[DESCRIPTION]

[TITLE OF INVENTION]

ANOMALOUS-VEHICLE EXTRACTION DEVICE, ANOMALOUS-VEHICLE EXTRACTION METHOD, AND PROGRAM

[Technical Field]

[0001]

The present invention relates to an anomalous-vehicle extraction device, an anomalous-vehicle extraction method, and a program.

Priority is claimed on Japanese Patent Application No. 2014-033875, filed on February 25, 2014, the content of which is incorporated herein by reference.

[Background Art]

[0002]

There has been known an on-board unit that specifies the position of a vehicle on the basis of a signal received by a satellite positioning system or the detection result of an acceleration sensor or the like, and acquires a vehicle position on a map corresponding to a position specified on the basis of map information prepared in advance (see, for example, Patent Literature 1). In this kind of on-board unit, for example, in a case where it is determined that a vehicle is traveling along a toll road on the basis of a vehicle position on a map, the toll fee of the toll road may be charged. In addition, information indicating the vehicle position on a map acquired by the on-board unit may be transmitted to a central server or the like, and traffic information indicating a traffic jam or a congestion situation may be generated on the basis of the information received by

the central server or the like. In this manner, the information indicating the vehicle position acquired by the on-board unit is used in various processes.

[Citation List]

[Patent Literature]

[0003]

[Patent Literature 1] Japanese Unexamined Patent Application, First Publication No. 2009-115588

[Summary of Invention]

[Technical Problem]

[0004]

However, in a case where the vehicle position acquired by the on-board unit has been altered using some kind of method, a process is performed on the basis of information which is not an actual vehicle position, which leads to concern of incorrect processing results being generated.

[0005]

The present invention is contrived in view of such circumstances, and an object thereof is to provide an anomalous-vehicle extraction device, an anomalous-vehicle extraction method, and a program which are capable of extracting an anomalous vehicle having the possibility of information acquired by an on-board unit being different from the actual status of a vehicle.

[Solution to Problem]

[0006]

According to a first aspect of the present invention, there is provided an anomalous-vehicle extraction device including: a traffic state value calculation unit that is configured to calculate a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle; and an anomalous-vehicle extraction unit that is configured to extract the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit, and the vehicle information acquired from the on-board unit of each vehicle.

With such a configuration, it is possible to extract an anomalous vehicle having the possibility of the information acquired by the on-board unit being different from the actual status of the vehicle, on the basis of a relative relation with another vehicle traveling along the same road.

[0007]

In addition, in a second aspect of the present invention according to the first aspect, the anomalous-vehicle extraction unit is configured to acquire a speed within the target area as the traffic state value calculated by the traffic state value calculation unit, and determine that the traveling conditions of the vehicle are anomalous in a case where an amount of deviation between the speed within the target area and the traveling speed of the vehicle indicated by the vehicle information exceeds a predetermined allowable range.

With such a configuration, it is possible to extract a vehicle having a high possibility of not corresponding to the state of traffic within the target area, that is, not being able to travel within the target area at a traveling speed included in the vehicle

information, as an anomalous vehicle. Thus, it is possible to extract a vehicle that pretends to travel within the target area by altering the vehicle information.

[0008]

In a third aspect of the present invention according to the second aspect, the anomalous-vehicle extraction unit is configured to acquire a density of vehicles within the target area as the traffic state value calculated by the traffic state value calculation unit, and determine that the traveling conditions of the vehicle are anomalous in a case where the density of vehicles within the target area is higher than a threshold and the amount of deviation exceeds a predetermined allowable range.

With such a configuration, an anomalous vehicle is detected on the basis of the state of traffic in a state where the density of vehicles traveling within the target area is higher than a threshold. In the state of traffic where the density of vehicles is high, it is possible to acquire a lot of vehicle information acquired from the on-board unit. Therefore, it is possible to calculate a traffic state value indicating the average state of traffic from a plurality of pieces of vehicle information. In addition, in the state of traffic where the density of vehicles is high, it can be considered that the interval with another vehicle is small, and that a space capable of traveling at a speed greater than the average speed within the target area is not sufficiently secured. For this reason, a speed capable of traveling within the target area is dependent on the state of traffic and is close to a speed indicated by the state of traffic within the target area. In this manner, since an anomalous vehicle can be detected on the basis of the traffic state value in a state where the traveling speed of a vehicle traveling within the target area is restricted to some extent, it is possible to improve the detection accuracy of an anomalous vehicle.

[0009]

In a fourth aspect of the present invention according to any one of the first to

third aspects, a traveling speed calculation unit is further included which is configured to calculate the traveling speed of the vehicle on the basis of position information of at least two points of the vehicle indicated by the vehicle information acquired from the same on-board unit at different timings, and the anomalous-vehicle extraction unit is configured to determine whether the traveling conditions of the vehicle indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traveling speed calculated by the traveling speed calculation unit.

With such a configuration, it is possible to calculate the traveling speed of a vehicle from the position of the vehicle on the basis of the position of the vehicle included in the vehicle information. In a case where the position of the vehicle included in the vehicle information is altered, it can be considered that there is a high possibility of the traveling speed of the vehicle calculated from the position of the vehicle diverging from actual traveling speed. Thus, it is possible to extract a vehicle having a high possibility of the position of the vehicle included in the vehicle information being altered, as an anomalous vehicle.

[0010]

In addition, in a fifth aspect of the present invention according to any one of the first to third aspects, a traffic state estimation unit is further included which is configured to estimate the state of traffic within the predetermined target area in the predetermined target time period, in a case where a density of the vehicle information within the predetermined target area in the predetermined target time period is less than a threshold, the traffic state value calculation unit is configured to calculate the traffic state value in a case where the density of the vehicle information is equal to or greater than the threshold, and the anomalous-vehicle extraction unit is configured to determine whether the traveling conditions of the vehicle indicated by the vehicle information are anomalous as

the vehicle traveling within the target area, on the basis of the state of traffic estimated by the traffic state estimation unit.

With such a configuration, in a case where the amount of vehicle information within the predetermined target area in the predetermined target time period is small, the state of traffic in the predetermined target area in the predetermined target time is estimated. Here, since only a small amount of vehicle information can be acquired in a case where the density of the vehicle information is low, there may be concern that the state of traffic is evaluated on the basis of biased vehicle information, or the state of traffic is evaluated by the state of a vehicle which is in a special state accidentally. However, in a case where the density of the vehicle information is lower than a threshold, the state of traffic is estimated without obtaining a traffic state value through the vehicle information acquired in the target time period, and the traffic state value is calculated on the basis of the estimated state of traffic, thereby allowing an anomalous vehicle to be extracted on the basis of the average state of traffic even in a target area where the density of the vehicle information is low.

[0011]

In addition, in a sixth aspect of the present invention according to any one of the first to third aspects, a notification unit is further included which is configured to give notice of the vehicle determined to be anomalous by the anomalous-vehicle extraction unit.

With such a configuration, information relating to the anomalous vehicle can be notified to a manager who manages fee payment regarding a toll road, an observer who monitors a traffic status on the basis of the vehicle information, or a driver of a vehicle which is determined to be an anomalous vehicle.

[0012]

In addition, in a seventh aspect of the present invention according to any one of the first to third aspects, a correction unit is further included which is configured to generate information for correcting a billing status regarding a vehicle determined to be anomalous by the anomalous-vehicle extraction unit.

With such a configuration, the information for correcting a billing status to be corrected by the correction unit is generated, and thus it is possible to perform a process of correcting a billing status.

[0013]

In addition, according to an eighth aspect of the present invention, there is provided an anomalous-vehicle extraction device including an anomalous-vehicle extraction unit that is configured to determine whether traveling conditions of a vehicle indicated by vehicle information are anomalous as the vehicle traveling within a predetermined target area, on the basis of the vehicle information corresponding to the target area in a predetermined target time period, among pieces of the vehicle information indicating a position and a traveling speed of the vehicle which are acquired from an on-board unit mounted in the vehicle.

With such a configuration, it is possible to extract an anomalous vehicle having the possibility of the information acquired by the on-board unit being different from the actual status of the vehicle. For example, the anomalous-vehicle extraction device may calculate the traveling speed of a vehicle traveling along a movement locus obtained by connecting the location information, on the basis of the location information. At this time, in a case where the position information of the vehicle included in the vehicle information is altered, the calculated traveling speed may increases (for example, 200 km/h) as the speed becomes more anomalous. The anomalous-vehicle extraction unit regards such a vehicle as an anomalous vehicle having the possibility of the information

acquired by the on-board unit being different from the actual status of the vehicle, and can extract a vehicle having a high possibility of not being able to travel within the target area at a traveling speed included in the vehicle information and having a high possibility of pretending to travel within the target area while traveling along another road. Thus, it is possible to extract a vehicle having a high possibility of the vehicle information being altered, as an anomalous vehicle.

[0014]

In addition, according to a ninth aspect of the present invention, there is provided an anomalous-vehicle extraction method including: a traffic state value calculation step of calculating a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle; and an anomalous-vehicle extraction step of extracting the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated in the traffic state value calculation step, and the vehicle information acquired from the on-board unit of each vehicle.

