

DESCRIPTION

TOLL-COMPUTATION DEVICE, CONTROL METHOD, AND PROGRAM

5 TECHNICAL FIELD

[0001]

The present invention relates to a toll computation device, a control method, and a program. In particular, the present invention relates to a toll computation device which computes a toll to be applied to a road network area including a plurality of roads, a control method of controlling the toll computation device, and a program for use in the toll computation device.

Priority is claimed on Japanese Patent Application No. 2011-188302, filed August 31, 2011, the content of which is incorporated herein by reference.

15 BACKGROUND ART

[0002]

In recent years, the introduction of road pricing has been studied for problems such as air pollution and traffic congestion in urban areas, tourist areas, etc. This road pricing is a system that specifies a target road network area and collects tolls for vehicles entering the target road area network area or passing through the target road area network. By collecting the tolls in the road pricing, it is possible to reduce a traffic volume of the target road network area, mitigate traffic congestion, and reduce air pollution. Road pricing has already been introduced in several other countries such as Singapore and the United Kingdom.

25 [0003]

When the toll is too high in implementing road pricing, it can be seen that the number of vehicles which avoid the target road network area increases and the mitigation of the traffic congestion or the reduction of the air pollution within the target road area network is improved. However, an air environment may deteriorate due to the occurrence of congestion in roads around the target road network area as a result. In contrast, when the toll is too low, the effect of road pricing is not sufficiently obtained. That is, in road pricing, it is desirable to set a reasonable toll at which congestion does not occur for a road manager and users.

[0004]

As technology made in view of such circumstances, a road toll setting device for setting tolls to be collected from vehicles which run through each path formed by a plurality of sections from a plurality of starting points to an end point set within the road area network is well known (for example, see Patent Document 1). The road toll setting device disclosed in Patent Document 1 stores previous traffic data within the road area network. Then, the road toll setting device estimates traffic demand on a target date for each combination of starting and end points through which each vehicle passes based on the stored previous traffic data. Then, the road toll setting device predicts traffic volumes and running times for each path and each section based on a preset initial value of a traffic volume distribution for each path and the estimated traffic demand. Then, the road toll setting device corrects the initial value of the traffic volume distribution based on the prediction to output the corrected value as a target traffic volume distribution. Then, the road toll setting device predicts the traffic amount distribution of each path based on the preset initial toll of each path and a distance of the path. Then, the road toll setting device corrects an initial toll so that the predicted traffic amount distribution approximates a target distribution and outputs the corrected toll as an

ultimate toll for each path.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

5 [0005]

[Patent Document 1]

Japanese Unexamined Patent Application, First Publication No. 2008-009639

DISCLOSURE OF INVENTION

10 PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

According to the road toll setting device disclosed in Patent Document 1, the occurrence of extreme unevenness of a traffic volume between paths connecting each starting point and each end point is suppressed, the occurrence of traffic congestion is suppressed as much as possible, environmental deterioration such as air pollution is suppressed, and beneficial toll settings for a road manager and a vehicle user are possible.

[0007]

Incidentally, the road toll setting device disclosed in Patent Document 1 determines a toll based on previous traffic data. However, the toll determined as described above is not always an optimum value for a current situation of traffic of the road network area.

MEANS FOR SOLVING THE PROBLEMS

25 [0008]

In order to solve the above-described problem, according to a first form of the present invention, there is provided a toll computation device which computes a toll to be applied to a road network area including a plurality of roads, the toll computation device including: a toll computation unit configured to compute the toll to be applied to the road network area based on: an aggregate QK relationship representing a correlation between an aggregate traffic flow rate (Q), which is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and an aggregate traffic density (K), which is the total number of vehicles within the road network area; and an estimation value of the aggregate traffic density (K) at a predetermined time.

