

Description

Title of Invention: ONBOARD UNIT, TOLL COLLECTION SYSTEM, TOLL
COLLECTION METHOD, AND PROGRAM

Technical Field

[0001]

The present disclosure relates to an onboard unit, a toll collection system, a toll collection method, and a program.

Background Art

[0002]

On a current toll road and an expressway, a toll fee is calculated using a toll table distributed from a center server to an exit tollgate server of an exit tollgate. The toll table defines a toll fee corresponding to a travel section (travel distance) from an entrance tollgate to an exit tollgate.

[0003]

There is a case where a toll fee is applied with a discount. For example, Patent Document 1 describes a technique of applying a time-of-day discount to a vehicle passed through an entrance tollgate in a specific time of day. There is a case where a different toll table is set depending on a travel route of a road.

[0004]

A toll table applied with a time-of-day discount, a (normal) toll table not applied with a time-of-day discount, and the like are distributed from the center server to each exit tollgate server at necessary timings such as start and end timings of the discount time of day, for example. The exit tollgate server calculates a toll fee of each vehicle by using the distributed toll table.

Citation List

Patent Literature

[0005]

Patent Document 1: JP 2009-199347 A

Summary of Invention

Technical Problem

[0006]

In recent years, it is required to flexibly change the toll fee of each vehicle depending on the route on which the vehicle has traveled. However, with the known mechanism, it has been difficult to take a flexible measure such

as changing a toll fee depending on a route on which an individual vehicle has actually traveled.

[0007]

5 An object of the present disclosure is to provide an onboard unit, a toll collection system, a toll collection method, and a program that can calculate a toll fee corresponding to a route on which a vehicle travels.

Solution to Problem

[0008]

10 According to one aspect of the present disclosure, an onboard unit includes: an operating distance map acquisition unit that acquires an operating distance map defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road; a travel
15 section specification unit that specifies a travel section in which a vehicle is traveling based on position information to be acquired while the vehicle is traveling; an operating distance acquisition unit that acquires an operating distance during traveling with reference to the operating distance specification information based on the travel section having been specified; an accumulation
20 unit that accumulates and records the operating distance obtained by the operating distance acquisition unit; and a notification unit that notifies an exit tollgate server of an exit tollgate of the toll road of the operating distance accumulated by the accumulation unit.

[0009]

25 According to one aspect of the present disclosure, a toll collection system includes: the above-described onboard unit; and an exit tollgate server provided at an exit tollgate of the toll road, in which the exit tollgate server includes an operating distance acquisition unit that acquires the operating distance having been accumulated of the vehicle notified by the onboard unit, a
30 toll fee calculation unit that calculates a toll fee of the vehicle based on the operating distance having been acquired, and a billing processing unit that performs billing processing of billing the vehicle for the toll fee having been calculated.

[0010]

35 According to one aspect of the present disclosure, a toll collection method includes: a step in which an onboard unit mounted on a vehicle acquires an operating distance map defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road; a step in which the onboard unit specifies a travel section in

which the vehicle is traveling based on position information to be acquired while the vehicle is traveling; a step in which the onboard unit acquires an operating distance during traveling with reference to the operating distance specification information associated with the travel section having been
 5 specified; a step in which the onboard unit accumulates the operating distance having been acquired; a step in which the onboard unit notifies an exit tollgate server of an exit tollgate of the toll road of the operating distance having been accumulated; a step in which the exit tollgate server calculates a toll fee of the vehicle based on the operating distance having been acquired; and a step in
 10 which the exit tollgate server performs billing processing of billing the vehicle for the toll fee having been calculated.
 [0011]

According to one aspect of the present disclosure, a program causes an onboard unit to execute a step of acquiring an operating distance map defining
 15 operating distance specification information for each predetermined travel section to be geometrically defined of a toll road, a step of specifying a travel section in which the vehicle is traveling based on position information to be acquired while the vehicle is traveling, a step of acquiring an operating distance during traveling with reference to the operating distance specification
 20 information associated with the travel section having been specified, and a step of accumulating the operating distance having been acquired.

Advantageous Effects of Invention

[0012]
 25 According to the above aspect, a toll fee corresponding to the route on which the vehicle has traveled can be calculated.

Brief Description of Drawings

[0013]
 30 FIG. 1 is a view illustrating an overall configuration of a toll collection system according to a first embodiment.

FIG. 2 is a view illustrating a functional configuration of an onboard unit according to the first embodiment.

FIG. 3 is a view illustrating a functional configuration of an entrance
 35 tollgate server according to the first embodiment.

FIG. 4 is a view illustrating a functional configuration of an exit tollgate server according to the first embodiment.

FIG. 5 is a view illustrating a functional configuration of a roadside device according to the first embodiment.

FIG. 6 is a sequence diagram illustrating an example of processing of the toll collection system according to the first embodiment.

5 FIG. 7 is a view illustrating a transmission example of an operating distance map, position information, and operating distance information according to the first embodiment.

FIG. 8 is a view illustrating an overall configuration of a toll collection system according to a second embodiment and a third embodiment.

10 FIG. 9 is a view illustrating a functional configuration of an onboard unit according to the second embodiment and the third embodiment.

FIG. 10 is a sequence diagram illustrating an example of processing of the toll collection system according to the second embodiment and the third embodiment.

15 FIG. 11 is a view illustrating a transmission example of an operating distance map, position information, and operating distance information according to the second embodiment and the third embodiment.

FIG. 12 is a schematic block diagram illustrating a configuration of a computer according to one embodiment.

20

Description of Embodiments

[0014]

First Embodiment

Hereinafter, the first embodiment of the present disclosure will be
25 described in detail with reference to FIGS. 1 to 7.

[0015]

Overall Configuration

FIG. 1 is a view illustrating the overall configuration of a toll collection system 100 according to the first embodiment. As illustrated in FIG. 1, the toll
30 collection system 100 includes an onboard unit 10 mounted on a vehicle V, an entrance tollgate server 20, an exit tollgate server 30, a roadside device 40, and a center server 50.

[0016]

The onboard unit 10 performs processing of automatically paying a toll
35 fee of a toll road of the vehicle V by an automatic toll collection system (also called an "electronic toll collection system". In Japan, it is called an electronic toll collection system (ETC system) (registered trademark)). In the present embodiment, an example of application to the ETC system in Japan will be

described, but the present invention may be applied to various other automatic toll collection systems. The onboard unit 10 of the present embodiment can acquire an operating distance map 1 (illustrated in FIG. 7. Details will be described later). The onboard unit 10 can record an operating distance
 5 (described later) of the vehicle V on the toll road based on the operating distance map 1. The onboard unit 10 notifies the exit tollgate server 30 of the recorded operating distance. The exit tollgate server 30 calculates the toll fee of the vehicle V from the operating distance notified by the onboard unit 10. In the present embodiment, an example in which the onboard unit 10 acquires the
 10 operating distance based on information notified by the entrance tollgate server 20, the roadside device 40, or the like will be described.

[0017]

Operating Distance Map

First, the "operating distance map" will be described.

15 The operating distance map is an information table defining operating distance specification information for each predetermined travel section of a toll road. The "operating distance specification information" is information that can specify an operating distance corresponding to the predetermined travel section. The "operating distance" is information indicating a travel distance in a
 20 case of traveling in the travel section, and is information to be set by determination of a road operator for the each travel section. The operating distance does not necessarily match the actual travel distance determined by the geometric shape of the travel section itself.

[0018]

25 For example, for a certain travel section and a detour corresponding to the travel section, the road operator can determine the operating distance of the detour as a distance shorter than the actual travel distance that is geometrically determined, based on the determination that the traffic volume of the vehicles in the detour is small.

30 [0019]

Specifically, the operating distance is a geometrically determined travel distance applied with a weighting set by the road operator. A specific example of the operating distance map in the first embodiment is an information table as indicated by reference sign 1 in FIG. 7. That is, the operating distance map 1 is
 35 an information table in which an identifier (e.g., "area X") uniquely assigned to each certain travel section is associated with operating distance specification information (XI) of the travel section. In this case, the operating distance specification information XI is determined as a fixed value (operating distance

fixed value) in which the actual travel distance geometrically determined in the travel section indicated by the area X is weighted based on determination of the road operator. The operating distance fixed value is one aspect of the operating distance specification information. Other aspects of the operating distance specification information include, for example, an operating distance coefficient described later.

[0020]

That is, in the operating distance map, for each predetermined travel section to be geometrically determined of the toll road, operating distance specification information associated therewith is defined. In the operating distance map 1 of the first embodiment, an example will be described in which an operating distance fixed value corresponding to a predetermined travel section is defined as the operating distance specification information as described above.

