is first detected is specified, the function-deriving unit 182 determines whether or not the characteristic detection information which is received thereafter is the characteristic detection information indicating that the vehicle 30 is last detected. In this process, it is determined whether the height information included in the characteristic detection information which is received is coincident with the height information of the road surface which is stored in advance. Then, in a case where they can be determined to be coincident even if taking into account the error, the function-deriving unit 182 determines that the characteristic detection information is the characteristic detection information indicating that the vehicle 30 is last detected. In a case where a plurality of pieces of the characteristic detection information which can be determined to be coincident with the height information of the road surface are received, the characteristic detection information including the characteristic detection time which is earliest among the

plurality of pieces of the characteristic detection information is determined as the characteristic detection information indicating that the vehicle 30 is last detected. Then, the function-deriving unit 182 determines the characteristic detection information indicating that the vehicle 30 is first detected, the characteristic detection information indicating that the vehicle 30 is last detected, and the characteristic detection information indicating the characteristic point of the vehicle 30 specified between the characteristic detection informations as the characteristic detection information indicating a plurality of characteristics for a single vehicle 30 which are detected in the entrance-side detection device 21.

10 [0051]

Here, it is assumed that the characteristic detection information indicating the characteristic points of the vehicle 30 which are detected in the entrance-side detection device 21 is four pieces of characteristic detection information F_{E1} , F_{E2} , F_{E3} , and F_{E4} respectively including the characteristic detection times t_{E1} , t_{E2} , t_{E3} , and t_{E4} shown in FIG.

15 4. Further, through the same process, the function-deriving unit 182 determines the characteristic detection information indicating the characteristic point of the vehicle 30 which is detected in the exit-side detection device 22. The characteristic detection information indicating the characteristic points of the vehicle 30 which are detected in the exit-side detection device 22 is eight pieces of characteristic detection information F_{P1} , F_{P2} , F_{P3} , F_{P4} , F_{P5} , F_{P6} , F_{P7} , and F_{P8} respectively including characteristic detection times t_{P1} , t_{P2} , t_{P3} , t_{P4} , t_{P5} , t_{P6} , t_{P7} , and t_{P8} , shown in FIG. 4.

[0052]

Next, the function-deriving unit 182 derives a function passing through a point (t_{E1}, t_{P1}) having the first characteristic detection time as a component in each of two detection devices of the entrance-side detection device 21 and the exit-side detection

25

device 22 and a point (t_{E4} , t_{P8}) having the last characteristic detection time for the vehicle 30 as a component in each of two detection devices (step S603). The function is a function in a two-dimensional coordinate system representing a relationship between the characteristic detection time when the entrance-side detection device 21 detects the characteristic of the vehicle 30 in a time axis after the entrance-side detection device 21 detects the detection signal for the vehicle 30 first, and the characteristic detection time when the exit-side detection device 22 detects the characteristic of the vehicle 30 in the time axis. Further, the function represents the traveling time of each characteristic of the vehicle 30 in each of the entrance-side detection device 21 and the exit-side detection device 22, by an average acceleration of the vehicle 30 traveling between the entrance-side detection device 21 and the exit-side detection device 22.

More specifically, the derived function is,

$$t_p = \{(t_{P8} - t_{P1}) \div (t_{E4} - t_{E1})\} t_E + t_{P1}.$$

[0053]

Then, the function-deriving unit 182 outputs the information of the derived function and the characteristic detection information F_{E1} to F_{E4} and F_{P1} to F_{P8} indicating the characteristic points of the vehicle 30 to the assumed time calculation unit 184, and outputs the characteristic detection information F_{E1} to F_{E4} and F_{P1} to F_{P8} indicating the characteristic points of the vehicle 30 to the reference detection device specification unit 183 and the detection signal corresponding relationship determination unit 187. In this case, it is notified that the characteristic detection information F_{E1} and F_{P1} is characteristic detection information indicating the first characteristic detection time of the vehicle 30 in each of two detection devices of the entrance-side detection device 21 and the exit-side detection device 22. In the same manner, it is notified that the characteristic detection information F_{E4} and F_{P8} is characteristic detection information

indicating the last characteristic detection time of the vehicle 30 in each of two detection devices of the entrance-side detection device 21 and the exit-side detection device 22.

Further, the function-deriving unit 182 outputs the information of the derived function and the characteristic detection information F_{E1} to F_{E4} and F_{P1} to F_{P8} indicating the

5 characteristic points of the vehicle 30 to the corresponding relationship determination stop unit 188.

[0054]

Next, the reference detection device specification unit 183 compares the number of times at which the characteristic of the vehicle 30 is detected between the first

10 characteristic detection time and the last characteristic detection time of the vehicle 30 in the entrance-side detection device 21 with the number of times at which the characteristic of the vehicle 30 is detected between the first characteristic detection time and the last characteristic detection time of the vehicle 30 in the exit-side detection device 22, based on the characteristic detection information F_{E1} to F_{E4} and F_{P1} to F_{P8} which is received.

15 In other words, the number of times at which the characteristic of the vehicle 30 is detected between the first characteristic detection time and the last characteristic detection time of the characteristic of the vehicle 30 in the entrance-side detection device 21 is two: characteristic detection information F_{E2} and F_{E3} . Further, the number of times at which the characteristic of the vehicle 30 is detected between the first

20 characteristic detection time and the last characteristic detection time of the vehicle 30 in the exit-side detection device 22 is six: characteristic detection information F_{E2} to F_{E7} .

