

[DESCRIPTION]

[TITLE OF INVENTION]

EVALUATION DEVICE, EVALUATION METHOD, AND PROGRAM

[Technical Field]

5 [0001]

The present invention relates to an evaluation device, an evaluation method, and a program.

[Background Art]

[0002]

10 A charging system of a charging target road (a toll road or the like) using a technology of a global navigation satellite system (GNSS) has been considered. For example, in Patent Document 1, a system charges a toll in a case in which it is detected that a vehicle has entered a charging target road (has passed through a charging point representing a predetermined place on a road such as an entrance of a charging target
15 road or the like) from a positioning result based on satellite signals received from GNSS satellites is described.

[0003]

In the GNSS charging system, there is a possibility of occurrences of a charging omission for a vehicle that has traveled on a charging target road, an erroneous charging
20 for a vehicle not traveling on a charging target road, and the like due to the influence of error included in a positioning result of the GNSS. In a performance verification test before start of the operation of a GNSS charging system, monitoring of system performance after start of the operation, and the like, an evaluation system evaluating to what degree of accuracy a charging process can be performed without incurring such
25 charging omissions and erroneous charging (a success rate of the charging process) is

considered.

[0004]

For example, an evaluation system collates the number of vehicles that passed through a charging point with the number of charging processes performed by the GNSS charging system and checks that charging omission and erroneous charging do not occur. At this time, in order to measure the number of vehicles that passed through the charging point, near a road on which the charging point is disposed, an antenna device performing radio communication with an on-board unit mounted on a vehicle and a camera used for reading a license plate of a vehicle that passes through the charging point (a license plate reading device) are installed.

[Citation List]

[Patent Document]

[0005]

[Patent Document 1]

PCT Publication No. 2020/039938

[Summary of Invention]

[Technical Problem]

[0006]

For example, in a case in which an antenna device is installed near a charging point, an evaluation system determines that a vehicle in which an on-board unit is mounted has passed through the charging point when communication is established between the antenna device and the on-board unit. However, in a case in which a communication range is wide, a case in which a wall or the like reflects radio waves, and the like, the antenna device may establish communication with an on-board unit mounted on a vehicle traveling on a road adjacent to the charging target road. On the other hand,

since this vehicle is not traveling on the charging target road, a GNSS charging system does not perform a charging process. In that case, although the GNSS charging system has performed a correct process, there is a possibility that the evaluation system erroneously evaluates presence of a charging omission. In other words, there is a possibility of the evaluation accuracy of the evaluation system being degraded due to erroneous communication of the antenna device.

[0007]

The present disclosure is in view of such problems and provides an evaluation device, an evaluation method, and a program capable of evaluating the performance of a GNSS charging system with high accuracy.

[Solution to Problem]

[0008]

According to one aspect of the present disclosure, there is provided an evaluation device performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit, the evaluation device including: a passing vehicle recording unit configured to acquire passage information including identification information of a vehicle passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device disposed at the charging point and record the passage information in a passing vehicle list; a road surface state estimating unit configured to acquire the identification information and an acceleration of the vehicle from the on-board unit and estimate an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle; a charging information acquiring unit

configured to acquire charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and an evaluation unit configured to extract unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list has passed, is disposed from charging point information in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is recorded in advance and evaluate a charging omission or erroneous charging of the charging system by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated by the road surface state estimating unit.

[0009]

According to one aspect of the present disclosure, there is provided an evaluation device performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit, the evaluation device including: a road surface state estimating unit configured to acquire identification information and an acceleration of the vehicle from the on-board unit and estimate an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle; a passing vehicle recording unit configured to determine that, in a case in which a charging point having unevenness state information matching an unevenness state of a road on which the vehicle has traveled is included in charging point information in which unevenness state information of road surfaces of roads on which a plurality of charging points are disposed is recorded in advance, the

vehicle has passed through the charging point and record passage information including the identification information of the vehicle and information that is able to identify the charging point in a passing vehicle list; a charging information acquiring unit configured to acquire charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and an evaluation unit configured to evaluate a charging omission or erroneous charging of the charging system by collating the passing vehicle list with the charging information.

[0010]

10 According to one aspect of the present disclosure, there is provided an evaluation method performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit, the evaluation method including:

15 a step of acquiring passage information including identification information of a vehicle passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device disposed at the charging point and recording the passage information in a passing vehicle list; a step of acquiring the identification information and an acceleration of the vehicle from the on-board unit and

20 estimating an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle; a step of acquiring charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and a step of extracting unevenness state information of a road on which a charging

25 point, through which one vehicle recorded in the passing vehicle list has passed, is

disposed from charging point information in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is recorded in advance and evaluating a charging omission or erroneous charging of the charging system by collating the extracted unevenness state information with the

5 unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated in the step of estimating the unevenness state.

[0011]

According to one aspect of the present disclosure, there is provided a program

10 causing an evaluation device performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit to execute: a step of acquiring passage information including identification information of a vehicle passing

15 through a charging point and information that is able to identify a passed charging point through a vehicle detecting device disposed at the charging point and recording the passage information in a passing vehicle list; a step of acquiring the identification information and an acceleration of the vehicle from the on-board unit and estimating an unevenness state of a road surface of a road on which the vehicle is traveling on the basis

20 of the acquired acceleration of the vehicle; a step of acquiring charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and a step of extracting unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list has passed, is disposed from charging point

25 information in which unevenness state information of a road surface of a road on which

each of a plurality of charging points is disposed is recorded in advance and evaluating a charging omission or erroneous charging of the charging system by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is
5 estimated in the step of estimating the unevenness state.

[Advantageous Effects of Invention]

[0012]

According to an evaluation device, an evaluation method, and a program relating to the present disclosure, the performance of a GNSS charging system can be evaluated
10 with high accuracy.

[Brief Description of Drawings]

[0013]

FIG. 1 is a schematic diagram showing the entire configuration of a GNSS charging system according to a first embodiment.

15 FIG. 2 is a block diagram showing a functional configuration of an evaluation device according to the first embodiment.

FIG. 3 is a flowchart showing one example of a process of the evaluation device according to the first embodiment.

FIG. 4 is a diagram showing one example of a passing vehicle list according to
20 the first embodiment.

FIG. 5 is a diagram showing one example of charging point information according to the first embodiment.

FIG. 6 is a first diagram showing one example of a non-charging target vehicle according to the first embodiment.

25 FIG. 7 is a second diagram showing one example of a non-charging target

vehicle according to the first embodiment.

FIG. 8 is a block diagram showing a functional configuration of an evaluation device according to a second embodiment.

FIG. 9 is a flowchart showing one example of a process of the evaluation device according to the second embodiment.