With such a configuration, it is possible to extract an anomalous vehicle having the possibility of the information acquired by the on-board unit being different from the actual status of the vehicle, on the basis of a relative relation with another vehicle traveling along the same road.

[0015]

In addition, according to a tenth aspect of the present invention, there is provided a program causing a computer to function as: traffic state value calculation unit for calculating a traffic state value indicating a state of traffic within a predetermined

target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle; and anomalous-vehicle extraction unit for extracting the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit, and the vehicle information acquired from the on-board unit of each vehicle.

With such a configuration, it is possible to extract an anomalous vehicle having the possibility of the information acquired by the on-board unit being different from the actual status of the vehicle, on the basis of a relative relation with another vehicle traveling along the same road.

[Advantageous Effects of Invention]

[0016]

According to the present invention, it is possible to detect a vehicle having the possibility of the vehicle position acquired by the on-board unit being different from the position of an actual vehicle.

[Brief Description of Drawings]

[0017]

FIG. 1 is a schematic diagram illustrating an example of an anomalous-vehicle extraction system 1 according to an embodiment of the present invention.

FIG. 2 is a diagram illustrating some roads included in map information.

FIG. 3 is a diagram illustrating a distribution of vehicle information acquired in roads shown in FIG. 2.

FIG. 4 is a diagram illustrating an example of a distribution of vehicles is within a target area in a predetermined time.

FIG. 5 is a diagram illustrating a traveling position and a traveling speed of a vehicle 400 on a map on the basis of five pieces of vehicle information S11 to S15 acquired by the vehicle 400.

FIG. 6 is a block diagram illustrating a configuration example of an on-board unit 100.

FIG. 7 is a block diagram illustrating a configuration example of an anomalous-vehicle extraction device 300.

FIG. 8 is a flow diagram illustrating an example of a process performed by the on-board unit 100.

FIG. 9 is a flow diagram illustrating an example of the entire process performed by the anomalous-vehicle extraction device 300.

FIG. 10 is a flow diagram illustrating an example of an anomalous-vehicle extraction process.

[Description of Embodiments]

[0018]

[First Embodiment]

Hereinafter, an example of an anomalous-vehicle extraction system 1 according to an embodiment of the present invention is illustrated. FIG. 1 is a schematic diagram illustrating an example of the anomalous-vehicle extraction system 1 according to an embodiment of the present invention.

[0019]

(Entire Configuration)

As shown in FIG. 1, the anomalous-vehicle extraction system 1 includes an on-board unit 100, a roadside device 200, and an anomalous-vehicle extraction device 300.

The on-board unit 100 is mounted in a vehicle 400, and generates vehicle information or the like to transmit the generated information to the roadside device 200. The vehicle information includes information indicating the position of the vehicle 400 and information indicating the traveling speed of the vehicle 400.

Although not shown in the drawing, the roadside device 200 receives vehicle information or the like from the on-board units 100 of a plurality of passing vehicles 400, and transmits the received information to the anomalous-vehicle extraction device 300. Thus, the vehicle information or the like from a plurality of on-board units 100 is transmitted to the anomalous-vehicle extraction device 300.

[0020]

The roadside device 200 is provided on a predetermined roadside such as an intersection point. The roadside device 200 is connected to a roadside antenna 201 provided on the roadside and performs communication with the on-board unit 100 located in a communication region through the roadside antenna 201. The roadside device 200 requests the on-board unit 100 capable of communication to transmit vehicle information or the like, and receives the vehicle information or the like from the on-board unit 100. Here, the on-board unit 100 transmits all the pieces of vehicle information or the like, generated after preceding communication having communicated with the roadside device 200, to the roadside device 200.

[0021]

The anomalous-vehicle extraction device 300 receives vehicle information from the roadside device 200 provided in each area, and extracts a vehicle 400 of which the

traveling conditions are anomalous, on the basis of the received vehicle information. In the present embodiment, the anomalous-vehicle extraction device 300 calculates a traffic state value indicating the state of traffic within a predetermined target area in a predetermined target time period. The anomalous-vehicle extraction device 300 extracts an anomalous vehicle in which the traveling conditions of the vehicle 400 indicated by vehicle information are anomalous as the vehicle 400 traveling within a target area, on the basis of the calculated traffic state value.

[0022]

The anomalous-vehicle extraction device 300 extracts the anomalous vehicle, and thus can extract an illegal vehicle that pretends to travel along an ordinary road by altering position information of the vehicle included in the vehicle information, position information of the vehicle used in a billing process, or the like using some kind of method, and attempts to evade paying the billing fee of a toll road. In addition, the anomalous-vehicle extraction device 300 can extract an illegal vehicle that pretends to travel in a time period when the billing fee of a toll road is exempt by altering the traveling date and time of the vehicle included in the vehicle information using some kind of method, and attempts to evade paying the billing fee. A case where the position information of the vehicle is altered using some kind of method also includes a case where map information registered in the on-board unit 100 is not updated, and it is erroneously determined to be most probable among roads included in the map information.

[0023]

(Regarding Map Information)

Here, reference will be made to FIG. 2 to describe map information for acquiring a position of the vehicle 400 on the map in the on-board unit 100. FIG. 2 is a

diagram illustrating some roads included in the map information.

As shown in FIG. 2, nodes ID and links ID are allocated to roads on a map. The node ID refers to identification information indicating a predetermined position (node) on a road. The link ID refers to identification information indicating a road region (link) interposed between two nodes. The nodes ID=N1 to N14 and the links ID=L1 to 11 are allocated to the roads shown in the drawing.

The roads of the links L2 to L4 are toll roads, and the other roads are ordinary roads.

In the present embodiment, the target area refers to at least one link, and links included in the target area are determined in advance. The target area may include a plurality of links (for example, links L2 to L4).

[0024]

(Regarding Relationship between Process of Anomalous-vehicle Extraction Device 300 and Traffic State)

Here, reference will be made to FIG. 3 to describe the density of vehicle information acquired in the roads shown in FIG. 2. FIG. 3 is a diagram illustrating a distribution of vehicle information acquired in the roads shown in FIG. 2.

FIG. 3 shows map locations of vehicles traveling along the roads shown in FIG. 2, on the basis of vehicle information acquired in a target time period (for example, 13: 00 to 13: 10, a certain month a certain day). FIG. 3 includes a plurality of map locations of the same vehicle which are acquired in the target time period. That is, FIG. 3 shows a state where all the pieces of vehicle information generated in the target time period are lined up on the basis of the map locations.

[0025]

As shown in the drawing, the density of the vehicle information is high in the

links L1, L6 to L8, and L5, and the density of the vehicle information is low in the links L9 to L11. The density of the vehicle information in the links L2 to L4 is lower than that of the links L1, L6 to L8, and L5, and is higher than that of the links L9 to L11. In a case where the density of the vehicle information is approximately equal to that of the links L2 to L4, it can be considered that the traveling speeds of vehicles traveling along a road are restricted to some extent from the traffic state of the vehicles traveling along the road. On the other hand, in a case where the density of the vehicle information is approximately equal to that of the links L9 to L11, it can be considered that the traveling speeds of vehicles are not restricted from the traffic state of the vehicles traveling along the road.

[0026]

Consequently, in a case where the density of the vehicle information is equal to or greater than a threshold, the anomalous-vehicle extraction device 300 obtains the state of traffic in the target area in the target time period, on the basis of the vehicle information acquired from the on-board unit 100. On the other hand, in a case where the density of the vehicle information is less than the threshold, the anomalous-vehicle extraction device 300 estimates the state of traffic in a direction other than in a method based on the vehicle information from the vehicles 400 traveling within the target area in the target time period. For example, the anomalous-vehicle extraction device 300 obtains the state of traffic in the target area in the target time period which is simulated by a simulator on the basis of a condition when the vehicle information is acquired. In addition, the anomalous-vehicle extraction device 300 may obtain the average state of traffic on the basis of vehicle information generated in the past than in the target time period.

[0027]

In addition, even in a case where the density of the vehicle information is equal to or greater than the threshold, the occurrence of variations in the traveling speeds of the vehicles 400 included in the vehicle information gives rise to concern of the accurate state of traffic not being reproduced on the basis of the vehicle information. Consequently, in a case where the calculated density of the vehicle information is equal to or greater than the threshold, the anomalous-vehicle extraction device 300 calculates the variance value of speeds on the basis of traveling speed information included in the vehicle information. In a case where the variance value is equal to or greater than a threshold determined in advance, the anomalous-vehicle extraction device 300 estimates the calculation of a traffic state value in the target area. On the other hand, in a case where the variance value is less than the threshold determined in advance, the anomalous-vehicle extraction device 300 calculates a traffic state value in the target area on the basis of the vehicle information.

[0028]

In the example shown in FIG. 3, the anomalous-vehicle extraction device 300 obtains the state of traffic of the links L1 to L8 in the target area in the target time period, on the basis of the vehicle information acquired from the on-board unit 100.

On the other hand, the anomalous-vehicle extraction device 300 estimates the state of traffic of the links L9 to L11 in the target area in the target time period, through a simulator.

