DESCRIPTION

Title of Invention

VEHICLE ELECTRIC POWER CONSUMPTION SIMULATION DEVICE, VEHICLE ELECTRIC POWER CONSUMPTION SIMULATION METHOD, AND PROGRAM

Technical Field

[0001]

The present invention relates to a vehicle electric power consumption simulation, a vehicle electric power consumption simulation method, and a program for calculating expected electric power consumption of a vehicle.

Background Art

[0002]

A method which uses a traffic simulator to simulate and estimate electric power consumption of a vehicle, such as an electric vehicle (EV) or a plug-in hybrid electric vehicle (PHEV), with a storage battery mounted therein is known.

In general, in a case where a traffic simulator is used, a traffic status needs to be reproduced in a virtual world on a computer.

In order to implement the status reproduction, spot

traffic volumes on a road and signal timings at principal intersections are acquired and trip times on principal roads are measured, and the like. Subsequently, origin-destination data is generated from person trip data in zones, and the like. Then, a simulation is performed, and tuning needs to be performed on a simulator such that the spot traffic volumes and the trip times match simulation results.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2012-141799

Summary of Invention

Technical Problem

[0004]

In a situation in which the status is reproduced by the status reproduction on the traffic simulator, in order to simulate travel of an EV or a PHEV and to simulate electric power consumption, acquisition of necessary data and time and costs for a status reproduction operation are required.

[0005]

The invention provides a vehicle electric power consumption simulation device, a vehicle electric power

consumption simulation method, and a program capable of reducing time and costs required for status reproduction in a traffic simulator.

Solution to Problem

[0006]

According to a first aspect of the invention, a vehicle electric power consumption simulation device includes a link setting unit that, with reference to information indicating a link that is a division of a road determined by a traffic simulation, sets a link, in which a travel object travels, based on position information of the travel object at each time acquired by a preliminary travel, a speed setting unit that sets an average free flow speed in the link set by the link setting unit based on speed information of the travel object at each time acquired by the preliminary travel, a traffic simulator that simulates vehicle traffic based on the link set by the link setting unit and the average free flow speed set by the speed setting unit, and an electric power consumption estimation unit that calculates the electric power consumption of a vehicle traveling in the link based on data relating to electric power consumption obtained from a travel status of the vehicle simulated by the traffic simulator.

[0007]

With this configuration, when calculating the electric power consumption, since it is not necessary to reproduce a traffic status and to calculate an average free flow speed in a link, it is possible to eliminate processing for reproducing a traffic status and to contribute to reduction in a processing load, reduction in a processing time, and reduction in power consumption.

[0008]

According to a second aspect of the invention, in the vehicle electric power consumption simulation device according to the first aspect, the speed setting unit selects one link from the links set by the link setting unit, determines whether or not a speed variation in each selected is greater than a threshold determined in advance based on the speed information, divides the link at a point where the speed variation is greater than the threshold, and sets the average free flow speed for each divided section.

[0009]

With this configuration, it is possible to determine the average free flow speed of each section with higher accuracy even in a case where change in speed in a link is large.

[0010]

According to a third aspect of the invention, in the

vehicle electric power consumption simulation device according to the first aspect or the second aspect, in a case where simulation conditions representing the travel status of the vehicle to be simulated are set, the traffic simulator simulates driving of the vehicle in a condition in which disturbance indicated by the simulation conditions is imparted to the travel status of the travel object.

[0011]

With this configuration, it is possible to eliminate processing for reproducing an actual travel status and to simulate vehicle traffic based on set simulation conditions.

[0012]

According to a fourth aspect of the invention, the vehicle electric power consumption simulation device according to any one of the first aspect to the third aspect further includes a storage unit that records attribute information relating to electric power consumption according to a vehicle type, and the electric power consumption estimation unit calculates the electric power consumption of the vehicle according to the vehicle type with reference to the attribute information stored in the storage unit.

[0013]

With this configuration, even if the position information of the travel object acquired by the preliminary travel is not acquired for each vehicle type, it is possible to calculate the electric power consumption according to the vehicle type.

[0014]

According to a fifth aspect of the invention, in the vehicle electric power consumption simulation device according to any one of the first aspect to the fourth aspect, the link setting unit sets a link corresponding to a road, on which the travel object travels, by applying position coordinates of the travel object at each time acquired by the preliminary travel to position coordinates set in the traffic simulation.

[0015]

According to a sixth aspect of the invention, a vehicle electric power consumption simulation method includes a link setting step of, with reference to information indicating a link that is a division of a road determined by a traffic simulation, setting a link, in which a travel object travels, based on position information of the travel object at each time acquired by a preliminary travel, a speed setting step of setting an average free flow speed in the link set in the link setting step based on speed information of the travel

object at each time acquired by the preliminary travel, a traffic simulation step of simulating vehicle traffic based on the link set in the link setting step and the average free flow speed set in the speed setting step, and an electric power consumption estimation step of calculating the electric power consumption of a vehicle traveling in the link based on data relating to electric power consumption obtained from a travel status of the vehicle simulated in the traffic simulation step.

[0016]

According to a seventh aspect of the invention, a program causes a computer to function as link setting means for, with reference to information indicating a link that is a division of a road determined by a traffic simulation, setting a link, in which a travel object travels, based on position information of the travel object at each time acquired by a preliminary travel, speed setting means for setting an average free flow speed in the link set by the link setting means based on speed information of the travel object at each time acquired by the preliminary travel, traffic simulation means for simulating vehicle traffic based on the link set by the link setting means and the average free flow speed set by the speed setting means, and electric power consumption estimation means for calculating the electric power

consumption of a vehicle traveling in the link based on data relating to electric power consumption obtained from a travel status of the vehicle simulated in the traffic simulation means.

Advantageous Effects of Invention

[0017]

According to the vehicle electric power consumption simulation device, the vehicle electric power consumption simulation method, and the program described above, it is possible to reduce time and costs required for status reproduction in the traffic simulator.

Brief Description of Drawings

[0018]

Fig. 1 is a schematic view of a vehicle electric power consumption simulation system according to a first embodiment of the invention.

Fig. 2 is a conceptual diagram showing an example of a system including a travel history information collection device of the first embodiment.

Fig. 3 is a block diagram showing the internal configuration of the travel history information collection device of the first embodiment.

Fig. 4 is a diagram showing an example of a travel history information table of the first embodiment.

Fig. 5 is a schematic view of a road network model

in a road traffic flow simulation of the first embodiment.

Fig. 6 is a diagram showing the internal configuration of a vehicle electric power consumption simulation device of the first embodiment.

Fig. 7 is a diagram showing an example of a link attribute setting table of the first embodiment.

Fig. 8 is a flowchart showing an example of a flow of processing of the road traffic flow simulation of the first embodiment.

Fig. 9 is a schematic view showing a difference between selected models of the first embodiment.

Fig. 10 is a reference diagram illustrating an example of a vehicle electric power consumption simulation system of a second embodiment of the invention.

Fig. 11 is a diagram showing an example of a travel history information table of the second embodiment.

Fig. 12A is a diagram showing an example of a link attribute setting table of the second embodiment.

Fig. 12B is a diagram showing an example of the link attribute setting table of the second embodiment.

Fig. 13 is a diagram illustrating an example of position detection of the travel history information collection device of the first and second embodiments.

Fig. 14 is a diagram illustrating an example of link setting of the vehicle electric power consumption

simulation device of the first and second embodiments.

Description of Embodiments

[0019]

[First Embodiment]

Hereinafter, an embodiment of the invention will be described referring to the drawings. Fig. 1 is a diagram showing an example of a vehicle electric power consumption simulation system 1 according to a first embodiment.

As shown in Fig. 1, the vehicle electric power consumption simulation system 1 according to this embodiment includes a travel history information collection device 100 and a vehicle electric power consumption simulation device 200.

The travel history information collection device 100 is, for example, an on-vehicle unit, a data logger, or the like which is mounted in a vehicle and collects information (hereinafter, referred to as travel history information) indicating a travel history of the vehicle.

[0020]

Next, an example of the travel history information in the travel history information collection device 100 will be described referring to Fig. 2. Fig. 2 is a conceptual diagram showing an example of a system including the travel history information collection device 100. This system includes the travel history information

collection device 100 which is mounted in a vehicle A preliminarily traveling on a road, and global positioning system (GPS) satellites 90.

In this embodiment, a target vehicle of which travel history information is collected by the travel history information collection device 100 is referred to as a "vehicle A". The vehicle A may be any one of various types of vehicles, or may be a gasoline vehicle, an electric vehicle, or the like. In this case, the travel history information collection device 100 may collect travel history information in addition to information, such as a vehicle type of the vehicle A.