[Description of Embodiments]

[0014]

<First Embodiment>

Hereinafter, a GNSS charging system (a charging system) 1 according to a first embodiment of the present disclosure will be described with reference to FIGS. 1 to 7.

[0015]

(Entire Configuration)

FIG. 1 is a schematic diagram showing the entire configuration of the GNSS charging system according to the first embodiment.

As shown in FIG. 1, the GNSS charging system 1 according to this embodiment includes an on-board unit 10 mounted on a vehicle A, a charging server 30 performing a charging process of a toll for the vehicle A, and an evaluation device 40 performing an evaluation of the GNSS charging system 1.

[0016]

The on-board unit 10 performs a map matching process on the basis of a positioning result based on satellite signals received from GNSS satellites and map data and estimates a traveling position of a vehicle A on the map data. The on-board unit 10 transmits the estimated traveling position (estimated positional information) to the charging server 30. The map matching process of the on-board unit 10 is known, and thus description thereof will be omitted.

[0017]

In addition, the on-board unit 10 according to this embodiment transmits sensor information acquired from a sensor of the vehicle A or the on-board unit 10 to the evaluation device 40 as traveling information. The traveling information, for example, includes an acceleration, a speed, and the like of the vehicle A. In addition, the traveling information includes identification information (license plate information, an on-board unit ID, and the like) of the vehicle A.

[0018]

The charging server 30 is connected to the on-board unit 10 through radio communication. The charging server 30 determines a traveling path of the vehicle A on the basis of the estimated positional information collected from the on-board unit 10 and charges a toll corresponding to a charging target road on which the vehicle A has traveled. For example, in a case in which a vehicle A travels along a path passing through a charging point that is a predetermined place on a road used for a charging process, the charging server 30 performs a charging process for this vehicle A. The charging process of the charging server 30 is known, and thus description thereof will be omitted. The charging point, for example, is an entrance of the charging target road. In addition, the charging point may be an exit of the charging target road.

[0019]

The charging target road, for example, is a toll road. In addition, the charging target road may be a road (or a partial section of a road) positioned inside a toll area for the purpose of resolving congestion.

[0020]

The charging server 30 according to this embodiment transmits charging information including identification information of a vehicle to which a toll has been

charged, a processing time of a charging process, and the like to the evaluation device 40.

[0021]

In this embodiment, near the charging point, a vehicle detecting device 20 that detects a vehicle A passing through the charging point and acquires identification

5 information of this vehicle A is disposed.

[0022]

The vehicle detecting device 20, for example, is a camera (a license number reading device) that photographs a license plate of a vehicle A and reads license plate information including text displayed on the license plate. In this case, the identification

10 information of the vehicle A is the license plate information.

[0023]

In addition, the vehicle detecting device 20 may be an antenna device that performs radio communication with the on-board unit 10 mounted on the vehicle A. In such a case, the identification information of the vehicle A is an on-board unit ID, license

15 plate information, and the like that are registered in the on-board unit 10.

[0024]

The vehicle detecting device 20 transmits passage information including the identification information acquired from the vehicle A and a passing time (a detection time) of the vehicle A at the charging point to the evaluation device 40.

20 [0025]

The evaluation device 40 evaluates the GNSS charging system 1 on the basis of the traveling information collected from the on-board unit 10, the charging information collected from the charging server 30, and the passage information collected from the vehicle detecting device 20.

25 [0026]

(Functional Configuration of Evaluation Device)

FIG. 2 is a block diagram showing a functional configuration of the evaluation device according to the first embodiment.

As shown in FIG. 2, the evaluation device 40 includes a CPU 41, a memory 42,
5 a storage 43, and a communication interface 44.

[0027]

The CPU 41 is a processor that performs various functions by operating in accordance with a program prepared in advance. The function of the CPU 41 will be described below.

10 [0028]

The memory 42 is a so-called main storage device and has a storage area required for an operation of the CPU 41.

[0029]

The storage 43 is a so-called auxiliary storage device and is a large-capacity
15 storage device such as a hard disk drive (HDD) or a solid state drive (SSD). In the storage 43, various kinds of information acquired and generated by each unit of the CPU 41 to be described below is recorded. In addition, charging point information D2 is recorded in the storage 43 in advance.

[0030]

20 The communication interface 44 is a connection interface for connecting the on-board unit 10, the vehicle detecting device 20, and the charging server 30 to be able to communicate with each other through wireless communication or wired communication.

[0031]

The CPU 41 functions as a passing vehicle recording unit 411, a road surface
25 state estimating unit 412, a charging information acquiring unit 413, and an evaluation

unit 414 by being operated in accordance with a program prepared in advance.

[0032]

The passing vehicle recording unit 411 acquires passage information including identification information of a vehicle A passing through a charging point and

5 information that is able to identify a passed charging point through the vehicle detecting device 20 disposed at the charging point and records the passage information in a passing vehicle list D1 of the storage 43.

[0033]

The road surface state estimating unit 412 acquires identification information

10 and an acceleration of a vehicle A from the on-board unit 10 and estimates an unevenness state of the road surface of a road on which the vehicle A is traveling on the basis of the acquired acceleration of the vehicle A.

[0034]

The charging information acquiring unit 413 acquires charging information

15 including identification information of a vehicle A for which the charging server 30 has performed a charging process from the charging server 30. The acquired charging information is recorded and accumulated in the storage 43.

[0035]

The evaluation unit 414 extracts unevenness state information of a road on

20 which a charging point, through which one vehicle recorded in a passing vehicle list D1 has passed, is disposed from the charging point information D2 in which the unevenness state information of road surfaces of roads in which a plurality of charging points are disposed is recorded in advance and evaluates a charging omission of the charging system by collating the extracted unevenness state information with the unevenness state
25 of a road, on which a vehicle having the same identification information as this one

vehicle has traveled, estimated by the road surface state estimating unit 412.

[0036]

The evaluation unit 414 according to this embodiment includes a classification unit 4141 and a charging omission evaluating unit 4142.

5 [0037]

The classification unit 4141, regarding a vehicle A included in the passing vehicle list D1, classifies whether this vehicle A is a charging target vehicle or a non-charging target vehicle (a vehicle other than a charging target) by collating the unevenness state of the road on which this vehicle A has traveled with the charging point information D2.

[0038]

The charging omission evaluating unit 4142 evaluates a charging success rate representing whether or not the charging system 1 has performed charging without omission on the basis of the number of pieces of charging information and the number of charging target vehicles.

[0039]

(Process Flow of Evaluation Device)

FIG. 3 is a flowchart showing one example of a process of the evaluation device according to the first embodiment.