[0009]

The toll computation device may further include: an aggregate QK relationship computation unit configured to compute the aggregate QK relationship representing the correlation between the aggregate traffic flow rate (Q), which is the sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and the aggregate traffic density (K), which is the total number of vehicles within the road network area, wherein the toll computation unit computes the toll to be applied to the road network area based on: the aggregate QK relationship computed by the aggregate QK relationship computation unit; and the estimation value of the aggregate traffic density (K) at the predetermined time.

[0010]

The toll computation device may further include: an aggregate traffic density (K) estimation unit configured to estimate the aggregate traffic density (K) at the predetermined time based on traffic flow simulation results in the road network area, wherein the toll computation unit computes the toll to be applied to the road network area

based on: the aggregate QK relationship representing the correlation between the aggregate traffic flow rate (Q), which is the sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and the aggregate traffic density (K), which is the total number of vehicles within the road network area; and the estimation value of the aggregate traffic density (K) estimated by the aggregate traffic density (K) estimation unit.

[0011]

The toll computation device may further include: a toll data distribution unit configured to distribute data representing the toll to be applied to the road network area computed by the toll computation unit to a user terminal of a user of a vehicle.

[0012]

According to a second form of the present invention, there is provided a control method of controlling a toll computation device which computes a toll to be applied to a road network area including a plurality of roads, the control method including: a toll computation step of computing the toll to be applied to the road network area based on: an aggregate QK relationship representing a correlation between an aggregate traffic flow rate (Q), which is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and an aggregate traffic density (K), which is the total number of vehicles within the road network area; and an estimation value of the aggregate traffic density (K) at a predetermined time.

[0013]

According to a third form of the present invention, there is provided a program for use in a toll computation device which computes a toll to be applied to a road

network area including a plurality of roads, the program causing the toll computation device to function as: a toll computation unit configured to compute the toll to be applied to the road network area based on: an aggregate QK relationship representing a correlation between an aggregate traffic flow rate (Q), which is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and an aggregate traffic density (K), which is the total number of vehicles within the road network area; and an estimation value of the aggregate traffic density (K) at a predetermined time.

[0014]

In addition, the above outline of the present invention does not include all the necessary characteristics of the present invention, and sub-combinations of groups of the characteristics can also be the aspects of the invention.

EFFECTS OF THE INVENTION

[0015]

As apparent from the above description, according to the present invention, it is possible to compute an optimum toll for a current situation of traffic of a road network area as compared to the known technology.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a diagram illustrating an example of an aggregate QK relationship.

Fig. 2 is a diagram illustrating an example of a toll computation device 100 according to an embodiment.

Fig. 3 is a diagram illustrating an example of information stored in an aggregate

QK relationship information storage unit 170 in the form of a table.

Fig. 4 is a diagram illustrating an example of information stored in a toll information storage unit 180 in the form of a table.

Fig. 5 is a diagram illustrating an example of an operation flow of the toll computation device 100.

Fig. 6 is a diagram illustrating another example of the operation flow of the toll computation device 100.

Fig. 7 is a diagram illustrating an example of a hardware configuration when the toll computation device 100 includes an electronic information processing device such as a computer.

PREFERRED EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0017]

Hereinafter, the present invention will be described through embodiments of the invention. However, the following embodiments are not intended to limit the present invention described in the claims, and all the combinations of characteristics described in the embodiments are not necessarily required for a solution means of the invention.

[0018]

In this embodiment, an aggregate traffic flow rate Q and an aggregate traffic density K are defined as traffic state amounts of a road network area including a plurality of roads, and a relationship between the two state amounts is referred to as an aggregate QK relationship. The aggregate traffic flow rate Q (the number of vehicles $\cdot$ km/h) is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area as shown in Equation (1). In addition, the aggregate traffic density K (the number of

vehicles) is the total number of vehicles within the road network area as shown in Equation (2).