That is, the travel history information registered in the vehicle electric power consumption simulation device 200 may include attribute information relating to the vehicle A correlated with the travel history information collected by the travel history information collection device 100. A target of which the travel history information is collected is not limited to a vehicle, but may be, for example, a bicycle, a motorcycle, or the like as long as it can travel on a road. A method in which a person gets on a bus, a vehicle, or the like in a state where the person carries the travel history information collection device 100 may be used.

[0021]

As shown in Fig. 2, if the travel history information collection device 100 detects a current position, for example, every 10 seconds in a state where the vehicle A is traveling on a road, position information P1, P2, P3, P4, P5, … is acquired. The speeds of the vehicle A are respectively speeds V1, V2, V3, V4, and V5 per hour at the positions indicated by the position information P1, P2, P3, P4, and P5. The travel history information collection device 100 stores the speeds (speed information) V1, V2, V3, V4, and V5 per hour of the vehicle A in a storage unit therein in correlation with the position information P1, P2, P3, P4, and P5.

[0022]

Fig. 3 is a block diagram showing the internal configuration of the travel history information collection device 100.

Hereinafter, a configuration example in a case where the travel history information collection device 100 is an on-vehicle will be described. The travel history information collection device 100 includes a power supply circuit 101, an internal battery 102, a position detection unit 103, a speed acquisition unit 104, a travel history information creation unit 105, a storage unit 106, an external interface 107, and a timepiece unit 108. The position detection unit 103 includes a GPS receiver 131, a

GPS complementary sensor unit 132, and a dead reckoning navigation processing unit 133.

The storage unit 106 includes a travel history information table 161 which stores the position information detected by the position detection unit 103 in correlation with the speed information acquired by the speed acquisition unit 104.

The power supply circuit 101 has a regulator stabilizing a power supply and a noise protector, and supplies power of 12 V or 24 V, which is received from the vehicle A, to the respective units of the travel history information collection device 100.

The internal battery 102 is a backup battery and supplies power to the units to protect data stored in the travel history information collection device 100 when the power supply of the vehicle A is extinguished or temporarily blacks out.

[0023]

The position detection unit 103 detects the position of the travel history information collection device 100, for example, at timings or intervals determined in advance using the GPS receiver 131, the GPS complementary sensor unit 132, and the dead reckoning navigation processing unit 133. In this embodiment, the position detection unit 103 detects the position of the travel history information

collection device 100 every 10 seconds.

The GPS receiver 131 receives radio waves from the GPS satellites 90, reads time information, and measures information of the latitude and the longitude based on received data.

The GPS complementary sensor unit 132 has a gyro sensor and an acceleration sensor, and performs an operation of estimating the position of the travel history information collection device 100 from information of the gyro sensor and the acceleration sensor. The GPS complementary sensor unit 132 may be, for example, a constituent unit which is used in a case where the reception sensitivity of radio waves from the GPS satellites 90 is not satisfactory.

The dead reckoning navigation processing unit 133 performs an operation of complementing the position of the travel history information collection device 100 based on information of the latitude and the longitude measured by the GPS receiver 131 and information of the position of the travel history information collection device 100 estimated by the GPS complementary sensor unit 132 according to the accuracy of information included in the radio waves received by the GPS receiver 131.

[0024]

The speed acquisition unit 104 acquires the speed of

the vehicle A at the position detected by the position detection unit 103. The speed acquisition unit 104 acquires the speed information of the vehicle A output from an engine control unit (ECU) of the vehicle A, for example, at the same time as detection of the position by the position detection unit 103. In this embodiment, the speed acquisition unit 104 acquires the speed of the vehicle A at the same time as detection of the position by the position detection unit 103, for example, every 10 seconds from the same start time.

The speed acquisition unit 104 may calculate the speed of the vehicle A based on the position information detected by the position detection unit 103. The speed acquisition unit 104 calculates the speed of the vehicle A between detection points, for example, based on information indicating the distance between the detection points calculated based on the position information and the time at which the position information is detected.

[0025]

The travel history information creation unit 105 writes the time information included in the radio waves from the GPS satellites 90 and the position information detected by the position detection unit 103 to the travel history information table 161 of the storage unit 106 in correlation with each other.

The travel history information creation unit 105 writes the speed information acquired by the speed acquisition unit 104 and the time information indicating the time, at which the vehicle A travels at the speed indicated by the speed information, to the travel history information table 161 of the storage unit 106 in correlation with each other.

The travel history information creation unit 105 is not limited to the time information included in the radio waves from the GPS satellites 90, but may correlate the position information and the speed information with output information from the timepiece unit 108 counting the time at which the position information and the speed information are acquired.

[0026]

The storage unit 106 stores a program or data used in the travel history information collection device 100. The storage unit 106 has the travel history information table 161 storing information of the latitude and the longitude detected by the position detection unit 103 and the speed information acquired by the speed acquisition unit 104 in correlation with the time information included in the radio waves from the GPS satellites 90, for example, as shown in Fig. 4.

The external interface 107 is connected to an

external device, for example, the vehicle electric power consumption simulation device 200 and outputs information stored in the storage unit 106 to the vehicle electric power consumption simulation device 200.

[0027]

Next, an example of the travel history information table 161 will be described referring to Fig. 4. Fig. 4 is a diagram showing an example of the travel history information table 161 according to this embodiment.

As shown in Fig. 4, the travel history information table 161 is a table in which the time information, position information (latitude and longitude), and the speed information (unit: km/h) are stored in correlation with one another.

In this embodiment, the position information and the speed information are information indicating the position and the speed of the vehicle A at the time indicated by the time information and is information indicating a travel track of the moving vehicle A every 10 seconds from the same start point.

[0028]

Next, an example of a road network model 400 in a traffic simulation according to this embodiment will be described referring to Fig. 5. Fig. 5 is a schematic view of the road network model 400 in the traffic simulation

according to this embodiment.

The road network model 400 is constructed by connecting links 42 as road models simulating minimum sections of a road at intersections or the like by nodes 44 simulating the intersections. That is, the links 42 are the divisions of the road determined in the traffic simulation. The nodes 44 are one end of the links 42. The road network model 400 may simulate an actual road network using links correlated with the road network, or may simulate a road network based on a travel track indicated by subdivisions of the links. The road network model 400 simulating an actual road network using links correlated with the actual road network will be described in this embodiment. The road network model 400 simulating a road network based on a travel track indicated by subdivisions of the links will be described in a second embodiment described below.

The links 42 are set in association with map data, or may not be set in association with map data. For example, the links 42 may be line segments which are defined by information indicating the latitude and the longitude of one end (nodes 44) of the links 42 and information indicating the latitude and the longitude of the other end (nodes 44) of the links 42. Alternatively, the links 42 may be given regions which are defined by

information of the latitude and the longitude of four points. The links 42 are not limited thereto, and can be arbitrarily set according to the specification of a vehicle electric power consumption simulation.

[0029]

In each of the links 42, the number of lanes, the presence or absence of right and left-turn lanes, the number of right and left-turn lanes, and the like are set. In each of the nodes 44, the presence or absence of installation of a signal model simulating a traffic signal for a vehicle is set.

In each of the links 42 and each of the nodes 44, the altitude can be set. For this reason, it is possible to determine the gradient of the road simulated by the links 42 from the difference in altitude between adjacent link 42 and node 44. Different altitudes can be set in the middle of the links 42.

[0030]

The signal model changes from blue to yellow, from yellow to red, and from red to blue at time intervals determined in advance. In a case where the signal model is blue, a vehicle model is permitted to move from the link 42 to another link 42 through the node 44 on which the signal model is installed, and in a case where the signal model is red, the vehicle model is inhibited from

moving from the link 42 to another link 42 through the node 44 on which the signal is installed.

In the road network model 400 according to this embodiment, charging station models 46 simulating a charging station for charging the storage battery of the electric vehicle can be disposed adjacent to the links 42.

[0031]

An electric vehicle model has the residual amount of electric power charged in the storage battery as an attribute value. A gasoline vehicle model simulating a gasoline vehicle does not have the residual amount of the storage battery as an attribute value.

In each of the charging station models 46, the number of electric vehicle models (the number of charging stands) which can be charged simultaneously, the number of waiting spaces where electric vehicle models waiting for charging are disposed, and a unit price (hereinafter, referred to as a "power selling unit price") of electric power to be sold are set.

In this embodiment, the road network model 400 is created in advance and stored in the vehicle electric power consumption simulation device 200.

[0032]

Next, an example of the vehicle electric power consumption simulation device 200 will be described

referring to Fig. 6. Fig. 6 is a block diagram showing a configuration example of an electric system of the vehicle electric power consumption simulation device 200 according to this embodiment. In this embodiment, a vehicle that is simulated in a traffic simulation of the vehicle electric power consumption simulation device 200 is referred to as a vehicle B. The vehicle B may be various types of vehicles, or may be a gasoline vehicle, an electric vehicle, or the like.