[0029]

In the present embodiment, the traffic state value indicating the state of traffic within the target area in the target time period includes information indicating a distribution of the traveling speeds of the vehicles 400 present in the target area in the target time period. In addition, the traffic state value includes the density of the vehicles

400 within the target area, or information indicating an average speed within the target area. For example, the traffic state value is information or the like indicating that 80% of the vehicles 400 present in the target area (link L1) in the target time period (13: 00 to 13: 10, a certain month a certain day) travel in a range of 35±10 km/h.

[0030]

(Regarding Anomalous Vehicle)

Here, an example of an anomalous vehicle will be described with reference to FIG. 4. FIG. 4 is a diagram illustrating an example of a distribution of vehicles in a target area in a predetermined time. Unlike FIG. 3, FIG. 4 is a diagram illustrating a distribution of vehicles in the state of traffic reproduced by cutting out a moment included in, for example, a target time period. FIG. 4(a) shows a state where the density of vehicles is within a target area is 75%. FIG. 4(b) shows a state where the density of vehicles is within a target area is 25%. In the shown example, the target area is a linear road having a road length of 30 m, and the number of lanes is 2.

In the example shown in FIG. 4(a), a state is shown in which nine vehicles travel at a speed of 29 to 31 km/h.

In the example shown in FIG. 4(b), a state is shown in which two vehicles travel at a speed of 20 km/h, and one vehicle travels at a speed of 50 km/h.

[0031]

The density of the vehicles within the target area is obtained by the calculation expression of the following Expression (1).

The density of the vehicles = (the number of vehicles × vehicle length)/(road length × the number of lanes) ··· Expression (1)

The vehicle length refers to the average length of the vehicles in a longitudinal direction, and can be set arbitrarily.

When the state of FIG. 4(a) is substituted into the right side of Expression (1), the density of the vehicles is calculated as follows.

(Nine × 5 m)/(30 m × 2)=0.75

When the state of FIG. 4(b) is substituted into the right side of Expression (1), the density of the vehicles is calculated as follows.

(Three × 5 m)/(30 m × 2)=0.25

In this manner, the anomalous-vehicle extraction device 300 can obtain that the density of the vehicles in a state shown in FIG. 4(a) is 75%, and that the density of the vehicles in a state shown in FIG. 4(b) is 25%.

[0032]

The average speed within the target area is obtained by the calculation expression of the following Expression (2).

The average speed within the target area

= (the sum of the traveling speeds of the vehicles within the target area)/(the number of vehicles) ··· Expression (2)

When the state of FIG. 4(a) is substituted into the right side of Expression (2), the average speed within the target area is calculated as follows.

(31+30+31+30+30+30+29+30+29)/(nine) = 30 km/h

When the state of FIG. 4(b) is substituted into the right side of Expression (2), the average speed within the target area is calculated as follows.

(20+20+50)/(nine) = 30 km/h

In this manner, the anomalous-vehicle extraction device 300 can obtain that both the average speeds within the target area in the states shown in FIGS. 4(a) and 4(b) are 30 km/h.

[0033]

As shown in FIG. 4(a), in a case where vehicles traveling at a traveling speed (for example, 50 km/h) distant from an average speed (30 km/h) within a target area are mixed together in a state where the density of the vehicles is high, it can be considered that there is a high possibility that these vehicles do not correspond to the state of traffic within the target area, that is, are not able to travel within the target area at a speed corresponding to the state of traffic. Consequently, in the state shown in FIG. 4(a), the anomalous-vehicle extraction device 300 extracts a vehicle having a traveling speed of 50 km/h, assuming that the traveling conditions are anomalous as a vehicle traveling within the target area.

On the other hand, as shown in FIG. 4(b), in a state where the density of vehicles is low, the average speed within the target area is the same 30 km/h. However, even in a case where vehicles having a traveling speed of 50km/h are mixed together, it cannot be said that there is a high possibility that these vehicles do not correspond to the state of traffic, that is, are not able to travel within the target area at a speed corresponding to the state of traffic. As in the state shown in FIG. 4(b), this is because, in a case where the density (25%) of vehicles is low, a space capable of traveling at a speed higher than the average speed within the target area is sufficiently secured. Thus, a state where it can be determined that vehicles traveling at a traveling speed distant from the average speed within the target area are anomalous is limited to a case where the density of the vehicles is higher than a predetermined value, as in the state shown in FIG. 4(a).

[0034]

In addition, even in the state shown in FIG. 4(b), in a case where the traveling speed of the vehicles 400 falls outside the range of traveling speed of an ordinary road, for example, 200 km/h, the anomalous-vehicle extraction device 300 extracts a vehicle

400 having a traveling speed of 200 km/h, assuming that the traveling conditions are anomalous as a vehicle traveling within the target area.

[0035]

Further, the anomalous-vehicle extraction device 300 extracts vehicles as being anomalous in a case where the amount of time-series change in the traveling speed of the vehicle 400 is equal to or greater than a threshold, or in a case where a variation occurs in the amount of change. A specific example will be described with reference to FIG. 5. FIG. 5 is a diagram illustrating the traveling positions and the traveling speeds of the vehicle 400 on a map, on the basis of five pieces of vehicle information S11 to S15 acquired by the vehicles 400.

The pieces of the vehicle information S11 to S15 are assumed to be, for example, vehicle information generated every second. In the example shown in the drawing, the map locations of the pieces of the vehicle information S12 to S14 are assumed to be altered.

[0036]

As shown in the drawing, the pieces of the vehicle information S11 to S15 include information indicating that the traveling speed is 31 km/h. In addition, the pieces of the vehicle information S11 to S15 include information indicating the map locations are P11 to P15, respectively. The anomalous-vehicle extraction device 300 calculates the traveling speed of the vehicle 400 between the respective points on the basis of the map locations P11 to P15, and on the basis of the distance and the traveling time between the respective points. When the anomalous-vehicle extraction device 300 calculates the traveling speeds between P11 and P12 and between P14 and P15, each of the traveling speeds is assumed to be 70 km/h. On the other hand, each of the traveling speeds between P12 and P13 and between P13 and P14 is assumed to be 31 km/h. In

this manner, in a case where a variation occurs in a time-series change in the traveling speed of the vehicle 400, the anomalous-vehicle extraction device 300 extracts the vehicle 400 as an anomalous vehicle. In addition, in such a state, the anomalous-vehicle extraction device 300 may determine that the amount of time-series change in the traveling speed of the vehicle 400 is equal to or greater than a threshold determined in advance, and extract the vehicle 400 as an anomalous vehicle. The anomalous-vehicle extraction device 300 compares the pieces of traveling speed information included in the vehicle information, and thus can determine that the traveling speeds between P11 and P12 and between P14 and P15 are anomalous. In this case, the anomalous-vehicle extraction device 300 can find the pieces of the vehicle information S12 to S14 having a high possibility of the map location being altered.

[0037]

(Configuration of On-board unit 100)

Next, a configuration example of the on-board unit 100 will be described with reference to FIG. 6. FIG. 6 is a block diagram illustrating a configuration example of the on-board unit 100.

The on-board unit 100 includes a communication unit 11, a timepiece 12, a location information acquisition unit 13, a vehicle state detection unit 14, a CPU 15, a storage unit 16, and a reader-writer 17.

The communication unit 11 performs, for example, short-range communication with the roadside device 200. The communication unit 11 may perform, for example, communication with the roadside device 200 through the Internet, without being limited thereto.

The timepiece 12 clocks the current date and time, and outputs information indicating the current date and time (hereinafter, referred to as current date and time

information) to the CPU 15.

The location information acquisition unit 13 acquires location information indicating the current position of the vehicle 400 using, for example, a satellite positioning system, and outputs the location information to the CPU 15.

[0038]

The vehicle state detection unit 14 is a detection unit that detects a change in the state of the vehicle 400. The vehicle state detection unit 14 includes, for example, a sensor that detects an engine speed, and outputs information indicating the engine speed of the vehicle 400. In addition, the vehicle state detection unit 14 may include an acceleration sensor, a geomagnetic sensor or the like, and may output information indicating the traveling direction of the vehicle 400 (hereinafter, referred to as orientation information).

[0039]

The CPU 15 is a control unit that controls the on-board unit 100 as a whole. The CPU 15 includes a map-matching processing unit 101, a speed information calculation unit 102, a vehicle information generation unit 103, a vehicle information output unit 104, and a billing processing unit 105.

[0040]

The storage unit 16 has map information 121, vehicle information 122, and billing condition information 123 stored therein.

The map information 121 is information obtained by associating each point on a map with longitude and latitude and is general information which is used when a position on a map is specified from longitude and latitude in a map-matching process.

The vehicle information 122 is vehicle information generated by the vehicle information generation unit 103 and is information which is temporarily stored until the

information is transmitted to the roadside device 200.

The billing condition information 123 is information obtained by associating the position of a billing area such as a toll road with a billing fee in the billing area and is general information which is used when a billing fee calculated from the position of the vehicle 400 on a map is obtained in a billing process.