[0019]

[Math. 1]

$$Q = \sum_{i \in L} (q_i \cdot d_i) \quad \dots (1)$$

5

Q: Aggregate traffic flow rate (number of vehicles · km/h)

q_i: Traffic flow rate (number of vehicles/h) of link i

d_i: Link length (km) of link i

L: Link set within area

10 [0020]

[Math. 2]

$$K = \sum_{i \in L} (k_i \cdot d_i) \quad \dots (2)$$

K: Aggregate traffic density (number of vehicles/area)

k_i: Space vehicle density (number of vehicles/km) of link i

15 d_i: Link length (km) of link i

L: Link set within area

[0021]

Fig. 1 illustrates an example of the aggregate QK relationship. A curve of the aggregate QK relationship of this example represents that although the aggregate traffic flow rate Q increases with an increase in the aggregate traffic density K while the aggregate traffic density K is smaller in the road network area, the aggregate traffic flow rate Q is saturated and degraded when the aggregate traffic density K is greater than or

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equal to a given amount in the course of time. At this time, if entry control is not performed in a situation in which a number of vehicles exceeding traffic processing capability of the road network area enter, this means that the aggregate traffic density K of the road network area gradually increases and the aggregate traffic flow rate Q is degraded, that is, the degradation of the vehicle processing capability of the road network area is caused, and the situation deteriorates with increasing speed.

[0022]

FIG. 2 illustrates an example of the toll computation device 100 according to the embodiment. The toll computation device 100 is a device which computes a toll to be applied to the road network area including a plurality of roads.

[0023]

The toll computation device 100 includes a traffic flow simulation result data input reception unit 110, an aggregate QK relationship computation unit 120, an aggregate traffic density (K) estimation unit 130, a toll computation unit 140, a toll data output unit 150, a toll data distribution unit 160, an aggregate QK relationship information storage unit 170, and a toll information storage unit 180. Hereinafter, the functions and operations of the components will be described.

[0024]

The traffic flow simulation result data input reception unit 110 receives an input of data representing traffic flow simulation results simulated by a traffic flow simulator.

[0025]

The aggregate QK relationship computation unit 120 calculates an aggregate QK relationship based on the traffic flow simulation results in the road network area.

[0026]

The aggregate traffic density (K) estimation unit 130 estimates an aggregate

traffic density K at a predetermined time based on traffic flow simulation results in the road network area.

[0027]

The toll computation unit 140 computes a toll to be applied to the road network
 5 area based on the aggregate QK relationship and an estimation value of the aggregate
 traffic density K at the predetermined time. More specifically, the toll computation unit
 140 computes the toll to be applied to the road network area based on the aggregate QK
 relationship computed by the aggregate QK relationship computation unit 120 and the
 estimation value of the aggregate traffic density K at the predetermined time. In
 10 addition, the toll computation unit 140 computes the toll to be applied to the road
 network area based on the aggregate QK relationship and the estimation value of the
 aggregate traffic density K estimated by the aggregate traffic density (K) estimation unit
 130.

[0028]

15 The toll data output unit 150 outputs data representing the toll to be applied to
 the road network area calculated by the toll computation unit 140.

[0029]

The toll data distribution unit 160 distributes the data representing the toll to be
 applied to the road network area calculated by the toll computation unit 140 to a user
 20 terminal of a user of a vehicle.

[0030]

Fig. 3 illustrates an example of information stored in the aggregate QK
 relationship information storage unit 170 in the form of a table. Information about the
 aggregate traffic density K (the number of vehicles/area) and the aggregate traffic flow
 25 rate Q (the number of vehicles $\cdot$ km/h) is associated and stored in the aggregate QK

relationship information storage unit 170.

[0031]

The aggregate traffic flow rate K (the number of vehicles/area) is the total number of vehicles within the road network area. The aggregate traffic flow rate Q (the number of vehicles · km/h) is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area when vehicles equal in number to the number of vehicles represented by the aggregate traffic flow rate K (the number of vehicles/area) are present within the road network area.

