

[DESCRIPTION]

[TITLE OF INVENTION]

DANGER NOTIFICATION DEVICE, DANGER NOTIFICATION SYSTEM,
DANGER NOTIFICATION METHOD, AND PROGRAM

5 [Technical Field]

[0001]

The present invention relates to a danger notification device, a danger notification system, a danger notification method, and a program.

This application claims priority based on Japanese Patent Application No.
10 2016-146620 filed in Japan on July 26, 2016, the entire content of which is incorporated herein by reference.

[Background Art]

[0002]

As a system to suppress collision between a vehicle and a pedestrian, a system
15 in which arrival points of a vehicle and a pedestrian are predicted on the basis of position information, speed information, and moving direction information acquired from each of an on-board unit mounted on the vehicle and a portable terminal carried by the pedestrian, and an alert is output from the on-board unit or the portable terminal when it is determined that the vehicle and the pedestrian are likely to collide is provided (for
20 example, Patent Document 1).

In addition, a system in which a driver of a vehicle is notified of the presence of a pedestrian and the like by displaying position information acquired from a portable terminal carried by the pedestrian on an on-board unit is provided (for example, Patent Document 2, Patent Document 3).

25 [Citation List]

[Patent Literature]

[0003]

[Patent Document 1]

Japanese Unexamined Patent Application, First Publication No. 2005-4542

5 [Patent Document 2]

Japanese Unexamined Patent Application, First Publication No. 2008-217429

[Patent Document 3]

Japanese Unexamined Patent Application, First Publication No. 2007-122735

[Summary of Invention]

10 [Technical Problem]

[0004]

However, even if vehicles and pedestrians are on the same road, for example, a degree of danger indicating collision between a vehicle and a pedestrian may be different between a situation in which a traffic volume of the road is large and a situation in which the traffic volume is small. For this reason, when an alert is output from an on-board unit or a portable terminal on the basis of only arrival points of a vehicle and a pedestrian as in the system described above, an alert may not be output even in a situation in which a degree of danger indicating collision between a vehicle and a pedestrian is high, or an alert may be output even in a situation in which the degree of danger indicating collision between a vehicle and a pedestrian is low.

[0005]

The present invention is made in view of such problems, and provides a danger notification device, a danger notification system, a danger notification method, and a program which notify of danger prediction information of a traffic accident according to a traffic situation for each road segment.

[Solution to Problem]

[0006]

In order to solve the above problems, the present invention adopts the following means.

5 According to one aspect of the present invention, a danger notification device includes a traffic state indicator acquisition unit configured to acquire a traffic state indicator of a road segment from a traffic state database, a danger prediction unit configured to predict a degree of danger indicating occurrence probability of a traffic accident in the road segment on the basis of the traffic state indicator, and an alert
10 information transmission unit configured to transmit alert information to at least one of an on-board unit mounted on a vehicle and a portable terminal carried by a pedestrian located in the road segment when the danger prediction unit determines that the degree of danger of the road segment is equal to or greater than a predetermined reference value.

 In this manner, the danger prediction unit predicts a degree of danger according
15 to a traffic state indicator of a road segment, and thus it is possible to improve accuracy in prediction of the degree of danger of each road segment. In addition, the alert information transmission unit can perform an alert operation by transmitting alert information to at least one of an on-board unit and a portable terminal located in a road segment which is determined to have a degree of danger equal to or greater than a
20 predetermined reference value by the danger prediction unit, and can suppress transmission of unnecessary alert information in a road segment which is determined not to have a degree of danger equal to or greater than the predetermined reference value by the danger prediction unit.

[0007]

25 According to another aspect of the present invention, in the danger notification

device of the aspect described above, the danger prediction unit predicts the degree of danger on the basis of the traffic state indicator acquired by the traffic state indicator acquisition unit and degree of danger correlation data in which the occurrence probability of a traffic accident with respect to the past traffic state indicator is associated with each road segment.

In this manner, the danger prediction unit can further improve accuracy in prediction of a degree of danger by referring to both a current traffic state indicator acquired by the traffic state indicator acquisition unit and degree of danger correlation data indicating the occurrence probability of a traffic accident with respect to the past traffic state indicator.

[0008]

According to still another aspect of the present invention, in the danger notification device of the aspect described above, the alert information transmission unit transmits alert information to the on-board unit when the danger prediction unit determines that a degree of danger of the road segment is equal to or greater than a predetermined reference value, and when a pedestrian is present in the road segment.

In this manner, the alert information transmission unit can appropriately perform an alert operation by transmitting alert information to an on-board unit in a road segment in which the degree of danger is equal to or greater than a predetermined reference value and a pedestrian is present, and can suppress transmission of unnecessary alert information in a road segment in which the degree of danger is equal to or greater than the predetermined reference value, but there is no pedestrian.

[0009]

According to still another aspect of the present invention, a danger notification system includes the danger notification device of any one of the aspects described above,

a probe data collection unit configured to collect on-board unit probe data including position information of an on-board unit mounted on each of a plurality of vehicles and portable terminal probe data including position information of a portable terminal carried by each of a plurality of pedestrians, and a traffic state indicator generation unit

- 5 configured to generate a traffic state indicator for each road segment and record it in a traffic state database on the basis of the on-board unit probe data and the portable terminal probe data.