Then, the reference detection device specification unit 183 specifies the detection device having a smaller number of detection times of the vehicle 30 out of the entrance-side detection device 21 and the exit-side detection device 22 as a reference detection device

25 (step S604). In the present embodiment, the entrance-side detection device 21 having a

smaller number of times at which the characteristic of the vehicle 30 is detected is specified as the reference detection device. Then, the reference detection device specification unit 183 outputs the identification number of the entrance-side detection device 21 which is specified as the reference detection device to the assumed time
 5 calculation unit 184.

[0055]

If the identification number of the entrance-side detection device 21 which is the reference detection device is input, the assumed time calculation unit 184 extracts the characteristic detection information F_{E2} and F_{E3} , except for the characteristic detection
 10 information F_{E1} indicating that the vehicle 30 is first detected and the characteristic detection information F_{E4} indicating that the vehicle 30 is last detected among the characteristic detection information F_{E1} to F_{E4} indicating the characteristic points of the vehicle 30 detected in the entrance-side detection device 21. Then, the assumed time calculation unit 184 calculates the assumed time $T1$ by substituting the characteristic
 15 detection time t_{E2} included in the characteristic detection information F_{E2} for the variable t_E in the function derived by the function-deriving unit 182 and calculating the characteristic detection time for the variable t_P of the function (step S605). If it is assumed that the vehicle 30 travels at an average acceleration between the entrance-side detection device 21 and the exit-side detection device 22, the assumed time $T1$ is an
 20 assumed time at which the characteristic indicating the characteristic detection information generated based on the received detection signal from the entrance-side detection device 21 may be detected in the exit-side detection device 22.

[0056]

Further, in the same manner as the calculation of the assumed time $T1$, the
 25 assumed time calculation unit 184 calculates the assumed time $T2$ by substituting the

characteristic detection time t_{E3} included in the characteristic detection information F_{E3} for the variable t_E of the function derived by the function-deriving unit 182 and calculating the characteristic detection time for the variable t_P of the function. Then, the assumed time calculation unit 184 outputs the assumed time T1 and the characteristic detection information F_{E2} used in the calculation of the assumed time T1 to the characteristic detection information candidate specification unit 185. Further, the assumed time calculation unit 184 outputs the assumed time T2 and the characteristic detection information F_{E3} used in the calculation of the assumed time T2 to the characteristic detection information candidate specification unit 185.

[0057]

If the assumed time T1 and the characteristic detection information F_{E2} used in the calculation of the assumed time T1 are input, the characteristic detection information candidate specification unit 185 extracts the height increase-decrease information included in the characteristic detection information F_{E2} . The height increase-decrease information included in the characteristic detection information F_{E2} indicates the “growth”, as represented by “↑” in FIG. 4 for the characteristic detection time t_{E2} included in the characteristic detection information F_{E2} . Accordingly, the characteristic detection information candidate specification unit 185 extracts the candidates F_{P2} , F_{P4} , and F_{P6} of the characteristic detection information which are indicated as the “growth” by the height increase-decrease information among characteristic detection information F_{P2} to F_{P7} , except for the characteristic detection information F_{P1} indicating that the vehicle 30 is first detected and the characteristic detection information F_{P8} indicating that the vehicle 30 is last detected among characteristic detection information F_{P1} to F_{P8} indicating the characteristic points of the vehicle 30 which are detected in the exit-side detection device 22 (step S606). Then, characteristic detection information candidate

specification unit 185 outputs the characteristic detection information F_{E2} indicating the characteristic point of the vehicle 30 detected in the entrance-side detection device 21, the assumed time $T1$ calculated using the characteristic detection information, and the candidate on the exit-side detection device 22 side corresponding to the characteristic
 5 detection information F_{E2} to the characteristic detection information specification unit 186. The candidate on the exit-side detection device 22 side is the characteristic detection information F_{P2} , F_{P4} , and F_{P6} which is specified by the characteristic detection information candidate specification unit 185 as the candidate of the characteristic detection information indicating the characteristic point of the vehicle 30 detected in the
 10 exit-side detection device 22.

[0058]

Then, the characteristic detection information specification unit 186 compares the assumed time $T1$ with the characteristic detection information F_{P2} , F_{P4} , and F_{P6} , and extracts the characteristic detection information including the characteristic detection
 15 time which is closest to the assumed time $T1$ calculated by the characteristic detection time t_{E2} included in the characteristic detection information F_{E2} , among the characteristic detection information F_{P2} , F_{P4} , and F_{P6} (step S607). In other words, " $t_{P2}-T1$ ", " $t_{P4}-T1$ ", and " $t_{P6}-T1$ " are respectively calculated using the assumed time $T1$ calculated by the characteristic detection time t_{E2} included in the characteristic detection information F_{E2}
 20 and the characteristic detection times t_{P2} , t_{P4} , and t_{P6} which are respectively included in the characteristic detection information F_{P2} , F_{P4} , and F_{P6} . Then, the characteristic detection information specification unit 186 extracts the characteristic detection information including a characteristic detection time in a case having the smallest time difference among the characteristic detection information F_{P2} , F_{P4} , and F_{P6} , for the
 25 calculation using the characteristic detection times t_{P2} , t_{P4} , and t_{P6} . In the present

embodiment, the characteristic detection information F_{P2} is extracted. Then, the characteristic detection information specification unit 186 outputs a pair of the characteristic detection information F_{E2} and the characteristic detection information F_{P2} corresponding to the characteristic detection information F_{E2} to the detection signal corresponding relationship determination unit 187.