[0021]

As illustrated in FIG. 1, in the first embodiment, the toll road is virtually divided into a plurality of travel sections. Operating distance specification information is defined for each of the divided travel sections. In the present embodiment, the toll road is virtually divided into a plurality of travel sections at a node such as an interchange or a divergence point. Each of the plurality of travel sections is defined such that no node exists at a part excluding a start point and an end point of the travel section. Hence, the vehicle V having entered a certain travel section does not exit the toll road in the middle of the travel section. That is, each travel section is set such that it can be determined that the vehicle V will travel through the entire travel section at a stage when the vehicle V enters a certain travel section.

[0022]

In the present embodiment, a part of a toll road is divided into a plurality of travel sections (areas 1 to 7) by nodes. The area 1 is a range from a node not illustrated to an A tollgate. The area 2 is a range from the A tollgate to a divergence point between the area 3 and the area 4. The area 3 is a range from the divergence point from the area 4 to a convergence point with (divergence point from) the area 5. The area 4 is a range from the divergence point from the area 3 to a B tollgate. The area 5 is a range from the B tollgate to a convergence point with (divergence point from) the area 3. The area 6 is a range from a convergence point (divergence point) between the area 3 and the area 5 to a C tollgate. The area 7 is a range from the C tollgate to a node not illustrated. Each of the travel sections from the area 1 to the area 7 can be

determined in that the vehicle V will travel through the entire travel section at a stage when the vehicle V enters.

[0023]

5 The operating distance map 1 of the present embodiment includes an identifier for specifying a travel section and operating distance specification information associated with the travel section.

[0024]

10 Note that in the present embodiment, a case where the vehicle V travels on the toll road toward one side (from the area 1 and the area 2 to the area 6 and the area 7) is exemplified.

[0025]

One entrance tollgate server 20 is provided at a tollgate office of each tollgate on a toll road, for example. In the example of FIG. 1, the tollgate offices of the A tollgate, the B tollgate, and the C tollgate are provided with
15 entrance tollgate servers 20A, 20B, and 20C, respectively. The entrance tollgate server 20 performs communication (e.g., DSRC communication) with the onboard unit 10 of the vehicle V via a roadside antenna 21 provided at the entrance tollgate. Regarding the roadside antenna 21, roadside antennas 21A, 21B, and 21C respectively corresponding to the entrance tollgate servers 20A,
20 20B, and 20C are provided. The entrance tollgate server 20 of the present embodiment transmits the operating distance map 1, entrance information (from which tollgate the vehicle has entered), and time information regarding when the vehicle V passed through the entrance to the onboard unit 10. Note that the operating distance map 1 is not limited to a form in which all of them (the
25 entire area of the toll road) are transmitted from the entrance tollgate server 20. For example, the entrance tollgate server 20 may transmit only the operating distance map 1 regarding the vicinity of the entrance tollgate (a range where the vehicle V having passed through a certain entrance tollgate can travel, the range to the roadside device 40 in the vicinity). At this time, the operating
30 distance map 1 of the range not transmitted by the entrance tollgate server 20 may be transmitted by another method (such as transmission by the roadside device 40).

[0026]

35 One exit tollgate server 30 is provided at a tollgate office of each tollgate of a toll road, for example. In the example of FIG. 1, the tollgate offices of the A tollgate, the B tollgate, and the C tollgate are provided with exit tollgate servers 30A, 30B, and 30C, respectively. The exit tollgate server 30 performs communication (e.g., DSRC communication) with the onboard unit

10 of the vehicle V via a roadside antenna 31 provided at the exit tollgate.
Regarding the roadside antenna 31, roadside antennas 31A, 31B, and 31C
respectively corresponding to the exit tollgate servers 30A, 30B, and 30C are
provided. The exit tollgate server 30 performs processing regarding collection
5 of the toll fee. In the present embodiment, the exit tollgate server 30 acquires
information transmitted from the onboard unit 10 and performs collection
processing of the toll fee.

[0027]

The roadside device 40 is provided at a predetermined notification point
10 of the toll road. The notification point includes, for example, a roadside
communication device provided at a divergence point of a toll road or the like,
a free flow billing point, and a connection point of a toll road having a different
toll system. The roadside device 40 performs communication (e.g., DSRC
communication) with the onboard unit 10 of the vehicle V passing through the
15 notification point via a roadside antenna 41 installed at the notification point.
The roadside device 40 transmits position information to the onboard unit 10 of
the vehicle V having arrived at the predetermined notification point. The
position information in the present embodiment is information indicating which
travel section the vehicle has entered. The roadside device 40 transmits, to the
20 onboard unit 10 of the vehicle V, time information regarding when the vehicle
V arrived at the predetermined notification point. That is, the roadside device
40 transmits, to the onboard unit 10 of the vehicle V, information on which
travel section at which time the vehicle V entered. Note that the roadside
device 40 may transmit other information than the position information and the
25 time information. For example, the operating distance map 1 of a range not
transmitted by the entrance tollgate server 20 may be transmitted.

[0028]

In the example of FIG. 1, roadside communication devices D, E, and F
are provided as the roadside device 40. Roadside antennas 41D, 41E, and 41F
30 respectively corresponding to the roadside communication devices D, E, and F
are provided. The roadside communication device D is provided at a point
where the vehicle V entered the area 4 from the divergence point. The roadside
communication device E is provided at a point where the vehicle V entered the
area 6 from the convergence point (divergence point) between the area 3 and
35 the area 5. The roadside communication device F is provided at a point where
the vehicle V entered the area 3 from the divergence point.

[0029]

The center server 50 distributes the operating distance map 1 to the entrance tollgate server 20 of each tollgate. The center server 50 may distribute the operating distance map 1 to the roadside device 40 at each notification point. The entrance tollgate server 20 at each tollgate and the roadside device 40 at each notification point transmit information including the operating distance map 1 to the onboard unit 10.

[0030]

The center server 50 may directly transmit the operating distance map 1 to the onboard unit 10 by cellular communication. In this case, the onboard unit 10 acquires the operating distance map 1 from the center server 50 using a cellular communication function mounted on the onboard unit 10 or using a cellular communication function of a terminal device 11 connectable to the onboard unit 10. The terminal device 11 is a smartphone, a tablet, or the like, and is communicably connected to the onboard unit 10 in a wired or wireless manner (e.g., Bluetooth (registered trademark)).

[0031]

Functional Configuration of Onboard Unit

FIG. 2 is a view illustrating the functional configuration of the onboard unit 10 according to the first embodiment. As illustrated in FIG. 2, the onboard unit 10 includes an operating distance map acquisition unit 101, a travel section specification unit 102, an operating distance acquisition unit 103, an accumulation unit 104, and a notification unit 105.

[0032]

The operating distance map acquisition unit 101 acquires the operating distance map 1. The operating distance map acquisition unit 101 of the present embodiment acquires the operating distance map 1 transmitted from the entrance tollgate server 20 of the entrance tollgate at the entrance tollgate of the toll road. The operating distance map acquisition unit 101 may also acquire the operating distance map 1 from the roadside device 40 or the like.

[0033]

The travel section specification unit 102 specifies a travel section in which the vehicle V is traveling based on position information to be acquired while the vehicle V is traveling. The travel section specification unit 102 of the present embodiment acquires position information to be transmitted from the entrance tollgate server 20 and the roadside device 40 to specify the travel section in which the vehicle V is traveling.

[0034]

Based on the travel section specified by the travel section specification unit 102, the operating distance acquisition unit 103 acquires the operating distance of the travel section during traveling with reference to the operating distance specification information (operating distance fixed value) recorded in the operating distance map acquisition unit 101. That is, based on the travel section having been specified, the operating distance acquisition unit 103 acquires at least the operating distance traveled by the vehicle V. Note that in the present embodiment, "to acquire an operating distance" means to acquire an operating distance fixed value.

[0035]

The accumulation unit 104 accumulates and records the operating distances acquired by the operating distance acquisition unit 103. The accumulation unit 104 of the present embodiment records the travel section and the time information together with the operating distance.

[0036]

The notification unit 105 notifies the exit tollgate server 30 of the exit tollgate of the toll road of the operating distance accumulated by the accumulation unit 104. The notification unit 105 of the present embodiment notifies the exit tollgate server 30 of the travel section and the time information associated with the operating distance together with the operating distance.

[0037]

Functional Configuration of Entrance Tollgate Server

FIG. 3 is a view illustrating the functional configuration of the entrance tollgate server 20 according to the first embodiment. As illustrated in FIG. 3, the entrance tollgate server 20 includes an operating distance map reception unit 201, an operating distance map transmission unit 202, and an entrance information transmission unit 203.

[0038]

The operating distance map reception unit 201 receives the operating distance map 1 transmitted from the center server 50. The operating distance map 1 to be received by the operating distance map reception unit 201 includes information regarding a travel section from an entrance tollgate provided with the entrance tollgate server 20 to at least some exit tollgates or notification points (the roadside devices 40) on the downstream side. The at least some exit tollgates are, for example, exit tollgates existing between an entrance tollgate and a next notification point.