10 [0032]

Fig. 4 is a diagram illustrating an example of information stored in the toll information storage unit 180 in the form of a table. Information about a ratio (%) to a maximum value Q_{MAX} of the aggregate traffic flow rate Q , whether the aggregate traffic density K is less than K_{MAX} corresponding to Q_{MAX} , and a toll (yen) are associated and stored in the toll information storage unit 180.

[0033]

Here, the aggregate QK relationship is drawn in a bow-shaped curve as illustrated in Fig. 1. Then, the aggregate traffic flow rate Q is increased and saturated when the aggregate traffic density K is increased and the aggregate traffic flow rate Q is decreased when the aggregate traffic density K is further increased. In the following description, when the variation of the aggregate traffic flow rate Q changes from an increase to a decrease, the maximum value of the aggregate traffic flow rate Q is referred to as Q_{MAX} and the value of the aggregate traffic density K corresponding to Q_{MAX} in the aggregate QK relationship is referred to as K_{MAX} . Here, an actual operation is likely to be too late after reaching Q_{MAX} . Accordingly, in this embodiment, a value of the

aggregate traffic density K which, for example, is about 5 (%) to 10 (%) less than an actual value K_{MAX} corresponding to Q_{MAX} is handled as K_{MAX} .

[0034]

Fig. 5 is a diagram illustrating an example of an operation flow of the toll computation device 100. This operation flow represents an operation of computing the aggregate QK relationship. In addition, in description of this operation flow, Figs. 1 to 4 will be referred to together.

[0035]

The toll computation device 100 computes the aggregate QK relationship based on traffic flow simulation results of the road network area by a traffic flow simulator. Traffic flow simulations are simulations for reproducing an actual road situation in a computer in a simulated manner and performing evaluation in advance.

[0036]

Upon receiving an input of data representing the traffic flow simulation results of the road network area from the traffic flow simulator (S101), the traffic flow simulation result data input reception unit 110 of the toll computation device 100 transmits the data to the aggregate QK relationship computation unit 120.

[0037]

Upon receiving the data transmitted from the traffic flow simulation result data input reception unit 110, the aggregate QK relationship computation unit 120 of the toll computation device 100 computes the aggregate QK relationship of the road network area (S102). For example, the aggregate QK relationship computation unit 120 computes a value of the aggregate traffic density K at a predetermined timing and a value of the aggregate traffic flow rate Q at that time from the traffic flow simulation results of the road network area represented by the data received from the traffic flow simulation

result data input reception unit 110, and iterates a process of associating the two values with time. Then, the aggregate QK relationship computation unit 120 computes a function of a curve representing the aggregate QK relationship by performing curve fitting on a plurality of combinations of corresponding aggregate traffic flow rates Q and aggregate traffic densities K. Then, the aggregate QK relationship computation unit 120 associates and stores a plurality of aggregate traffic densities K and aggregate traffic flow rates Q obtained by substituting the values of the aggregate traffic densities K into the computed function in the aggregate QK relationship information storage unit 170 (S103).

10 [0038]

In this manner, information representing the aggregate QK relationship of the road network area is stored in the aggregate QK relationship information storage unit 170 of the toll computation device 100. In addition, a series of processes is assumed to be executed every time at least an environment of the road network area varies. The variation of the environment of the road network area represents cases in which a tendency of a path through which a vehicle passes within the road network area varies, for example, according to the blocking of a road due to an influence of a traffic accident or the opening of new commercial facilities.

[0039]

20 Fig. 6 is a diagram illustrating another example of the operation flow of the toll computation device 100. This operation flow represents an operation of computing a toll to be applied to the road network area. In addition, in description of this operation flow, Figs. 1 to 5 will be referred to together.

[0040]

25 The toll computation device 100 computes a toll to be applied to the road

network area based on traffic flow simulation results of the road network area by the traffic flow simulator.