[0041]

The reader-writer 17 reads and writes amount information with respect to a charge card 500 which a predetermined amount is charged. In the billing process performed by the billing processing unit 105, the reader-writer 17 reads information indicating an amount which is charged from the charge card 500 and writes information indicating that a billing fee is paid from the read amount, in the charge card 500.

[0042]

The map-matching processing unit 101 refers to the map information 121, and specifies the position of the vehicle 400 on a map on the basis of the location information which is input from the location information acquisition unit 13. The map-matching processing unit 101 outputs information (hereinafter, referred to as map location information) indicating the specified position of the vehicle 400 on a map (hereinafter, referred to as a map location) to the vehicle information generation unit 103. The map-matching processing unit 101 may specify the position of the vehicle 400 on a map on the basis of the orientation information detected by the vehicle state detection unit 14.

[0043]

The speed information calculation unit 102 acquires the traveling speed of the vehicle 400 on the basis of the detection result of the vehicle state detection unit 14, and outputs information indicating the acquired traveling speed of the vehicle 400 (hereinafter, referred to as traveling speed information) to the vehicle information

generation unit 103. For example, on the basis of an output of a sensor that detects the engine speed among sensors included in the vehicle state detection unit 14, the speed information calculation unit 102 calculates the traveling speed of the vehicle 400 corresponding to the detected engine speed.

[0044]

The vehicle information generation unit 103 generates vehicle information indicating the map location, the traveling speed, and the traveling date and time of the vehicle 400 at a generation timing of the vehicle information, on the basis of the map location information which is input from the map-matching processing unit 101, the traveling speed information which is input from the speed information calculation unit 102, and the current date and time information which is input from the timepiece 12. The generation timing of the vehicle information is set after the elapse of a predetermined time or after traveling of a predetermined distance, for example, from the time when the preceding vehicle information has been generated. In the former case, in a case where it is determined that a predetermined time has elapsed from the time when the preceding vehicle information has been generated, on the basis of the information which is input from the timepiece 12, the vehicle information generation unit 103 generates vehicle information indicating the map location, the traveling speed, and the traveling date and time of the vehicle 400 at the time of the determination. In the latter case, in a case where it is determined that the vehicle 400 has traveled by a predetermined distance from a map location when the preceding vehicle information has been generated, on the basis of the information which is input from the speed information calculation unit 102, the vehicle information generation unit 103 generates vehicle information indicating the map location, the traveling speed, and the traveling date and time of the vehicle 400 at the time of the determination. The vehicle information

generation unit 103 outputs the generated vehicle information to the vehicle information output unit 104 and the billing processing unit 105.

The vehicle information generation unit 103 generates vehicle information including unique identification information allocated to the on-board unit 100. In addition, the vehicle information generation unit 103 may generate information indicating the map location obtained by the map-matching processing unit 101, as the map location information, by the link ID or the node ID.

[0045]

The vehicle information output unit 104 outputs the vehicle information generated by the vehicle information generation unit 103 to the roadside device 200 through the communication unit 11. In addition, the vehicle information output unit 104 outputs information indicating the result of the billing process (hereinafter, referred to as billing information) performed by the billing processing unit 105 to the roadside device 200 through the communication unit 11.

[0046]

The billing processing unit 105 refers to the billing condition information 123, and executes the billing process on the basis of the vehicle information which is input from the vehicle information generation unit 103. Specifically, in a case where the map location of the vehicle 400 is located within a billing area which is a target for billing, the billing processing unit 105 calculates a billing fee which is charged to the vehicle 400. The billing processing unit 105 subtracts the calculated billing fee from the deposit amount deposited to the charge card 500, through the reader-writer 17.

The billing processing unit 105 outputs the billing information indicating the result of the executed billing process to the vehicle information output unit 104. The billing processing unit 105 includes information indicating the billing date and time when

the billing process is executed, in the billing information, on the basis of the output from the timepiece 12.

[0047]

(Configuration of Anomalous-Vehicle Extraction Device 300)

Next, a configuration example of the anomalous-vehicle extraction device 300 will be described with reference to FIG. 7. FIG. 7 is a block diagram illustrating a configuration example of the anomalous-vehicle extraction device 300.

The anomalous-vehicle extraction device 300 includes a communication unit 31, a registration unit 32, a vehicle information data base (DB) 33, an estimation information data base (DB) 34, a billing-information DB 35, a CPU 36, and a notification unit 37.

The communication unit 31 receives, for example, the vehicle information and the billing information from the roadside device 200 through the Internet. The communication unit 31 outputs the received information to the registration unit 32. In addition, the communication unit 31 may output notification information which is input from the notification unit 37 to an external notification device (not shown).

The registration unit 32 writes the map location, the traveling speed, and the traveling date and time in the vehicle information DB 33 in association therewith, for each on-board unit 100, on the basis of the vehicle information which is input from the communication unit 31. In addition, the registration unit 32 writes the billing fee and the billing date and time in the billing-information DB 35 in association therewith, for each on-board unit 100, on the basis of the billing information which is input from the communication unit 31.

[0048]

Information obtained by associating the map location, the traveling speed, and the traveling date and time with, for example, unique identification information for

identifying each on-board unit 100 (hereinafter, referred to as an on-board unit ID) is stored in the vehicle information DB 33.

Information for estimating the state of traffic is stored in the estimation information DB 34. For example, information for simulating the state of traffic in accordance with conditions, information for obtaining the average state of traffic on the basis of the past vehicle information, and the like are stored in the estimation information DB 34.

For example, information obtained by associating billing fee and the billing date and time with the on-board unit ID is stored in the billing-information DB 35.

[0049]

The CPU 36 includes a determination unit 301, a traffic state value calculation unit 302, a traveling speed calculation unit 303, an anomalous-vehicle extraction unit 304, a traffic state estimation unit 305, a learning unit 306, and a correction unit 307.

[0050]

The determination unit 301 determines whether either the traffic state value calculation unit 302 or the traffic state estimation unit 305 is selected as a target which is instructed to calculate the state of traffic. The determination unit 301 calculates the density of the vehicle information within a target area on the basis of the vehicle information stored in the vehicle information DB 33 and determines whether the calculated density of the vehicle information is equal to or greater than a threshold determined in advance. The determination unit 301 calculates the density of the vehicle information in accordance with, for example, the calculation expression of the following Expression (3).

The density of the vehicle information = (the sum of the vehicle information within a target area in a target time period)/(road length × the number of lanes) ···

Expression (3)

The sum of the vehicle information within the target area in the target time period refers to the number of pieces of the vehicle information in which the traveling time included in the vehicle information is included in the target time period, and the map location included in the vehicle information is included within the target area.

[0051]

In a case where the calculated density of the vehicle information is less than a threshold, the determination unit 301 instructs the traffic state estimation unit 305 to calculate the state of traffic in the target area. On the other hand, in a case where the calculated density of the vehicle information is equal to or greater than the threshold, the determination unit 301 calculates the variance value of speeds on the basis of the traveling speed information included in the vehicle information. In a case where the variance value is equal to or greater than the threshold determined in advance, the determination unit 301 instructs the traffic state estimation unit 305 to calculate the state of traffic in the target area. On the other hand, in a case where the variance value is less than the threshold determined in advance, the determination unit 301 instructs the traffic state value calculation unit 302 to calculate the state of traffic in the target area.

The determination unit 301 may execute a determination process for each predetermined time interval, and may execute the determination process by an operator giving an instruction for the start of the determination process through an operating unit which is not shown in the drawing.

[0052]

In a case where the determination unit 301 gives an instruction for the calculation of the traffic state value, the traffic state value calculation unit 302 calculates a traffic state value indicating the state of traffic within a predetermined target area in a

predetermined target time period, on the basis of the vehicle information stored in the vehicle information DB 33. The traffic state value calculation unit 302 substitutes information indicated by the vehicle information or the like, as the traffic state value, into Expression (1), and calculates the density of the vehicles within the target area. In addition, the traffic state value calculation unit 302 substitutes information indicated by the vehicle information or the like, as the traffic state value, into Expression (2), and calculates an average speed within the target area. In addition, the traffic state value calculation unit 302 may extract only vehicles having traveling speeds included within a back-and-forth predetermined range on the basis of the average speed within the target area, and may calculate the density of the vehicles within the target area.

[0053]

The speed within the target area which is calculated by the traffic state value calculation unit 302 may preferably be a speed corresponding to a flow of the vehicles within the target area, without being limited to the average value of the traveling speeds of the vehicles within the target area. For example, the traffic state value calculation unit 302 may obtain a speed corresponding to a flow of the vehicles within the target area on the basis of the variance value based on a legal speed determined in advance in the target area. In addition, the traffic state value calculation unit 302 may exclude the vehicle information acquired by the on-board unit 100 having a drastic change in traveling speed on the basis of vehicle information generated at a different timing from the same on-board unit 100, from a target when a speed within the target area is calculated. Thereby, since the vehicle information of the vehicle 400 having its speed changed temporarily is not included, it is possible to obtain a more accurate traffic state value.

