CLAIMS

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

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

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

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

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

a length calculation unit that calculates a length in the traveling direction of the

object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection times in any one or all of the plurality of detection devices.

3. The device for measuring an object to be measured according to Claim 2, wherein the input unit receives height information in addition to a strength of the light reflection signal from each of the plurality of detection devices which detect height information of the object to be measured using a radiation-reception interval between a radiation time of a light radiation signal which is radiated to the object to be measured and a reception time of a light reflection signal corresponding to the light radiation signal,

wherein each of the detection devices includes

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

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

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

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

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

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

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

calculating a time difference between signal strength detection times of respective signal strengths in the plurality of detection devices that detect respective signal strengths included in the corresponding relationship of a signal strength indicating

the same portion, for each corresponding relationship of the classified signal strength, by a first velocity calculation unit; and

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

5. The processing method according to Claim 4, further comprising:

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

6. The processing method according to Claim 5, further comprising:

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

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

portion of the object to be measured by a height corresponding relationship determination unit;

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

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

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

input portion for receiving a strength of a light reflection signal corresponding to a light radiation signal which is radiated to the object to be measured from each of a

plurality of detection devices, the detection devices being located in respective installation positions which are provided spaced apart in a traveling direction of the object to be measured;

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

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

8. The program according to Claim 7, that causes the computer to function as length calculation portion for calculating a length in the traveling direction of the object to be measured moving between the plurality of detection devices, based on a velocity of the object to be measured, which is calculated for each corresponding relationship of the classified signal strength, at the signal strength detection times in any one or all of the plurality of detection devices.

9. The program according to Claim 8,

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

wherein the program causes the computer to function as:

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

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

wherein the length calculation portion calculates a length in the traveling direction of the object to be measured moving between the plurality of detection devices,

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

CLAIMS

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

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

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

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

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

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

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

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

wherein each of the detection devices includes

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

10. The processing method according to any one of Claims 6 to 9, further comprising:

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

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

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

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

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

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

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

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

13. The program according to Claim 12,

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

wherein the program further causes the computer to function as:

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

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

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

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

14. The program according to Claim 13,

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

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

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

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