The vehicle electric power consumption simulation device 200 is a device that executes a traffic simulation simulating the travel of a vehicle model simulating a vehicle in the road network model 400 simulating a road network including a plurality of roads and intersections connecting the roads.

The vehicle model according to this embodiment includes an electric vehicle model simulating an electric vehicle. In the following description, a vehicle refers to both of a gasoline vehicle and an electric vehicle.

A road refers to a road, such as a paved road, an unpaved road, a national road, a prefectural road, a private road, and a parking lot, on which a vehicle can travel, without limit to the number of lanes and the number of right and left-turn lanes.

Of the vehicles, a gasoline vehicle refers to a

motorcycle, an ordinary vehicle (including a taxi), a bus, a truck, and the like which are driven with gasoline.

An electric vehicle refers to a motorcycle, an ordinary vehicle (including a taxi), a bus, and a truck which are driven with electric power, and a hybrid vehicle (hybrid vehicles of various vehicles described above) of gasoline and electricity, in which a storage battery is chargeable.

[0033]

The vehicle electric power consumption simulation device 200 includes a central processing unit (CPU) 201 that takes charge of operations of the entire vehicle electric power consumption simulation device 200, a read only memory (ROM) 202 in which various programs or various parameters are stored in advance, a random access memory (RAM) 203 that is used as a work area when the CPU 201 executes various programs, and a hard disk drive (HDD) 204 which serves as storage means for storing various programs, such as a traffic simulation program, of which details will be described below, and various kinds of information. The CPU 201 includes a link setting unit 211, a speed setting unit 212, a traffic simulator 213, an electric power consumption estimation unit 214, a simulation model setting unit 215, and a charging determination unit 216.

[0034]

The HDD 204 primarily stores a travel history information table 241, a link attribute setting table 242, and a road network model 400.

The travel history information table 241 is a table that stores the same information as information stored in the travel history information table 161 of the travel history information collection device 100.

The link attribute setting table 242 is a table in which pieces of attribute information of links used in a traffic simulation is correlated with each other, for example, as shown in Fig. 7. Fig. 7 is a diagram showing an example of the link attribute setting table 242. As shown in Fig. 7, the link attribute setting table 242 is a table in which information indicating a link (hereinafter, referred to as a link position) set by the link setting unit 211 in which the vehicle A travels is correlated with information indicating the speed (hereinafter, referred to as a link speed) of the vehicle A in the link set by the speed setting unit 212. In the link attribute setting table 242, the link position indicates the links arranged in a time series in which the vehicle A passes.

For example, unique identification information (hereinafter, referred to as a link ID) for identifying each link is allocated to each link. In this embodiment, the link ID indicated by R1, R2, R3, … is allocated to

each link.

The link position stored in the link attribute setting table 242 is used as information indicating a travel track of the vehicle B simulated in the traffic simulation. The link speed stored in the link attribute setting table 242 is used as information indicating an average free flow speed of the vehicle B simulated in the traffic simulation.

[0035]

The vehicle electric power consumption simulation device 200 includes an operation input unit 205 that has a keyboard, a mouse, and the like and receives an input of various operations, an image display unit 206 that displays various images, such as an image for prompting a user to input various kinds of information required for a traffic simulation and an image indicating a result of the traffic simulation, an external interface 207 that is connected to an external device, such as a printer or another computer, and is used to transmit and receive various kinds of information to and from the external device, and a reading unit 208 that reads information stored in a portable storage medium 300. Examples of the portable storage medium 300 include a magnetic disk, an optical disc, such as a compact disc (CD) or a digital versatile disc (DVD), an integrated circuit (IC) card, a

memory card, and the like.

[0036]

The CPU 201, the ROM 202, the RAM 203, the HDD 204, the operation input unit 205, the image display unit 206, the external interface 207, and the reading unit 208 are electrically connected to one another through a system bus 209. Accordingly, the CPU 201 can access the ROM 202, the RAM 203, and the HDD 204, ascertain an operation state on the operation input unit 205, display various images on the image display unit 206, transmit and receive various kinds of information to and from the external device through the external interface 207, read information from the portable storage medium 300 through the reading unit 208, and the like.

[0037]

In this embodiment, the vehicle electric power consumption simulation device 200 is connected to the travel history information collection device 100, for example, through the external interface 207, reads information stored in the travel history information table 161 of the storage unit 106 of the travel history information collection device 100, and stores the read information in the HDD 204. Accordingly, the HDD 204 stores the travel history information table 241 including the same information as in the travel history information

table 161.

[0038]

The CPU 201 simulates the travel of the vehicle B as a target of the traffic simulation using the link setting unit 211, the speed setting unit 212, the traffic simulator 213, the electric power consumption estimation unit 214, the simulation model setting unit 215, and the charging determination unit 216.

The link setting unit 211 sets a link, in which the vehicle A travels, based on the position information stored in the travel history information table 241 of the HDD 204. In this embodiment, the link setting unit 211 determines a link, in which the vehicle A travels, from the respective position coordinates included in the travel track of the vehicle A traveling on an actual road based on the travel history information stored in the travel history information table 241 of the HDD 204. As a determination method of a link by the link setting unit 211, for example, a general method, such as map matching, can be used. The links 42 and the nodes 44 in the road network model 400 are allocated to a road on digital map data of map matching.

For example, the link setting unit 211 detects a link, in which the vehicle A travels, by matching information of the position of the link from road map data

stored in the HDD 204 and the position information of the vehicle A stored in the travel history information table 241. That is, the link setting unit 211 determines a link, in which the vehicle A travels, from a plurality of links as the sections of the road by applying the position coordinates of the vehicle A at each time acquired by the travel history information collection device 100 to the position coordinates set in the traffic simulation.

For example, the position information P1, P2, P3, … is detected by the position detection unit 103 of the travel history information collection device 100. The position information P1, P2, P3, P4, and P5 is position information that belongs to the same link R1. In this case, the link setting unit 211 determines that the position information P1, P2, P3, P4, and P5 are points included in the same link R1 or corresponding points. That is, the link setting unit 211 sets a link, in which the vehicle A travels, to the link R1. For convenience of description, a travel position determined as a point included in the link or a corresponding point by the link setting unit 211 is expressed as a travel position included in the link. However, even in a case where a travel position is outside a link, it may be determined that the vehicle A travels in the link, and this travel position is expressed as a travel position included in the

link.

[0039]

This embodiment is not limited thereto, and the link setting unit 211 may set a link, in which the vehicle A travels, in a link not associated with map data.

[0040]

The link setting unit 211 stores the links corresponding to the position information P1, P2, P3, … in the item of the link position of the link attribute setting table 242 in a time series according to the time at which the position information is detected, thereby set a link indicating a travel history of the vehicle A. This embodiment is not limited thereto, and a configuration in which the travel track of the vehicle A is analyzed according to the order of the links corresponding to the position information P1, P2, P3, … may be mounted in the CPU 201.

[0041]

The speed setting unit 212 sets the link speed (that is, average free flow speed) of the vehicle A in the link set by the link setting unit 211 based on the speed information. In this embodiment, the speed setting unit 212 calculates an average value of the speeds of the vehicle A in the same link and sets the calculated average value as the link speed of the link. For example, the

speed setting unit 212 calculates the average value of the speeds V1, V2, V3, V4, and V5 corresponding to the position information P1, P2, P3, P4, and P5 determined as being in the same link and sets the average value as the link speed of the link R1. That is, the speed setting unit 212 calculates the link speed of the vehicle A in the link R1 determined as the link, in which the vehicle A travels, by the link setting unit 211. In a case where the average free flow speed of the vehicle A in the link set by the link setting unit 211 is calculated, the speed setting unit 212 writes the average free flow speed to the link attribute setting table 242 of the HDD 204 in correlation with information (link ID) indicating the link. This embodiment is not limited thereto, and the speed setting unit 212 may set a representative value among the speeds V1, V2, V3, V4, and V5 corresponding to the position information P1, P2, P3, P4, and P5 determined as being in the same link as the link speed. For example, the speed setting unit 212 can set a value (that is, the third fastest value and the third slowest value) of the speed in the middle order among the speeds V1, V2, V3, V4, and V5 as the link speed.

[0042]

The traffic simulator 213 simulates the traffic of the vehicle B as a target of the traffic simulation based

on the link set by the link setting unit 211 and the link speed (average free flow speed) set by the speed setting unit 212. In this embodiment, in a case where simulation conditions representing a travel status of the vehicle B to be simulated are set, the traffic simulator 213 simulates driving of the vehicle B in a present status in which disturbance indicated by the simulation conditions is imparted to an actual travel status of the vehicle A. The simulation conditions are the motion of other vehicles or people, a travel status expected to be changed according to weather or a time zone, and the like.