[0039]

The operating distance map transmission unit 202 transmits information including the operating distance map 1 to the onboard unit 10 of the vehicle V having arrived at the entrance tollgate via the roadside antenna 21 of the entrance tollgate.

5 [0040]

The entrance information transmission unit 203 transmits entrance information to the onboard unit 10 of the vehicle V having arrived at the entrance tollgate via the roadside antenna 21 of the entrance tollgate. The entrance information includes identification information on the entrance tollgate where the vehicle V has entered, and time information on time when the vehicle V arrived at the entrance tollgate (processing execution date and time information).

[0041]

Functional Configuration of Exit Tollgate Server

15 FIG. 4 is a view illustrating the functional configuration of the exit tollgate server 30 according to the first embodiment. As illustrated in FIG. 4, the exit tollgate server 30 includes a toll calculation information acquisition unit 301, an operating distance reception unit 302, a toll fee calculation unit 303, and a billing processing unit 304.

20 [0042]

The toll calculation information acquisition unit 301 receives and records toll calculation information transmitted from the center server 50. The toll calculation information is information that can calculate a toll fee of the vehicle V from information to be transmitted from the onboard unit 10 of the vehicle V. The toll calculation information is, for example, a fixed value per operating distance. The toll calculation information may be defined to a different value for each time of day, such as a discount at night.

[0043]

30 The operating distance reception unit 302 receives the operating distance having been accumulated of the vehicle V from the onboard unit 10 of the vehicle V having arrived at the exit tollgate. The operating distance reception unit 302 of the present embodiment also receives time information associated with the operating distance.

[0044]

35 The toll fee calculation unit 303 calculates the toll fee of the vehicle V based on the information (including the operating distance) received by the operating distance reception unit 302. Specifically, the toll fee calculation unit

303 of the present embodiment calculates the toll fee of the vehicle V based on the operating distance and the time information.

[0045]

5 The billing processing unit 304 performs billing processing of billing the vehicle V for the toll fee calculated by the toll fee calculation unit 303.

[0046]

Functional Configuration of Roadside Device

FIG. 5 is a view illustrating the functional configuration of the roadside device 40 according to the first embodiment. As illustrated in FIG. 5, the roadside device 40 includes a position information transmission unit 401, an
10 operating distance map reception unit 402, and an operating distance map transmission unit 403.

[0047]

The position information transmission unit 401 transmits position
15 information to the onboard unit 10 of the vehicle V having arrived at the predetermined notification point. As mentioned earlier, the position information to be transmitted from the position information transmission unit 401 is information indicating which travel section the vehicle has entered. The position information transmission unit 401 transmits time information
20 associated with the position information to the onboard unit 10 of the vehicle V together with the position information.

[0048]

The operating distance map reception unit 402 receives the operating distance map 1 from the center server 50. The operating distance map 1
25 includes information regarding a travel section to at least some exit tollgates or notification points (the roadside devices 40) on the downstream side of the notification point provided with the roadside device 40. The at least some of the exit tollgates are exit tollgates existing, for example, until the next notification point.

30 [0049]

The operating distance map transmission unit 403 transmits information including the operating distance map 1 received by the operating distance map reception unit 402 to the onboard unit 10 of the vehicle V having arrived at the notification point provided with the roadside device 40.

35 [0050]

An example of specific processing regarding transmission/reception of the operating distance map 1 between the operating distance map transmission unit 202 of the entrance tollgate server 20 and the operating distance map

transmission unit 403 of the roadside device 40 and the onboard unit 10 is as follows.

[0051]

For example, when the vehicle V arrives at the A tollgate of FIG. 1, the entrance tollgate server 20A (the operating distance map transmission unit 202)
5 transmits the operating distance map 1 of the area 2, which is the range from the A tollgate to the roadside communication device D on the downstream side, to the onboard unit 10 of the vehicle V.

[0052]

10 Next, when the vehicle V selects a route on the area 4 to the area 5 side (hereinafter, also described as a main lane route) and passes through the roadside communication device D, the operating distance map transmission unit 403 of the roadside communication device D transmits the operating distance map 1 of the range on the downstream side of the roadside communication
15 device D (the area 4 and the area 5) to the onboard unit 10. Thereafter, when the vehicle V passes through the roadside communication device E, the operating distance map transmission unit 403 of the roadside communication device E transmits the operating distance map 1 of the range on the downstream side (the area 6 and the area 7) to the onboard unit 10.

20 [0053]

When the vehicle V selects a route on the area 3 side (hereinafter, also referred to as a detour route) and passes through the roadside communication device F, the roadside communication device F transmits the operating distance map 1 of the range on the downstream side of the roadside communication
25 device F (the area 3) to the onboard unit 10. Thereafter, when the vehicle V passes through the roadside communication device E, the roadside communication device E transmits the operating distance map 1 of the range on the downstream side of the roadside communication device E (the area 6 and the area 7) to the onboard unit 10.

30 In this manner, the operating distance map transmission unit 403 of each of the roadside communication devices (and the operating distance map transmission unit 202 of the entrance tollgate) sequentially transmits, to the vehicle V having arrived, the operating distance map 1 of the area to the next roadside communication device.

35 [0054]

Another example is as follows.

When the vehicle V arrives at the A tollgate of FIG. 1, the entrance tollgate server 20A (the operating distance map transmission unit 202)

transmits, to the onboard unit 10 of the vehicle V, the operating distance map 1 of the plurality of areas (the area 2, the area 3, the area 4, and the area 5) belonging to a predetermined range (a range to the roadside communication device E) on the downstream side from the A tollgate.

5 Next, when the vehicle V selects the main lane route to pass through the roadside communication device D, the operating distance map transmission unit 403 of the roadside communication device D transmits, to the onboard unit 10, the operating distance map 1 of a plurality of areas (the area 4, the area 5, the area 6, and the area 7) belonging to the predetermined range on the downstream
10 side. At this time, the onboard unit 10 discards or overwrites information regarding the area 4 and the area 5 overlapping with the operating distance map 1 having already been received to record, in the operating distance map acquisition unit 101, the operating distance map 1 received from the roadside communication device D.

15 When the vehicle V selects the detour route to pass through the roadside communication device F, the roadside communication device F transmits, to the onboard unit 10, the operating distance map 1 of a plurality of areas (the area 3, the area 6, and the area 7) belonging to the predetermined range on the downstream side of the roadside communication device F. At this time, the
20 onboard unit 10 discards or overwrites information regarding the area 3 overlapping with the operating distance map 1 having already been received to record, in the operating distance map acquisition unit 101, the operating distance map 1 received from the roadside communication device F.

In this manner, the operating distance map transmission unit 403 (and
25 the operating distance map transmission unit 202 of the entrance tollgate) of each of the roadside communication devices sequentially transmits, to the vehicle V having arrived, the operating distance maps 1 of the plurality of areas belonging to the predetermined range on the downstream side. Each time receiving the operating distance map 1 from each of the roadside
30 communication devices, the onboard unit 10 updates, while discarding or overwriting, the information of the area overlapping with the operating distance map 1 having already been received.

[0055]

In this case, the following may be further performed.

35 When the vehicle V arrives at the A tollgate, the onboard unit 10 acquires information indicating that the vehicle V has entered the toll road from the A tollgate (information indicating the entrance tollgate). The information indicating the entrance tollgate is entrance information recorded in an IC card

(also referred to as an ETC card in Japan) inserted in the onboard unit 10 and used in the automatic toll collection system, for example. Also when passing through each of the roadside communication devices, the onboard unit 10 keeps a record indicative of having performed communication with the roadside communication device.

[0056]

When the operating distance map transmission unit 403 of each of the roadside communication devices transmits the operating distance map 1, each of the roadside communication devices may acquire, from the onboard unit 10, information (information indicating the entrance tollgate and information indicating the roadside communication device) of a point through which vehicle V passes that is held by the onboard unit 10. With reference to information on a point through which the vehicle V has passed, each of the roadside communication devices transmits, to the onboard unit 10, the operating distance map 1 with a limited range not transmitted at each of the points. By doing this, the operating distance map transmission unit 403 of each of the roadside communication devices can transmit the operating distance map 1 avoiding overlapping with the operating distance map 1 having already been received by the onboard unit 10. Therefore, the operating distance map transmission unit 403 of each of the roadside communication devices can transmit the operating distance map 1 to the onboard unit 10 while suppressing the data amount.

[0057]

Processing Example of Toll Collection System

FIG. 6 is a sequence diagram illustrating an example of the processing of the toll collection system according to the first embodiment. FIG. 7 is a view illustrating a transmission example of the operating distance map 1, the position information, and the operating distance information according to the first embodiment. Note that the operating distance information refers to information including an accumulated operating distance. A flow of processing of the toll collection system 100 in the present embodiment will be described with reference to FIGS. 6 and 7.