20 Here, details of an evaluation process of the evaluation device 40 will be described with reference to FIG. 3.

[0040]

When a vehicle A passes through a charging point, the vehicle detecting device 20 acquires identification information of this vehicle A. In a case in which the vehicle detecting device 20 is a camera, the identification information of the vehicle A is license

25

plate information. In a case in which the vehicle detecting device 20 is an antenna device, the identification information of the vehicle A is an on-board unit ID, license plate information, or the like that is registered in the on-board unit 10. Then, the passing vehicle recording unit 411 of the evaluation device 40 acquires passage information including the identification information of the vehicle A that has passed through the charging point from the vehicle detecting device 20 (Step S100). In addition, a charging point ID that is able to identify a charging point at which the vehicle detecting device 20 is disposed and a charging point passing time (a detection time according to the vehicle detecting device 20) of the vehicle A may be further included in the passage information.

[0041]

Furthermore, the passing vehicle recording unit 411 records the acquired passage information in the passing vehicle list D1 (FIG. 4) (Step S101).

[0042]

FIG. 4 is a diagram showing one example of a passing vehicle list according to the first embodiment.

As shown in FIG. 4, the passing vehicle list D1 includes a charging point ID, a passing time, and identification information. Every time passage information is acquired from the vehicle detecting device 20, the passing vehicle recording unit 411 updates the list by adding the information to the passing vehicle list D1.

[0043]

In addition, the road surface state estimating unit 412 acquires traveling information from the on-board unit 10 of the vehicle A (Step S102). Identification information of the vehicle A, measured values of sensors and the like, and a measurement time are included in the traveling information. The measured values are an acceleration

of the vehicle A measured by an acceleration sensor, a speed of the vehicle A measured by a vehicle-speed sensor, a traveling distance, and the like. The traveling information acquired from the on-board unit 10 is accumulated in the storage 43 for each vehicle.

[0044]

5 Next, the road surface state estimating unit 412 estimates an unevenness state of the road surface of a road on which the vehicle A has traveled on the basis of the traveling information of the vehicle A (Step S103).

[0045]

 The road surface state estimating unit 412 according to this embodiment
10 calculates an International Roughness Index (also referred to as “IRI”) on the basis of an acceleration of the vehicle A in a vertical direction as an estimated value representing an unevenness state of the road surface. The IRI represents a ratio between an accumulated value of displacements of a vehicle in the vertical direction and a traveling distance of the vehicle to express a degree of unevenness of a road surface as a number.
15 For example, the unit is m/km or m/m. In addition, the calculated IRI is recorded and accumulated in the storage 43.

[0046]

 The road surface state estimating unit 412 calculates an IRI, for example, every time a vehicle A travels a predetermined distance. In this case, the road surface state
20 estimating unit 412 acquires a displacement amount of the vehicle A in the vertical direction at each time on the basis of accelerations of the vehicle A accumulated in the storage 43 in a period from a time at which the previous IRI was calculated to a current time. Then, the road surface state estimating unit 412 calculates an IRI by dividing an accumulated value of displacements from the previous time to the current time by a
25 traveling distance. In addition, in a case in which traveling information of a plurality of

vehicles is recorded in the storage 43, the road surface state estimating unit 412 estimates an unevenness state of a traveled road for each vehicle.

[0047]

In addition, the road surface state estimating unit 412 may calculate an IRI every
5 time when a predetermined time elapses or every time when a predetermined amount of sensor information is collected.

[0048]

Next, the classification unit 4141 of the evaluation unit 414, for each vehicle included in the passing vehicle list D1, collates the unevenness state estimated by the
10 road surface state estimating unit 412 with the unevenness state information of a charging point included in the charging point information D2 (FIG. 5), thereby determining whether each vehicle is a charging target vehicle (Step S104).

[0049]

FIG. 5 is a diagram showing one example of charging point information
15 according to the first embodiment.

In the example shown in FIG. 5, a charging point PN1 is disposed on a link LK1 connecting a node ND1 and a node ND2. The charging point information D2 includes a charging point ID, information (a link ID) representing a link in which the charging point is disposed, information representing a position of the charging point on a link, and
20 unevenness state information of the link in which the charging point is disposed.

[0050]

The position on the link, for example, is represented by a distance from a start point node of the link. In the charging point information D2, it is recorded that a charging point PN1 is disposed at a position X3m from a start point node ND1 of a link
25 LK1.

[0051]

The unevenness state information is an index representing an unevenness state of the road surface of a road (link) on which a charging point on the road is disposed.

The unevenness state information according to this embodiment is a reference IRI of the

5 vicinity of a charging point (a link in which a charging point is disposed) measured by a

measurement vehicle in advance. In addition, the unevenness state information may

include a reference IRI for each speed that is measured while travelling a measurement

vehicle at a plurality of speeds. Furthermore, in order to more accurately determine

whether a vehicle passes a charging point, the unevenness state information may further

10 include a reference IRI of an adjacent link (links before/after a link in which a charging point is disposed, a parallel link, or the like).

[0052]

In addition, the unevenness state information may be represented by not the value of a reference IRI but a level based on the reference IRI. For example, the

15 unevenness state information may be represented by three levels (IRI levels) of “low”,

“intermediate”, and “high” in accordance with the magnitude of the value of the

reference IRI. In addition, the unevenness state information may be further classified

into a plurality of levels (1 to n levels).

[0053]

20 The classification unit 4141 identifies a charging point ID through which the

vehicle A is determined to have passed by referring to the passing vehicle list D1. In

addition, the classification unit 4141 extracts the unevenness state information relating to

this charging point ID by referring to the charging point information D2. In a case in

which the unevenness state (the IRI calculated in Step S103) of the road (the link) on

25 which the vehicle A has traveled matches the unevenness state information (the reference

IRI) extracted from the charging point information D2, the classification unit 4141 determines that this vehicle A is a charging target vehicle that has passed through the charging point (Step S104: Yes). At this time, in a case in which the calculated IRI has a value within a predetermined range from the reference IRI, the classification unit 4141 determines that the IRI and the reference IRI match each other.

[0054]

In a case in which the reference IRI level (“low”, “intermediate”, “high”, or the like) is recorded in the unevenness state information of the charging point information D2, the classification unit 4141 identifies an IRI level (any one of “low”, “intermediate”, and “high”) from the magnitude of the value of the IRI calculated in Step S103. Then, in a case in which the identified IRI level and the unevenness state information (the reference IRI level) match each other, the classification unit 4141 determines that the vehicle A is a charging target vehicle that has passed through the charging point (Step S104: Yes).

[0055]

In addition, in a case in which the vehicle A is determined to be a charging target vehicle (Step S104: Yes), the classification unit 4141 records the identification information of this vehicle A in the charging target vehicle list (Step S105).