For example, in a case of adding a plurality of vehicles to the travel status of the vehicle A and simulating the travel of the vehicle B in a more congested status than the actual travel status of the vehicle A, the traffic simulator 213 sets disturbance by congestion. With this, the traffic simulator 213 can eliminate a simulation for status reproduction to reproduce the travel status of the vehicle A based on the travel track and the link speed stored in the link attribute setting table 242 and can simulate the traffic of the vehicle B in a congested status.

[0043]

As a result of simulating the traffic of the vehicle B, in a case where the charging determination unit 216

determines that there is an electric vehicle model requiring charging, the traffic simulator 213 performs simulation settings as settings for simulating the charging behavior of the vehicle B for a charging-requiring EV model and simulates the travel of the vehicle B in the charging requiring EV model. In addition, as a result of simulating the travel of the vehicle B in the charging requiring EV model, in a case where the charging requiring EV model reaches a selected charging station model, but the charging station model is congested, the traffic simulator 213 performs charging station movement determination about whether or not to move the reached charging requiring EV model to a different charging station model. The traffic simulator 213 may simulate the traffic of the vehicle B based on the link set by the link setting unit 211 and the link speed (average free flow speed) set by the speed setting unit 212, thereby calculating the trip time of the vehicle B based on an actual travel history.

[0044]

The electric power consumption estimation unit 214 calculates the electric power consumption of the vehicle B based on data relating to electric power consumption obtained from the travel status of the vehicle B simulated by the traffic simulator 213.

In the simulation of the traffic of the traffic simulator 213, the electric power consumption estimation unit 214 calculates power consumption according to a target vehicle with reference to attribute information prepared for each vehicle type. With this, it is possible to calculate the electric power consumption based on the travel history acquired by the travel history information collection device 100.

The simulation model setting unit 215 sets the road network model 400.

The charging determination unit 216 determines whether or not there is an electric vehicle model requiring charging as a result of simulating the traffic of the vehicle B based on the electric power consumption of the vehicle calculated by the electric power consumption estimation unit 214 and the residual amount of the storage battery of the vehicle B.

[0045]

The configuration of the vehicle electric power consumption simulation device 200 shown in Fig. 6 is an example, and for example, other forms may be made in which a large-capacity semiconductor storage device is used instead of the HDD 204, the traffic simulation program is stored in the portable storage medium 300, and the like.

[0046]

Next, an example of a vehicle electric power consumption simulation method according to this embodiment will be described referring to Fig. 8.

Fig. 8 is a flowchart showing the flow of processing of a vehicle electric power consumption simulation program which is executed by the CPU 201. The vehicle electric power consumption simulation program is stored in a predetermined area of the HDD 204 in advance. The vehicle electric power consumption simulation program starts to be executed in a case where an execution instruction is input by an operator through the operation input unit 205.

[0047]

(Step ST1)

First, the simulation model setting unit 215 sets the road network model 400.

Specifically, the simulation model setting unit 215 records set values of various values relating to the road network model 400, such as connection of the links 42 and the nodes 44, settings of the lanes and the right and left-turn lanes of the links 42, and time intervals at which respective colors of a signal model change, in the HDD 204.

The simulation model setting unit 215 registers, as the set values of the road network model 400, values relating to the number and installation positions of

charging station models 46 and the values relating to each charging station model 46 in the HDD 204.

The simulation model setting unit 215 records, as the set value of the road network model 400, the ratio of the number of electric vehicle models with respect to the total number of vehicle models in the HDD 204.

[0048]

In addition, the simulation model setting unit 215 registers the end conditions of the traffic simulation program in the HDD 204 in this step. As the end conditions, for example, a simulation execution time, reaching of all vehicle models or a vehicle model set in advance to a destination, and the like, are used.

[0049]

(Step ST2)

Next, the link setting unit 211 sets a link, in which the vehicle A actually travels, based on the position information stored in the travel history information table 241 of the HDD 204. In this embodiment, the link setting unit 211 determines links corresponding to all pieces of position information stored in the HDD 204 and writes determination results, for example, in correlation with the position information of the travel history information table 241. The link setting unit 211 stores the links corresponding to the position information

P1, P2, P3, … in the item of the link position of the link attribute setting table 242 in a time series according to the time at which the position information is detected with reference to the travel history information table 241. In this embodiment, in a case where the same link is stored in the travel history information table 241 successively in a time-series direction, the link setting unit 211 stores one link ID in one column of the link attribute setting table 242.

[0050]

(Step ST3)

The speed setting unit 212 calculates, for example, the average value of the speeds V1 to V5 of the vehicle A in the same link R1 with reference to the travel history information table 241 and sets the calculated average value as the link speed (average free flow speed) of the link R1. The speed setting unit 212 writes the calculated link speed (average free flow speed) of the link R1 in the item of the link speed of the link attribute setting table 242 in correlation with the link ID of the item of the link speed.

[0051]

(Step ST4)

Next, the simulation model setting unit 215 performs an initial setting of a vehicle model for the vehicle B.

Specifically, for example, the origin and destination (O-D information) of each vehicle model and a departure time are set through the operation input unit 205. simulation model setting unit 215 registers the set set origin and destination (O-D information) of each vehicle model and the departure time are registered in the HDD 204 as an initial value of a vehicle model.

If the charge amount of the storage battery is set as an attribute value of each electric vehicle model through the operation input unit 205, the simulation model setting unit 215 registers the set charge amount of of the storage battery in the HDD 204 as an attribute value of each electric vehicle model.

[0052]

Various kinds of processing in Steps ST1 and ST4 are performed with an input of numerical values and the like by an operator through the operation input unit 205. In Steps ST1 and ST4, the road network model 400 for which various settings are performed in advance may be read from the HDD 204 and set.

[0053]

(Step ST5)

The traffic simulator 213 simulates the behavior of the vehicle model for the vehicle B, that is, the travel of the vehicle B in each vehicle model on the road network

model 400 at every predetermined interval. The predetermined time interval is a time interval in the traffic simulation and may be different from an actual time interval.

In this embodiment, when simulating the travel of the vehicle B, the traffic simulator 213 reads the average free flow speed of the vehicle B traveling in the link with reference to the link speed of the link attribute setting table 242 of the HDD 204 and simulates the travel of the vehicle traveling in the link based on the read average free flow speed. With this, since the traffic simulator 213 does not need to reproduce a traffic status and to calculate the speed of the vehicle B traveling in the link, it is possible to eliminate processing for reproducing a traffic status and to contribute to reduction in a processing load, reduction in a processing time, and reduction in power consumption.

[0054]

The traffic simulator 213 calculates the travel state of the vehicle B in the vehicle model based on weather set in the road network model 400, the number of vehicle models traveling in each link 42 (road congestion status), and the like. As a specific calculation method, any known method in the related art may be used. In a case where the signal of the signal model is red, for

waiting for a signal, the travel of the vehicle model is stopped, and the stop time of each vehicle model is calculated from a matrix model simulating a state where a plurality of vehicle models are stopped in a row.

In this embodiment, the traffic simulator 213 simulates the traffic of the vehicle B in the vehicle model, and the electric power consumption estimation unit 214 calculates the mount of electric power consumption (that is, the residual amount of the storage battery, and hereinafter, referred to as "storage battery residual amount") of the vehicle B simulating and traveling at the link position in the electric vehicle model based on a simulation result of the vehicle B by the traffic simulator 213.

[0055]

As a method of calculating the storage battery residual amount by the electric power consumption estimation unit 214, a model expression indicated by Expression (1) described below is used as an example.

Current storage battery residual amount = previous storage battery residual amount - storage battery consumption per unit time … (1)

[0056]

The "previous storage battery residual amount" in Expression (1) is a storage battery residual amount when

the behavior of the vehicle model at the previous time is calculated.

For the "storage battery consumption per unit time", for example, any one of consumption calculation models 1 to 3 shown in Table 1 described below is used. The consumption calculation models 1 to 3 are only examples, and if a term relating to the travel speed of the electric vehicle model is used, a consumption calculation model in which a part of another term included in the consumption calculation models 1 to 3 is not use, a consumption calculation model in which another term is newly added, or the like may be used.