In this manner, the traffic state indicator generation unit can generate a traffic state indicator in accordance with an actual situation of a road segment on the basis of
10 on-board unit probe data and portable terminal probe data successively collected by the probe data collection unit. For this reason, the traffic state indicator generation unit can increase accuracy of a traffic state indicator. In addition, the danger notification device can improve accuracy in prediction of a degree of danger of each road segment on the basis of a traffic state indicator with higher accuracy in this manner.

15 [0010]

According to still another aspect of the present invention, a danger notification method includes a traffic state indicator acquisition step of acquiring a traffic state indicator of a road segment from a traffic state database, a danger prediction step of predicting a degree of danger in the road segment on the basis of the traffic state indicator,
20 and an alert information transmission step of transmitting alert information to at least one of an on-board unit mounted on a vehicle and a portable terminal carried by a pedestrian located in the road segment when it is determined that a degree of danger of the road segment is equal to or greater than a predetermined reference value in the danger prediction step.

25 [0011]

According to still another aspect of the present invention, a program which causes a computer of the danger notification device to function as a traffic state indicator acquisition unit configured to acquire a traffic state indicator of a road segment from a traffic state database, a danger prediction unit configured to predict a degree of danger in the road segment on the basis of the traffic state indicator, and an alert information transmission unit configured to transmit alert information to at least one of an on-board unit mounted on a vehicle and a portable terminal carried by a pedestrian located in the road segment when the danger prediction unit determines that a degree of danger of the road segment is equal to or greater than a predetermined reference value.

10 [Advantageous Effects of Invention]

[0012]

According to the danger notification device, the danger notification system, the danger notification method, and the program described above, it is possible to notify of danger prediction information of traffic accidents in accordance with a traffic state for each road segment.

15

[Brief Description of Drawings]

[0013]

FIG. 1 is a diagram which shows an overall configuration of a danger notification system according to a first embodiment of the present invention.

20 FIG. 2 is a diagram which shows an example of a road segment according to the first embodiment of the present invention.

FIG. 3 is a diagram which shows a function of a traffic state indicator generation unit according to the first embodiment of the present invention.

FIG. 4 is a diagram which shows an example of a traffic state table according to the first embodiment of the present invention.

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FIG. 5 is a first diagram which shows a processing flow of the traffic state indicator generation unit according to the first embodiment of the present invention.

FIG. 6 is a second diagram which shows the processing flow of the traffic state indicator generation unit according to the first embodiment of the present invention.

5 FIG. 7 is a third diagram which shows the processing flow of the traffic state indicator generation unit according to the first embodiment of the present invention.

FIG. 8 is a diagram which shows a functional configuration of a danger notification device according to the first embodiment of the present invention.

10 FIG. 9 is a diagram which shows an example of degree of danger correlation data according to the first embodiment of the present invention.

FIG. 10 is a first diagram which shows an example of alert information according to the first embodiment of the present invention.

FIG. 11 is a second diagram which shows the example of alert information according to the first embodiment of the present invention.

15 FIG. 12 is a first diagram which shows a processing flow of the danger notification device according to the first embodiment of the present invention.

FIG. 13 is a second diagram which shows the processing flow of the danger notification device according to the first embodiment of the present invention.

20 FIG. 14 is a diagram which shows an example of a hardware configuration of the danger notification device according to the first embodiment of the present invention.

FIG. 15 is a diagram which shows a processing flow of a danger notification device according to a modified example of the first embodiment of the present invention.

FIG. 16 is a diagram which shows an example of degree of danger correlation data according to the modified example of the first embodiment of the present invention.

25 [Description of Embodiments]

[0014]

<First embodiment>

Hereinafter, a danger notification system 1 according to a first embodiment of the present invention will be described with reference to FIGS. 1 to 14.

5 [0015]

(Overall configuration of danger notification system)

FIG. 1 is a diagram which shows an overall configuration of a danger notification system according to a first embodiment of the present invention.

As shown in FIG. 1, the danger notification system 1 of the present embodiment
10 includes a probe data collection unit 10, a traffic state indicator generation unit 20, a traffic state database 30, and a danger notification device 40 which are communicably connected to one another via a network NW such as the Internet.

Note that the probe data collection unit 10, the traffic state indicator generation unit 20, the traffic state database 30, and the danger notification device 40 may also be
15 communicably connected using a dedicated line such as a local area network (LAN).

[0016]

The probe data collection unit 10 collects probe data transmitted from on-board units A mounted on vehicles and portable terminals T carried by pedestrians (on-board unit probe data and portable terminal probe data) every predetermined time (for example,
20 every second).

Specifically, the probe data collection unit 10 collects on-board unit probe data transmitted from the on-board units A (on-board units A1 to An) mounted on each of a plurality of vehicles via the network NW. In addition, the probe data collection unit 10 collects portable terminal probe data transmitted from the portable terminals T (portable
25 terminals T1 to Tn) carried by each of a plurality of pedestrians via the network NW.

Note that an application for transmitting portable terminal probe data and receiving alert information indicating that “a degree of danger of the occurrence of a traffic accident is high” from the danger notification device 40 is installed on the portable terminals T carried by pedestrians in advance.