[0056]

On the other hand, in a case in which the unevenness state of the road (the link) (the IRI calculated in Step S103) on which the vehicle A has traveled does not match the unevenness state information (the reference IRI) extracted from the charging point information D2, the classification unit 4141 determines that this vehicle A is not a vehicle that has passed through the charging point, that is, a charging target vehicle (Step S104:

No).

[0057]

In this case, the classification unit 4141 records the identification information of this vehicle A in a non-charging target vehicle list (Step S106).

[0058]

5 FIG. 6 is a first diagram showing one example of a non-charging target vehicle according to the first embodiment.

For example, as shown in FIG. 5, it is assumed that an ordinary road (a link LK1) in which no charging point is disposed and a charging target road (a link LK2) in which a charging point PN1 is disposed are adjacent to each other.

10 [0059]

Near the charging point PN1, an antenna device is disposed as the vehicle detecting device 20. When radio communication with an on-board unit 10 positioned within a communication range R is established, the antenna device 20 determines that this vehicle has passed through the charging point PN1. However, there are cases in
15 which the communication range R includes a part of an adjacent link LK1. In those cases, as in the example shown in FIG. 5, the antenna device 20 may establish radio communication with a vehicle A traveling on an adjacent link LK1 (erroneous communication). In addition, in a place in which a wall or the like is present in the communication range R, radio waves are reflected on the wall, and thus the antenna
20 device 20 may erroneously communicate with a vehicle A traveling on the adjacent link LK1. In such a case, the antenna device 20 erroneously detects that a vehicle A traveling on the adjacent link LK1 has passed through the charging point PN1 (the vehicle A has traveled on the link LK2). In that case, the identification information of the vehicle A that has not passed through the charging point PN1 is erroneously recorded
25 in the passing vehicle list D1.

[0060]

In order to prevent evaluation accuracy due to such an erroneous detection of an antenna device 20, the classification unit 4141 performs processes of Steps S104 to S106 and classifies a vehicle not traveling on a link in which a charging point is disposed as a non-charging target vehicle.

[0061]

In addition, the classification unit 4141 may further classify a vehicle that has passed through the charging point by performing abnormal traveling as a non-charging target vehicle. For example, in a case in which a vehicle A has moved along a path on which the vehicle cannot travel on the map data, it is determined that abnormal traveling has been performed.

[0062]

FIG. 7 is a second diagram showing one example of a non-charging target vehicle according to the first embodiment.

As shown in FIG. 7, it is assumed that a vehicle A made a U turn on an ordinary road (a link LK1) on which a U turn is prohibited and entered a charging target road (a link LK2) on which a charging point PN1 is disposed. Since a U turn is prohibited in the link LK1, the charging server 30 determines that continuous traveling between the link LK1 and the link LK2 is impossible (it is impossible to move from the link LK1 to the link LK2). For this reason, in the charging server 30, in a case in which estimated positional information indicating that the vehicle A moves onto a unconnected (impassable) link is acquired, there is a possibility of presence of error in this estimated positional information, and thus a charging process may not be performed (an exceptional process is performed) for preventing erroneous charging.

[0063]

On the other hand, there are case in which a position at which the vehicle A made a U turn is not included in a photographing range, the vehicle detecting device 20 (for example, a camera) disposed near the charging point PN1 cannot determine whether or not the vehicle A performed abnormal traveling. For this reason, the camera 20 detects passage of the charging point PN1 regardless whether or not this vehicle A performed abnormal traveling, and thus identification information of the vehicle A that has been excluded from the charging process as an exceptional process is recorded in the passing vehicle list D1.

[0064]

In the charging system 1 in which such an exceptional process of the charging server 30 is allowed, the classification unit 4141, in Steps S104 to 106, classifies a vehicle that performed abnormal traveling as a non-charging target vehicle for preventing an inappropriately low evaluation. More specifically, the classification unit 4141 determines whether the vehicle A performed abnormal traveling on the basis of the IRI of a predetermined past period from a passage time of the vehicle A at the charging point PN1. For example, in a case in which the IRI of this predetermined period matches the unevenness state information (the reference IRI) of the link LK1, the classification unit 4141 determines that the vehicle A performed abnormal traveling of moving from the link LK1 to the link LK2. In addition, for example, in a case in which a vehicle A moves from the link LK1 to the link LK2 by crossing over a median strip or the like, there is a possibility that an IRI that is different from the unevenness state information (the reference IRI) of both the link LK1 and the link LK2 is measured. In this way, in a case in which an IRI that is greatly different from the reference IRI is measured, the classification unit 4141 may determine that the vehicle A performed abnormal traveling.

[0065]

Next, the charging information acquiring unit 413 acquires charging information from the charging server 30 (Step S107). In addition, the charging information acquiring unit 413 may acquire charging information every time the charging server 30 performs a charging process or may acquire a plurality of pieces of charging information together for every predetermined time (for example, 24 hours).

[0066]

Next, the charging omission evaluating unit 4142 of the evaluation unit 414 evaluates the charging system 1 on the basis of the charging information and the charging target vehicle list. In this embodiment, the charging omission evaluating unit 4142 calculates a charging success rate by dividing the number of charging processes indicated by the charging information by the number of vehicles included in the charging target vehicle list (Step S108). In accordance with this, the charging omission evaluating unit 4142 can evaluate whether a charging process is performed without omission for all vehicles to be charged detected at charging points.

[0067]

In Steps S104 to S106, a vehicle that has been erroneously detected by the vehicle detecting device 20 and vehicles for which a charging process is not performed due to abnormal traveling are excluded from a denominator (the number of vehicles included in the charging target vehicle list) for calculating the charging success rate. In accordance with this, the charging omission evaluating unit 4142 can evaluate the charging system 1 more accurately without having an influence of erroneous detection of the vehicle detecting device 20 and the like.

[0068]

In addition, the charging omission evaluating unit 4142 may calculate a charging success rate by excluding charging information having identification information that is

not recorded in the passing vehicle list D1 from the charging information at the time of calculating the charging success rate. In accordance with this, the charging omission evaluating unit 4142 can prevent degradation of evaluation accuracy due to erroneous recognition of the identification information (the license plate information) according to the vehicle detecting device 20 and the like.

[0069]

(Operation and Effects)

As above, the evaluation device 40 according to this embodiment includes: a passing vehicle recording unit 411 configured to acquire passage information including identification information of a vehicle A passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device 20 disposed at the charging point and record the passage information in a passing vehicle list D1; a road surface state estimating unit 412 configured to acquire the identification information and an acceleration of the vehicle from the on-board unit 10 and estimate an unevenness state of a road surface of a road on which the vehicle A is traveling on the basis of the acquired acceleration of the vehicle A; a charging information acquiring unit 413 configured to acquire charging information including identification information of a vehicle A for which a charging process has been performed by the charging server 30 from the charging server 30; and an evaluation unit 414 configured to extract unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list D1 has passed, is disposed from charging point information D2 and evaluate a charging omission or erroneous charging of the charging system 1 by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle A having the same identification information as the one vehicle has traveled, that is estimated by the road

surface state estimating unit 412.