[0057]

[Table 1]

Consumption Calculation Model 1	Storage Battery Consumption Per Unit Time = A × Travel Speed + B × Light ON State + C × Air-Conditioning Operation State + D × External Air Temperature + E × Gradient + F (A to F are fixed parameters)
Consumption Calculation Model 2	Storage Battery Consumption Per Unit Time = A × Travel Speed + B × Acceleration/Deceleration + C × Light ON State + D × Air-Conditioning Operation State + E × External Air Temperature + F × Gradient + G (A to G are fixed parameters)
Consumption Calculation Model 3	Storage Battery Consumption Per Unit Time = Function f (Travel Speed, Acceleration/Deceleration, Light ON State, Air-Conditioning Operation State, External Air Temperature, Gradient)

[0058]

Each fixed parameter in the consumption calculation models 1 and 2 is used as a weight in each term.

[0059]

The light ON state is a value based on the number of lights turned on of the electric vehicle different depending on a time zone simulated in the traffic simulation, and the air-conditioning operation state is a value based on the difference between the air-conditioning temperature of the electric vehicle and the external air temperature set in advance as the set value of the road network model 400.

In a case where the light of the electric vehicle model is off, the value as the light ON state becomes 0 (zero), and in a case where the air conditioning of the electric vehicle model is off, the value as the air-conditioning operation state becomes 0 (zero).

[0060]

The consumption calculation models 1 to 3 calculate the storage battery consumption according to the external air temperature. The reason that the external air temperature is included in the calculation expression of the storage battery consumption is because the discharge amount of the storage battery changes depending on temperature.

[0061]

The consumption calculation models 2 and 3 calculate the storage battery consumption according to the acceleration/deceleration of the electric vehicle. The storage battery is discharged in a case where the electric vehicle accelerates, and the storage battery is charged in a case where the electric vehicle decelerates. Accordingly, in the consumption calculation models 2 and 3, in a case where the electric vehicle model accelerates from the previous time to the current time, the sign of the acceleration/deceleration is set to be positive, in a case where the electric vehicle model decelerates from the previous time to the current time, the sign of the acceleration/deceleration is set to be negative, and in a case where the electric vehicle does not accelerate or decelerate from the previous time to the current time, the acceleration/deceleration is 0 (zero).

In this way, in the traffic simulation by the traffic simulator 213 according to this embodiment, since the storage battery consumption of the electric vehicle model is calculated based on an apparatus or the like which consumes electric power in an actual electric vehicle, it is possible to calculate the storage battery consumption with higher accuracy.

[0062]

The electric power consumption estimation unit 214 can calculate the storage battery consumption by substituting the average free flow speed of the link in which the vehicle B travels and the average free flow speed read from the link attribute setting table 242 in the travel speed in the consumption calculation models 1 to 3.

Accordingly, the electric power consumption estimation unit 214 calculates the electric power consumption of the vehicle B simulated by the traffic simulator 213 based on travel history information collected by the travel history information collection device 100.

[0063]

(Step ST6)

Next, the traffic simulator 213 determines whether or not the end conditions determined in advance are satisfied, and in a case where the determination result is affirmative, processes to processing of Step ST10. In a case where the determination result is negative, the traffic simulator 213 progresses to processing of Step ST7.

[0064]

(Step ST7)

The charging determination unit 216 determines whether or not charging of the storage battery of the

vehicle B in the electric vehicle model is required based on the electric power consumption of the vehicle calculated by the electric power consumption estimation unit 214 and the residual amount of the storage battery of the vehicle B.

The charging determination unit 216 determines that charging of the storage battery is required, for example, for the electric vehicle model in which the value based on the storage battery residual amount calculated in Step ST5 is less than a threshold determined in advance.

The value based on the storage battery residual amount is a value obtained by dividing the storage battery residual amount by the full storage amount as the maximum charge amount in the storage battery, and as a specific charging necessity determination, charging necessity determination models 1 to 3 shown in Table 2 described below are used.

[0065]

[Table 2]

Charging Necessity Determination Model 1	$\frac{\text{Storage Battery Residual Amount}}{\text{Full Storage}} < \text{Threshold A}$ (for example, A = 10%)
Charging Necessity Determination Model 2	$\frac{\text{Storage Battery Residual Amount}}{\text{Full Storage}} < \text{Threshold A}$ (for example, A = 30%) and Storage Battery Residual Amount < Travel Distance to Destination × Fuel Efficiency + Margin
Charging Necessity Determination Model 3	$\frac{\text{Storage Battery Residual Amount}}{\text{Full Storage}} < \text{Threshold A}$ (for example, A = 50%) and Empty charging station is encounter during traveling

[0066]

In the traffic simulation by the traffic simulator 213 according to this embodiment, the traffic simulator 213 of the CPU 201 sets the charging necessity determination models 1 to 3 for the respective electric vehicle models randomly and performs a charging necessity determination using the charging necessity determination model set for each electric vehicle model. However, the invention is not limited thereto, and instead of the traffic simulator 213 of the CPU 201 setting the charging necessity determination models 1 to 3 for the electric vehicle models randomly, the operator may set the charging necessity determination models 1 to 3 for the electric vehicle models individually. Among the charging necessity determination models 1 to 3, one or two may be used, or another charging necessity determination model may be used.

In this way, since the charging necessity determination models 1 to 3 are models simulating the behavior of the driver in a case where charging is performed in the electric vehicle, it is possible to simulate the charging behavior of the electric vehicle with higher accuracy.

[0067]

(Step ST8)

Next, the charging determination unit 216 determines

whether or not there is an electric vehicle model (hereinafter, referred to as "charging requiring EV model") requiring charging based on a result of the charging necessity determination executed in Step ST7. In the charging determination unit 216, in a case where the determination result is affirmative, the process progresses to processing of Step ST9, and in a case where the determination result is negative, the process returns to the processing of Step ST5.

[0068]

(Step ST9)

The traffic simulator 213 performs the simulation settings as the settings for simulating the charging behavior of the vehicle B for the charging requiring EV model.

The simulation settings of the charging behavior, that is, a charging station model corresponding to the charging requiring EV model for charging the storage battery is selected and a path to a charging station is derived.

Next, if the simulation settings of the charging behavior to newly set a new travel path (in the example of Fig. 9, a travel path X or a travel path Y) traveling to a destination through the selected charging station model 46 end, the traffic simulator 213 returns to Step ST5.

[0069]

In Step ST5, as described above, the traffic simulator 213 simulates the travel of the vehicle model, and in a case where there is a charging requiring EV model, simulates the travel of the vehicle B in the charging requiring EV model to the charging station model 46 by the travel path set in the Step ST9. Even in a case of simulating the travel of the vehicle B in the charging requiring EV model, the traffic simulator 213 reads the speed of the vehicle B traveling in the link with reference to the link attribute setting table 242 of the HDD 204 and simulates the travel of the vehicle B traveling in the link based on information read from the link attribute setting table 242 of the HDD 204.

[0070]

In Step ST5, in a case where the charging requiring EV model reaches the charging station model selected in Step ST9, but the charging station model is congested, that is, in a case where there are charging requiring EV models exceeding the number of charging requiring EV models to be simultaneously charged in the charging station model and a waiting time to charging is caused, the traffic simulator 213 performs a charging station movement determination about whether or not to move the reached charging requiring EV model to a different

charging station model.

The charging station movement determination by the traffic simulator 213 performs a determination for newly selecting another charging station model 46 in a case where the value based on the time required for charging in the charging station model 46 in Step ST9 is equal to or greater than a predetermined value.

[0071]

Next, a case where a charging requiring EV model which waits for charging in the charging station model 46 is generated will be described.

In the traffic simulation by the traffic simulator 213 according to this embodiment, in a case where the charging requiring EV models exceeding the number of charging requiring EV models to be simultaneously charged are positioned in the charging station model 46, that is, in a case where the charging station models are congested, the traffic simulator 213 calculates the waiting time to charging for the charging requiring EV model waiting for charging using a matrix model.

In the traffic simulation, if the number of charging requiring EV models waiting for charging in the charging station model 46 exceeds the number of waiting spaces set as the set value of the charging station model 46, the traffic simulator 213 stops the charging requiring EV

model in the link 42 as an adjacent road model.

[0072]

As described above, the CPU 201 according to this embodiment repeats the processing of the traffic simulation of Step ST5 to Step ST9 until the end conditions are satisfied.

If it is determined in Step ST6 that the end conditions are satisfied, as described above, the CPU 201 progresses to Step ST10.

[0073]

(Step ST10)

In Step ST10, the CPU 201 outputs a result of the traffic simulation and ends this program.

The CPU 201 calculates, for example, the time (hereinafter, referred to as "trip time") required for each vehicle model traveling from an origin to a destination and a travel distance required for each vehicle model traveling from the origin to the destination as a result of the traffic simulation. The CPU 201 displays the result of the traffic simulation, for example, on the image display unit 206 in a graph or the like, stores a calculated result in the HDD 204 as data, prints the calculated result on a recording sheet using a printer connected through the external interface 207, or the like.