[0054]

The traveling speed calculation unit 303 calculates a traveling speed between two points of the vehicle on the basis of the vehicle information stored in the vehicle information DB 33, and on the basis of the position of the same vehicle indicated by the vehicle information. The traveling speed calculation unit 303 calculates the traveling speed as described with reference to FIG. 5.

[0055]

The anomalous-vehicle extraction unit 304 extracts a vehicle of which the traveling conditions indicated by the vehicle information are anomalous as a vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit 302 or the traffic state estimation unit 305. The anomalous-vehicle extraction unit 304 calculates the traveling speed as described with reference to FIGS. 6 and 7.

[0056]

In a case where the determination unit 301 gives an instruction for the calculation of the traffic state value, the traffic state estimation unit 305 estimates a traffic state value indicating the state of traffic within a predetermined target area in a predetermined target time period, on the basis of the estimation information stored in the estimation information DB 34. The traffic state estimation unit 305 may obtain the average value of the state of traffic within the predetermined target area in the predetermined target time period, on the basis of the past vehicle information, and may use the average value as a traffic state value. In addition, the traffic state estimation unit 305 may use a simulator to simulate the state of traffic of traveling within the target area on the basis of the current condition, and thus may calculate a traffic state value indicating the state of traffic within the predetermined target area in the predetermined target time period.

[0057]

The learning unit 306 causes the estimation information DB 34 to learn in accordance with a processing result of the anomalous-vehicle extraction unit 304. Specifically, in a case where an anomalous vehicle is detected, the learning unit 306 causes it to learn the estimation information of the estimation information DB 34 on the basis of the vehicle information DB 33, with the exception of the vehicle information corresponding to the detected anomalous vehicle. In a case where the anomalous vehicle is not detected, the learning unit 306 causes it to learn the estimation information of the estimation information DB 34 on the basis of the vehicle information DB 33.

[0058]

The correction unit 307 generates information for correcting a billing status with respect to the anomalous vehicle extracted by the anomalous-vehicle extraction unit 304. For example, the correction unit 307 generates information for correcting the billing information stored in the billing-information DB 35. Without being limited thereto, the correction unit 307 may generate information for correcting billing information of a server, provided outside, which manages a billing process, and may transmit the generated information to the server through the communication unit 31.

[0059]

In addition, in a case where a vehicle having a high possibility of the map location being altered is found from the anomalous vehicles by the anomalous-vehicle extraction device 300, the correction unit 307 obtains a map location at which the vehicle having a high possibility of the map location being altered is more likely to travel in reality. For example, on the roads shown in FIG. 2, the map location information indicating passage through the links L6 to L8 is included in the vehicle information acquired from the vehicle 400, but the traveling conditions of the links L6 to L8 are

determined to be anomalous, and the vehicle is assumed to be extracted as an anomalous vehicle. In this case, the correction unit 307 determines whether branch roads other than the link L6 are present. In the example shown in the drawing, since the links L2 to L4 are branched from the link L1, the correction unit 307 determines that branch roads other than the link L6 are present, and determines whether the vehicle 400 corresponds to the state of traffic of the links L2 to L4, on the basis of the traffic state values of the links L2 to L4. In a case where it is determined that the vehicle 400 corresponds to the state of traffic of the links L2 to L4, information corresponding to the links L2 to L4 is acquired as a map location at which the vehicle 400 is more likely to travel in reality. Thereby, since the vehicle 400 is more likely to travel in reality along the links L2 to L4 which are a toll road, the correction unit 307 writes information, indicating that the billing process is required to be executed on the vehicle 400, in the billing-information DB 35. The correction unit 307 may cause the notification unit 37 to give notice that the execution of the billing process is required.

[0060]

In a case where the anomalous vehicle is extracted by the anomalous-vehicle extraction unit 304, the notification unit 37 gives notice of the extracted vehicle being an anomalous vehicle. The notification unit 37 may be a display, a speaker or the like that outputs notification information, and may output the notification information to the on-board unit 100 or an external notification device through the communication unit 31.

[0061]

(Example of Process Performed by On-board unit)

Next, an example of a process performed by the on-board unit 100 will be described with reference to FIG. 8. FIG. 8 is a flow diagram illustrating an example of a process performed by the on-board unit 100. To begin with, the power supply of the

vehicle 400 is turned on, and thus the power supply of the on-board unit 100 is also turned on.

[0062]

(Step ST101)

When the power supply of the on-board unit 100 is turned on, the vehicle information generation unit 103 determines whether it is the generation timing of the vehicle information. For example, the vehicle information generation unit 103 determines whether a predetermined time has elapsed from the time when the preceding vehicle information has been generated, or whether traveling by a predetermined distance has been performed.

(Step ST102)

In a case where it is determined that it is the generation timing of the vehicle information (Step ST101: YES), the vehicle information generation unit 103 instructs the map-matching processing unit 101 to acquire a map location through a map-matching process. The map-matching processing unit 101 acquires the position of the current vehicle 400 on a map, for example, on the basis of information which is output by the location information acquisition unit 13, in accordance with the instruction of the vehicle information generation unit 103, and outputs the map location information to the vehicle information generation unit 103.

(Step ST103)

In addition, the vehicle information generation unit 103 instructs the speed information calculation unit 102 to acquire a traveling speed. The speed information calculation unit 102 acquires the traveling speed of the current vehicle 400 on the basis of the engine speed which is output by the vehicle state detection unit 14, in accordance with the instruction of the vehicle information generation unit 103, and outputs the

traveling speed information to the vehicle information generation unit 103.

(Step ST104)

The vehicle information generation unit 103 generates vehicle information on the basis of the map location information which is input from the map-matching processing unit 101, and the traveling speed information which is input from the speed information calculation unit 102.

The vehicle information generation unit 103 outputs the generated vehicle information to the vehicle information output unit 104 and the billing processing unit 105.

[0063]

(Step ST105)

When the vehicle information is input from the vehicle information generation unit 103, the billing processing unit 105 refers to the billing condition information 123, and determines whether the map location of the vehicle 400 is within a billing area which is a target for billing, on the basis of the input vehicle information.

(Step ST106)

In a case where it is determined that the map location of the vehicle 400 is within the billing area (Step ST105: YES), the billing processing unit 105 calculates a billing fee which is charged to the vehicle 400 on the basis of the vehicle information which is input from the vehicle information generation unit 103, and subtracts the calculated billing fee from a deposit amount which is deposited to the charge card 500 through the reader-writer 17. The billing processing unit 105 outputs billing information indicating the result of the executed billing process to the vehicle information output unit 104, and writes the billing information in the billing condition information 123.

[0064]

(Step ST107)

Next, the vehicle information output unit 104 determines whether it is an output timing at which the vehicle information is output.

(Step ST108)

In a case where it is determined that it is the output timing of the vehicle information (Step ST107: YES), the vehicle information output unit 104 outputs the vehicle information which is input from the vehicle information generation unit 103 and the vehicle information 122 which is read out from the storage unit 16, to an external device designated in advance, through the communication unit 11.

(Step ST109)

On the other hand, in a case where it is not determined that it is the output timing of the vehicle information (Step ST107: NO), the vehicle information output unit 104 writes the vehicle information which is input from the vehicle information generation unit 103 in the vehicle information 122 of the storage unit 16.

[0065]

(Example of Entire Process of Anomalous-vehicle Extraction Device 300)

Next, an example of the entire process performed by the anomalous-vehicle extraction device 300 will be described with reference to FIG. 9. FIG. 9 is a flow diagram illustrating an example of the entire process performed by the anomalous-vehicle extraction device 300. The anomalous-vehicle extraction device 300 sequentially designates target time periods and target areas, and executes the following processes for each of the target areas in the target time periods.

(Step ST201)

In a case where the target time periods and the target areas are designated, the

determination unit 301 determines whether the state of traffic is estimated. In other words, the determination unit 301 determines whether either the traffic state value calculation unit 302 or the traffic state estimation unit 305 is selected as a target which is instructed to calculate the traffic state value. In the present embodiment, the determination unit 301 reads out vehicle information corresponding to the designated target time period and target area from the vehicle information DB 33, and calculates the density of the vehicle information in the target area of the designated target time period. For example, it is assumed that a link LX is designated as the target area, and that 13: 00 to 13: 10, a certain month a certain day is designated as the target time period. In addition, the determination unit 301 calculates the variance value of traveling speeds on the basis of the traveling speed information included in the vehicle information.

[0066]

(Step ST202)

In a case where the density of vehicle information in the link LX is equal to or greater than a threshold, and the variance value is less than the threshold, the determination unit 301 determines that the state of traffic is not required to be estimated (Step ST201: NO).

In this case, the determination unit 301 instructs the traffic state value calculation unit 302 to calculate the traffic state value of the target area. The traffic state value calculation unit 302 then reproduces the state of traffic of vehicles within the target area on the basis of vehicle information indicating that vehicles are present within the link LX which is a target area in the target time period (13: 00 to 13: 10, a certain month a certain day), among the pieces of the vehicle information stored in the vehicle information DB 33, and calculates a traffic state value indicating the state of traffic within a predetermined target area in a predetermined target time period. The

reproduction of the state of traffic refers to, for example, an operation for obtaining the number of vehicles 400 present in a target area, the positional relationship therebetween, the average speed thereof, the density of the vehicles 400, and the like at each time in a target time period.