[0070]

By configuring as such, even in a case in which the vehicle detecting device 20 makes error detection, the evaluation device 40 can correctly determine whether or not the vehicle A has actually passed through the charging point from the unevenness state in which the vehicle A has traveled. In accordance with this, the evaluation device 40 can evaluate the performance of the GNSS charging system 1 with high accuracy.

[0071]

In addition, the evaluation unit 414 includes: a classification unit 4141 configured to classify, for each of vehicles A included in the passing vehicle list D1, that the vehicle A is a charging target vehicle or a non-charging target vehicle (a vehicle other than a charging target) by collating the unevenness state of a road on which the vehicle A has traveled with the charging point information D2; and a charging omission evaluating unit 4142 configured to evaluate a charging success rate representing whether the GNSS charging system 1 has performed charging without omission on the basis of the number of pieces of the charging information and the number of charging target vehicles.

[0072]

By configuring as such, the evaluation device 40 can evaluate the GNSS charging system 1 more accurately by excluding erroneous detection of the vehicle detecting device 20, a case of an exceptional process of the charging server 30, and the like.

[0073]

In addition, the charging omission evaluating unit 4142 evaluates the charging success rate by excluding charging information having identification information not recorded in the passing vehicle list D1 from the charging information.

[0074]

By configuring as such, the evaluation device 40 can prevent degradation of evaluation accuracy due to erroneous recognition of the identification information of the vehicle detecting device 20 and the like.

5 [0075]

In addition, the road surface state estimating unit 412 calculates an international roughness index (IRI) on the basis of the acceleration and estimates the unevenness state on the basis of the international roughness index.

[0076]

10 By configuring as such, the evaluation device 40 can acquire an IRI generally common to the vehicles without depending on a type of the vehicle. In accordance with this, even when a charging process has been performed for any vehicle, the evaluation device 40 can evaluate the GNSS charging system 1 with high accuracy.

[0077]

15 <Modified Example of First Embodiment>

In the first embodiment, although an aspect in which the road surface state estimating unit 412 calculates an IRI from the acceleration of a vehicle A as an estimated value of the unevenness state of the road surface has been described, but the present invention is not limited thereto. In this modified example, an aspect in which the road surface state estimating unit 412 estimates an unevenness state of the road surface on the basis of an acceleration and a speed of a vehicle A will be described.

[0078]

For example, it is assumed that the lengths of the link LK1 and the link LK2 shown in FIG. 6 are 100 m. In addition, it is assumed that five grooves of about 10 cm are present in the link LK1, and 10 grooves of about 5 cm are present in the link LK2.

At this time, an accumulated value of displacements of the vehicle A in a vertical direction during traveling along each of the link LK1 and the link LK2 is 100 cm, and an IRI of any one thereof is 0.1 [m/m]. In this way, when there are links that have coincident IRIs while the unevenness states of the road surfaces (magnitudes and the number of grooves) are different from each other, there are cases in which it is difficult for the evaluation unit 414 according to the first embodiment to determine whether or not a vehicle A is a charging target vehicle.

[0079]

In consideration of presence of such links, a road surface state estimating unit 412 according to this modified example calculates a frequency of displacements (vibrations) of the vehicle A in the vertical direction from the acceleration of the vehicle A using a technique such as a Fourier transform in Step S103 shown in FIG. 3. In addition, the road surface state estimating unit 412 estimates an unevenness state of the road surface on the basis of the frequency and the speed of the vehicle A. More specifically, the road surface state estimating unit 412 obtains a value acquired by dividing the calculated frequency by the speed of the vehicle A as an estimated value of the unevenness state of the road surface. This value corresponds to the number of uneven parts of the road surface in a unit distance.

[0080]

In addition, similarly, an estimated value of the unevenness state measured by a measuring vehicle (= frequency/speed) is recorded for each link in the unevenness state information of the charging point information D2. The classification unit 4141 determines whether the vehicle A is a charging target vehicle by collating the estimated value of the unevenness state calculated by the road surface state estimating unit 412 with the unevenness state information of the charging point information D2 (Step S104

shown in FIG. 3).

[0081]

In the example of the link LK1 and the link LK2 described above, the numbers of the grooves are different from each other, and thus estimated values of the unevenness states have different values. Thus, it becomes easy for the classification unit 4141 to identify the link LK1 and the link LK2. In accordance with this, the classification unit 4141 can classify with high accuracy whether the vehicle A is a non-charging target vehicle that has traveled along the link LK1 or a charging target vehicle that has traveled along the link LK2.

10 [0082]

<Second Embodiment>

Next, an evaluation device 40 according to a second embodiment of the present disclosure will be described with reference to FIGS. 8 and 9. The same reference signs will be assigned to constituent elements that are common to the first embodiment, and detailed description will be omitted.

15 [0083]

(Functional Configuration of Evaluation Device)

FIG. 8 is a block diagram showing a functional configuration of an evaluation device according to the second embodiment.

20 As shown in FIG. 8, an evaluation unit 414 of the evaluation device 40 according to this embodiment further includes an extraction unit 4143 and an erroneous charging evaluating unit 4144.

[0084]

The extraction unit 4143 extracts a vehicle which is not included in a passing vehicle list D1 and of which charging information is present as a vehicle for which

25

erroneous charging is suspected to have been performed.

[0085]

The erroneous charging evaluating unit 4144 evaluates whether or not the charging server 30 has performed erroneous charging for a vehicle by collating the unevenness state of a road on which the extracted vehicle has traveled with charging point information D2.

[0086]

(Process Flow of Evaluation Device)

FIG. 9 is a flowchart showing one example of a process of the evaluation device according to the second embodiment.

Here, details of an evaluation process of the evaluation device 40 will be described with reference to FIG. 9. The evaluation device 40 according to this embodiment performs a series of processes of FIG. 9 to be described below in parallel with the series of processes of FIG. 3 of the first embodiment. In addition, an evaluation device 40 according to another embodiment may perform a series of processes of FIG. 9 to be described below in place of the series of the processes of FIG. 3 of the first embodiment. In such a case, in the evaluation unit 414, the classification unit 4141 and the charging omission evaluating unit 4142 may be omitted.

[0087]

The passing vehicle recording unit 411 acquires passage information including identification information of a vehicle A that has passed through a charging point from the vehicle detecting device 20 (Step S200). In addition, the passing vehicle recording unit 411 records the acquired passage information in the passing vehicle list D1 (FIG. 4) (Step S201). These processes are same as Steps S100 to S101 shown in FIG. 3.