5 On-board unit probe data includes “transmission date and time,” “apparatus type,” “apparatus ID,” “position information,” “moving speed,” “alert setting,” and the like. In addition, portable terminal probe data includes “apparatus type,” “apparatus ID,” “position information,” “alert setting,” and the like.

 “Transmission date and time” is information indicating a date and time at which
 10 probe data is transmitted from an on-board unit A and a portable terminal T. “Apparatus type” is information for identifying whether a transmission source of probe data is an on-board unit A or a portable terminal T. “Apparatus ID” is information that can identify a transmission source of probe data between an on-board unit A or a portable terminal T. “Position information” is information indicating a point (latitude, longitude,
 15 and the like) at which a vehicle on which an on-board unit A is mounted or a pedestrian carrying a portable terminal T is located at a date and time at which probe data is transmitted. “Moving speed” is information indicating a traveling speed (m/s) of the vehicle on which an on-board unit A is mounted at the date and time at which probe data is transmitted.

20 “Alerting setting” is information indicating whether an on-board unit A and a portable terminal T receive alert information (“ON” or “OFF”). The driver of a vehicle can arbitrarily switch whether to receive the alert information through the on-board unit A. In addition, a pedestrian can arbitrarily switch whether to receive the alert information through an application installed on the portable terminal T.

25 [0017]

FIG. 2 is a diagram which shows an example of a road segment according to the first embodiment of the present invention.

The traffic state indicator generation unit 20 generates a traffic state indicator for each road segment every predetermined time (for example, every second) on the basis of probe data (on-board unit probe data and portable terminal probe data) collected by the probe data collection unit 10. Note that the traffic state indicator generation unit 20 generates a “vehicle traffic state indicator” which indicates a traffic state of a vehicle and a “pedestrian traffic state indicator” which indicates a traffic state of a pedestrian for each road segment in the present embodiment.

A road segment, as shown in FIG. 2, indicates a region between two adjacent nodes among nodes set for each of a plurality of traffic nodes (intersections, and the like) on a road. A “link ID” capable of identifying a road segment is attached to each road segment. For example, as shown in FIG. 2, a link ID “B20a” is attached to a road segment which indicates a lane toward one side, and a link ID “B20b” is attached to a road segment which indicates a lane toward the other side in a region between two nodes (intersections). Note that a node may be further set every predetermined distance when a distance between traffic nodes is longer than a predetermined distance (for example, 100 meters). In the present embodiment, the traffic state indicator generation unit 20 has map data in which “link ID,” “road segment position information” which indicates the position of a road segment (for example, latitude and longitude of a start point and an end point of a road segment), and “length of a road segment” are associated with each other in advance.

Traffic state indicators (a vehicle traffic state indicator and a pedestrian traffic state indicator) are information indicating traffic states of a vehicle and a pedestrian within a road segment. In the present embodiment, traffic state indicators include

“traffic volume,” “traffic density,” and “average speed.” “Traffic volume” indicates the number of traveling vehicles per second (vehicles/second) or the number of traveling pedestrians (people/second) in a road segment.

“Traffic density” indicates the number of vehicles (vehicles/m) or the number of pedestrians (people/m) per meter in a road segment. “Average speed” indicates an average moving speed (m/s) of traveling vehicles or traveling pedestrians in a road segment.

In addition, the traffic state indicator generation unit 20 adds data in which a road segment (a link ID) and information (a part of probe data) of an on-board unit A and a portable terminal T located in the road segment are associated with each other to the traffic state table D10 of the traffic state database 30 (FIG. 4) and updates the traffic state table D10 on the basis of probe data used when a traffic state indicator is calculated. Details of the traffic state table D10 will be described below.

[0018]

In the traffic state database 30, a traffic state indicator (a vehicle traffic state indicator and a pedestrian traffic state indicator) generated by the traffic state indicator generation unit 20, and the traffic state table D10 shown in FIG. 4 are accumulated.

[0019]

The danger notification device 40 predicts a degree of danger which indicates a probability of the occurrence of a traffic accident in each road segment on the basis of a traffic state indicator for each road segment recorded in the traffic state database 30. In addition, the danger notification device 40 transmits alert information indicating that “a degree of danger is high” to at least one of an on-board unit A and a portable terminal T located in a corresponding road segment when it is determined that a “degree of danger” of a certain road segment is high.

[0020]

(Function of traffic state indicator generation unit)

FIG. 3 is a diagram which shows a function of a traffic state indicator generation unit according to the first embodiment of the present invention.

5 FIG. 4 is a diagram which shows an example of a traffic state table according to the first embodiment of the present invention.

Hereinafter, a function of the traffic state indicator generation unit 20 of the present embodiment will be described with reference to FIGS. 3 and 4.

As shown in FIG. 3, the traffic state indicator generation unit 20 first acquires
10 probe data from the probe data collection unit 10. Then, the traffic state indicator generation unit 20 generates a traffic state indicator for each road segment based on probe data collected from a plurality of on-board units A and portable terminals T using known big data distribution processing technology, stream data processing technology, and the like. If the traffic state indicator generation unit 20 generates a traffic state
15 indicator, it records the traffic state indicator in the traffic state database 30 for each road segment. As a result, the traffic state indicator generation unit 20 can generate a traffic state indicator in real time according to an actual situation for each road segment.