[0059]

If the difference between the characteristic detection time t_{P2} in a case having the smallest time difference and the assumed time $T1$ is a predetermined threshold or more, the pair of the characteristic detection information F_{E2} and the characteristic detection information F_{P2} corresponding to the characteristic detection information F_{E2} may be discarded. It is considered that the acceleration or deceleration of the vehicle traveling between the entrance-side detection device 21 and the exit-side detection device 22 is more or less within an expected range. However, if the difference between the characteristic detection time t_{P2} and the assumed time $T1$ is a predetermined threshold or more, acceleration or deceleration over the expected range may be made between the entrance-side detection device 21 and the exit-side detection device 22 and thus the characteristic point becomes unreliable information. Accordingly, in order not to adopt such information, the pair of the characteristic detection information F_{E2} and the characteristic detection information F_{P2} corresponding to the characteristic detection information F_{E2} is discarded.

[0060]

In the same manner as the specification of the pair of the characteristic detection information F_{E2} and the characteristic detection information F_{P2} corresponding to the characteristic detection information F_{E2} , the characteristic detection information specification unit 186 specifies the pair of the characteristic detection information F_{E3}

and the characteristic detection information F_{P7} corresponding to the characteristic detection information F_{E3} so as to be output to the detection signal corresponding relationship determination unit 187.

[0061]

5 Next, the detection signal corresponding relationship determination unit 187 determines the detection signal E1 used for generation of the characteristic detection information F_{E1} indicating that the vehicle 30 is first detected in the entrance-side detection device 21 and the detection signal P1 used for generation of the characteristic detection information F_{P1} indicating that the vehicle 30 is first detected in the exit-side
10 detection device 22 as the corresponding detection signal when the characteristic point of the vehicle 30 is detected, based on the characteristic detection information F_{E1} to F_{E4} , and F_{P1} to F_{P8} indicating the characteristic points of the vehicle 30 which are received from the function-deriving unit 182 (step S608).

[0062]

15 Further, the detection signal corresponding relationship determination unit 187 determines the detection signal E4 used for generation of the characteristic detection information F_{E4} indicating that the vehicle 30 is last detected in the entrance-side detection device 21 and the detection signal P8 used for generation of the characteristic detection information F_{P8} indicating that the vehicle 30 is last detected in the exit-side
20 detection device 22 as the corresponding detection signal when the characteristic point of the vehicle 30 is detected, based on the characteristic detection information F_{E1} to F_{E4} , and F_{P1} to F_{P8} indicating the characteristic points of the vehicle 30 which are received from the function-deriving unit 182.

[0063]

25 Further, the detection signal corresponding relationship determination unit 187

determines the detection signal E2 used for generation of the characteristic detection information F_{E2} in the entrance-side detection device 21 and the detection signal P2 used for generation of the characteristic detection information F_{P2} in the exit-side detection device 22 as the corresponding detection signal when the characteristic point of the vehicle 30 is detected, based on the pair of the characteristic detection information F_{E2} and the characteristic detection information F_{P2} corresponding to the characteristic detection information F_{E2} which is received from the characteristic detection information specification unit 186.

[0064]

Further, the detection signal corresponding relationship determination unit 187 determines the detection signal E3 used for generation of the characteristic detection information F_{E3} in the entrance-side detection device 21 and the detection signal P7 used for generation of the characteristic detection information F_{P7} in the exit-side detection device 22 as the corresponding detection signal when the characteristic point of the vehicle 30 is detected, based on the pair of the characteristic detection information F_{E3} and the characteristic detection information F_{P7} corresponding to the characteristic detection information F_{E3} which is received from the characteristic detection information specification unit 186.

[0065]

Then, the processing result output unit 189 outputs respective pieces of information included in the corresponding detection signals E1 and P1, the corresponding detection signals E2 and P2, the corresponding detection signals E3 and P7, and the corresponding detection signal E4 and P8 when the characteristic points of the vehicle 30 determined by the detection signal corresponding relationship determination unit 187 is determined to the height corresponding relationship determination unit 13 and the signal

strength corresponding relationship determination unit 14 (step S609).

More specifically, the processing result output unit 189 reads height information, an amount of reflected light, a detection time and the identification number of a detection device from respective detection signals determined by the detection signal

5 corresponding relationship determination unit 187 and outputs the combination information of the height information, the detection time and the identification number of the detection device used in detection (identification number for identifying any one of the entrance-side detection device 21 and the exit-side detection device 22) to the height corresponding relationship determination unit 13. Further, the processing result output
10 unit 189 reads height information, an amount of reflected light, and a detection time from the detection signal which is received, and outputs the combination information of the amount of reflected light, the detection time and the identification number of the detection device used in detection (identification number for identifying any one of the entrance-side detection device 21 and the exit-side detection device 22) to the signal
15 strength corresponding relationship determination unit 14.