[0058]

The center server 50 transmits the operating distance map 1 to the entrance tollgate server 20 at predetermined time intervals, for example (step S101). The operating distance map 1 transmitted from the center server 50 is received by the operating distance map reception unit 201 of the entrance tollgate server 20 to be recorded.

[0059]

For example, as illustrated in FIG. 7, it is assumed that the vehicle V enters the toll road from the A tollgate. When the vehicle V reaches the entrance tollgate of the A tollgate, the operating distance map transmission unit
 5 202 of the entrance tollgate server 20 transmits the latest operating distance map 1 to the onboard unit 10 of the vehicle V (step S102). In step S102, the entrance information transmission unit 203 of the entrance tollgate server 20 transmits, to the onboard unit 10 of the vehicle V, the identification information on the A tollgate and the entrance information including time information (t1)
 10 on time when the vehicle V arrived at the A tollgate. The entrance information transmission unit 203 of the entrance tollgate server 20 transmits the entrance information to the onboard unit 10 via the roadside antenna 21.

[0060]

The operating distance map 1 transmitted from the entrance tollgate server 20 is recorded in the operating distance map acquisition unit 101 of the
 15 onboard unit 10 (step S103). In step S103, the travel section specification unit 102 of the onboard unit 10 specifies which travel section the vehicle V is traveling (the vehicle V is to travel) in based on the entrance information transmitted from the entrance tollgate server 20. Specifically, when entering the
 20 toll road from the A tollgate as illustrated in FIG. 7, the vehicle V inevitably travels in either the area 1 or the area 2. In the present embodiment, the vehicle V travels in the area 2. Furthermore, information including operating distance specification information acquired based on the operating distance map 1 from the travel section specified by the travel section specification unit 102 and the
 25 time information (t1) is recorded in the accumulation unit 104 in association with the travel section.

[0061]

The center server 50 transmits the operating distance map 1 to each roadside device 40 at predetermined time intervals, for example (step S111).
 30 The operating distance map 1 transmitted from the center server 50 is received by the operating distance map reception unit 402 of each roadside device 40 to be recorded.

[0062]

It is assumed that the vehicle V having entered the toll road from the A tollgate arrives at the roadside communication device F at time (t2). At this
 35 time, at the roadside communication device F, the operating distance map transmission unit 403 of a roadside device 40F transmits the operating distance map 1 to the onboard unit 10 of the vehicle V via a roadside antenna 41F (step

S112). The operating distance map 1 to be transmitted from the operating distance map transmission unit 403 is a part not transmitted by the operating distance map transmission unit 202 of the entrance tollgate. In other words, the operating distance map transmission unit 403 transmits the operating distance map 1 that is additional. As a specific example, the operating distance map 1 to the roadside communication device D and the roadside communication device F is transmitted at the A tollgate, and the operating distance map 1 to the roadside communication device E is transmitted at the roadside communication device F. [0063]

In step S112, at the roadside communication device F, the position information transmission unit 401 of the roadside device 40F transmits the position information to the onboard unit 10 of the vehicle V. At this time, time information (t2) regarding when the vehicle V arrived at the roadside communication device F is also transmitted to the onboard unit 10. Specifically, the position information to be transmitted by the roadside communication device F is information indicating that the vehicle V has entered the area 3. [0064]

The operating distance map acquisition unit 101 of the onboard unit 10 records the operating distance map 1 transmitted from the operating distance map transmission unit 403 of the roadside communication device F (step S113). In step S113, the travel section specification unit 102 of the onboard unit 10 specifies which travel section the vehicle V is traveling in based on the position information transmitted from the roadside communication device F. [0065]

The operating distance acquisition unit 103 of the onboard unit 10 acquires the operating distance based on the travel section specified by the travel section specification unit 102 and the operating distance map 1 (step S114). Specifically, the operating distance acquisition unit 103 acquires operating distance specification information (operating distance fixed value) from the operating distance map 1, and sets this as the operating distance of the travel section in which the vehicle is traveling.

The operating distance acquisition unit 103 accumulates the operating distance acquired in step S114 into the accumulation unit 104 to record it (step S115). In other words, the operating distance acquisition unit 103 acquires the operating distance with reference to the operating distance specification information (operating distance fixed value) associated with the travel section having been specified, and accumulates the operating distance during traveling to the accumulation unit 104. Specifically, the accumulation unit 104 records

that the vehicle V has traveled in the area 2 and the area 3 by passing through the roadside communication device F.

[0066]

The above steps S111 to S115 are executed every time the vehicle V
 5 arrives at each roadside device 40 until exiting the toll road from the exit tollgate. In the present embodiment, the vehicle V having passed through the roadside communication device F passes through the roadside communication device E. At this time, processing similar to that in steps S111 to S115 is executed. Note that at the roadside communication device E, the operating
 10 distance map 1 on the downstream side of the roadside communication device E is transmitted. At the roadside communication device E, information indicating that the vehicle V has entered the area 6 at time t3 is transmitted.

[0067]

Processing when the vehicle V exits the toll road from the exit tollgate
 15 of the C tollgate will be described.

[0068]

The center server 50 transmits the toll calculation information to the exit tollgate server 30 at predetermined time intervals, for example (step S121). The toll calculation information transmitted from the center server 50 is received by
 20 the toll calculation information acquisition unit 301 of the exit tollgate server 30 to be recorded.

[0069]

When the vehicle V reaches the exit tollgate of the C tollgate, the notification unit 105 of the onboard unit 10 transmits the operating distance
 25 information accumulated and recorded by the accumulation unit 104 to the exit tollgate server 30 (step S122). Note that on the toll road on which different toll fees are billed depending on the vehicle type, the onboard unit 10 also transmits information on the vehicle type to the exit tollgate server 30. The information including the operating distance information transmitted from the
 30 notification unit 105 is received by the operating distance reception unit 302 of the exit tollgate server 30. Note that in step S122, the exit tollgate server 30 may request information from the vehicle V, thereby causing the notification unit 105 of the onboard unit 10 to transmit the operating distance information to the exit tollgate server 30.

35 [0070]

The toll fee calculation unit 303 of the exit tollgate server 30 calculates the toll fee of the vehicle V based on the operating distance information received by the operating distance reception unit 302 (step S123). At this time,

the toll fee calculation unit 303 calculates the toll fee of the vehicle V with reference to the toll calculation information recorded in the toll calculation information acquisition unit 301. On a toll road on which a different toll fee is billed depending on the vehicle type, the toll fee of the vehicle V is calculated
5 also based on the vehicle type of the vehicle V.

[0071]

In step S123, a toll fee with a time-of-day discount may be calculated to the vehicle V having traveled on the toll road in a specific time of day. At this time, the toll fee of the vehicle V is calculated based on the time information
10 recorded in association with the operating distance.

[0072]

Next, the billing processing unit 304 of the exit tollgate server 30 performs billing processing of billing the vehicle V for the toll fee calculated by the toll fee calculation unit 303 (step S124). The content of the billing
15 processing is similar to the billing processing in the known automatic toll collection system. Upon completing the billing processing, the billing processing unit 304 of the exit tollgate server 30 transmits the billing information to the center server 50 to end the processing. The billing information includes, for example, identification information on the onboard
20 unit 10 and the toll fee.

[0073]

Case Where Vehicle V Travels on Another Route

When the vehicle V enters the toll road from the A tollgate and enters the area 4 from the area 2, the following processing may be performed as an
25 example.

[0074]

When the vehicle V arrives at the roadside communication device D, the roadside communication device D transmits position information indicating that the vehicle V has entered the area 4. When the vehicle V exits the toll road
30 from the B tollgate, the vehicle V is subjected to billing processing for the toll fee for passing through the area 2 and the area 4. On the other hand, when the vehicle V enters the area 5, upon obtaining the position information at the roadside communication device E, the travel section specification unit 102 and the operating distance acquisition unit 103 may retroactively specify that the
35 vehicle V has also traveled in the area 5 to record the information into the accumulation unit 104. The roadside device 40 may be further provided at a location where the vehicle V enters the area 5 from the area 4, and position

information indicating that the vehicle V has entered the area 5 may be transmitted.

[0075]

Operational Effects of First Embodiment

5 As described above, the onboard unit 10 according to the present embodiment includes: the operating distance map acquisition unit 101 that acquires the operating distance map 1 defining operating distance specification information for each predetermined travel section to be geometrically defined of the toll road; the travel section specification unit 102 that specifies a travel
10 section in which the vehicle V is traveling based on position information to be acquired while the vehicle V is traveling; the operating distance acquisition unit 103 that acquires an operating distance during traveling with reference to the operating distance specification information based on the travel section having been specified; the accumulation unit 104 that accumulates and records
15 the operating distances acquired by the operating distance acquisition unit 103; and the notification unit 105 that notifies the exit tollgate server 30 of the exit tollgate of the toll road of the operating distance accumulated by the accumulation unit 104.