[0041]

Upon receiving an input of data representing the traffic flow simulation results
 5 of the road network area from the traffic flow simulator (S201), the traffic flow
 simulation result data input reception unit 110 of the toll computation device 100
 transmits the data to the aggregate traffic density (K) estimation unit 130.

[0042]

Upon receiving the data transmitted from the traffic flow simulation result data
 10 input reception unit 110, the aggregate traffic density (K) estimation unit 130 of the toll
 computation device 100 estimates an aggregate traffic density K at a predetermined time
 from the traffic flow simulation results of the road network area represented by the data
 (S202). For example, the aggregate traffic density (K) estimation unit 130 estimates the
 aggregate traffic density K after 5 minutes. Then, the aggregate traffic density (K)
 15 estimation unit 130 transmits data representing an estimation value K_{EST} of the estimated
 aggregate traffic density K to the toll computation unit 140.

[0043]

Upon receiving the data transmitted from the aggregate traffic density (K)
 estimation unit 130, the toll computation unit 140 of the toll computation device 100
 20 computes a toll to be applied to the road network area (S203). For example, upon
 receiving the data transmitted from the aggregate traffic density (K) estimation unit 130,
 the toll computation unit 140 reads information stored in the aggregate QK relationship
 information storage unit 170. Then, the toll computation unit 140 specifies a value of a
 maximum value Q_{MAX} of an aggregate traffic flow rate Q based on the information read
 25 from the aggregate QK relationship information storage unit 170. In addition, the toll

computation unit 140 specifies a value K_{MAX} of the aggregate traffic density K corresponding to Q_{MAX} . In addition, the toll computation unit 140 specifies a value Q_{EST} of the aggregate traffic flow rate Q corresponding to K_{EST} represented by data received from the aggregate traffic density (K) estimation unit 130. Then, the toll computation unit 140 computes a ratio of Q_{EST} to Q_{MAX} . In addition, the toll computation unit 140 compares K_{MAX} to K_{EST} . Then, the toll computation unit 140 computes the toll to be applied to the road network area based on the information stored in the toll information storage unit 180, the ratio of Q_{EST} to Q_{MAX} , and the comparison result between K_{MAX} and K_{EST} . For example, information as illustrated in Fig. 4 is assumed to be stored in the toll information storage unit 180. Then, when the ratio of Q_{EST} to Q_{MAX} is 47 (%) and K_{EST} is less than K_{MAX} , the toll computation unit 140 sets the toll to be applied to the road network area to 500 (yen). Then, the toll computation unit 140 transmits toll data representing the toll to the toll data output unit 150 and the toll data distribution unit 160.

15 [0044]

Upon receiving the toll data transmitted from the toll computation unit 140, the toll data output unit 150 of the toll computation device 100 outputs the toll data to an external device (S204). For example, the toll data output unit 150 outputs data for causing a toll represented by the toll data to be displayed on a display screen to a display. In this case, the toll to be applied to the road network area is displayed on the display. It is only necessary for a manager of the road network area to perform a predetermined task for applying the toll displayed on the display.

[0045]

In addition, for example, the toll data output unit 150 outputs the toll data to a tollbooth device which collects a toll of the road network area. In this case, the setting

of the toll to be collected is automatically applied to the tollbooth device.

[0046]

On the other hand, upon receiving the toll data transmitted from the toll computation unit 140, the toll data distribution unit 160 of the toll computation device 100 distributes the toll data to the user terminal of the user of the vehicle (S205). Here, the user terminal includes portable information terminals such as portable telephones and personal digital assistants (PDAs), a personal computer, and an in-vehicle device. In this manner, the vehicle user can know the toll of the road network area. In addition, this series of processes is assumed to be executed at intervals of predetermined times.

10 [0047]

As described above, the toll computation device 100 can compute an optimum toll for a current situation of traffic of the road network area as compared to the known technology.