[0088]

In addition, the road surface state estimating unit 412 acquires traveling information from the on-board unit 10 of the vehicle A (Step S202). Then, the road surface state estimating unit 412 estimates an unevenness state (IRI) of the road surface of a road on which the vehicle A has traveled on the basis of the traveling information of the vehicle A (Step S203). These processes are same as Steps S102 to S103 shown in FIG. 3. In addition, the road surface state estimating unit 412 may obtain an estimated value (= frequency/speed) of the unevenness state as with the modified example of the first embodiment.

[0089]

Next, the charging information acquiring unit 413 acquires charging information from the charging server 30 (Step S204). This process is same as Step S107 shown in FIG. 3.

[0090]

Next, by collating the identification information of the charging information with the identification information recorded in the passing vehicle list D1, the extraction unit 4143 of the evaluation unit 414 extracts a vehicle of which the identification information is present in the charging information and of which the identification information is not present in the passing vehicle list D1 as a vehicle for which erroneous charging is suspected to have been performed (Step S205).

[0091]

Next, the erroneous charging evaluating unit 4144 identifies a charging point ID through which a vehicle is determined to have passed by referring to the charging information of the extracted vehicle. In addition, the erroneous charging evaluating unit 4144 extracts unevenness state information relating to this charging point ID by referring to the charging point information D2. The erroneous charging evaluating unit 4144

determines and evaluates presence/absence of erroneous charging by collating the unevenness state (the IRI calculated in Step S203) of the road (the link) on which the vehicle has traveled with the unevenness state information (the reference IRI) extracted from the charging point information D2 (Step S206).

5 [0092]

More specifically, in a case in which the unevenness state (the IRI) of the road (link) on which the vehicle has traveled matches the unevenness state information (the reference IRI) extracted from the charging point information D2, the erroneous charging evaluating unit 4144 evaluates that this vehicle has passed through the charging point,
10 and erroneous charging has not been performed (that is a detection omission of the vehicle detecting device 20).

[0093]

On the other hand, in a case in which the unevenness state (the IRI) of the road (link) on which the vehicle has traveled does not match the unevenness state information
15 (the reference IRI) extracted from the charging point information D2, the erroneous charging evaluating unit 4144 evaluates that this vehicle has not passed through the charging point, and erroneous charging has been performed.

[0094]

The erroneous charging evaluating unit 4144 performs the process of Step S206
20 for all the vehicles for which erroneous charging is suspected.

[0095]

(Operation and Effects)

As above, in the evaluation device 40 according to this embodiment, the evaluation unit 414 includes: an extraction unit 4143 configured to extract a vehicle
25 which is not included in the passing vehicle list D1 and of which the charging

information is present as a vehicle for which erroneous charging is suspected to have been performed; and an erroneous charging evaluating unit 4144 configured to evaluate whether erroneous charging has been performed for the vehicle by collating the unevenness state of a road on which the extracted vehicle has traveled with the charging point information D2.

[0096]

By configuring as such, the evaluation device 40 can evaluate whether or not the GNSS charging system 1 has performed erroneous charging with high accuracy without being influenced by error detection and the like of the vehicle detecting device 20.

[0097]

While several embodiments of the present disclosure have been described as above, all these embodiments are presented as examples and are not intended to limit the scope of the invention. These embodiments can be performed in other various forms, and various additions, omissions, substitutions, and modifications can be made without departing from the concept of the invention. Accordingly, these embodiments and the modifications thereof, similar to a case of being included in the scope or the concept of the invention, are included in the invention described in the claims and the scope of equivalency thereof.

[0098]

<Other Embodiment>

In the embodiment described above, although a form in which the passing vehicle recording unit 411 acquires passage information from the vehicle detecting device 20 and records the passage information in the passing vehicle list D1 has been described, the present invention is not limited thereto. In another embodiment, the passing vehicle recording unit 411 may determine whether or not a vehicle A has passed

through the charging point on the basis of the unevenness state of the road (link), on which the vehicle A has traveled, that is estimated by the road surface state estimating unit 412.

[0099]

5 For example, on a road surface of a road on which charging points are disposed, a different uneven pattern is disposed for each charging point. In accordance with this, different unevenness state information for each charging point is recorded in the charging point information D2. In a case in which the unevenness state of the road on which a vehicle A has traveled matches the unevenness state information of a charging point PN1, 10 the passing vehicle recording unit 411 determines that the vehicle A has passed through the charging point PN1. Then, the passing vehicle recording unit 411 records a charging point ID representing this charging point PN1, identification information of the vehicle A, and a measurement time of traveling information used for estimating the unevenness state (a charging point passing time) by adding them to the passing vehicle 15 list D1. By configuring as such, the evaluation device 40 can omit the vehicle detecting device 20.

[0100]

In addition, in the embodiment described above, although an example in which a person generating the charging point information D2 measures unevenness state 20 information of the vicinity of each charging point using a measuring vehicle has been described, the present invention is not limited thereto. In another embodiment, a center server not shown may collect probe data including a map matching result (estimated positional information) and sensor information (an acceleration and the like) from a plurality of on-board units and generate unevenness state information of the vicinity of 25 each charging point.

[0101]

For a link in which a certain charging point is disposed, when probe data corresponding to a predetermined number (for example, 10,000) or more is collected from a plurality of on-board units, the center server generates unevenness state information relating to this charging point on the basis of the collected probe data. In addition, for a charging point for which probe data corresponding to a predetermined number or more has not been collected, the center server sets the unevenness state information to “NULL”. Furthermore, for a charging point for which probe data corresponding to a predetermined number or more has not been collected, the center server may generate unevenness state information based on probe data that can be collected at a current time point and set a flag indicating that data accuracy is low. Every time unevenness state information is generated or every time a predetermined time elapses, the center server transmits the unevenness state information to the evaluation device 40 to update the charging point information D2. In addition, the function of generating the unevenness state information may be included in the evaluation device 40.

[0102]

In addition, in the embodiment described above, although an example in which the road surface state estimating unit 412 estimates the unevenness state of each road (link) on which the vehicle A has traveled has been described, the present invention is not limited thereto. In another embodiment, the road surface state estimating unit 412 may extract traveling information acquired in a predetermined period (for example, between N seconds before/after a charging point passing time) before/after the passage of the vehicle A through the charging point by referring to the passing vehicle list D1 and estimate only the unevenness state of the road on which the vehicle A has traveled in this predetermined period. In accordance with this, the processing load of the evaluation

device 40 can be reduced.

[0103]

<Supplement>

The evaluation device, the evaluation method, and the program described in the
5 embodiment described above, for example, are perceived as below.