[0076]

20 In the known technique, the toll fee is calculated based on which entrance tollgate the vehicle has entered from and which exit tollgate the vehicle has exited from, and the toll fee reflecting the route on which the individual vehicle has traveled cannot be calculated. In other words, in the known technique, the toll fee is calculated from a rough route. For this reason,
25 it was difficult to calculate a toll fee corresponding to a route on which each vehicle has actually traveled. In contrast, in the present embodiment, the toll road is divided into a plurality of travel sections. The onboard unit 10 of the vehicle V can accumulate and record which travel section the vehicle V has traveled in. By calculating the toll fee from these pieces of information, the toll
30 collection system 100 of the present embodiment can calculate the toll fee corresponding to the route on which the vehicle V has traveled.

[0077]

In the present embodiment, the operating distance specification information is defined for each of the travel sections. In particular, in the
35 present embodiment, an operating distance fixed value is defined as the operating distance specification information. According to this, when the vehicle travels in a certain travel section, the operating distance is uniquely determined. Therefore, for example, the operating distance remains unchanged

even if the vehicle travels in an inner lane in order to shorten the travel distance at a curved location of a lane. Hence, the toll collection system 100 of the present embodiment can obtain a route on which the vehicle V has actually traveled without including an element that can cause the driver to perform driving while changing the travel lane many times in accordance with the curve of the lane.

[0078]

When there is a rest area in a certain travel section, the operating distance remains unchanged even if the vehicle enters such a location. Hence, the toll collection system 100 of the present embodiment can obtain a route on which the vehicle V has actually traveled without including an element that causes the driver to perform driving for a long time in an attempt to avoid an increase in travel distance due to entering a rest area. In other words, the toll collection system 100 of the present embodiment can obtain a route on which the vehicle V has actually traveled without causing a disadvantage caused by taking a rest in a rest area.

[0079]

The operating distance can be changed by determination of the road operator. Hence, for example, when a right route and a left route exist, the operating distance is set identically even if the Euclidean distances (geometrically obtained distances) are different. This can adjust the travel amount of the vehicle on each route. When the travel amount of the vehicle on one route is large, the number of vehicles traveling on the one route can be increased by setting the operating distance of the other route to be short. When one route passes through the tunnel and the other route passes along the mountain, the operating distance can be adjusted in consideration of the burden on the road. Furthermore, the operating distance corresponding to the Euclidean distance can be varied between urban and rural areas.

[0080]

The operating distance map acquisition unit 101 of the onboard unit 10 acquires the operating distance map 1 transmitted from the entrance tollgate server 20 of the entrance tollgate.

[0081]

By doing this, the onboard unit 10 acquires the operating distance map 1 at the entrance tollgate. Hence, even if the operating distance map 1 is not saved in advance in the onboard unit 10, it is possible to accumulate the operating distances as described above. By transmission of the operating distance map 1 at the entrance tollgate, the latest operating distance

information at the time point of entering the toll road can be acquired. Furthermore, since the operating distance map 1 is divided and transmitted not only from the entrance tollgate but also from the roadside device 40 and the like, the data amount to be sent at a time can be reduced. Therefore, it is possible to suppress communication failure such as failure in receiving the operating distance map 1 while passing through the entrance tollgate.

[0082]

The toll collection system 100 of the present embodiment can bill the vehicle V for a toll fee flexibly applied with the route on which the vehicle V has actually traveled and the time of travel, based on information (operating distance and time information) to be notified by the onboard unit 10.

[0083]

Specifically, due to the vehicle V passing through the notification point (the entrance tollgate or the roadside device 40), the onboard unit 10 can record the travel section in which the vehicle V has actually traveled. The roadside device 40 can transmit time information. This enables the onboard unit 10 to also record in which travel section and at which time the vehicle V traveled. This enables the toll collection system 100 to flexibly calculate the toll fee corresponding to the travel section in which the vehicle V has actually traveled and the travel time.

[0084]

Second Embodiment

Next, the second embodiment of the present disclosure will be described in detail with reference to FIGS. 8 to 11. Note that the description of similar configurations as those of the first embodiment will be omitted.

[0085]

A toll collection system 100a according to the second embodiment is different from that of the first embodiment in a specification method of a travel section. The toll collection system 100a in the second embodiment does not include the roadside device 40 of the first embodiment. In the first embodiment, the travel section of the vehicle V is specified based on position information to be transmitted from the roadside device 40, but in the second embodiment, the travel section of the vehicle V is specified based on position information to be obtained by a positioning function. The operating distance map 1 in the second embodiment includes a geometric position that is range information (indicated by longitude and latitude) of a travel section. The geometric position is associated as a geometric position XP for a certain travel section (e.g., an area X) (see FIG. 11).

[0086]

Overall Configuration

FIG. 8 is a view illustrating the overall configuration of the toll collection system 100a according to the second embodiment. As illustrated in FIG. 8, the toll collection system 100a includes an onboard unit 10a mounted on the vehicle V, the entrance tollgate server 20, the exit tollgate server 30, and the center server 50.

[0087]

Functional Configuration of Onboard Unit

FIG. 9 is a view illustrating the functional configuration of the onboard unit 10a according to the second embodiment. As illustrated in FIG. 9, the onboard unit 10a includes the operating distance map acquisition unit 101, a travel section specification unit 102a, an operating distance acquisition unit 103a, the accumulation unit 104, and the notification unit 105. The onboard unit 10a includes a GNSS antenna not illustrated.

[0088]

The travel section specification unit 102a specifies a travel section in which the vehicle V is traveling based on position information to be acquired while the vehicle V is traveling. The travel section specification unit 102a of the second embodiment acquires position information by the positioning function to specify the travel section in which the vehicle V is traveling. The positioning function is specifically a GNSS positioning function. That is, the onboard unit 10a according to the second embodiment can acquire position information by acquiring GNSS positioning information from a GNSS satellite 60.

[0089]

The travel section specification unit 102a specifies a travel section in which the vehicle V is traveling from the acquired position information and the operating distance map 1. Specifically, the travel section specification unit 102a performs map matching between the acquired position information and the operating distance map 1, thereby specifying the travel section in which the vehicle V is traveling. Time information transmitted simultaneously with GNSS positioning information from the GNSS satellite 60 is associated with the travel section having been specified.

[0090]

The operating distance acquisition unit 103a acquires the operating distance during traveling with reference to the operating distance specification information recorded in the operating distance map acquisition unit 101 based

on the travel section specified by the travel section specification unit 102a. That is, based on the travel section having been specified, the operating distance acquisition unit 103a acquires at least the operating distance traveled by the vehicle V. Note that also in the second embodiment, similarly to the first
 5 embodiment, an operating distance fixed value is defined as the operating distance specification information.

[0091]

The accumulation unit 104 accumulates and records the operating distances acquired by the operating distance acquisition unit 103a. The
 10 accumulation unit 104 records, together with the operating distance, the travel section and the time information associated with the operating distance. Note that GNSS positioning information associated with these may be further recorded in the accumulation unit 104.

[0092]

15 Processing Example of Toll Collection System

FIG. 10 is a sequence diagram illustrating an example of the processing of the toll collection system 100a according to the second embodiment. FIG. 11 is a view illustrating a transmission example of the operating distance map 1, the position information, and the operating distance information according to
 20 the second embodiment. A flow of processing of the toll collection system 100a in the second embodiment will be described with reference to FIGS. 10 and 11. Note that the processing of the toll collection system 100a in the second embodiment is different from that in the first embodiment only in the processing of travel section determination, and thus description of other
 25 processing will be omitted.

[0093]

The GNSS satellite 60 transmits position information and time information of the vehicle V to the onboard unit 10a of the vehicle V (step S116).

30 [0094]

The travel section specification unit 102a of the onboard unit 10a receives the position information transmitted from the GNSS satellite 60 to perform map matching with the operating distance map 1, thereby specifying the travel section in which the vehicle V is traveling (step S117). Note that as
 35 described above, even when the travel section specification unit 102a cannot clearly specify the travel section, the following processing may be performed.

[0095]

The operating distance acquisition unit 103a of the onboard unit 10a acquires the operating distance based on the travel section specified by the travel section specification unit 102a and the operating distance map 1 (step S118). Specifically, the operating distance acquisition unit 103a acquires
 5 operating distance specification information (operating distance fixed value), and sets this as the operating distance of the travel section in which the vehicle is traveling. The accumulation unit 104 of the onboard unit 10a accumulates the operating distance during traveling having been acquired (step S119). In other words, the operating distance acquisition unit 103a acquires the operating
 10 distance with reference to the operating distance specification information (operating distance fixed value) associated with the travel section having been specified, and accumulates the operating distance during traveling to the accumulation unit 104.