[0067]

(Step ST203)

On the other hand, in a case where the density of the vehicle information in the link LX is less than a threshold, or the density of the vehicle information in the link LX is equal to or greater than the threshold, and the variance value is equal to or greater than a threshold, the determination unit 301 determines that the state of traffic is required to be estimated (Step ST201: YES). In this case, the determination unit 301 instructs the traffic state estimation unit 305 to calculate the traffic state value of the target area. The traffic state estimation unit 305 then estimates the status of vehicles (for example, information indicating the map locations and traveling speeds of traveling vehicles) within the target area estimated in the target time period on the basis of the estimation information stored in the estimation information DB 34, and obtains an estimation result.

(Step ST204)

The traffic state estimation unit 305 then reproduces the state of traffic of vehicles within the target area on the basis of the estimation result obtained in step ST203, and calculates a traffic state value indicating the state of traffic within a predetermined target area in a predetermined target time period.

[0068]

(Step ST205)

Next, the anomalous-vehicle extraction unit 304 executes an anomalous-vehicle extraction process for extracting a vehicle of which the traveling conditions indicated by

the vehicle information are anomalous as a vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit 302 or the traffic state estimation unit 305. The details of the process contents will be described later with reference to FIG. 10.

(Step ST206)

The anomalous-vehicle extraction unit 304 determines whether an anomalous vehicle is extracted in the process of step ST205.

[0069]

(Step ST207)

In a case where it is determined that the anomalous vehicle is extracted (Step ST206: YES), the anomalous-vehicle extraction unit 304 causes the notification unit 37 to give notice of the anomalous vehicle being extracted.

(Step ST208)

The learning unit 306 then causes the estimation information DB 34 to learn in accordance with the processing result of the anomalous-vehicle extraction unit 304. Specifically, in a case where the anomalous vehicle is detected in step ST207, the learning unit 306 causes it to learn the estimation information of the estimation information DB 34 on the basis of the vehicle information DB 33, with the exception of the vehicle information corresponding to the detected anomalous vehicle. In a case where the anomalous vehicle is not detected in step ST207, the learning unit 306 causes it to learn the estimation information of the estimation information DB 34 on the basis of the vehicle information DB 33.

(Step ST209)

The anomalous-vehicle extraction unit 304 determines whether the anomalous-vehicle extraction process is terminated with respect to all the target areas.

In a case where it is determined that the anomalous-vehicle extraction process is not terminated with respect to all the target areas (Step ST209: NO), the anomalous-vehicle extraction unit 304 returns to step ST201, and the process is repeated. On the other hand, in a case where it is determined that the anomalous-vehicle extraction process is terminated with respect to all the target areas (Step ST209: YES), the anomalous-vehicle extraction unit 304 terminates the process.

[0070]

(Example of Anomalous-vehicle Extraction Process)

Next, an example of the anomalous-vehicle extraction process will be described with reference to FIG. 10. FIG. 10 is a flow diagram illustrating an example of the anomalous-vehicle extraction process. The process shown in FIG. 10 is equivalent to the process of step ST205 shown in FIG. 9.

(Step ST301)

The anomalous-vehicle extraction unit 304 acquires an average speed for each target area, as the traffic state value from the traffic state value calculation unit 302 or the traffic state estimation unit 305. The anomalous-vehicle extraction unit 304 may acquire the average speed for each target area which is calculated by the traffic state value calculation unit 302 or the traffic state estimation unit 305 and may calculate the average speed for each target area by itself, on the basis of the traffic state value from the traffic state value calculation unit 302 or the traffic state estimation unit 305.

(Step ST302)

Next, the anomalous-vehicle extraction unit 304 acquires the density of vehicles for each target area, on the basis of the traffic state value from the traffic state value calculation unit 302 or the traffic state estimation unit 305. The anomalous-vehicle extraction unit 304 may acquire the density of vehicles for each target area calculated by

the traffic state value calculation unit 302 or the traffic state estimation unit 305, and may calculate the density of vehicles for each target area by itself, on the basis of the traffic state value from the traffic state value calculation unit 302 or the traffic state estimation unit 305.

[0071]

(Step ST303)

The anomalous-vehicle extraction unit 304 determines whether the density of vehicles calculated in step ST302 is equal to or greater than a threshold determined in advance.

(Step ST304)

In a case where it is determined that the density of vehicles is equal to or greater than the threshold (Step ST303: YES), the anomalous-vehicle extraction unit 304 set an allowable range determined in advance in accordance with the density of vehicles. For example, it can be considered that a difference between the traveling speeds of vehicles is small in a case where the density of vehicles is high, and a difference between the traveling speeds of vehicles is large in a case where the density of vehicles is low. It is assumed that the allowable range in a case where the density of vehicles is equal to or greater than 90% is set to ±5 km/h, the allowable range in a case where the density of vehicles is equal to or greater than 80% and less than 90% is set to ±7 km/h, ..., and that the allowable range in a case where the density of vehicle is equal to or greater than 50% and less than 60% is set to ±12 km/h. Although not shown, information indicating the allowable ranges which are set in accordance with these densities is stored in the storage unit having the anomalous-vehicle extraction unit 304 built-in.

[0072]

(Step ST305)

Next, the anomalous-vehicle extraction unit 304 determines, for each vehicle, whether the traveling speed included in the vehicle information diverges from the average speed within the target area calculated in step ST301, on the basis of the vehicle information indicating that the vehicle 400 is present in the target area in the target time period, among the pieces of the vehicle information stored in the vehicle information DB 33. Specifically, the anomalous-vehicle extraction unit 304 determines whether the traveling speed included in the vehicle information is included in the allowable range based on the average speed within the target area. For example, in a case where the numeral of the average speed within the target area is included within the allowable range, the anomalous-vehicle extraction unit 304 determines that the traveling speed included in the vehicle information is included within the allowable range based on the average speed within the target area. Without being limited thereto, in a case where the ratio of the numeral of the average speed within the target area to the numeral of the traveling speed included in the vehicle information is included within a predetermined range, the anomalous-vehicle extraction unit 304 may determine that the traveling speed included in the vehicle information is included within the allowable range based on the average speed within the target area.

[0073]

(Step ST306)

In a case where it is determined that the traveling speed included in the vehicle information diverges from the average speed within the target area (Step ST305: YES), the anomalous-vehicle extraction unit 304 extracts a vehicle of which the traveling speed included in the vehicle information is not included within the allowable range based on the average speed within the target area, as an anomalous vehicle.

[0074]

(Step ST307)

The anomalous-vehicle extraction unit 304 then determines whether the anomalous-vehicle extraction process is executed on all the vehicles, on the basis of the vehicle information indicating that the vehicle 400 is present in the target area in the target time period, among the pieces of the vehicle information stored in the vehicle information DB 33. In a case where it is not determined that the anomalous traveling extraction process is executed on all the vehicles (Step ST307: NO), the anomalous-vehicle extraction unit 304 returns to step ST304, and the process is repeated. On the other hand, in a case where it is determined that the anomalous traveling extraction process is executed on all the vehicles (Step ST307: YES), the anomalous-vehicle extraction unit 304 terminates the process.

[0075]

(Step ST308)

In the determination of step ST303, in a case where it is determined that the density of vehicles is less than a threshold (Step ST303: NO), the anomalous-vehicle extraction unit 304 calculates a traveling speed between at least two points of the vehicle 400 indicated by the map location included in the vehicle information, on the basis of the vehicle information indicating that the vehicle 400 is present in the target area in the target time period, among the pieces of the vehicle information stored in the vehicle information DB 33. For example, the anomalous-vehicle extraction unit 304 calculates a traveling speed between two points of a map location P1 at time T1 when vehicle information S1 is generated and a map location P2 at time T2 when the next vehicle information S2 is generated, in accordance with the following Expression (4), on the basis of the pieces of the vehicle information S1 and S2 acquired from the same on-board unit 100 at different timings.

Traveling speed = (distance from P1 to P2)/(time T2 - time T1) ··· Expression (4)

[0076]

(Step ST309)

The anomalous-vehicle extraction unit 304 determines whether the traveling speed itself of the vehicle 400 calculated in step ST308 is anomalous. For example, a vehicle traveling along an ordinary road at 200 km/h is anomalous. In a case where the traveling speed of the vehicle 400 calculated in step ST308 is equal to or greater than an anomalous speed determined in advance, the anomalous-vehicle extraction unit 304 determines that the traveling speed itself is anomalous (Step ST309: YES), and proceeds to step ST311.

[0077]

(Step ST310)

In a case where the traveling speed of the vehicle 400 calculated in step ST308 is less than the anomalous speed determined in advance (Step ST309: NO), the anomalous-vehicle extraction unit 304 determines whether a change in the traveling speed of the vehicle 400 calculated in step ST308 is anomalous. For example, in a case where the traveling speed after a few seconds changes drastically, or a drastic change is repeated, an vehicle traveling in this manner is anomalous. In a case where a variation occurs in a time-series change in the traveling speed of the vehicle 400 calculated in step ST308, or the amount of time-series change in the traveling speed of the vehicle 400 calculated in step ST308 is equal to or greater than a threshold determined in advance, the anomalous-vehicle extraction unit 304 determines that a time-series change in traveling speed is anomalous (Step ST310: YES), and proceeds to step ST311.