[0104]

(1) According to a first aspect of the present invention, there is provided an
evaluation device (40) performing an evaluation of a charging system (1) including an
on-board unit (10) estimating a traveling position of a vehicle on which the on-board unit
10 (10) is mounted and a charging server (30) performing a charging process of a toll for the
vehicle on the basis of the traveling position collected from the on-board unit (10), the
evaluation device (40) including: a passing vehicle recording unit (411) configured to
acquire passage information including identification information of a vehicle passing
through a charging point through a vehicle detecting device (20) disposed at the charging
15 point and record the passage information in a passing vehicle list (D1); a road surface
state estimating unit (412) configured to acquire the identification information and an
acceleration of the vehicle from the on-board unit (10) and estimate an unevenness state
of a road surface of a road on which the vehicle is traveling on the basis of the acquired
acceleration of the vehicle; a charging information acquiring unit (413) configured to
20 acquire charging information including identification information of a vehicle for which
a charging process has been performed by the charging server (30) from the charging
server (30); and an evaluation unit (414) configured to extract unevenness state
information of a road on which a charging point, through which one vehicle recorded in
the passing vehicle list (D1) has passed, is disposed from charging point information
25 (D2) in which unevenness state information of a road surface of a road on which each of

a plurality of charging points is disposed is recorded in advance and evaluate a charging omission or erroneous charging of the charging system (1) by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is
5 estimated by the road surface state estimating unit (412).

[0105]

By configuring as such, even in a case in which the vehicle detecting device performs error detection, the evaluation device can correctly determine whether or not the vehicle has actually passed through the charging point from the unevenness state in
10 which the vehicle has traveled. In accordance with this, the evaluation device can evaluate the performance of the charging system with high accuracy.

[0106]

(2) According to a second aspect of the present disclosure, in the evaluation device (40) according to the first aspect, the evaluation unit (414) includes: a
15 classification unit (4141) configured to classify, for each of vehicles included in the passing vehicle list (D1), that the vehicle is a charging target vehicle or a non-charging target vehicle by collating the unevenness state of a road on which the vehicle has traveled with the charging point information (D2); and a charging omission evaluating unit (4142) configured to evaluate a charging success rate representing whether the
20 charging system (1) has performed charging without omission on the basis of the number of pieces of the charging information and the number of charging target vehicles.

[0107]

By configuring as such, the evaluation device can evaluate the charging system more accurately by excluding erroneous detection of the vehicle detecting device, a case
25 of an exceptional process of the charging server 30, and the like.

[0108]

(3) According to a third aspect of the present disclosure, in the evaluation device (40) according to the second aspect, the charging omission evaluating unit (4142) evaluates the charging success rate by excluding charging information having identification information not recorded in the passing vehicle list (D1) from the charging information.

[0109]

By configuring as such, the evaluation device can prevent degradation of evaluation accuracy due to erroneous recognition of the identification information of the vehicle detecting device and the like.

[0110]

(4) According to a fourth aspect of the present disclosure, in the evaluation device (40) according to any one of the first to third aspects, the evaluation unit (414) includes: an extraction unit (4143) configured to extract a vehicle which is not included in the passing vehicle list (D1) and of which the charging information is present as a vehicle for which erroneous charging is suspected to have been performed; and an erroneous charging evaluating unit (4144) configured to evaluate whether erroneous charging has been performed for the vehicle by collating the unevenness state of a road on which the extracted vehicle has traveled with the charging point information (D2).

20 [0111]

By configuring as such, the evaluation device can evaluate whether or not the charging system has performed erroneous charging with high accuracy without being influenced by error detection and the like of the vehicle detecting device.

[0112]

25 (5) According to a fifth aspect of the present disclosure, in the evaluation device

(40) according to any one of the first to fourth aspects, the road surface state estimating unit (412) calculates an international roughness index on the basis of the acceleration and estimates the unevenness state on the basis of the international roughness index.

[0113]

5 By configuring as such, the evaluation device can acquire an IRI generally common to the vehicles without depending on a type of the vehicle. In accordance with this, even when a charging process has been performed for any vehicle, the evaluation device can evaluates the charging system with high accuracy.

[0114]

10 (6) According to a sixth aspect of the present disclosure, in the evaluation device (40) according to any one of the first to fourth aspects, the road surface state estimating unit (412) calculates a frequency of a vibration of the vehicle in a vertical direction due to unevenness of the road surface on the basis of an acceleration and estimates an unevenness state of the road surface on the basis of the frequency and a speed acquired
15 from the vehicle.

[0115]

By configuring as such, the evaluation device can detect characteristics (the number of uneven parts and the like) of an unevenness state of each road and thus can perform an evaluation of the charging system with higher accuracy.

20 [0116]

(7) According to a seventh aspect of the present disclosure, there is provided an evaluation device (40) performing an evaluation of a charging system (1) including an on-board unit (10) estimating a traveling position of a vehicle on which the on-board unit (10) is mounted and a charging server (30) performing a charging process of a toll for the
25 vehicle on the basis of the traveling position collected from the on-board unit (10), the

evaluation device (40) including: a road surface state estimating unit (412) configured to acquire identification information and an acceleration of the vehicle from the on-board unit (10) and estimate an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle; a passing
5 vehicle recording unit (411) configured to determine that, in a case in which a charging point having unevenness state information matching an unevenness state of a road on which the vehicle has traveled is included in charging point information (D2) in which unevenness state information of road surfaces of roads on which a plurality of charging points are disposed is recorded in advance, the vehicle has passed through the charging
10 point and record passage information including the identification information of the vehicle and information that is able to identify the charging point in a passing vehicle list (D1); a charging information acquiring unit (413) configured to acquire charging information including identification information of a vehicle for which a charging process has been performed by the charging server (30) from the charging server (30);
15 and an evaluation unit (414) configured to evaluate a charging omission or erroneous charging of the charging system (1) by collating the passing vehicle list (D1) with the charging information.

[0117]

(8) According to an eighth embodiment of the present disclosure, there is
20 provided an evaluation method performing an evaluation of a charging system (1) including an on-board unit (10) estimating a traveling position of a vehicle on which the on-board unit (10) is mounted and a charging server (30) performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit (10), the evaluation method including: a step of acquiring passage information
25 including identification information of a vehicle passing through a charging point and

information that is able to identify a passed charging point through a vehicle detecting device (20) disposed at the charging point and recording the passage information in a passing vehicle list (D1); a step of acquiring the identification information and an acceleration of the vehicle from the on-board unit (10) and estimating an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle; a step of acquiring charging information including identification information of a vehicle for which a charging process has been performed by the charging server (30) from the charging server (30); and a step of extracting unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list has passed, is disposed from charging point information in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is recorded in advance and evaluating a charging omission or erroneous charging of the charging system (1) by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated by the road surface state estimating unit (412).