[0048]

15 Fig. 7 is a diagram illustrating an example of a hardware configuration when the toll computation device 100 includes an electronic information processing device such as a computer. The toll computation device 100 includes a central processing unit (CPU) peripheral unit, an input/output (I/O) unit, and a legacy I/O unit. The CPU peripheral unit includes a CPU 802, a random access memory (RAM) 803, a graphic controller 804, and a display device 805, which are connected to each other via a host controller 801. 20 The I/O unit includes a communication interface (I/F) 807, a hard disk drive 808, and a compact disk-read only memory (CD-ROM) drive 809 which are connected to the host controller 801 via an I/O controller 806. The legacy I/O unit includes a ROM 810 and a flexible disk (FD) drive 811, and an I/O chip 812 which are connected to the I/O 25 controller 806.

[0049]

The host controller 801 connects the RAM 803, the CPU 802 which accesses the RAM 803 at a high transfer rate, and the graphic controller 804. The CPU 802 operates based on programs stored in the ROM 810 and the RAM 803, and controls all the units.

- 5 The graphic controller 804 obtains image data generated on a frame buffer provided in the RAM 803 by the CPU 802 and the like, and causes the display device 805 to display the image data. Alternatively, the graphic controller 804 may internally include a frame buffer which stores image data generated by the CPU 802 and the like.

[0050]

- 10 The I/O controller 806 connects the host controller 801, the hard disk drive 808 which is a comparatively high-speed I/O device, the communication I/F 807, and the CD-ROM drive 809. The hard disk drive 808 stores programs and data used by the CPU 802. The communication I/F 807 connects to a network communication device 891 to transmit and receive programs and data. The CD-ROM drive 809 reads
15 programs and data from a CD-ROM 892, and provides the programs and data to the hard disk drive 808 and the communication I/F 807 via the RAM 803.

[0051]

- The ROM 810 and comparatively low-speed I/O devices, namely an FD drive 811 and an I/O chip 812, are connected to the I/O controller 806. The ROM 810 stores
20 a boot program to be executed when the toll computation device 100 is activated, or programs depending on the hardware of the toll computation device 100, etc. The FD drive 811 reads programs and data from an FD 893, and provides the programs and data to the hard disk drive 808 and the communication I/F 807 via the RAM 803. The I/O chip 812 connects various I/O devices via the FD drive 811, or via a parallel port, a serial
25 port, a keyboard port, a mouse port, etc.

[0052]

The programs to be executed by the CPU 802 are stored in the FD 893, the CD-ROM 892, or a recording medium such as an integrated circuit (IC) card, and are provided by a user. A program stored in the recording medium can be compressed or
5 uncompressed. The program is installed from the recording medium to the hard disk drive 808, read by the RAM 803, and executed by the CPU 802. The program executed by the CPU 802 causes the toll computation device 100 to function as the traffic flow simulation result data input reception unit 110, the aggregate QK relationship computation unit 120, the aggregate traffic density (K) estimation unit 130, the toll
10 computation unit 140, the toll data output unit 150, the toll data distribution unit 160, the aggregate QK relationship information storage unit 170, and the toll information storage unit 180 described with reference to Figs. 1 to 6.

[0053]

The programs described above can be stored in an external recording medium.
15 As the recording medium, in addition to the FD 893 and the CD-ROM 892, it is possible to use an optical recording medium such as a digital versatile disk (DVD) or a phase disk (PD), a magneto-optical recording medium such as a minidisk (MD), a tape medium, a semiconductor memory such as an IC card, etc. Using a storage medium such as a hard disk or a RAM provided in a server system connected to a dedicated communication
20 network or the Internet as the recording medium, the programs may be provided as programs via this network.

[0054]

Although the present invention has been described with reference to embodiments, the technical scope of the present invention is not limited to the scope of
25 the abovementioned embodiments. It is apparent to those skilled in the art that various

alterations and improvements can be made to the abovementioned embodiments. It is apparent from the appended claims that embodiments with the various alterations and improvement will be included in the technical scope of the present invention.