[0096]

15 In the second embodiment, the travel section and the operating distance may be retroactively recorded in the accumulation unit 104. Specifically, when the operating distance acquisition unit 103a cannot clearly specify the travel section, temporary information may be recorded in the accumulation unit 104, and the travel section and the operating distance may be retroactively recorded
 20 in the accumulation unit 104 at a stage when the travel section is clearly specified. For example, when the vehicle V enters the area 3 from the area 2, immediately after entering the area 3, there is a possibility of being unable to determine which of the area 3 and the area 4 the vehicle V has entered. At this time, at a stage when it is clearly specified that the vehicle V has entered the
 25 area 3, the travel section and the operating distance may be retroactively recorded in the accumulation unit 104.

[0097]

The above steps S116 to S119 are executed as needed at predetermined time intervals, for example, until the vehicle V exits the toll road from the exit
 30 tollgate. However, when the travel section of the vehicle V specified by the travel section specification unit 102a is the same as the most recent travel section, steps S118 and S119 may be omitted.

[0098]

Operational Effects of Second Embodiment

35 As described above, the onboard unit 10a according to the second embodiment acquires position information by the positioning function. The onboard unit 10a specifies the travel section from the obtained position information and operating distance map 1. Hence, similarly to the first

embodiment, the onboard unit 10a according to the second embodiment can obtain a route on which the vehicle V has traveled. Therefore, the toll collection system 100a of the second embodiment can calculate the toll fee corresponding to the route on which the vehicle V has traveled.

5 [0099]

Use of the time information to be transmitted from the GNSS satellite 60 in association with the position information can calculate the toll fee applied with the time information regarding traveling on the toll road. That is, the toll collection system 100a can flexibly calculate the toll fee by applying the travel
10 section in which the vehicle V has actually traveled and the time at which the vehicle V traveled in the travel section.

[0100]

Use of the positioning function enables the toll collection system 100a to acquire position information without being provided with the roadside device
15 40. Hence, adding the onboard unit 10a with an antenna can achieve the operational effect as described above. In other words, it is possible to configure the toll collection system 100a without installing the roadside device 40. This can suppress the initial cost for introducing the toll collection system 100a. It is also possible to shorten a preparation period for introducing the toll collection
20 system 100a.

[0101]

The toll collection system 100a performs map matching between the position information and the operating distance map 1. Since the operating distance map 1 describes information regarding the toll road, map matching
25 may be performed only by determining where on the toll road the vehicle is. In other words, a general road needs not be considered in map matching in the toll collection system 100a. Therefore, the toll collection system 100a can suppress failure in processing due to difficulty in determining whether the vehicle V is present on a toll road or present on a general road adjacent to a toll road.

30 [0102]

Third Embodiment

The third embodiment of the present disclosure will be described in detail. Note that the description of similar configurations as those of the first embodiment and the second embodiment will be omitted.

35 [0103]

A toll collection system 100b according to the third embodiment has a basic configuration similar to that of the toll collection system 100a according to the second embodiment. The toll collection system 100b is common to the

toll collection system 100a according to the second embodiment in obtaining position information by the positioning function. On the other hand, the toll collection system 100b is different from the toll collection system 100a according to the second embodiment in use of not an operating distance fixed value but an operating distance coefficient as operating distance specification information. The operating distance coefficient is one aspect of the operating distance specification information.

[0104]

The overall configuration of the toll collection system 100b according to the third embodiment is as illustrated in FIG. 8. The toll collection system 100b includes an onboard unit 10b mounted on the vehicle V, the entrance tollgate server 20, the exit tollgate server 30, and the center server 50.

[0105]

Functional Configuration of Onboard Unit

The functional configuration of the onboard unit 10b according to the third embodiment is as illustrated in FIG. 9. The onboard unit 10b includes the operating distance map acquisition unit 101, a travel section specification unit 102b, an operating distance acquisition unit 103b, the accumulation unit 104, and the notification unit 105. The onboard unit 10b includes a GNSS antenna not illustrated.

[0106]

The travel section specification unit 102b specifies a travel section in which the vehicle V is traveling based on position information to be acquired while the vehicle V is traveling. The travel section specification unit 102b of the third embodiment acquires position information by the positioning function to specify the travel section in which the vehicle V is traveling. The travel section specification unit 102b specifies a travel section in which the vehicle V is traveling from the acquired position information and the operating distance map 1. Specifically, the travel section specification unit 102b performs map matching between the acquired position information and the operating distance map 1, thereby specifying the travel section in which the vehicle V is traveling.

[0107]

The operating distance acquisition unit 103b acquires the operating distance during traveling with reference to the operating distance specification information recorded in the operating distance map acquisition unit 101 based on the travel section having been specified.

The operating distance acquisition unit 103b of the third embodiment acquires the operating distance also based on the position information acquired

by the positioning function. Specifically, the operating distance acquisition unit 103b calculates the Euclidean distance moved therebetween from the position information obtained at a certain time and the position information obtained immediately before. The operating distance acquisition unit 103b obtains an operating distance coefficient that is operating distance specification information based on the travel section having been specified. The operating distance acquisition unit 103b calculates the operating distance by multiplying the obtained Euclidean distance by the operating distance coefficient. Note that calculating the operating distance by multiplying the Euclidean distance by the operating distance coefficient by the operating distance acquisition unit 103b is also included in the meaning of "the operating distance acquisition unit 103b acquires the operating distance".

[0108]

The accumulation unit 104 accumulates and records the operating distances calculated by the operating distance acquisition unit 103b. The accumulation unit 104 records, together with the operating distance, the travel section and the time information associated with the operating distance. The accumulation unit 104 records various types of information each time the operating distance acquisition unit 103b calculates the operating distance.

[0109]

Processing Example of Toll Collection System

A sequence diagram illustrating an example of the processing of the toll collection system 100b according to the third embodiment is as illustrated in FIG. 10. A view illustrating a transmission example of the operating distance map 1, the position information, and the operating distance information according to the second embodiment is as illustrated in FIG. 11. A flow of processing of the toll collection system 100b in the third embodiment will be described with reference to FIGS. 10 and 11. Note that description will be omitted regarding processing common to the second embodiment.

[0110]

The GNSS satellite 60 transmits position information and time information of the vehicle V to the onboard unit 10b of the vehicle V (step S116).

[0111]

The travel section specification unit 102b of the onboard unit 10b receives the position information transmitted from the GNSS satellite 60 to perform map matching with the operating distance map 1, thereby specifying the travel section in which the vehicle V is traveling (step S117).

[0112]

The operating distance acquisition unit 103b of the onboard unit 10b calculates the Euclidean distance moved therebetween from the position information obtained at a certain time and the position information obtained immediately before (step S118). In step S118, the operating distance acquisition unit 103b obtains the operating distance specification information (operating distance coefficient) based on the travel section specified by the travel section specification unit 102b and the operating distance map 1. The operating distance acquisition unit 103b calculates the operating distance by multiplying the obtained Euclidean distance by the operating distance coefficient. The accumulation unit 104 accumulates the operating distance during traveling calculated by the operating distance acquisition unit 103b (step S119). That is, the accumulation unit 104 records, from moment to moment, information on how much operating distance the vehicle has proceeded at what time.

[0113]

The above steps S116 to S119 are executed as needed at predetermined time intervals, for example, until the vehicle V exits the toll road from the exit tollgate. In other words, steps S116 to S119 are performed every time the position information is obtained continuously until the vehicle exits the toll road. Note that steps S116 to S119 may be set so as to be performed not every time the position information is obtained but every predetermined time interval. In the third embodiment, the operating distance coefficient in a rest area or the like is set to 0. That is, the operating distance is 0 while the vehicle V enters a rest area or the like from a toll road and travels in the section.

[0114]

Note that the position information to be used as the position information obtained immediately before by the operating distance acquisition unit 103b may be that recorded in the accumulation unit 104. As another example, the position information obtained immediately before may be temporarily recorded and used by the operating distance acquisition unit 103b.

[0115]

Operational Effects of Third Embodiment

As described above, the onboard unit 10b according to the third embodiment acquires the position information by the positioning function. The onboard unit 10b uses the operating distance coefficient as the operating distance specification information. The onboard unit 10b records, from moment to moment, the operating distance traveled in a certain time width. According

to this, by determining the operating distance coefficient for each travel section, the toll collection system 100b according to the third embodiment can achieve similar operational effects to those of the first embodiment and the second embodiment. The toll collection system 100b can more finely record where and at what time the vehicle was present. This can more finely apply a toll discount depending on the time of day. That is, according to the toll collection system 100b, it is possible to more flexibly calculate the toll fee.