[0021]

In addition, the traffic state indicator generation unit 20 adds traffic state data in
20 which a road segment (a link ID) and information (a part of probe data) of an on-board unit A and a portable terminal T located in the road segment are associated with each other to the traffic state table D10 of the traffic state database 30 and updates the traffic state table D10 on the basis of probe data used when a traffic state indicator is calculated. As shown in FIG. 4, “transmission date and time” of each piece of probe data, “apparatus
25 type,” “apparatus ID,” “position information,” and “alert setting” of an on-board unit A

and a portable terminal T which are transmission sources of each piece of probe data, and “link ID” of a road segment in which a vehicle on which the on-board unit A is mounted and a pedestrian carrying the portable terminal T are located are associated with each other and recorded in the traffic state table D10.

5 [0022]

(Processing flow of traffic state indicator generation unit)

FIG. 5 is a first diagram which shows a processing flow of the traffic state indicator generation unit according to the first embodiment of the present invention.

Hereinafter, a flow of processing of the traffic state indicator generation unit 20
10 of the present embodiment will be described with reference to FIG. 5.

[0023]

As shown in FIG. 5, the traffic state indicator generation unit 20 acquires probe data collected by the probe data collection unit 10 (on-board unit probe data and portable terminal probe data) (step S200).

15 [0024]

Next, the traffic state indicator generation unit 20 generates a traffic state indicator (a vehicle traffic state indicator and a pedestrian traffic state indicator) for each road segment, and updates a traffic state table D10 on the basis of probe data (on-board unit probe data and portable terminal probe data) (step S201). Generation processing of
20 a traffic state indicator and update processing of the traffic state table D10 will be described below in detail.

[0025]

Next, the traffic state indicator generation unit 20 records and stores a generated traffic state indicator and the traffic state table D10 for each road segment in the traffic
25 state database 30 whenever a traffic state indicator is calculated. (step S202)

As described above, the traffic state indicator generation unit 20 repeatedly executes the processing described above whenever probe data is acquired.

[0026]

FIG. 6 is a second diagram which shows the processing flow of the traffic state indicator generation unit according to the first embodiment of the present invention.

FIG. 7 is a third diagram which shows the processing flow of the traffic state indicator generation unit according to the first embodiment of the present invention.

Hereinafter, processing of generating a traffic state indicator by the traffic state indicator generation unit 20 and processing of updating the traffic state table D10 will be described with reference to FIGS. 6 and 7.

[0027]

The traffic state indicator generation unit 20, first, as shown in FIG. 6, performs processing P21 of identifying a road segment in which a vehicle on which the on-board unit A that is a transmission source of each piece of probe data is mounted is located (hereinafter, a road segment in which a vehicle is located), and a road segment in which a pedestrian carrying a portable terminal T is located (hereinafter, a road segment in which a pedestrian is located).

In the processing P21, first, the traffic state indicator generation unit 20 reads “position information” from each piece of probe data (on-board unit probe data and portable terminal probe data) (step S210).

[0028]

Next, the traffic state indicator generation unit 20 identifies a road segment in which each vehicle and each pedestrian are located on the basis of the “position information” of each piece of probe data (step S211).

Specifically, the traffic state indicator generation unit 20 searches for a road

segment having “road segment position information” including the “position information” (latitude and longitude) of probe data from map data and identifies it.

[0029]

Next, the traffic state indicator generation unit 20 adds a “link ID” of an identified road segment to each piece of probe data (step S212).

[0030]

Next, the traffic state indicator generation unit 20 adds traffic state data in which the “transmission date and time,” “apparatus type,” “apparatus ID,” and “alert setting” of each piece of probe data are associated with the “link ID” of a road segment added in step S212 to the traffic state table D10 (FIG. 4) recorded in the traffic state database 30, and updates it (step S213).

As described above, the traffic state indicator generation unit 20 repeatedly executes the processing P21 whenever probe data is acquired.

[0031]

In addition, as shown in FIG. 7, the traffic state indicator generation unit 20 performs processing P22 of calculating a traffic state indicator at each time in each road segment on the basis of a plurality of pieces of probe data (on-board unit probe data and portable terminal probe data) to which “link ID” is added by the processing P21 described above.

In the processing P22, first, the traffic state indicator generation unit 20 extracts target probe data to be subjected to calculation among the plurality of pieces of probe data (step S220).

In the present embodiment, the traffic state indicator generation unit 20 extracts probe data indicating that a vehicle is present in an arbitrary target road segment at an arbitrary target time as target probe data of arithmetic processing on the basis of the

“transmission date and time” and the “link ID” of each piece of probe data. Specifically, the traffic state indicator generation unit 20 extracts probe data having the same “link ID” as the link ID of an arbitrary target road segment that is probe data having the “transmission date and time” within a predetermined time (for example, one second)

5 from an arbitrary target time as target probe data of arithmetic processing.