[0066]

In addition, in the process of each processing unit of the detection signal extraction unit 18 described above, an example of a case is shown where the detection signal when the geometric characteristic point of the vehicle 30 is detected is output to
20 the height corresponding relationship determination unit 13 and the signal strength corresponding relationship determination unit 14 based on the height information and the height increase-decrease information. However, the detection signal extraction unit 18 further outputs the detection signal when the optical characteristic point of the vehicle 30 is detected to the height corresponding relationship determination unit 13 and the signal
25 strength corresponding relationship determination unit 14, based on the amount of

reflected light which is the strength of the light reflection signal corresponding to the light radiation signal which is radiated to the vehicle 30 and the signal strength increase-decrease information.

Otherwise, only one of any of the detection signal when the geometric
 5 characteristic point is detected and the detection signal when the optical characteristic point is detected may be output to the height corresponding relationship determination unit 13 and the signal strength corresponding relationship determination unit 14.

[0067]

Here, while the process described above is performed, the corresponding
 10 relationship determination stop unit 188 may stop the determination of a corresponding relationship of the characteristic points for the vehicle 30. In this case, more specifically, the corresponding relationship determination stop unit 188 determines a time relationship of the characteristic detection time t_{E1} included in the detection signal which is first received for the vehicle 30 from the entrance-side detection device 21 and the
 15 characteristic detection time t_{P1} included in the detection signal which is first received for the vehicle 30 from the exit-side detection device 22. Further, the corresponding relationship determination stop unit 188 determines a time relationship of the characteristic detection time t_{E4} included in the detection signal which is last received for the vehicle 30 from the entrance-side detection device 21 and the characteristic detection
 20 time t_{P8} included in the detection signal which is last received for the vehicle 30 from the exit-side detection device 22. The corresponding relationship determination stop unit 188 compares the two time relationships, and if the time relationships are different, it determines to stop the determination of the corresponding relationship of the detection signals which are received from the entrance-side detection device 21 and the exit-side
 25 detection device 22.

[0068]

Here, if these two time relationships are different, this means that even though the entrance-side detection device 21 was faster than the exit-side detection device 22 in the first detection of the vehicle 30, the exit-side detection device 22 was faster than the entrance-side detection device 21 in the last detection of the vehicle 30. Since such a phenomenon is unlikely to occur, the determination of the corresponding relationship of the detection signals received from the entrance-side detection device 21 and the exit-side detection device 22 is able to be stopped.

[0069]

According to the process described above, it is possible to determine the pair of detection signals showing the same characteristic among the detection signal that detects the characteristic of the vehicle 30 in the entrance-side detection device 21 and the detection signal that detects the characteristic of the vehicle 30 in the exit-side detection device 22. Thus, it is possible to extract an appropriate detection signal of a vehicle 30 among the detection signals received from two detection devices installed spaced apart, by measuring the vehicle length of the vehicle 30.

[0070]

FIG. 7 is a diagram showing measurement result data based on the information which is received by the input unit.

FIG. 7 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. 7 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. 7 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.

[0071]

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.

[0072]

In addition, the device 10 for measuring an object to be measured stores 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 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. 7.

[0073]

The measurement result data of FIG. 7 shows that the entrance-side detection 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 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.

[0074]

Further, the measurement result data of FIG. 7 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.

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.

[0075]

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 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 measurement result data.

10 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 that is shown in the measurement result data.

15 [0076]

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 received from the entrance-side detection device 21 or a geometric characteristic based
20 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.

[0077]

FIG. 8 is a diagram showing a data example of information that is output from the detection signal extraction unit.

25 Next, a specific calculation method of the 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
5 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
10 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
15 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.

20 [0078]

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
25 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,

5 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

10 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 $t3 < \text{the characteristic detection time } tn_1 < \text{the characteristic detection time } tn_2 < \text{the characteristic detection time } t11 < \text{the characteristic}$

15 $\text{detection time } t23 < \text{the characteristic detection time } t30$.

[0079]

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

20 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 predetermined threshold or more is detected at time tn_7 . Thus, the device 10 for

25 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 .

[0080]

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 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 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 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 $tn_3 < \text{the characteristic detection time } tn_4 < \text{the characteristic detection time } tn_5 < \text{the characteristic detection time } tn_6 < \text{the characteristic detection time } tn_7 < \text{the characteristic detection time } tn_8$.

[0081]

5 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 exit-side detection device 22, the velocity of the vehicle 30 at the characteristic detection

10 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 = $D \div (tn_3 - t_3)$ ” using the difference ($tn_3 - t_3$) between the characteristic detection times and the installation interval D for the

15 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 = $D \div (tn_6 - t_{11})$ ” using the difference ($tn_6 - t_{11}$) between the characteristic detection times and the installation interval D for the height information B1. The device 10 for measuring an object to be measured calculates the velocity V3 by the equation of “velocity V3 of

20 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 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.

[0082]

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 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 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 = $D \div (t_{n3} - t_3)$ ” using the difference ($t_{n3} - t_3$) 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 30 = $D \div (t_{n4} - t_{n1})$ ” using the difference ($t_{n4} - t_{n1}$) 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 = $D \div (t_{n5} - t_{n2})$ ” using the difference ($t_{n5} - t_{n2}$) 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.

[0083]

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.

[0084]

FIG. 9 is a diagram showing a relationship between each characteristic detection time and a velocity calculated using the characteristic detection time.