[0078]

(Step ST311)

In a case where it is determined to be anomalous in step ST309 or step ST310 (Step ST309: YES, step ST310: YES), the anomalous-vehicle extraction unit 304 extracts the vehicle determined to be anomalous as an anomalous vehicle.

[0079]

(Step ST312)

The anomalous-vehicle extraction unit 304 then determines whether the anomalous-vehicle extraction process is executed on all the vehicles, on the basis of the vehicle information indicating that the vehicle 400 is present in the target area in the target time period, among the pieces of the vehicle information stored in the vehicle information DB 33. In a case where it is not determined that the anomalous traveling extraction process is executed on all the vehicles (Step ST312: NO), the anomalous-vehicle extraction unit 304 returns to step ST308, and the process is repeated. On the other hand, in a case where it is determined that the anomalous traveling extraction process is executed on all the vehicles (Step ST312: YES), the anomalous-vehicle extraction unit 304 terminates the process.

[0080]

(Other Substitutions or Changes of Each Configuration)

Besides, the components in the above-described embodiment can be appropriately replaced with well-known components without departing from the spirit and scope of the present invention. In addition, the technical scope of the present invention is not limited to the aforementioned embodiment, and various changes and modifications can be added without departing from the spirit and scope of the present invention.

[0081]

For example, a description has been given in which the anomalous-vehicle extraction unit 304 of the anomalous-vehicle extraction device 300 extracts the anomalous vehicle on the basis of the traffic state value, but there is no limitation thereto. For example, the anomalous-vehicle extraction unit 304 may determine whether the anomalous vehicle is present on the basis of the vehicle information of the target area in the target time period which is read out from the vehicle information DB 33. As described above, the anomalous-vehicle extraction unit 304 extracts the vehicle having a traveling speed of 200 km/h, as the vehicle of which the traveling conditions are anomalous as a vehicle traveling within the target area. In addition, in a case where the amount of time-series change in the traveling speed of the vehicle 400 is equal to or greater than a threshold, or a variation occurs in the amount of change, the anomalous-vehicle extraction unit 304 extracts the vehicle as an anomalous vehicle.

[0082]

The billing processing unit 105 is not limited to performing a process of paying a billing fee with respect to the charge card 500 and may execute a process of paying a billing fee using a credit card or the like.

[0083]

The on-board unit 100 may be connected to a central server (not shown) that delivers the map information, the billing condition information, or the like. Thereby, the on-board unit 100 can specify the map location of the vehicle 400 on the basis of the latest map information, and include the specified map information in the vehicle information. In addition, the on-board unit 100 can execute a billing process on the basis of the latest billing condition information. Thereby, it is possible to increase the reliability of a billing system.

[0084]

The on-board unit 100 is not limited to a device including the map location obtained by the map-matching processing unit 101 in the vehicle information and may be a device including information acquired by the location information acquisition unit 13, as it is, in the vehicle information.

[0085]

The traffic state value calculation unit 302 and the anomalous-vehicle extraction unit 304 may exclude a parked vehicle. In this case, the on-board unit 100 includes information indicating that the engine (ignition) of the vehicle 400 is turned off in the vehicle information, and transmits the information to the anomalous-vehicle extraction device 300.

The traffic state value calculation unit 302 and the anomalous-vehicle extraction unit 304 execute a predetermined process with the exception of information of a vehicle of which the engine is turned off.

[0086]

A description has been given of an example in which the billing process is executed by the on-board unit 100, but the billing process may be executed by an external server.

[0087]

When it is determined whether the state of traffic is estimated, the determination unit 301 is not limited to an example of making a determination on the basis of the density of the vehicle information and the variance value of the traveling speeds. For example, the determination unit 301 may instruct the traffic state value calculation unit 302 to calculate the traffic state value in a case where the density of the vehicle information is equal to or greater than a threshold, and may instruct the traffic state estimation unit 305 to calculate the traffic state value in a case where the density of the

vehicle information is less than the threshold.

[0088]

(Operation and Effect)

As described above, the anomalous-vehicle extraction device 300 according to the present embodiment includes the anomalous-vehicle extraction unit 304 that extracts a vehicle of which the traveling conditions indicated by the vehicle information are anomalous as a vehicle traveling within the target area, on the basis of the vehicle information indicating the position and traveling speed of the on-board unit mounted in the vehicle.

With such a configuration, the anomalous-vehicle extraction device 300 can extract an anomalous vehicle having the possibility of information acquired by the on-board unit being different from the status of an actual vehicle. Thereby, it is possible to specify an illegal passing vehicle which has vehicle information acquired by the on-board unit altered using some kind of method, and attempts to evade paying a toll fee regardless of the vehicle traveling along a toll road originally, and to improve the reliability of the billing system. In addition, it is possible to prevent traffic information indicating a traffic jam or a congestion situation from being generated on the basis of a situation different from actual traveling information.

[0089]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment includes the traffic state value calculation unit 302 that calculates a traffic state value indicating the state of traffic within a predetermined target area in a predetermined target time period, on the basis of the vehicle information indicating the position and traveling speed of the on-board unit mounted in the vehicle.

In addition, the anomalous-vehicle extraction device 300 according to the

present embodiment extracts a vehicle as being anomalous in a case where the amount of deviation between a speed in the target area and a traveling speed indicated by actual vehicle information exceeds a predetermined allowable range.

With such a configuration, the anomalous-vehicle extraction device 300 can detect an anomalous vehicle on the basis of the state of traffic. Thereby, even in a case where the traveling speed itself of a vehicle or a change in traveling speed is not anomalous, it is possible to determine anomaly for each vehicle 400 on the basis of a relative relation with another vehicle traveling along the same road. Thus, it is possible to extract a vehicle having a high possibility of not corresponding to the state of traffic within the target area, that is, not being able to travel within the target area at a speed corresponding to the state of traffic, as an anomalous vehicle, and to extract a vehicle that pretends to travel within the target area by altering the vehicle information.

[0090]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment extracts a vehicle as being anomalous in a case where the density of vehicles within the target area indicated by the traffic state value is higher than a threshold, and the amount of deviation between a speed in the target area indicated by the traffic state value and a traveling speed indicated by actual vehicle information exceeds a predetermined allowable range.

With such a configuration, an anomalous vehicle is detected on the basis of the state of traffic in a state where the density of vehicles traveling within the target area is higher than a threshold. In the state of traffic where the density of vehicles is high, it is possible to acquire a lot of vehicle information acquired from the on-board unit. Therefore, it is possible to calculate a traffic state value indicating the average state of traffic from a plurality of pieces of vehicle information. In addition, in the state of

traffic where the density of vehicles is high, it can be considered that the interval with another vehicle is small, and that a space capable of traveling at a speed greater than the average speed within the target area is not sufficiently secured. For this reason, a speed capable of traveling within the target area is dependent on the state of traffic and is close to a speed indicated by the state of traffic within the target area. In this manner, since an anomalous vehicle can be detected on the basis of the traffic state value in a state where the traveling speed of a vehicle traveling within the target area is restricted to some extent, it is possible to improve the detection accuracy of an anomalous vehicle.

[0091]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment further includes the traveling speed calculation unit 303 that calculates the traveling speed of the vehicle 400 on the basis of position information of at least two points of the vehicle 400 indicated by the vehicle information acquired from the same on-board unit 100 at different timings.

With such a configuration, it is possible to calculate the traveling speed of a vehicle from the position of the vehicle on the basis of the position of the vehicle included in the vehicle information. In a case where the position of the vehicle included in the vehicle information is altered, it can be considered that there is a high possibility of the traveling speed of the vehicle calculated from the position of the vehicle diverging from actual traveling speed. Thus, it is possible to extract a vehicle having a high possibility of the position of the vehicle included in the vehicle information being altered, as an anomalous vehicle.

[0092]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment further includes the traffic state estimation unit 305 that estimates

the state of traffic within a predetermined target area in a predetermined target time period in a case where the density of the vehicle information within the predetermined target area in the predetermined target time period is less than a threshold.

With such a configuration, the traffic state estimation unit 305 estimates the state of traffic in the predetermined target area in the predetermined target time, in a case where the amount of vehicle information within the predetermined target area in the predetermined target time period is small. Here, since only a small amount of vehicle information can be acquired in a case where the density of the vehicle information is low, there may be concern that the state of traffic is evaluated on the basis of incorrect vehicle information, or the state of traffic is evaluated by the state of a vehicle which is in a special state accidentally. However, in a case where the density of the vehicle information is lower than a threshold, the state of traffic is estimated without obtaining a traffic state value through the vehicle information acquired in the target time period, and the traffic state value is calculated on the basis of the estimated state of traffic, thereby allowing an anomalous vehicle to be extracted on the basis of the average state of traffic even in a target area where the density of the vehicle information is low.