[0116]

Embodiment of Computer Configuration

FIG. 12 is a schematic block diagram illustrating the configuration of a computer according to the first embodiment, the second embodiment, and the third embodiment. A computer 900 includes a processor 901, a main storage device 902, an auxiliary storage device 903, and an interface 904. The onboard units 10, 10a, and 10b, the entrance tollgate server 20, the exit tollgate server 30, and the roadside device 40 described above are implemented respectively in different computers 900. Then, the operation of each processing unit described above is stored in the auxiliary storage device 903 in the form of a program. The processor 901 reads the program from the auxiliary storage device 903, deploys it in the main storage device 902, and executes the above processing in accordance with the program. The processor 901 secures, in the main storage device 902, a storage area used in the above processing in accordance with the program.

[0117]

The program may be for implementing some of the functions to be exerted by the computer 900. For example, the program may exert the function by a combination with another program already stored in the auxiliary storage device 903 or a combination with another program mounted on another device. Note that in other embodiments, the computer may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD) in addition to or in place of the above configuration. Examples of the PLD include a programmable array logic (PAL), a generic array logic (GAL), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA). In this case, some or all of the functions implemented by the processor may be implemented by the integrated circuit.

[0118]

Examples of the auxiliary storage device 903 include a hard disk drive (HDD), a solid state drive (SSD), a magnetic disk, a magneto-optical disk, a compact disc read only memory (CD-ROM), a digital versatile disc read only

memory (DVD-ROM), and a semiconductor memory. The auxiliary storage device 903 may be an internal medium directly connected to a bus of the computer 900 or may be an external medium (an external storage device 910) connected to the computer 900 via the interface 904 or a communication line.

5 In a case where this program is distributed to the computer 900 via the communication line, the computer 900 having received the distribution may deploy the program in the main storage device 902 and execute the above processing. In at least one embodiment, the auxiliary storage device 903 is a non-transitory tangible storage medium.

10 [0119]

Other Embodiments

While one embodiment has been described in detail with reference to the drawings, the specific configuration is not limited to that described above, and various design changes and the like can be made. That is, in other
15 embodiments, the order of the above-described processing may be appropriately changed. Parts of processing may be executed in parallel.

[0120]

For example, the roadside device 40 according to one embodiment needs not include the operating distance map reception unit 402 and the operating
20 distance map transmission unit 403. Specifically, the roadside device 40 including the operating distance map reception unit 402 and the operating distance map transmission unit 403 and the roadside device 40 not including them may be mixed in accordance with the size of data. Furthermore, when the entrance tollgate server 20 can transmit all the operating distance map 1, all the
25 roadside devices 40 need not include the operating distance map reception unit 402 and the operating distance map transmission unit 403.

[0121]

In the toll collection systems 100, 100a, and 100b according to one embodiment, the toll fee may be calculated by the onboard units 10, 10a, and
30 10b. At this time, for example, the toll calculation information is transmitted from the exit tollgate server 30 to the onboard units 10, 10a, and 10b. The onboard units 10, 10a, and 10b calculate the toll fee of the vehicle V based on the transmitted toll calculation information and the information of the accumulation unit 104. The billing processing may be executed by the exit
35 tollgate server 30 being notified of the toll fee calculated by the onboard units 10, 10a, and 10b.

[0122]

Supplementary Notes

The above-described one embodiment is understood as follows, for example.

[0123]

(1) The onboard units 10, 10a, and 10b according to the first aspect
 5 respectively include: the operating distance map acquisition unit 101 that
 acquires the operating distance map 1 defining operating distance specification
 information for each predetermined travel section to be geometrically defined
 of the toll road; the travel section specification units 102, 102a, and 102b that
 specify a travel section in which the vehicle V is traveling based on position
 10 information to be acquired while the vehicle V is traveling; the operating
 distance acquisition units 103, 103a, and 103b that acquires an operating
 distance during traveling with reference to the operating distance specification
 information based on the travel section having been specified; the accumulation
 unit 104 that accumulates and records the operating distances obtained by the
 15 operating distance acquisition units 103, 103a, and 103b; and the notification
 unit 105 that notifies the exit tollgate server 30 of the exit tollgate of the toll
 road of the operating distance accumulated by the accumulation unit 104.

[0124]

In the known technique, the toll fee is calculated based on which
 20 entrance tollgate the vehicle has entered from and which exit tollgate the
 vehicle has exited from, and the toll fee reflecting the route on which the
 individual vehicle has traveled cannot be calculated. For this reason, it was
 difficult to calculate a toll fee corresponding to a route on which each vehicle
 has actually traveled. In contrast, in the present embodiment, the toll road is
 25 divided into a plurality of travel sections. In the operating distance map 1, the
 operating distance specification information is defined for each travel section.
 The onboard units 10, 10a, and 10b of the vehicle V can accumulate and record
 which travel section the certain vehicle V has traveled in. By calculating the
 toll fee from these pieces of information, it is possible to calculate the toll fee
 30 corresponding to the route on which the vehicle V has traveled.

[0125]

(2) The onboard units 10, 10a, and 10b according to the second aspect
 are the onboard units 10, 10a, and 10b of (1), in which the operating distance
 map acquisition unit 101 acquires the operating distance map 1 to be
 35 transmitted from the entrance tollgate server 20 of the entrance tollgate at the
 entrance tollgate of the toll road.

[0126]

By doing this, the onboard units 10, 10a, and 10b acquire the operating distance map 1 at the entrance tollgate. Hence, even if the operating distance map 1 is not saved in advance in the onboard units 10, 10a, and 10b, it is possible to accumulate the operating distances as described above. By transmission of the operating distance map 1 at the entrance tollgate, the latest operating distance map 1 at the time point of entering the toll road can be acquired.

[0127]

(3) The toll collection systems 100, 100a, and 100b according to the third aspect are the toll collection systems 100, 100a, and 100b including: the onboard units 10, 10a, and 10b of (1) or (2); and the exit tollgate server 30 provided at an exit tollgate of the toll road, in which the exit tollgate server 30 includes the operating distance reception unit 302 that receives the operating distance having been accumulated of the vehicle V notified by the onboard units 10, 10a, and 10b, the toll fee calculation unit 303 that calculates a toll fee of the vehicle V based on the operating distance having been acquired, and the billing processing unit 304 that performs billing processing of billing the vehicle V for the toll fee having been calculated.

[0128]

By doing this, the toll collection systems 100, 100a, and 100b can bill the vehicle V for the toll fee flexibly calculated depending on the route on which the vehicle V has actually traveled at the exit tollgate.

[0129]

(4) The toll collection systems 100, 100a, and 100b according to the fourth aspect are the toll collection systems 100, 100a, and 100b of (3) further including the entrance tollgate server 20 provided at an entrance tollgate of the toll road, in which the entrance tollgate server 20 includes the operating distance map transmission unit 202 that transmits the operating distance map 1 to the onboard units 10, 10a, and 10b.

[0130]

By doing this, the toll collection systems 100, 100a, and 100b transmit the operating distance map 1 to the onboard units 10, 10a, and 10b by the operating distance map transmission unit 202 at the entrance tollgate. Hence, the entrance tollgate server 20 can transmit the latest operating distance map 1 to the onboard units 10, 10a, and 10b of the vehicle V having passed through the entrance tollgate.

[0131]

(5) The toll collection system 100 according to the fifth aspect is the toll collection system 100 of (3) or (4) further including the roadside device 40 provided at a predetermined notification point of the toll road, in which the roadside device 40 includes the position information transmission unit 401 that transmits position information to the onboard unit 10 of the vehicle V having arrived at the notification point, and the travel section specification unit 102 acquires the position information transmitted from the roadside device 40 to specify the travel section.

[0132]

By doing this, due to the vehicle V passing through the notification point, the onboard unit 10 can record the travel section in which the vehicle V has actually traveled. This enables the toll collection system 100 to calculate the toll fee corresponding to the route on which the vehicle V has actually traveled to bill the vehicle V.

[0133]

(6) The toll collection systems 100, 100a, and 100b according to the sixth aspect are the toll collection systems 100, 100a, and 100b of (3) to (5), in which the roadside device 40 includes the operating distance map transmission unit 403 that transmits the operating distance map 1 to the onboard units 10, 10a, and 10b.

[0134]

By doing this, the toll collection systems 100, 100a, and 100b transmit the operating distance map 1 to the onboard units 10, 10a, and 10b of the vehicle V having passed through the notification point. Hence, the latest operating distance map 1 can be transmitted to the onboard units 10, 10a, and 10b of the vehicle V having passed through the notification point. Since the operating distance map 1 can be transmitted from each notification point, the operating distance map 1 can be divided and transmitted. Therefore, the data amount to be transmitted at a time from the operating distance map transmission unit 403 can be reduced.