FIG. 9 shows the following relationships:

- a relationship between the characteristic detection time t_3 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 t_3 ;
- 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 ;
- 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 $t11$;

a relationship between the characteristic detection time $t23$ at which the height
5 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 object to be measured using the characteristic detection time $t30$.

10 [0085]

The device 10 for measuring an object to be measured integrates expressions indicating relationships between the characteristic detection times shown in FIG. 8 and velocities calculated by the device 10 for measuring an object to be measured using the characteristic detection times from $t3$ to $t30$, thereby calculating the length of the vehicle
15 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 information) and optical characteristics (the amount of reflected light) of the vehicle 30
20 which is an object to be measured is detected.

[0086]

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 time (detection end time) $T2$ of the vehicle 30 in the entrance-side detection device 21, a
25 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,

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

$$L = (D \div t) \cdot (T_2 - T_1).$$

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 of the velocity v , the velocity does not become a correct value if the vehicle 30 passes
 10 between the entrance-side detection device 21 and the exit-side detection device 22 while changing the velocity.

[0087]

Therefore, the device 10 for measuring an object to be measured according to the present embodiment calculates the vehicle length L in view of the change in the
 15 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 the number of characteristics of the vehicle 30, the more accurate the vehicle length L . Therefore, not only the geometric characteristic but also the optical characteristic is used. Since the optical characteristic
 20 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 amount of change in the geometric characteristic, for example, the vehicle
 25 height.

[0088]

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

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

The detection signal extraction unit 18 sequentially receives the detection signal including height information, an amount of reflected light, detection times, and the like at a predetermined time interval depending on time elapsed (step S101). Then, as described above, the detection signal extraction unit 18 reads the height information, the
10 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 detection device 21 and the exit-side detection device 22) of the detection device which
15 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 (identification number for identifying any one of the entrance-side detection device 21
20 and the exit-side detection device 22) of the detection device which detects them to the signal strength corresponding relationship determination unit 14.

[0089]

Thus, the height corresponding relationship determination unit 13 receives each piece of information corresponding to the height information and the detection time in
25 the examples of data of “information input from the entrance-side detection device 21”

shown in FIG. 8 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”.

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. 8 and each information corresponding to the amount of reflected light and the detection time in the examples of data of “information input from the exit-side detection device 22”.

[0090]

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 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 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. 8, 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.

[0091]

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. 8, 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 tn3. 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 .

[0092]

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 $t3$ with the characteristic detection time $t3$, and associates the height information A1 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 second velocity calculation unit 15.

[0093]

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
5 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 the same classification. Then, the height corresponding relationship determination unit 13 associates the height information B1 that is detected by the entrance-side detection
10 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 queue provided in the second velocity calculation unit 15.

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 height corresponding relationship determination unit 13 determines that they belong to
20 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 tn_7 with the characteristic detection time tn_7 , as the
25 classification information belonging to the same classification, so as to be written into the

queue provided in the second velocity calculation unit 15.

[0094]

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.

[0095]

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.

[0096]

Subsequently, the second velocity calculation unit 15 reads first classification
 5 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
 10 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
 15 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.

[0097]

20 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,
 25 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 t_{l1} and the height information $B1$ detected by the entrance-side detection device 21 at the characteristic detection time t_{l1} , or a pair of the characteristic detection time t_{n6} and the height information $B1$ detected by the exit-side detection device 22 at the characteristic detection time t_{n6} . The second velocity calculation unit 15 acquires the characteristic detection time t_{l1} and the characteristic detection time t_{n6} included in the classification information which is read, calculates the velocity $V2$ of the vehicle 30 at the characteristic detection time t_{l1} or the characteristic detection time t_{n6} by the equation of $V2=D/(t_{n6}-t_{l1})$ using the acquired times and the installation interval D , and writes the velocity $V2$ into the queue provided in the length calculation unit 17 in association with any one of the characteristic detection time t_{l1} and the characteristic detection time t_{n6} . In the present embodiment, it is assumed that the velocity $V2$ and the characteristic detection time t_{l1} are associated and written into the queue provided in the length calculation unit 17.

[0098]

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 t_{23} and the height information $C1$ detected by the entrance-side detection device 21 at the characteristic detection time t_{23} , or a pair of the characteristic detection time t_{n7} and the height information $C1$ detected by the exit-side detection device 22 at the characteristic detection time t_{n7} . The second velocity calculation unit 15 acquires the characteristic detection time t_{23} and the characteristic detection time t_{n7} included in the classification information which is read, calculates the velocity $V3$ of the vehicle 30 at the characteristic detection time t_{23} or the characteristic detection time t_{n7} by the equation of $V3=D/(t_{n7}-t_{23})$ 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
5 written into the queue provided in the length calculation unit 17.

[0099]

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
10 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
15 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
20 detection time tn_8 . In the present embodiment, it is assumed that the velocity $V7$ and the characteristic detection time $t30$ are associated and written into the queue provided in the length calculation unit 17.

[0100]

Then, if the vehicle traveling information is read from the queue, the second
25 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.

[0101]

In contrast, each time receiving the amount of reflected light included in the
5 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
10 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
15 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. 8, a time at which the amount of reflected light m1 is detected first in the entrance-side detection device 21 is determined as the characteristic detection time t3. Further, in the same manner, a time at which the amount of reflected light n1 is detected first in the
20 entrance-side detection device 21 is determined as the characteristic detection time tn₁, 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 tn₂.