[0032]

Next, the traffic state indicator generation unit 20 acquires a “moving speed” of a vehicle on which each on-board unit A is mounted (hereinafter, the “moving speed” of a vehicle) and a “moving speed” of a pedestrian carrying each portable terminal T
10 (hereinafter, the “moving speed” of a pedestrian), which are included in the target probe data (step S221).

Specifically, the traffic state indicator generation unit 20 first determines whether the transmission source of each piece of probe data is the on-board unit A or the portable terminal T on the basis of an “apparatus type” of each piece of probe data
15 included in the target probe data.

When the “apparatus type” of probe data is the on-board unit A, the “moving speed” of a vehicle is included in corresponding probe data (on-board unit probe data). For this reason, the traffic state indicator generation unit 20 reads and acquires the “moving speed” of a vehicle included in the probe data. Note that, although an example
20 in which the “moving speed” of on-board unit probe data is recorded in meters per second (m/s) is described in the present embodiment, it may be recorded in other units such as in kilometers per hour (km/h) in other embodiments. When the “moving speed” is recorded in other units, the traffic state indicator generation unit 20 may acquire the “moving speed” by converting it into meters per second (m/s).

25 On the other hand, when the “apparatus type” of probe data is the portable

terminal T, the “moving speed” of a pedestrian is not included in corresponding probe data (portable terminal probe data). For this reason, the traffic state indicator generation unit 20 acquires the “moving speed” of a pedestrian by calculating it in meters per second (m/s) on the basis of corresponding probe data. For example, the traffic state indicator generation unit 20 searches for probe data having the same “apparatus ID” as the “apparatus ID” of corresponding probe data among probe data having “transmission date and time” a predetermined time (for example, 10 seconds) before the “transmission date and time” of corresponding probe data, and extracts it as reference probe data. Then, the traffic state indicator generation unit 20 acquires the “moving speed” of a pedestrian related to the probe data by calculating it on the basis of a distance from a point indicated by “position information” of the reference probe data to a point indicated by “position information” of corresponding probe data, and time difference (10 seconds) in “transmission date and time” of the reference probe data and the probe data.

As described above, when the traffic state indicator generation unit 20 acquires the “moving speeds” of a vehicle and a pedestrian from respective probe data included in the target probe data, the procedure proceeds to a next step.

[0033]

Next, the traffic state indicator generation unit 20 calculates “the number of vehicles” indicating the number of vehicles on which the on-board units A located in a target road segment are mounted, and calculates “the number of pedestrians” indicating the number of pedestrians carrying the portable terminal T located in a target road segment on the basis of each piece of probe data included in the target probe data (step S222).

[0034]

Then, the traffic state indicator generation unit 20 sets the “link ID” of a target

road segment as a search key and acquires a “length of the target road segment” by searching for it from map data (step S223).

[0035]

Then, the traffic state indicator generation unit 20 calculates a traffic volume of vehicles and a traffic volume of pedestrians at a target time of the target road segment, respectively. (step S224).

Specifically, the traffic state indicator generation unit 20, first, sets “the number of vehicles” calculated in step S222 as N, the “moving speed” of each vehicle acquired in step S221 as v_i ($i=1$ to N), and the “length of a target road segment” acquired in step S223 as K, and obtains a traffic volume q (vehicles/second) of vehicles using the following equation (1).

[0036]

[Equation 1]

$$q = \sum_{i=1}^N \frac{v_i}{K} \quad \cdot \cdot \cdot (1)$$

15 [0037]

In addition, in the same manner, the traffic state indicator generation unit 20 sets “the number of pedestrians” calculated in step S222 as N, the “moving speed” of each pedestrian acquired in step S221 as v_i ($i=1$ to N), and the “length of a target road segment” acquired in step S223 as K, and obtains a traffic volume q (people/second) of pedestrians using the equation (1) described above.

[0038]

Next, the traffic state indicator generation unit 20 calculates traffic density of vehicles and traffic density of pedestrians at a target time of a target road segment,

respectively (step S225).

Specifically, the traffic state indicator generation unit 20 sets “the number of vehicles” calculated in step S222 as N and the “length of a target road segment” acquired in step S223 as K, and obtains a traffic density k (vehicles/m) of vehicles using the following equation (2).

[0039]

[Equation 2]

$$k = \frac{N}{K} \quad \cdot \cdot \cdot (2)$$

[0040]

10 In addition, in the same manner, the traffic state indicator generation unit 20 sets “the number of pedestrians” calculated in step S222 as N and the “length of a target road segment” acquired in step S223 as K, and obtains a traffic density k (people/m) of pedestrians using the equation (2) described above.

[0041]

15 Next, the traffic state indicator generation unit 20 calculates an average speed of vehicles at a target time of a target road segment and an average speed of pedestrians, respectively (step S226).

Specifically, the traffic state indicator generation unit 20 sets “the number of vehicles” calculated in step S222 as N and the “moving speed” of each vehicle acquired in step S221 as v_i ($i=1$ to N), and obtains an average speed v_s (m/s) of vehicles using the following equation (3).