[0093]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment further includes the notification unit 37 that gives notice of an anomalous vehicle.

With such a configuration, information relating to the anomalous vehicle can be notified to a manager who manages fee payment regarding a toll road, an observer who monitors a traffic status on the basis of the vehicle information, or a driver of a vehicle which is determined to be an anomalous vehicle.

[0094]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment further includes the correction unit 307 that generates information for correcting a billing status regarding a vehicle which is determined to be anomalous by the anomalous-vehicle extraction unit 304.

With such a configuration, the information for correcting a billing status to be corrected is generated, and a process for correcting the billing status is facilitated.

[0095]

In addition, the anomalous-vehicle extraction device 300 according to the present embodiment uses a map location included in the vehicle information in a case where the traffic state value is calculated.

With such a configuration, it is possible to improve the reproduction accuracy of the state of traffic, as compared with a case that information indicating longitude and latitude as position information of a vehicle.

[0096]

A program for realizing functions of the on-board unit 100 and the anomalous-vehicle extraction device 300 in the present invention may be recorded in a computer readable recording medium, and thus a process of each unit may be performed by causing a computer system to read and execute the program recorded in this recording medium. The term "computer system" as used herein is assumed to include an OS or hardware such as peripheral devices. In addition, the "computer system" is also assumed to include a WWW system provided with a homepage providing environment (or a display environment). In addition, the term "computer readable recording medium" refers to a flexible disk, a magneto-optic disc, a ROM, a portable medium such as a CD-ROM, and a storage device such as a hard disk built into the computer system. Further, the "computer readable recording medium" is also assumed to include a medium

that holds a program for a certain period of time like a volatile memory (RAM) inside a computer system serving as a server or a client when the program is transmitted through networks such as the Internet or communication lines such as a telephone line.

[0097]

In addition, the above program may be transmitted from a computer system having the program stored in a storage device or the like through a transmission medium or through transmitted waves in the transmission medium to other computer systems. Here, the "transmission medium" that transmits a program refers to a medium having a function of transmitting information like networks (communication networks) such as the Internet or communication channels (communication lines) such as a telephone line. In addition, the above-mentioned program may realize a portion of the above-mentioned functions. Further, the above-mentioned program may be a so-called difference file (difference program) capable of realizing the above-mentioned functions by a combination with a program which is already recorded in a computer.

[Industrial Applicability]

[0098]

According to the device, the method, and the program described above, it is possible to detect a vehicle having the possibility of the vehicle position acquired by the on-board unit being different from the position of an actual vehicle.

[Reference Signs List]

[0099]

1: anomalous-vehicle extraction system

100: on-board unit

200: roadside device

201: roadside antenna

300: anomalous-vehicle extraction device

500: charge card

11: communication unit

12: timepiece

13: location information acquisition unit

14: vehicle state detection unit

15: CPU

16: storage unit

17: reader-writer

101: map-matching processing unit

102: speed information calculation unit

103: vehicle information generation unit

104: vehicle information output unit

105: billing processing unit

121: map information

122: vehicle information

123: billing condition information

31: communication unit

32: registration unit

33: vehicle information DB

34: estimation information DB

35: billing-information DB

36: CPU

37: notification unit

301: determination unit

302: traffic state value calculation unit

303: traveling speed calculation unit

304: anomalous-vehicle extraction unit

305: traffic state estimation unit

306: learning unit

307: correction unit

CLAIMS

1. An anomalous-vehicle extraction device comprising:

a traffic state value calculation unit that is configured to calculate a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle; and

an anomalous-vehicle extraction unit that is configured to extract the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit, and the vehicle information acquired from the on-board unit of each vehicle,

wherein the anomalous-vehicle extraction unit is configured to acquire a speed within the target area and a density of vehicles within the target area as the traffic state value calculated by the traffic state value calculation unit, and determine that the traveling conditions of the vehicle are anomalous in a case where the density of vehicles within the target area is higher than a threshold and an amount of deviation between the speed within the target area and the traveling speed of the vehicle indicated by the vehicle information exceeds a predetermined allowable range.

2. The anomalous-vehicle extraction device according to claim 1, further comprising a traveling speed calculation unit that is configured to calculate the traveling speed of the vehicle on the basis of position information of at least two points of the vehicle indicated by the vehicle information acquired from the same on-board unit at different timings,

wherein the anomalous-vehicle extraction unit is configured to determine whether the traveling conditions of the vehicle indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traveling speed calculated by the traveling speed calculation unit.

3. The anomalous-vehicle extraction device according to claim 1 or 2, further comprising a notification unit that is configured to give notice of the vehicle determined to be anomalous by the anomalous-vehicle extraction unit.

4. The anomalous-vehicle extraction device according to any one of claims 1 to 3, further comprising a correction unit that is configured to generate information for correcting a billing status regarding the vehicle determined to be anomalous by the anomalous-vehicle extraction unit.

5. An anomalous-vehicle extraction device comprising:

a traffic state value calculation unit that is configured to calculate a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle;

an anomalous-vehicle extraction unit that is configured to extract the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit, and the vehicle information acquired from the on-board unit of each vehicle; and

a traffic state estimation unit that is configured to estimate the state of traffic within the predetermined target area in the predetermined target time period, in a case where a

density of the vehicle information within the predetermined target area in the predetermined target time period is less than a threshold,

wherein the traffic state value calculation unit is configured to calculate the traffic state value in a case where the density of the vehicle information is equal to or greater than the threshold, and

the anomalous-vehicle extraction unit is configured to determine whether the traveling conditions of the vehicle indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the state of traffic estimated by the traffic state estimation unit.

6. The anomalous-vehicle extraction device according to claim 5, further comprising a notification unit that is configured to give notice of the vehicle determined to be anomalous by the anomalous-vehicle extraction unit.

7. The anomalous-vehicle extraction device according to claim 5 or 6, further comprising a correction unit that is configured to generate information for correcting a billing status regarding the vehicle determined to be anomalous by the anomalous-vehicle extraction unit.

8. An anomalous-vehicle extraction method comprising:

a traffic state value calculation step of calculating a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle; and

an anomalous-vehicle extraction step of extracting the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated in the traffic state value calculation step, and the vehicle information acquired from the on-board unit of each vehicle,

wherein the anomalous-vehicle extraction step comprises a step of acquiring a speed within the target area and a density of vehicles within the target area as the traffic state value calculated by the traffic state value calculation unit, and determining that the traveling conditions of the vehicle are anomalous in a case where the density of vehicles within the target area is higher than a threshold and an amount of deviation between the speed within the target area and the traveling speed of the vehicle indicated by the vehicle information exceeds a predetermined allowable range.

9. A program causing a computer to function as:

traffic state value calculation unit for calculating a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle; and

anomalous-vehicle extraction unit for extracting the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit, and the vehicle information acquired from the on-board unit of each vehicle,

wherein the anomalous-vehicle extraction unit is configured to acquire a speed within the target area and a density of vehicles within the target area as the traffic state value calculated by the traffic state value calculation unit, and determine that the traveling conditions of the vehicle are anomalous in a case where the density of vehicles within the target area is higher than a threshold and an amount of deviation between the speed within the

target area and the traveling speed of the vehicle indicated by the vehicle information exceeds a predetermined allowable range.

10. An anomalous-vehicle extraction method comprising:

a traffic state value calculation step of calculating a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle;

an anomalous-vehicle extraction step of extracting the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated in the traffic state value calculation step, and the vehicle information acquired from the on-board unit of each vehicle; and

a traffic state estimation step of estimating the state of traffic within the predetermined target area in the predetermined target time period, in a case where a density of the vehicle information within the predetermined target area in the predetermined target time period is less than a threshold,

wherein the traffic state value calculation step comprises a step of calculating the traffic state value in a case where the density of the vehicle information is equal to or greater than the threshold, and

the anomalous-vehicle extraction step comprises a step of determining whether the traveling conditions of the vehicle indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the state of traffic estimated in the traffic state estimation step.

11. A program causing a computer to function as:

traffic state value calculation unit for calculating a traffic state value indicating a state of traffic within a predetermined target area in a predetermined target time period, on the basis of vehicle information indicating a position and a traveling speed of a vehicle which are acquired from an on-board unit mounted in the vehicle;

anomalous-vehicle extraction unit for extracting the vehicle of which traveling conditions indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the traffic state value calculated by the traffic state value calculation unit, and the vehicle information acquired from the on-board unit of each vehicle; and

traffic state estimation unit for estimating the state of traffic within the predetermined target area in the predetermined target time period, in a case where a density of the vehicle information within the predetermined target area in the predetermined target time period is less than a threshold,

wherein the traffic state value calculation unit is configured to calculate the traffic state value in a case where the density of the vehicle information is equal to or greater than the threshold, and

the anomalous-vehicle extraction unit is configured to determine whether the traveling conditions of the vehicle indicated by the vehicle information are anomalous as the vehicle traveling within the target area, on the basis of the state of traffic estimated by the traffic state estimation unit.