[0118]

(9) According to a ninth aspect of the present disclosure, there is provided a program causing an evaluation device (40) performing an evaluation of a charging system (1) including an on-board unit (10) estimating a traveling position of a vehicle on which the on-board unit (10) is mounted and a charging server (30) performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit (10) to execute: a step of acquiring passage information including identification information of a vehicle passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device (20)

disposed at the charging point and recording the passage information in a passing vehicle list (D1); a step of acquiring the identification information and an acceleration of the vehicle from the on-board unit (10) and estimating an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle; a step of acquiring charging information including identification information of a vehicle for which a charging process has been performed by the charging server (30) from the charging server (30); and a step of extracting unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list (D1) has passed, is disposed from charging point information (D2) in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is recorded in advance and evaluating a charging omission or erroneous charging of the charging system (1) by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated in the step of estimating the unevenness state.

[Industrial Applicability]

[0119]

According to an evaluation device, an evaluation method, and a program of the present disclosure, the performance of a GNSS charging system can be evaluated with high accuracy.

[Reference Signs List]

[0120]

1 GNSS charging system (charging system)

10 On-board unit

25 20 Vehicle detecting device (camera, antenna device)

	30	Charging server
	40	Evaluation device
	41	CPU
	411	Passing vehicle recording unit
5	412	Road surface state estimating unit
	413	Charging information acquiring unit
	414	Evaluation unit
	4141	Classification unit
	4142	Charging omission evaluating unit
10	4143	Extraction unit
	4144	Erroneous charging evaluating unit
	42	Memory
	43	Storage
	44	Communication interface
15	D1	Passing vehicle list
	D2	Charging point information

[CLAIMS]

[Claim 1]

An evaluation device performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit, the evaluation device comprising:

a passing vehicle recording unit configured to acquire passage information including identification information of a vehicle passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device disposed at the charging point and record the passage information in a passing vehicle list;

a road surface state estimating unit configured to acquire the identification information and an acceleration of the vehicle from the on-board unit and estimate an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle;

a charging information acquiring unit configured to acquire charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and

an evaluation unit configured to extract unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list has passed, is disposed from charging point information in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is recorded in advance and evaluate a charging omission or erroneous charging of the charging system by collating the extracted unevenness state information with the

unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated by the road surface state estimating unit.

[Claim 2]

The evaluation device according to claim 1,

5 wherein the evaluation unit includes:

a classification unit configured to classify, for each of vehicles included in the passing vehicle list, that the vehicle is a charging target vehicle or a non-charging target vehicle by collating the unevenness state of a road on which the vehicle has traveled with the charging point information; and

10 a charging omission evaluating unit configured to evaluate a charging success rate representing whether the charging system has performed charging without omission on the basis of the number of pieces of the charging information and the number of charging target vehicles.

[Claim 3]

15 The evaluation device according to claim 2, wherein the charging omission evaluating unit evaluates the charging success rate by excluding charging information having identification information not recorded in the passing vehicle list from the charging information.

[Claim 4]

20 The evaluation device according to any one of claims 1 to 3, wherein the evaluation unit includes:

an extraction unit configured to extract a vehicle which is not included in the passing vehicle list and of which the charging information is present as a vehicle for which erroneous charging is suspected to have been performed; and

25 an erroneous charging evaluating unit configured to evaluate whether erroneous

charging has been performed for the vehicle by collating the unevenness state of a road on which the extracted vehicle has traveled with the charging point information.

[Claim 5]

5 The evaluation device according to any one of claims 1 to 4, wherein the road surface state estimating unit calculates an international roughness index on the basis of the acceleration and estimates the unevenness state on the basis of the international roughness index.

[Claim 6]

10 The evaluation device according to any one of claims 1 to 4, wherein the road surface state estimating unit further acquires a speed of the vehicle from the on-board unit, calculates a frequency of a vibration of the vehicle in a vertical direction due to unevenness of the road surface on the basis of the acceleration, and estimates an unevenness state of the road surface on the basis of the frequency and the speed of the vehicle.

15 [Claim 7]

 An evaluation device performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit, the evaluation device
20 comprising:

 a road surface state estimating unit configured to acquire identification information and an acceleration of the vehicle from the on-board unit and estimate an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle;

25 a passing vehicle recording unit configured to determine that, in a case in which

a charging point having unevenness state information matching an unevenness state of a road on which the vehicle has traveled is included in charging point information in which unevenness state information of road surfaces of roads on which a plurality of charging points are disposed is recorded in advance, the vehicle has passed through the charging point and record passage information including the identification information of the vehicle and information that is able to identify the charging point in a passing vehicle list;

a charging information acquiring unit configured to acquire charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and

an evaluation unit configured to evaluate a charging omission or erroneous charging of the charging system by collating the passing vehicle list with the charging information.

[Claim 8]

An evaluation method performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit, the evaluation method comprising:

a step of acquiring passage information including identification information of a vehicle passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device disposed at the charging point and recording the passage information in a passing vehicle list;

a step of acquiring the identification information and an acceleration of the vehicle from the on-board unit and estimating an unevenness state of a road surface of a road on which the vehicle is traveling on the basis of the acquired acceleration of the

vehicle;

a step of acquiring charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and

5 a step of extracting unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list has passed, is disposed from charging point information in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is recorded in advance and evaluating a charging omission or erroneous charging of the
10 charging system by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated in the step of estimating the unevenness state.

[Claim 9]

15 A program causing an evaluation device performing an evaluation of a charging system including an on-board unit estimating a traveling position of a vehicle on which the on-board unit is mounted and a charging server performing a charging process of a toll for the vehicle on the basis of the traveling position collected from the on-board unit to execute:

20 a step of acquiring passage information including identification information of a vehicle passing through a charging point and information that is able to identify a passed charging point through a vehicle detecting device disposed at the charging point and recording the passage information in a passing vehicle list;

a step of acquiring the identification information and an acceleration of the
25 vehicle from the on-board unit and estimating an unevenness state of a road surface of a

road on which the vehicle is traveling on the basis of the acquired acceleration of the vehicle;

5 a step of acquiring charging information including identification information of a vehicle for which a charging process has been performed by the charging server from the charging server; and

a step of extracting unevenness state information of a road on which a charging point, through which one vehicle recorded in the passing vehicle list has passed, is disposed from charging point information in which unevenness state information of a road surface of a road on which each of a plurality of charging points is disposed is
10 recorded in advance and evaluating a charging omission or erroneous charging of the charging system by collating the extracted unevenness state information with the unevenness state of a road, on which a vehicle having the same identification information as the one vehicle has traveled, that is estimated in the step of estimating the unevenness state.