[0102]

Further, in the same manner, each time receiving the amount of reflected light
25 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 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 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. 8, 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 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 .

[0103]

Then, the signal strength corresponding relationship determination unit 14 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 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 t_3 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_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 m_1 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 the amount of reflected light m_1 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.

[0104]

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 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 $o1$ 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 $o1$ 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.

[0105]

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.

[0106]

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 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 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 are associated and written into the queue provided in the length calculation unit 17.

[0107]

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 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 n_1 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.

[0108]

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 time tn_2 and the characteristic detection time tn_5 . In the present embodiment, it is

assumed that the velocity V_6 and the characteristic detection time t_{n_2} are associated and written into the queue provided in the length calculation unit 17.

[0109]

Then, if the vehicle traveling information is read from the queue, the first
 5 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.

[0110]

In this case, the information stored into the queue provided in the length
 10 calculation unit 17 is as follows:

Information in which the velocity V_1 and the characteristic detection time t_3 are associated;

Information in which the velocity V_2 and the characteristic detection time t_{11} are associated;

15 Information in which the velocity V_3 and the characteristic detection time t_{23} are associated;

Information in which the velocity V_4 and the characteristic detection time t_3 are associated;

Information in which the velocity V_5 and the characteristic detection time t_{n_1}
 20 are associated;

Information in which the velocity V_6 and the characteristic detection time t_{n_2} are associated;

Information in which the velocity V_7 and the traveling time t_{30} are associated;
 and

25 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
5 information of the velocity V4 and the characteristic detection time t3, the combination information of the velocity V5 and the characteristic detection time tn1, the combination information of the velocity V6 and the characteristic detection time tn2, 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
10 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
15 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
20 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.

[0111]

Then, the length calculation unit 17 calculates the vehicle length L of the vehicle
25 30 using the combination information of the velocity V1 and the characteristic detection

time t_3 , the combination information of velocity V_2 and the characteristic detection time t_{11} , the combination information of the velocity V_3 and the characteristic detection time t_{23} , the combination information of the velocity V_5 and the characteristic detection time tn_1 , and the combination information of the velocity V_6 and the characteristic detection

5 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 V_1 and the characteristic detection time t_3 , and the combination information of the velocity V_5 and the characteristic detection time tn_1 are specified. Then, the length calculation unit 17 calculates an integral value from the

10 characteristic detection time t_3 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 V_1 , characteristic detection time t_3) and (velocity V_5 , characteristic detection time tn_1). The combination information including the earliest characteristic detection time is excluded from the information used for

15 processing. The combination information that has been excluded is the combination information of the velocity V_1 and the characteristic detection time t_3 .

[0112]

Subsequently, the length calculation unit 17 specifies two pieces of combination information in order from the earliest characteristic detection time among pieces of

20 combination information which currently remain and are not being excluded. Here, the combination information of the velocity V_5 and the characteristic detection time tn_1 and the combination information of the velocity V_6 and the characteristic detection time tn_2 are specified.

Then, the length calculation unit 17 calculates an integral value from the

25 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
5 processing.

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

[0113]

Subsequently, the length calculation unit 17 specifies two pieces of combination
10 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.

15 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
20 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 V6 and the characteristic detection time tn_2 .

[0114]

25 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} .

[0115]

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 V7, characteristic detection time t30). 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
 5 information of the velocity V3 and the characteristic detection time t23.

[0116]

Then, if only one piece of combination information of the velocity V7 and the characteristic detection time t30 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
 10 be output as the length L of the vehicle 30.

[0117]

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 V1, characteristic detection time t3),
 15 (velocity V5, characteristic detection time t_{n1}), (velocity V6, characteristic detection time t_{n2}), (velocity V2, characteristic detection time t11), (velocity V3, characteristic detection time t23), and (velocity V7, characteristic detection time t30), calculate an integral value from the characteristic detection time t3 which is earliest in the detection time to the characteristic detection time t30 which is latest in the detection time, using the
 20 approximation equation, and output the integral value as the length L of the vehicle 30.

[0118]

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
 25 to be measured accurately.

[0119]

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

5 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

10 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

15 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. 7, for example, the detection time t_4 is determined as the characteristic detection time of the height

20 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.

[0120]

In addition, in the process of step S107 and step S108 described above, if the

25 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 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 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 within the threshold may be determined as the characteristic detection time.

In other words, in this case, if describing using FIG. 8, 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 reflected light $o1$.

[0121]

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 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
5 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.

[0122]

10 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
15 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.

[0123]

20 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.

Industrial Applicability

[0124]

According to the process of the device for measuring an object to be measured of the present invention, it is possible to extract an appropriate detection signal of a vehicle among the detection signals received from a plurality of detection devices installed spaced apart, in the measurement of a vehicle length of the vehicle.