[0074]

As a specific example of the calculated trip time, a total trip time of all gasoline vehicle models, an average movement time per gasoline vehicle model, a total trip time of all electric vehicle models, an average movement time per electric vehicle model, a total trip time of all of gasoline vehicle models and electric vehicle models, an average movement time per gasoline vehicle model or electric vehicle model, and the like are used.

As a specific example of the calculated travel distance, a total travel distance of all gasoline vehicle models, an average travel distance per gasoline vehicle model, a total travel distance of all electric vehicle models, an average travel distance per electric vehicle model, a total travel distance of all of gasoline vehicle models and electric vehicle models, an average travel distance per gasoline vehicle model or electric vehicle model, and the like are used.

[0075]

In the traffic simulation according to this embodiment, it is possible to derive the optimum number, the disposition positions, or the like of charging station models 46 by simulating the traffic of the electric vehicle model multiple times while changing the parameters in a stepwise manner such that the ratio of the electric vehicle models included in the vehicle models set in Step

ST1 or at least one of the number of charging station models 46 or the disposition positions of the charging station models 46 set in Step ST1 is different.

As an example of stepwise changing, changing the ratio of the electric vehicle models from 0% to 100% in units of 10%, determining a plurality of areas for disposing the charging station models 46 in advance and changing the number of charging station models 46 disposed in the areas in a stepwise manner, disposing the disposition positions of the charging station models 46 in the areas evenly, disposing more a larger number of disposition positions of the charging station models 46 on a road having heavy traffic, disposing the disposition positions of the charging station models 46 in proportion to a traffic volume, or the like is used.

[0076]

As described above, the vehicle electric power consumption simulation device 200 according to this embodiment can acquire a travel track (link position) based on a measurement and the average free flow speed (link speed) of the link based on a measurement based on the position information and the speed information detected by the travel history information collection device 100 mounted in the vehicle A preliminarily traveling. Accordingly, the vehicle electric power

consumption simulation device 200 sets the acquired link speed as the average free flow speed on the road link in the vehicle electric power consumption simulation, whereby it is possible to simulate the electric power consumption in a case where the vehicle B as a target of the traffic simulation is an EV.

[0077]

The invention is not limited to the foregoing embodiment.

For example, the link setting unit 211 can set a link by applying the coordinates (latitude and longitude) acquired as a GPS track to the position of the link set in the traffic simulation even if there is no map data.

The vehicle electric power consumption simulation device 200 stores the attribute information relating to the electric power consumption according to the vehicle type in the HDD 204. The electric power consumption estimation unit 214 calculates the electric power consumption of the vehicle B according to the vehicle type with reference to the attribute information. As the attribute information, for example, an electric power consumption calculation model according to the type of vehicle or a table in which information for calculating the electric power consumption is stored can be prepared. With this, it is possible to simulate and estimate the

electric power consumption for various EVs and PHEVs. Even if position information of a travel object acquired by a preliminary travel is not acquired for each vehicle type, it is possible to calculate the electric power consumption according to the vehicle type.

The vehicle electric power consumption simulation device 200 sets the travel track or the average free flow speed of the link set based on the travel history information acquired by the travel history information collection device 100 as a base case and mixes other vehicles on a travel route for the base case to create congestion conditions, whereby it is possible to simulate and estimate the electric power consumption under congestion conditions during traffic concentration.

[0078]

For the travel in the link, the speed may be an instantaneous value, and as in the embodiment, an average speed from a start point to an end point on the link may be set as the average free flow speed in the link. For improvement of simulation and estimation accuracy by the method according to this embodiment, it is preferable to set links by dividing a road such that an increase/decrease of change in speed can be reflected in the average free flow speed.

For the division of the links, the difference

between the average free flow speed in the link and the speed measured by the travel history information collection device 100 at the same time with the acquisition of the travel track is evaluated, a link having a large difference is extracted, the link is divided, and the average free flow speed on the links after division is reset, whereby it is possible to decrease the difference between the measured value and the speed on the link. The setting of the average free flow speed on the link may be executed by the CPU 201. For example, the CPU 201 compares the average free flow speed of the link R1 set by the speed setting unit 212 with the speeds V1 to V5 correlated with P1 to P5 read from the travel history information table 241. In a case where the difference between the speeds V1 to V5 and the average free flow speed is equal to or greater than a threshold, the CPU 201 divides the link R1 into two parts, allocates the link ID to links R11 and R12 after division, and writes information indicating the positions of the links R11 and R12 to the link attribute setting table 242.

[0079]

In Step ST1, the vehicle electric power consumption simulation device 200 according to this embodiment sets the ratio of the number of electric vehicle models with respect to the total number of vehicle models and the

number and the installation positions of charging station models in which charging is performed in the storage battery of the electric vehicle model. In Step ST7, the vehicle electric power consumption simulation device 200 calculates the residual amount of the storage battery of the electric vehicle model traveling in the road network model 400, and in Step ST9, selects the charging station model 46 corresponding to the charging requiring EV model, in which the value based on the calculated residual amount of the storage battery is less than the threshold determined in advance, for charging the storage battery.

Accordingly, the vehicle electric power consumption simulation device 200 according to this embodiment can simulate the charging behavior of the electric vehicle.

[0080]

[Second Embodiment]

Hereinafter, a second embodiment according to the invention will be described with reference to the drawings. Fig. 10 is a reference diagram illustrating an example of a setting method of an average free flow speed which can be applied to a vehicle electric power consumption simulation system 2 according to the second embodiment. The vehicle electric power consumption simulation system 2 according to this embodiment includes a travel history information collection device 100 and a vehicle electric

power consumption simulation device 200 having the same configuration as those in the vehicle electric power consumption simulation system 1 described above. Since the vehicle electric power consumption simulation device 200 of the vehicle electric power consumption simulation system 2 according to the second embodiment has the same functions as those in the vehicle electric power consumption simulation device 200 of the vehicle electric power consumption simulation system 1 according to the first embodiment, except that a setting method of an average free flow speed corresponding to each link described below is different, the same configurations having the same functions are represented by the same reference numerals, and detailed description thereof will not be repeated.

[0081]

For example, the vehicle A travels on a road including links R21 to 24 shown in Fig. 10. In this case, the travel history information collection device 100 detects a current position, for example, at intervals of 10 seconds and acquires the detected position information. The travel history information collection device 100 writes the speed (speed information) of the vehicle A per hour to the travel history information table 161 of the storage unit 106 in correlation with the position

information.

In this embodiment, the vehicle A travels in the link R21 at the substantially same speed when traveling in the links R21, R22, R23, and R24 as a graph indicating the relationship between speed and time of Fig. 10, and significantly decreases in speed in the middle of the link R22.

[0082]

The vehicle electric power consumption simulation device 200 is connected to the travel history information collection device 100, for example, through the external interface 207, reads information stored in the travel history information table 161 of the travel history information collection device 100, and stores information in the travel history information table 241 of the HDD 204. Accordingly, the same information (that is, the travel history information) as that in the travel history information table 161 is stored in the travel history information table 241 of the HDD 204. Fig. 11 shows an example of the travel history information table 241. As shown in Fig. 11, the time, the position information, and the speed are correlated with one another.

[0083]

Next, the link setting unit 211 determines a link, in which the vehicle A will travel, from the respective

position coordinates included in the travel track of the vehicle A traveling on an actual road based on the travel history information stored in the travel history information table 241 of the HDD 204. As a link determination method by the link setting unit 211, for example, a general method, such as map matching, can be used. In this embodiment, as shown in Fig. 12A, the link setting unit 211 writes the link ID of the link determined as the link, in which the vehicle A will travel, and the travel position of the vehicle A corresponding to the link indicating the link ID to a link attribute setting table 242_1 in which the link ID and the travel position of the vehicle A are correlated with each other. The travel position of the vehicle A included in the link is the position information stored in the travel history information table 241.

[0084]

For example, position information P221, P222, P223, P224, P225, … is detected by the position detection unit 103 of the travel history information collection device 100. Speed information V221, V222, V223, V224, V225, … of the vehicle A in the position information P221, P222, P223, P224, P225, … is acquired by the speed acquisition unit 104. The position information P221, P222, P223, P224, and P225 is position information included in the same link

R221. In this case, the link setting unit 211 determines that the position information P221, P222, P223, P224, and P225 is points included in the same link R221 or corresponding points. That is, the link setting unit 211 sets the link, in which the vehicle A travels, to the link R221. With this, the link setting unit 211 writes the link ID (link R221) indicating the link, in which the vehicle A travels, and the travel positions (P221, P222, P223, P224, P225) of the vehicle A corresponding to the link R211 to the link attribute setting table 242_1 in correlation with each other.