[0135]

(7) The toll collection system 100 according to the seventh aspect is the toll collection system 100 of (5) or (6) in which the position information transmission unit 401 transmits time information associated with the position information to the onboard unit 10 of the vehicle V together with the position information, the accumulation unit 104 further records the time information in association with the operating distance, the notification unit 105 notifies the exit tollgate server 30 of the time information associated with the operating

distance together with the operating distance having been accumulated, the operating distance reception unit 302 receives the time information associated with the operating distance together with the operating distance having been accumulated, and the toll fee calculation unit 303 calculates the toll fee of the vehicle V based on the operating distance and the time information.

[0136]

By doing this, the toll collection system 100 can flexibly calculate the toll fee by applying the travel section in which the vehicle V has actually traveled and the time at which the vehicle V traveled in the travel section.

[0137]

(8) The toll collection systems 100a and 100b according to the eighth aspect are the toll collection systems of (3) to (7), in which the travel section specification units 102a and 102b acquire the position information by a positioning function to specify the travel section.

[0138]

By doing this, the toll collection systems 100a and 100b can record the travel section in which the vehicle V has actually traveled by the positioning function. This enables the toll collection systems 100a and 100b to calculate the toll fee corresponding to the route on which the vehicle V has actually traveled to bill the vehicle V.

[0139]

(9) The toll collection systems 100a and 100b according to the ninth aspect are the toll collection systems 100a and 100b of (8), in which the travel section specification units 102a and 102b acquire, together with the position information, time information associated with the position information to specify the travel section, the accumulation unit 104 further records the time information in association with the operating distance, the notification unit 105 notifies the exit tollgate server 30 of the time information associated with the operating distance together with the operating distance having been accumulated, the operating distance reception unit 302 receives the time information associated with the operating distance together with the operating distance having been accumulated, and the toll calculation unit 303 calculates the toll fee of the vehicle V based on the operating distance and the time information.

[0140]

By doing this, the toll collection systems 100a and 100b can flexibly calculate the toll fee by applying the travel section in which the vehicle V has

actually traveled and the time at which the vehicle V traveled in the travel section.

[0141]

(10) The toll collection method according to the tenth aspect includes: a step in which the onboard units 10, 10a, and 10b mounted on the vehicle acquire the operating distance map 1 defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road; a step in which the onboard unit 10 specifies a travel section in which the vehicle V is traveling based on position information to be acquired while the vehicle V is traveling; a step in which the onboard unit 10 acquires an operating distance during traveling with reference to the operating distance specification information associated with the travel section having been specified; a step in which the onboard unit 10 accumulates the operating distance having been acquired; a step in which the onboard unit 10 notifies the exit tollgate server 30 of an exit tollgate of the toll road of the operating distance having been accumulated; a step in which the exit tollgate server 30 calculates a toll fee of the vehicle V based on the operating distance having been acquired; and a step in which the exit tollgate server 30 performs billing processing of billing the vehicle V for the toll fee having been calculated.

[0142]

(11) The program according to the eleventh aspect causes the onboard units 10, 10a, and 10b to execute a step of acquiring the operating distance map 1 defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road, a step of specifying a travel section in which the vehicle V is traveling based on position information to be acquired while the vehicle V is traveling, a step of acquiring an operating distance during traveling with reference to the operating distance specification information associated with the travel section having been specified, and a step of accumulating the operating distance having been acquired.

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Reference Signs List

[0143]

100 Toll collection system
1 Operating distance map
10 Onboard unit
101 Operating distance map acquisition unit
102 Travel section specification unit
103 Operating distance acquisition unit

- 104 Accumulation unit
- 105 Notification unit
- 11 Terminal device
- 20 Entrance tollgate server
- 5 201 Operating distance map reception unit
- 202 Operating distance map transmission unit
- 203 Entrance information transmission unit
- 21 Roadside antenna
- 30 Exit tollgate server
- 10 301 Toll calculation information acquisition unit
- 302 Operating distance reception unit
- 303 Toll fee calculation unit
- 304 Billing processing unit
- 31 Roadside antenna
- 15 40 Roadside device
- 41 Roadside antenna
- 401 Position information transmission unit
- 402 Operating distance map reception unit
- 403 Operating distance map transmission unit
- 20 50 Center server
- 100a Toll collection system
- 10a Onboard unit
- 102a Travel section specification unit
- 103a Operating distance acquisition unit
- 25 100b Toll collection system
- 10b Onboard unit
- 102b Travel section specification unit
- 103b Operating distance acquisition unit
- 60 GNSS satellite
- 30 900 Computer
- 901 Processor
- 902 Main storage device
- 903 Auxiliary storage device
- 904 Interface
- 35 910 External storage device
- V Vehicle

Claims

[Claim 1]

An onboard unit comprising:

an operating distance map acquisition unit that acquires an operating distance map defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road;

a travel section specification unit that specifies a travel section in which a vehicle is traveling based on position information to be acquired while the vehicle is traveling;

an operating distance acquisition unit that acquires an operating distance during traveling with reference to the operating distance specification information based on the travel section having been specified;

an accumulation unit that accumulates and records the operating distance obtained by the operating distance acquisition unit; and

a notification unit that notifies an exit tollgate server of an exit tollgate of the toll road of the operating distance accumulated by the accumulation unit.

[Claim 2]

The onboard unit according to claim 1, wherein

the operating distance map acquisition unit acquires the operating distance map to be transmitted from an entrance tollgate server of an entrance tollgate at the entrance tollgate of the toll road.

[Claim 3]

A toll collection system comprising:

the onboard unit according to claim 1 or 2; and

an exit tollgate server provided at an exit tollgate of the toll road,

wherein

the exit tollgate server includes

an operating distance reception unit that receives the operating distance having been accumulated of the vehicle from the onboard unit,

a toll fee calculation unit that calculates a toll fee of the vehicle based on the operating distance having been acquired, and

a billing processing unit that performs billing processing of billing the vehicle for the toll fee having been calculated.

[Claim 4]

The toll collection system according to claim 3 further comprising
an entrance tollgate server provided at an entrance tollgate of the toll
road, wherein

the entrance tollgate server includes an operating distance map
transmission unit that transmits the operating distance map to the onboard unit.

[Claim 5]

The toll collection system according to claim 3 or 4 further comprising
a roadside device provided at a predetermined notification point of the
toll road, wherein

the roadside device includes a position information transmission unit
that transmits position information to the onboard unit of the vehicle having
arrived at the notification point, and

the travel section specification unit acquires the position information
transmitted from the roadside device to specify the travel section.

[Claim 6]

The toll collection system according to any one of claims 3 to 5, wherein
the roadside device includes an operating distance map transmission unit
that transmits the operating distance map to the onboard unit.

[Claim 7]

The toll collection system according to claim 5 or 6, wherein

the position information transmission unit transmits time information
associated with the position information to the onboard unit of the vehicle
together with the position information,

the accumulation unit further records the time information in association
with the operating distance,

the notification unit notifies the exit tollgate server of the time
information associated with the operating distance together with the operating
distance having been accumulated,

the operating distance reception unit receives the time information
associated with the operating distance together with the operating distance
having been accumulated, and

the toll fee calculation unit calculates the toll fee of the vehicle based on
the operating distance and the time information.

[Claim 8]

The toll collection system according to any one of claims 3 to 7, wherein the travel section specification unit acquires the position information by a positioning function to specify the travel section.

[Claim 9]

The toll collection system according to claim 8, wherein the travel section specification unit acquires, together with the position information, time information associated with the position information to specify the travel section,

the accumulation unit further records the time information in association with the operating distance,

the notification unit notifies the exit tollgate server of the time information associated with the operating distance together with the operating distance having been accumulated,

the operating distance reception unit receives the time information associated with the operating distance together with the operating distance having been accumulated, and

the toll fee calculation unit calculates the toll fee of the vehicle based on the operating distance and the time information.

[Claim 10]

A toll collection method comprising:

a step in which an onboard unit mounted on a vehicle acquires an operating distance map defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road;

a step in which the onboard unit specifies a travel section in which the vehicle is traveling based on position information to be acquired while the vehicle is traveling;

a step in which the onboard unit acquires an operating distance during traveling with reference to the operating distance specification information associated with the travel section having been specified;

a step in which the onboard unit accumulates the operating distance having been acquired;

a step in which the onboard unit notifies an exit tollgate server of an exit tollgate of the toll road of the operating distance having been accumulated;

a step in which the exit tollgate server calculates a toll fee of the vehicle based on the operating distance having been acquired; and

a step in which the exit tollgate server performs billing processing of billing the vehicle for the toll fee having been calculated.

[Claim 11]

A program that causes an onboard unit to execute

a step of acquiring an operating distance map defining operating distance specification information for each predetermined travel section to be geometrically defined of a toll road,

a step of specifying a travel section in which the vehicle is traveling based on position information to be acquired while the vehicle is traveling,

a step of acquiring an operating distance during traveling with reference to the operating distance specification information associated with the travel section having been specified, and

a step of accumulating the operating distance having been acquired.