Reference Signs List

[0125]

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

CLAIMS

1. A device for measuring an object to be measured comprising:

an input unit that receives a detection signal representing a characteristic of the
5 object to be measured from each of an entrance-side detection device and an exit-side
detection device which are installed at a predetermined installation interval in a traveling
direction of the object to be measured;

a characteristic detection information generation unit that generates
characteristic detection information including characteristic increase-decrease
10 information indicating a value of an increase or decrease of the characteristic of the
object to be measured and a characteristic detection time included in the detection signal,
based on the received detection signal, each time the detection signal is received from the
entrance-side detection device and the exit-side detection device;

a function-deriving unit that derives a function passing through a point having a
15 first characteristic detection time as a component in each of two detection devices of the
entrance-side detection device and the exit-side detection device and a point having a last
characteristic detection time for the object to be measured as a component in each of two
detection devices, in a two-dimensional coordinate system representing a relationship
between the characteristic detection time when the entrance-side detection device detects
20 the object to be measured in a time axis after the entrance-side detection device first
detects the detection signal for the object to be measured and the characteristic detection
time when the exit-side detection device detects the object to be measured in the time
axis, the function representing a traveling time of each characteristic of the object to be
measured in the entrance-side detection device and the exit-side detection device at an
25 average acceleration of the object to be measured traveling between the entrance-side

detection device and the exit-side detection device;

an assumed time calculation unit that calculates the other component by substituting the characteristic detection time included in the received detection signal as one component for the function, and calculates an assumed time at which a characteristic indicated by the characteristic detection information generated based on the detection signal received from any one detection device of the entrance-side detection device and the exit-side detection device may be detected in the other detection device, in a case of assuming that the object to be measured travels at the average acceleration between the entrance-side detection device and the exit-side detection device;

a characteristic detection information candidate specification unit that specifies the characteristic detection information which is generated based on one detection signal received from the one detection device, reads characteristic increase-decrease information from the characteristic detection information, and specifies the characteristic detection information including characteristic increase-decrease information indicating the same value as any value of the increase or decrease indicated by the characteristic increase-decrease information which is read, among the characteristic detection information which is generated based on the detection signal received from the other detection device;

a characteristic detection information specification unit that specifies characteristic detection information including a characteristic detection time which is closest to an assumed time obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as one component for the function and calculating the other component, among the specified characteristic detection information; and

a detection signal corresponding relationship determination unit that determines

one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic detection information which is specified by the characteristic detection information specification unit, as a corresponding detection signal when a characteristic point of the object to be measured is detected.

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

a reference detection device specification unit that compares the number of times at which the entrance-side detection device detects the object to be measured between the first characteristic detection time and the last characteristic detection time, with the number of times at which the exit-side detection device detects the object to be measured between the first characteristic detection time and the last characteristic detection time, and specifies the detection device having a smaller number of detection times of the object to be measured out of the entrance-side detection device and the exit-side detection device as one detection device.

3. The device for measuring an object to be measured according to claim 1 or 2,

wherein the input unit respectively receives a detection signal including a characteristic indicating strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured and a characteristic detection time thereof, from the entrance-side detection device and the exit-side detection device, and

wherein the characteristic detection information generation unit generates

characteristic detection information including characteristic increase-decrease
information indicating a value of an increase or decrease of the characteristic of the
object to be measured indicating an optical characteristic of the object to be measured
and a characteristic detection time included in the detection signal, based on the detection
5 signal.

4. The device for measuring an object to be measured according to any one of
claims 1 to 3,

wherein the input unit respectively receives a detection signal including a
10 characteristic indicating height information of the object to be measured which is
detected using a radiation-transmission interval between a radiation time of the light
radiation signal and a reception time of the light reflection signal and a characteristic
detection time thereof, from the entrance-side detection device and the exit-side detection
device, and

15 wherein the characteristic detection information generation unit generates
characteristic detection information including characteristic increase-decrease
information indicating a value of an increase or decrease of the characteristic of the
object to be measured indicating a geometric characteristic of the object to be measured
and a characteristic detection time included in the detection signal, based on the detection
20 signal.

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

wherein the detection signal corresponding relationship determination unit
25 determines one detection signal received from the one detection device and a detection

signal received from another detection device used in generation of the characteristic detection information which is specified by the characteristic detection information specification unit, as the corresponding detection signal when the characteristic point of the object to be measured is detected, only if the characteristic detection time which is closest to the assumed time is within a predetermined time difference from the assumed time, the assumed time being obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as one component for the function and calculating the other component, among characteristic detection times included in the characteristic detection information which is specified by the characteristic detection information candidate specification unit.

6. The device for measuring an object to be measured according to any one of claims 1 to 5, further comprising:

a corresponding relationship determination stop unit that compares a time relationship between the characteristic detection time included in the detection signal which is first received for the object to be measured from the entrance-side detection device and the characteristic detection time included in the detection signal which is first received for the object to be measured from the exit-side detection device, with the time relationship between the characteristic detection time included in the detection signal which is last received for the object to be measured from the entrance-side detection device and the characteristic detection time included in the detection signal which is last received for the object to be measured from the exit-side detection device, and stops the determination of the corresponding relationship of the detection signals which are received from the entrance-side detection device and the exit-side detection device, if the time relationships are different.

7. The device for measuring an object to be measured according to any one of claims 1 to 6, further comprising:

a velocity calculation unit that calculates a velocity for each of the characteristic points of the object to be measured, based on combined information of one detection signal received from the one detection device which is determined as the corresponding detection signal when the characteristic point of the object to be measured is detected and characteristic detection times included in each of detection signals received from the other detection device, and the installation interval.