Though detailed description will be omitted, the link setting unit 211 determines links corresponding to other pieces of position information stored in the travel history information table 241 and writes the link ID indicating the link, in which the vehicle A travels, and the travel positions corresponding to the link ID to the link attribute setting table 242_1 in correlation with each other. The link setting unit 211 stores the link IDs of the links corresponding to the position information P221, P222, P223, … in the item of the link ID of the link attribute setting table 242_1 according to the time, at which the position information is detected, in a time series, whereby it is possible to set the link indicating the travel history of the vehicle A.

[0085]

Next, the speed setting unit 212 selects one link from the links set by the link setting unit 211 and determines whether or not change in speed in each selected link is greater than a threshold set in advance based on the speed information stored in the travel history information table 241. The speed setting unit 212 divides the selected link at a point where a speed variation is greater than a threshold and sets the link speed (that is, average free flow speed) of the vehicle A for each divided section. In a case where there is no point where the speed variation is greater than the threshold in the selected link, the speed setting unit 212 sets the average free flow speed of the vehicle A in the selected link without dividing the selected link.

In this embodiment, the speed setting unit 212 calculates an average value of the speeds of the vehicle A in the divided section or the link and sets the calculated average value as the link speed (average free flow speed) of the divided section or the link.

[0086]

Specifically, the speed setting unit 212 calculates the speed variation between the travel positions in each link with reference to the travel history information table 241 and the link attribute setting table 242_1. The

speed setting unit 212 calculates the difference ΔVn = ABS(Vn - Vini) between a speed Vini at an initial travel position on the selected link and a speed Vn at an N-th travel position on the link to determine a speed variation ΔVn. The speed setting unit 212 compares the calculated speed variation ΔVn with a division threshold VDivTh determined in advance. In a case where the speed variation ΔVn is greater than the division threshold VDivTh (speed variation ΔVn > division threshold VDivTh), the speed setting unit 212 cuts the initial travel position to the N-th travel position on the selected link from the selected link and sets an average free flow speed for the cut section (also referred to as a divided link). The speed setting unit 212 repeats the same processing for the remaining divided links with the end point of cutting as the initial coordinates of the remaining divided links.

In a case where the speed variation ΔVn is equal to or less than the division threshold VDivTh (speed variation ΔVn ≤ division threshold VDivTh), the average free flow speed to the N-th travel position is calculated without dividing the selected link.

In regards to the initial travel position to the N-th travel position, when the travel positions corresponding to the same link are arranged in a time series, the initial travel position is a travel position

most previously acquired, and the N-th travel position is a travel position acquired N times into the future. In a case where the travel positions in the same link are stored in correlation with each link ID in the link attribute setting table 242_1 in a time series of acquisition, the speed setting unit 212 calculates the speed variation ΔVn between the travel positions in the link correlated with the link ID and compares the speed variation ΔVn with the division threshold VDivTh.

[0087]

For example, the speed setting unit 212 selects one link R21 from the links R21, R22, R23, R24, … set by the link setting unit 211. The speed setting unit 212 reads travel speeds V211, V212, and V213 corresponding to travel positions P211, P212, and P213 included in the link R21 from the travel history information table 241. The speed setting unit 212 calculates the difference between the travel speed V211 at the travel position P211 and the travel speed V212 at the travel position P212 to determine a speed variation ΔV2. The speed variation ΔV2 is compared with the division threshold VDivTh. Here, speed variation ΔV2 ≤ division threshold VDivTh. In this case, the speed setting unit 212 subsequently calculates the difference between the travel speed V211 at the travel position P211 and the travel speed V213 at the travel

position P213 to determine a speed variation ΔV3. Here, speed variation ΔV3 ≤ division threshold VDivTh. In this case, the speed setting unit 212 calculates the average free flow speed of the link R21 based on the travel speeds V211, V212, and V213 without dividing the selected link R21. The speed setting unit 212 writes a calculated average free flow speed α21 to a link attribute setting table 242_2 shown in Fig. 12B in correlation with the link ID of the link R21.

[0088]

Next, the speed setting unit 212 selects one link R22 from the links R21, R22, R23, R24, … set by the link setting unit 211. The speed setting unit 212 reads travel speeds V221, V222, V223, and V214 corresponding to travel position P221, P222, P223, and P214 included in the link R22 from the travel history information table 241. The speed setting unit 212 calculates the difference between the travel speed V221 at the travel position P221 and the travel speed V222 at the travel position P222 to determine a speed variation ΔV2. The speed variation ΔV2 is compared with the division threshold VDivTh. Here, speed variation ΔV2 ≤ division threshold VDivTh. In this case, the speed setting unit 212 subsequently calculates the difference between the travel speed V221 at the travel position P221 and the travel speed V223 at the travel

position P223 to determine a speed variation ΔV3. Here, speed variation ΔV3 > division threshold VDivTh. In this case, the speed setting unit 212 divides the selected link R21 at the travel position P223 and writes the travel positions P221 to P223 as the divided sections in the column of the division position of the link attribute setting table 242_1 in correlation with the link ID of the link R21.

[0089]

Subsequently, the speed setting unit 212 calculates the difference between the travel speed V221 at the travel position P221 and the travel speed V224 at the travel position P224 to determine a speed variation ΔV4. The speed variation ΔV4 is compared with the division threshold VDivTh. Here, speed variation ΔV4 ≤ division threshold VDivTh. In this case, the speed setting unit 212 subsequently calculates the difference between the travel speed V221 at the travel position P221 and the travel speed V225 at the travel position P225 to determine a speed variation ΔV5. The speed variation ΔV5 is compared with the division threshold VDivTh. Here, speed variation ΔV5 ≤ division threshold VDivTh.

The speed setting unit 212 writes the travel positions P223 to P225 as the remaining section of the selected link R22 at the travel position P223 where change

in speed is greater than the threshold to the column of the division position of the link attribute setting table 242_1 in correlation with the link ID of the link R21.

[0090]

Next, the speed setting unit 212 calculates the average free flow speed for each of the divided section (P221 to P223) and the remaining divided section (P223 to P225). That is, the speed setting unit 212 calculates an average free flow speed α22-1 of the divided section (P221 to P223) based on the travel speeds V211, V212, and V213. The speed setting unit 212 calculates an average free flow speed α22-2 of the remaining divided section (P223 to P225) based on the travel speeds V213 and V214. The speed setting unit 212 writes the calculated average free flow speeds α22-1 and α22-2 to the link attribute setting table 242_2 in correlation with the divided sections (P221 to P223) and (P223 to P225).

In this way, in a case where change in speed in the link is equal to or greater than the threshold, the average free flow speed is determined for each divided section of the link. With this, it is possible to determine a travel track using the link ID and to determine the average free flow speed for each section with higher accuracy even in a case where change in speed in the link is great.

[0091]

[Example of Position Detection Method]

Next, a detection example of the position detection unit 103 of the travel history information collection device 100 will be described referring to Fig. 13.

The GPS receiver 131 of the travel history information collection device 100 of the vehicle A receives radio waves from the GPS satellites 90 regularly. The GPS receiver 131 measures the latitude and the longitude from information included in the received radio waves and outputs information of the latitude and the longitude, information of the time included in the received radio waves, and information indicating the reliability of information included in the received radio waves.

In this embodiment, the GPS receiver 131 outputs information in which information indicating that the position of the travel history information collection device 100 is a point P11 (latitude $\psi 1$, longitude $\lambda 1$), time information indicating the time T at which the position is detected, and information indicating reliability "high" are correlated with one another.

[0092]

Next, the GPS complementary sensor unit 132 performs an operation of estimating the position of the travel

history information collection device 100 at the time T1 output from the GPS receiver 131 based on the direction of rotation of the vehicle A obtained from a gyro sensor and information of the speed of the vehicle A obtained from an acceleration sensor.

In this embodiment, the GPS complementary sensor unit 132 obtains information indicating a point P12 (latitude $\psi 2$, longitude $\lambda 2$) as the position of the travel history information collection device 100 by an operation result.

The dead reckoning navigation processing unit 133 calculates the position of the travel history information collection device 100 using information of the two positions obtained from the GPS receiver 131 and the GPS complementary sensor unit 132 by a method shown in Fig. 13.

Specifically, the position of the travel history information collection device 100 estimated by the operation in the GPS complementary sensor unit 132 is a position indicated by the point P12 (latitude $\psi 2$, longitude $\lambda 2$), and the position by information of the latitude and the longitude output from the GPS receiver 131 is a position indicated by the point P11 (latitude $\psi 1$, longitude $\lambda 1$). In this case, the dead reckoning navigation processing unit 133 calculates the position of a point P13 (latitude $\psi 3$, longitude $\lambda 3$) as the position of

the travel history information collection device 100 by a weighted averaging operation with the reliability of information output from the GPS receiver 131 as a weight.