20

[0042]

[Equation 3]

$$\bar{v}_s = \sum_{i=1}^N \frac{v_i}{N} \quad \cdot \cdot \cdot (3)$$

[0043]

In addition, in the same manner, the traffic state indicator generation unit 20 sets “the number of pedestrians” calculated in step S222 as N and the “moving speed” of each
 5 pedestrian acquired in step S221 as v_i ($i=1$ to N), and obtains an average speed v_s (m/s) of pedestrians using the equation (3) described above.

[0044]

As described above, the traffic state indicator generation unit 20 repeatedly executes the processing P22 described above whenever probe data is acquired, and
 10 thereby calculates a traffic state indicator (a vehicle traffic state indicator and a pedestrian traffic state indicator) at each time in each road segment.

[0045]

(Functional configuration of danger notification device)

FIG. 8 is a diagram which shows a functional configuration of a danger
 15 notification device according to the first embodiment of the present invention.

FIG. 9 is a diagram which shows an example of degree of danger correlation data according to the first embodiment of the present invention.

FIG. 10 is a first diagram which shows an example of alert information according to the first embodiment of the present invention.

20 FIG. 11 is a second diagram which shows the example of alert information according to the first embodiment of the present invention.

Hereinafter, a functional configuration of the danger notification device 40 of the present embodiment will be described with reference to FIGS. 8 to 11.

As shown in FIG. 8, the danger notification device 40 includes a traffic state indicator acquisition unit 410, a danger prediction unit 420, a portable terminal data extraction unit 430, an on-board unit data extraction unit 440, an alert information transmission unit 450, and a recording medium 460.

5 [0046]

The traffic state indicator acquisition unit 410 acquires a traffic state indicator for each road segment from the traffic state database 30 via a network NW. In the present embodiment, the traffic state indicator acquisition unit 410 acquires only a vehicle traffic state indicator from traffic state indicators recorded in the traffic state
10 database 30.

[0047]

The danger prediction unit 420 predicts a degree of danger indicating a probability of the occurrence of a traffic accident in each road segment on the basis of a vehicle traffic state indicator of each road segment acquired by the traffic state indicator
15 acquisition unit 410, and degree of danger correlation data D20 of each road segment recorded in advance in the recording medium 460 (FIG. 9).

Note that the danger prediction unit 420 refers to map data recorded in advance in the recording medium 460, and may not perform prediction of a degree of danger on road segments in which a vehicle and a pedestrian are less likely to collide with each
20 other such as a road segment having a dedicated sidewalk, and a road segment having only an exclusive motor-vehicle way. Thereby, it is possible to reduce processing in which the danger prediction unit 420 performs the prediction of a degree of danger, and to suppress an alert information transmission unit 450 (to be described below) from transmitting unnecessary alert.

25 [0048]

The degree of danger correlation data D20 is data showing a correlation between each of the traffic volume, traffic density, and average speed of vehicles and a degree of danger which indicates the probability of the occurrence of a traffic accident for each road segment. Each piece of the degree of danger correlation data D20 has “traffic

5 volume-degree of danger correlation data D20a,” “traffic density-degree of danger correlation data D20b,” and “average speed-degree of danger correlation data D20c” as shown in FIG. 9.

“Traffic volume-degree of danger correlation data D20a” shows the traffic volume (vehicles/second) of vehicles on the horizontal axis and a degree of danger (%)

10 for the traffic volume of vehicles on the vertical axis. A degree of danger for the traffic volume of vehicles is data represented as the occurrence probability (%) of traffic accidents for the traffic volume of vehicles by statistically calculating the number of occurrences of traffic accidents for the traffic volume, and the like among vehicle traffic indicators in each road segment in the past.

15 “Traffic density-degree of danger correlation data D20b” shows the traffic density (vehicles/m) of vehicles on the horizontal axis and a degree of danger (%) for the traffic density of vehicles on the vertical axis. A degree of danger for the traffic density of vehicles is data represented as the occurrence probability (%) of traffic accidents for the traffic density of vehicles by statistically calculating the number of occurrences of

20 traffic accidents for the traffic density, and the like among vehicle traffic indicators in each road segment in the past.

“Average speed-degree of danger correlation data D20c” shows the average speed (m/s) of vehicles on the horizontal axis and a degree of danger (%) for the average speed of vehicles on the vertical axis. A degree of danger for the average speed of

25 vehicles is data represented as the occurrence probability (%) of traffic accidents for the

average speed of vehicles by statistically calculating the number of occurrences of traffic accidents for the average speed, and the like among vehicle traffic indicators in each road segment in the past.

[0049]

5 In the present embodiment, the danger prediction unit 420 determines that “a degree of danger is high” when a degree of danger of the degree of danger correlation data D20 is equal to or greater than a predetermined reference value r1. Specifically, as shown in FIG. 9, the reference value r1 is set to, for example, 10% in a road segment B10a whose link ID is “B10a.” In this case, the danger prediction unit 420 determines
10 that “a degree of danger is high” when all of the traffic volume, traffic density, and average speed of vehicles traffic state indicator of the road segment B10a have degrees of danger with values equal to or greater than the reference value r1 (10%). Moreover, the danger prediction unit 420 determines “a degree of danger is low” when at least one of the traffic volume, traffic density, and average speed of vehicles traffic state indicator of
15 the road segment B10a has a value of degree of danger less than the reference value r1 (10%).