8. The device for measuring an object to be measured according to claim 7, further comprising:

a length calculation unit that calculates a length in the traveling direction of the object to be measured, based on a velocity for each of the characteristic points and any one or both of a characteristic detection time included in the detection signal received from the entrance-side detection device and a characteristic detection time included in the detection signal received from the exit-side detection device.

9. A processing method of a device for measuring an object to be measured causing:

an input unit to receive a detection signal representing a characteristic of the object to be measured from each of an entrance-side detection device and an exit-side detection device which are installed at a predetermined installation interval in a traveling direction of the object to be measured;

a characteristic detection information generation unit to generate characteristic

detection information including characteristic increase-decrease information indicating a value of an increase or decrease of the characteristic of the object to be measured and a characteristic detection time included in the detection signal, based on the received detection signal, each time the detection signal is received from the entrance-side

5 detection device and the exit-side detection device;

a function-deriving unit to derive a function passing through a point having a first characteristic detection time as a component in each of two detection devices of the entrance-side detection device and the exit-side detection device and a point having a last characteristic detection time for the object to be measured as a component in each of two

10 detection devices, in a two-dimensional coordinate system representing a relationship between the characteristic detection time when the entrance-side detection device detects the object to be measured in a time axis after the entrance-side detection device first detects the detection signal for the object to be measured and the characteristic detection time when the exit-side detection device detects the object to be measured in the time
15 axis, the function representing a traveling time of each characteristic of the object to be measured in the entrance-side detection device and the exit-side detection device at an average acceleration of the object to be measured traveling between the entrance-side detection device and the exit-side detection device;

an assumed time calculation unit to calculate the other component by

20 substituting the characteristic detection time included in the received detection signal as one component for the function, and to calculate an assumed time at which a characteristic indicated by the characteristic detection information generated based on the detection signal received from any one detection device of the entrance-side detection device and the exit-side detection device may be detected in the other detection device, in
25 a case of assuming that the object to be measured travels at the average acceleration

between the entrance-side detection device and the exit-side detection device;

a characteristic detection information candidate specification unit to specify the characteristic detection information which is generated based on one detection signal received from the one detection device, to read characteristic increase-decrease

5 information from the characteristic detection information, and to specify the characteristic detection information including characteristic increase-decrease information indicating the same value as any value of an increase or decrease indicated by the characteristic increase-decrease information which is read, among the characteristic detection information which is generated based on the detection signal
10 received from the other detection device;

a characteristic detection information specification unit to specify characteristic detection information including a characteristic detection time which is closest to an assumed time obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as one component
15 for the function and calculating the other component, among the specified characteristic detection information; and

a detection signal corresponding relationship determination unit to determine one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic detection
20 information which is specified by the characteristic detection information specification unit, as a corresponding detection signal when a characteristic point of the object to be measured is detected.

10. A program causing a computer of a device for measuring an object to be
25 measured to function as:

input portion for receiving a detection signal representing a characteristic of the object to be measured from each of an entrance-side detection device and an exit-side detection device which are installed at a predetermined installation interval in a traveling direction of the object to be measured;

5 characteristic detection information generation portion for generating characteristic detection information including characteristic increase-decrease information indicating a value of an increase or decrease of the characteristic of the object to be measured and a characteristic detection time included in the detection signal, based on the received detection signal, each time the detection signal is received from the
10 entrance-side detection device and the exit-side detection device;

 function-deriving portion for deriving a function passing through a point having a first characteristic detection time as a component in each of two detection devices of the entrance-side detection device and the exit-side detection device and a point having a last characteristic detection time for the object to be measured as a component in each of
15 two detection devices, in a two-dimensional coordinate system representing a relationship between the characteristic detection time when the entrance-side detection device detects the object to be measured in a time axis after the entrance-side detection device first detects the detection signal for the object to be measured and the characteristic detection time when the exit-side detection device detects the object to be
20 measured in the time axis, the function representing a traveling time of each characteristic of the object to be measured in the entrance-side detection device and the exit-side detection device at an average acceleration of the object to be measured traveling between the entrance-side detection device and the exit-side detection device;

 assumed time calculation portion for calculating the other component by
25 substituting the characteristic detection time included in the received detection signal as

one component for the function, and for calculating an assumed time at which a characteristic indicated by the characteristic detection information generated based on the detection signal received from any one detection device of the entrance-side detection device and the exit-side detection device may be detected in the other detection device, in
5 a case of assuming that the object to be measured travels at the average acceleration between the entrance-side detection device and the exit-side detection device;

characteristic detection information candidate specification portion for specifying the characteristic detection information which is generated based on one detection signal received from the one detection device, for reading characteristic
10 increase-decrease information from the characteristic detection information, and for specifying the characteristic detection information including characteristic increase-decrease information indicating the same value as any value of an increase or decrease indicated by the characteristic increase-decrease information which is read, among the characteristic detection information which is generated based on the detection
15 signal received from the other detection device;

characteristic detection information specification portion for specifying characteristic detection information including a characteristic detection time which is closest to an assumed time obtained by substituting the characteristic detection time included in the one detection signal which is received from the one detection device as
20 one component for the function and calculating the other component, among the specified characteristic detection information; and

detection signal corresponding relationship determination portion for determining one detection signal received from the one detection device and a detection signal received from another detection device used in generation of the characteristic
25 detection information which is specified by the characteristic detection information

specification unit, as a corresponding detection signal when a characteristic point of the object to be measured is detected.