That is, the higher the reliability of information output from the GPS receiver 131, the closer the position of the point P13 (latitude $\psi 3$, longitude $\lambda 3$) to the position of the point P11 (latitude $\psi 1$, longitude $\lambda 1$) output from the GPS receiver 131.

The dead reckoning navigation processing unit 133 writes information of the calculated position (that is, information indicating the point P13 (latitude $\psi 3$, longitude $\lambda 3$)) and information indicating the time T1 output from the GPS receiver 131 to the travel history information table 161 in correlation with each other.

A position which becomes the origin when the GPS complementary sensor unit 132 performs an operation of estimating the position becomes a position indicated by the point P13 (latitude $\psi 3$, longitude $\lambda 3$).

[0093]

[Example of Map Matching]

An example of map matching by the link setting unit 211 will be described. The link setting unit 211 reads the position information of the vehicle A stored in the travel history information table 241 and the time information correlated with the position information from

the HDD 204 and arranges information in a time series to determine the track of the vehicle A, that is, the track of the travel history information collection device 100.

For example, the track of the travel history information collection device 100 is a track I indicated by a dotted line of Fig. 14. The link setting unit 211 extracts three paths of path candidates C1, C2, and C3 as a candidate of a path corresponding to the determined track I from road map data stored in the HDD 204 based on the track I. The link setting unit 211 determines a path candidate with the smallest error amount from an area (a half-tone region of Fig. 14) of a region surrounded by the determined track I and the path of each of the path candidates C1, C2, and C3. In this embodiment, the link setting unit 211 determines the path candidate C2 with the smallest area (the half-tone region of Fig. 14) of the region surrounded by the track I and each path candidate as a path corresponding to the track I of the travel history information collection device 100.

[0094]

The link setting unit 211 detects the link where the travel history information collection device 100 is present by matching the path C2 determined as the path of the track I and information of the latest position. The link setting unit 211 records information (link ID)

indicating the detected link based on the time information corresponding to the link ID in association with information of the position and the time of the link attribute setting table 242 of the HDD 204.

In this embodiment, the point P13 (latitude $\psi 3$, longitude $\lambda 3$) is a position included in the area corresponding to the link R1. In this case, the link setting unit 211 determines that the travel history information collection device 100 is in the link R1 at the time T2. The link setting unit 211 writes "1" to the item of the link corresponding to the time T2. The link setting unit 211 writes "-" to the item of the link in the table in a case where the corresponding link ID is not detectable.

[0095]

A program for implementing the functions of the respective processing units in the invention may be recorded on a computer-readable recording medium. The program recorded on the recording medium may be loaded into a computer system and executed to perform conversion of an assembly program.

The "computer system" used herein includes an OS and hardware, such as peripheral devices. Furthermore, the "computer system" includes a WWW system comprising a homepage providing environment (or display environment).

Furthermore, the "computer-readable recording medium" refers to a storage device including a flexible disk, a magneto-optical disk, a ROM, a portable medium, such as a CD-ROM, and a hard disk incorporated in the computer system. In addition, the "computer-readable recording medium" includes a recording medium that holds a program for a constant period of time, like a volatile memory (RAM) inside the computer system serving as a server or a client in a case where the program is transmitted through a network, such as the Internet, or a communication line, such as a telephone line.

[0096]

The program described above may be transmitted from a computer system, in which the program is stored in a storage device or the like, to another computer system through a transmission medium or using a transmission wave in a transmission medium. Here, the "transmission medium" on which a program is transmitted refers to a medium having a function of transmitting information, like a network (communication network), such as the Internet, or a communication line (communication cable), such as a telephone line. The program described above may be a program for implementing some of the functions described above. The program described above may also be a program, called a differential file (differential program), capable

of implementing the functions described above in a combination with a program already on a computer system.

Industrial Applicability

[0097]

According to the vehicle electric power consumption simulation device, the vehicle electric power consumption simulation method, and the program described above, it is possible to reduce time and costs required for status reproduction in the traffic simulator.

Reference Signs List

[0098]

1: vehicle electric power consumption simulation system

100: travel history information collection device

101: power supply circuit

102: internal battery

103: position detection unit

104: speed acquisition unit

105: travel history information creation unit

106: storage unit

107: external interface

108: timepiece unit

131: GPS receiver

132: GPS complementary sensor unit

133: dead reckoning navigation processing unit

161: travel history information table

200: vehicle electric power consumption simulation device

201: CPU

202: ROM

203: RAM

204: HDD

205: operation input unit

206: image display unit

207: external interface

208: reading unit

211: link setting unit

212: speed setting unit

213: traffic simulator

214: electric power consumption estimation unit

215: simulation model setting unit

216: charging determination unit

241: travel history information table

242: link attribute setting table

243: travel track table

300: portable storage medium

400: road network model

42: link

44: node

46: charging station model

90: GPS satellite

CLAIMS

1. A vehicle electric power consumption simulation device comprising:

a link setting unit that, with reference to information indicating a link that is a division of a road determined by a traffic simulation, sets a link, in which a travel object travels, based on a track of the travel object in which position information of the travel object at each time acquired by a preliminary travel are arranged in a time series;

a speed setting unit that sets an average free flow speed in the link set by the link setting unit based on speed information of the travel object at each time acquired by the preliminary travel;

a traffic simulator that simulates vehicle traffic based on the link set by the link setting unit and the average free flow speed set by the speed setting unit; and

an electric power consumption estimation unit that calculates the electric power consumption of a vehicle traveling in the link based on data relating to electric power consumption obtained from a travel status of the vehicle simulated by the traffic simulator, wherein

the link setting unit determines a path candidate with the smallest area of a region surrounded by the track and each path candidate as a path corresponding to the track of a travel history information collection device that collects information indicating a travel history of the vehicle.

2. The vehicle electric power consumption simulation device according to claim 1,

wherein the speed setting unit selects one link from the links set by the link setting unit, determines whether or not a speed variation in each selected link is greater than a threshold determined in advance based on the speed information, divides the link at a point where the speed variation is greater than the threshold, and sets the average free flow speed for each divided section.

3. The vehicle electric power consumption simulation device according to claim 1 or 2,

wherein, in a case where simulation conditions representing the travel status of the vehicle to be simulated are set, the traffic simulator simulates driving of the vehicle in a condition in which disturbance indicated by the simulation conditions is imparted to the travel status of the travel object.

4. The vehicle electric power consumption simulation device according to any one of claims 1 to 3, further comprising:

a storage unit that records attribute information relating to electric power consumption according to a vehicle type,

wherein the electric power consumption estimation unit calculates the electric power consumption of the vehicle according to the vehicle type with reference to the attribute information stored in the storage unit.

5. The vehicle electric power consumption simulation device according to any one of claims 1 to 4,

wherein the link setting unit sets a link corresponding to a road, on which the travel object travels, by applying position coordinates of the travel object at each time acquired by the preliminary travel to position coordinates set in the traffic simulation.

6. A vehicle electric power consumption simulation method comprising:

a link setting step of, with reference to information indicating a link that is a division of a road determined by a traffic simulation, setting a link, in which a travel object travels, based on a track of the travel object in which position information of the travel object at each time acquired by a preliminary travel are arranged in a time series and determining a path candidate with the smallest area of a region surrounded by the track and

each path candidate as a path corresponding to the track of a travel history information collection device that collects information indicating a travel history of the vehicle;

a speed setting step of setting an average free flow speed in the link set in the link setting step based on speed information of the travel object at each time acquired by the preliminary travel;

a traffic simulation step of simulating vehicle traffic based on the link set in the link setting step and the average free flow speed set in the speed setting step; and

an electric power consumption estimation step of calculating the electric power consumption of a vehicle traveling in the link based on data relating to electric power consumption obtained from a travel status of the vehicle simulated in the traffic simulation step.

7. A program which causes a computer to function as:

link setting means for, with reference to information indicating a link that is a division of a road determined by a traffic simulation, setting a link, in which a travel object travels, based on a track of the travel object in which position information of the travel object at each time acquired by a preliminary travel are arranged in a time series and determining a path candidate with the smallest area of a region surrounded by the track and each path candidate as a path corresponding to the track of a travel history information collection devicethat collects information indicating a travel history of the vehicle;

speed setting means for setting an average free flow speed in the link set by the link setting means based on speed information of the travel object at each time acquired by the preliminary travel;

traffic simulation means for simulating vehicle traffic based on the link set by the link setting means and the average free flow speed set by the speed setting means; and

electric power consumption estimation means for calculating the electric power consumption of a vehicle traveling in the link based on data

relating to electric power consumption obtained from a travel status of the vehicle simulated in the traffic means.