 Note that the predetermined reference value r1 may be set as the same value for a plurality of road segments, and may also be set as different values for each road segment. In addition, the predetermined reference value r1 may be set as different
20 values for each of “traffic density-degree of danger correlation data D20a,” “traffic density-degree of danger correlation data D20b,” and “average speed-degree of danger correlation data D20c.”

 Furthermore, an example in which, when there is a road segment in which all of the traffic volume, traffic density, and average speed of vehicles have values of degree of
25 danger equal to or greater than the reference value r1, the danger prediction unit 420

determines that the road segment has “a high degree of danger” has been described in the present embodiment, but the present invention is not limited thereto.

In other embodiments, when there is a road segment in which at least one of the traffic volume, traffic density, and average speed of vehicles has a value of degree of
5 danger equal to or greater than the reference value $r1$, the danger prediction unit 420 may also determine “a degree of danger is high” in the road segment.

[0050]

Note that different degree of danger correlation data D20 for each month, each day of week, and each time zone may further be recorded in advance in the recording
10 medium 460. In this case, the danger prediction unit 420 refers to the degree of danger correlation data D20 on the basis of a month, a day of week, and a time zone on which the prediction of a degree of danger is performed. As a result, for example, even if there is a road segment having different degrees of danger in daytime and nighttime, it is possible to improve accuracy of predicting a degree of danger by referring to the
15 different degree of danger correlation data D20 on the basis of a time zone on which the danger prediction unit 420 performs the prediction of a degree of danger.

In addition, an example of obtaining a degree of danger by statistically calculating the number of occurrences of traffic accidents for each of the traffic volume, traffic density, and average speed of vehicles in each road segment in the past has been
20 described in the present embodiment, but the present invention is not limited thereto. In addition to the number of occurrences of traffic accidents (the number of actual traffic accidents), a degree of danger may also be set by statistically calculating the number of traffic accidents likely to occur (for example, the number of acquisitions of data indicating sudden braking such as the “moving speed” of on-board unit probe data being
25 sharply decreased in a short time).

[0051]

Then, the danger prediction unit 420 outputs a road segment which is determined as “the degree of danger is high” to the portable terminal data extraction unit 430 as a danger road segment. Specifically, the danger prediction unit 420 outputs the “link ID” of the danger road segment to the portable terminal data extraction unit 430 and the on-board unit data extraction unit 440.

[0052]

The portable terminal data extraction unit 430 extracts data of a portable terminal T carried by a pedestrian who is traveling the danger road segment from the traffic state table D10 of the traffic state database 30.

Specifically, the portable terminal data extraction unit 430 extracts data of a portable terminal T having the “link ID” of a danger road segment (data in which the “apparatus type” is a “portable terminal”). In addition, the portable terminal data extraction unit 430 further extracts data of a portable terminal T in which “alert setting” is “ON” from the extracted data of a portable terminal T.

When the portable terminal data extraction unit 430 extracts one or more pieces of the data of a portable terminal T which have the “link ID” of a corresponding danger road segment, and in which “alert setting” is “ON,” the portable terminal data extraction unit 430 outputs the extracted data of a portable terminal T to the alert information transmission unit 450 for each danger road segment.

[0053]

The on-board unit data extraction unit 440 extracts data of an on-board unit A mounted on a vehicle which is driving a danger road segment in which pedestrians are present from the traffic state table D10 of the traffic state database 30.

Specifically, the on-board unit data extraction unit 440 identifies, first, a danger

road segment in which a pedestrian is present among danger road segments output from the danger prediction unit 420. For example, the on-board unit data extraction unit 440 acquires the “link ID” of a danger road segment in which a pedestrian (the data of a portable terminal T) having the “alert setting” of a portable terminal T set to “ON” is
 5 present from the portable terminal data extraction unit 430, thereby identifying such a danger road segment. Then, the on-board unit data extraction unit 440 extracts data of an on-board unit A (data in which the “apparatus type” is a “on-board unit”) having the same “link ID” as the “link ID” of the identified danger road segment. In addition, the on-board unit data extraction unit 440 further extracts data of an on-board unit A in
 10 which the “alert setting” is “ON” from the extracted data of an on-board unit A.

As described above, when the on-board unit data extraction unit 440 extracts one or more pieces of the data of an on-board unit A which have the “link ID” of a danger road segment in which a pedestrian is present, and in which the “alert setting” is “ON,” the on-board unit data extraction unit 440 outputs the extracted data of the on-board unit
 15 A to the alert information transmission unit 450 for each danger road segment.

[0054]

The alert information transmission unit 450 transmits alert information to at least one of the portable terminal T and the on-board unit A via the network NW on the basis of the data of the portable terminal T and the on-board unit A, which are extracted
 20 by the portable terminal data extraction unit 430 and the on-board unit data extraction unit 440.

The alert information includes at least one of a text, an image, voice, and the like which indicate that a degree of danger at which a traffic accident occurs is high. In addition, the alert information may also include “position information” of a portable
 25 terminal T and an on-board unit A.