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INDUSTRIAL APPLICABILITY

[0055]

The present invention relates to a toll computation device which computes a toll to be applied to a road network area including a plurality of roads, a control method of controlling the toll computation device, and a program for use in the toll computation device. According to the present invention, it is possible to compute an optimum toll for a current situation of traffic of a road network area.

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DESCRIPTION OF THE REFERENCE SYMBOLS

[0056]

15

100 Toll computation device

110 Traffic flow simulation result data input reception unit

120 Aggregate QK relationship computation unit

130 Aggregate traffic density (K) estimation unit

140 Toll computation unit

20

150 Toll data output unit

160 Toll data distribution unit

170 Aggregate QK relationship information storage unit

180 Toll information storage unit

801 Host controller

25

802 CPU

803 RAM

804 Graphic controller

805 Display device

806 I/O controller

5 807 Communication I/F

808 Hard disk drive

809 CD-ROM drive

810 ROM

811 FD drive

10 812 I/O chip

891 Network communication device

892 CD-ROM

893 FD

15

CLAIMS

[Claim 1]

A toll computation device which computes a toll to be applied to a road network area including a plurality of roads, the toll computation device comprising:

5 a toll computation unit configured to compute the toll to be applied to the road network area based on:

an aggregate QK relationship representing a correlation between an aggregate traffic flow rate (Q), which is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated
10 included in the road network area, and an aggregate traffic density (K), which is the total number of vehicles within the road network area; and

an estimation value of the aggregate traffic density (K) at a predetermined time.

[Claim 2]

15 The toll computation device according to claim 1, further comprising:

an aggregate QK relationship computation unit configured to compute the aggregate QK relationship representing the correlation between the aggregate traffic flow rate (Q), which is the sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the
20 road network area, and the aggregate traffic density (K), which is the total number of vehicles within the road network area,

wherein the toll computation unit computes the toll to be applied to the road network area based on:

the aggregate QK relationship computed by the aggregate QK
25 relationship computation unit; and

the estimation value of the aggregate traffic density (K) at the predetermined time.

[Claim 3]

The toll computation device according to claim 1 or 2, further comprising:

5 an aggregate traffic density (K) estimation unit configured to estimate the aggregate traffic density (K) at the predetermined time based on traffic flow simulation results in the road network area,

wherein the toll computation unit computes the toll to be applied to the road network area based on:

10 the aggregate QK relationship representing the correlation between the aggregate traffic flow rate (Q), which is the sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and the aggregate traffic density (K), which is the total number of vehicles within the road network area; and

15 the estimation value of the aggregate traffic density (K) estimated by the aggregate traffic density (K) estimation unit.

[Claim 4]

The toll computation device according to any one of claims 1 to 3, further comprising:

20 a toll data distribution unit configured to distribute data representing the toll to be applied to the road network area computed by the toll computation unit to a user terminal of a user of a vehicle.

[Claim 5]

A control method of controlling a toll computation device which computes a toll
25 to be applied to a road network area including a plurality of roads, the control method

comprising:

a toll computation step of computing the toll to be applied to the road network area based on:

an aggregate QK relationship representing a correlation between an aggregate traffic flow rate (Q), which is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and an aggregate traffic density (K), which is the total number of vehicles within the road network area; and

an estimation value of the aggregate traffic density (K) at a predetermined time.

[Claim 6]

A program for use in a toll computation device which computes a toll to be applied to a road network area including a plurality of roads, the program causing the toll computation device to function as:

a toll computation unit configured to compute the toll to be applied to the road network area based on:

an aggregate QK relationship representing a correlation between an aggregate traffic flow rate (Q), which is a sum of the number of vehicles per unit distance per unit time calculated by regarding each road as a unit for the roads to be evaluated included in the road network area, and an aggregate traffic density (K), which is the total number of vehicles within the road network area; and

an estimation value of the aggregate traffic density (K) at a predetermined time.