Note that the alert information transmission unit 450 may also transmit different alert information between a portable terminal T and an on-board unit A according to functions of the portable terminal T and the on-board unit A. For example, the alert information transmission unit 450 may also transmit an instruction to operate vibration to a portable terminal T having a vibration function as alert information. In addition, when a portable terminal T is outputting sound such as music, the alert information transmission unit 450 may also transmit an instruction to suspend the sound and to output sound for alert information to the portable terminal T as alert information.

[0055]

Specifically, the alert information transmission unit 450, on the basis of an “apparatus ID” included in the data of a portable terminal T extracted by the portable terminal data extraction unit 430, transmits alert information to a portable terminal T having the same “apparatus ID” as the “apparatus ID.”

If the portable terminal T receives alert information, for example, as shown in FIG. 10, it outputs the alert information as visual information such as text and images as shown in FIG. 11. In addition, the portable terminal T may output the alert information as voice information from a speaker, and may also notify a pedestrian that the alert information is received using vibration or the like. Furthermore, when the “position information” of an on-board unit A is included in the alert information, the position of the on-board unit A may be indicated by an image, map, sound, or the like. By performing such notification, it is possible to cause a pedestrian carrying the portable terminal T to recognize that a “degree of danger” of a road segment in which the pedestrian is currently traveling is high.

In addition, the alert information transmission unit 450, on the basis of an “apparatus ID” included in data of an on-board unit A extracted by the on-board unit data

extraction unit 440, transmits alert information to an on-board unit A having the same “apparatus ID” as the “apparatus ID.”

If the on-board unit A receives alert information, for example, the on-board unit A outputs the alert information as visual information such as text or images as shown in
5 FIG. 11. In addition, the on-board unit A may also output the alert information as voice information from a speaker. Moreover, when the alert information includes the “position information” of a portable terminal T, the position of the portable terminal T may be indicated by an image, a map, sound, or the like. By performing such a notification, it is notified to a driver of a vehicle and the like on which the on-board unit
10 A is mounted that a “degree of danger” of a road segment in which the driver is currently traveling is high and a pedestrian having “alert setting” set to “ON” is present in the road segment in which the driver is currently traveling.

Note that an example in which the alert information transmission unit 450 transmits alert information to a portable terminal T and an on-board unit A has been
15 described in the present embodiment, but the present invention is not limited thereto. The alert information transmission unit 450 may also transmit alert information only to a portable terminal T, and may also transmit alert information only to an on-board unit A.
[0056]

The degree of danger correlation data D20 and the map data are recorded in the
20 recording medium 460 in advance.
[0057]

(Processing flow of danger notification device)

FIG. 12 is a first diagram which shows a processing flow of the danger notification device according to the first embodiment of the present invention.

25 FIG. 13 is a second diagram which shows the processing flow of the danger

notification device according to the first embodiment of the present invention.

Hereinafter, a flow of processing of the danger notification device 40 of the present embodiment will be described with reference to FIGS. 12 and 13.

[0058]

5 First, the danger notification device 40 performs processing P40 of predicting a degree of danger which indicates the probability of the occurrence of a traffic accident of each road segment as shown in FIG. 12.

In the processing P40, the traffic state indicator acquisition unit 410, first, selects a road segment on which the prediction of a degree of danger is performed as a “target
10 road segment” (step S400).

The traffic state indicator acquisition unit 410 selects, for example, a road segment having a link ID with the smallest value as a target road segment. In the example of FIG. 2, the traffic state indicator acquisition unit 410 selects the road segment B10a having the smallest value of “B10a” among a plurality of link IDs as a target road
15 segment.

[0059]

Next, the traffic state indicator acquisition unit 410 acquires the vehicle traffic state indicator of a target road segment from the traffic state database 30 via the network NW (step S401). Specifically, the traffic state indicator acquisition unit 410 acquires a
20 vehicle traffic state indicator having the same link ID as the link ID of a target road segment among a plurality of vehicle traffic information indicators by searching for it from the traffic state database 30.

[0060]

Next, the danger prediction unit 420 acquires the degree of danger correlation
25 data D20 of a target road segment from the recording medium 460 (step S402).

Specifically, the danger prediction unit 420 acquires degree of danger correlation data D20 having the same “link ID” as the “link ID” of a target road segment by searching for it from a plurality of pieces of degree of danger correlation data D20 recorded in the recording medium 460.

5 [0061]

Then, the danger prediction unit 420 determines whether a “degree of danger for a traffic volume” of a target road segment is equal to or greater than a reference value r1 on the basis of the vehicle traffic state indicator of the target road segment and the degree of danger correlation data D20 of the target road segment (step S403).

10 In the degree of danger correlation data D20 (the traffic volume-degree of danger correlation data D20a) shown in FIG. 9, the reference value r1 of the “degree of danger for a traffic volume” of the road segment B10a which is a target road segment is set to, for example, 10%. In addition, a range of a value for the traffic volume in which the degree of danger is equal to or greater than the reference value r1 (10%) is “equal to
15 or greater than q1 and less than q2.”

For this reason, when a “traffic volume” of the vehicle traffic state indicator of the road segment B10a is within the range of “equal to or greater than q1 and less than q2”, the danger prediction unit 420 determines that “the degree of danger for the traffic volume of the road segment B10a is equal to or greater than the reference value r1” (YES
20 in step S403), and the procedure proceeds to a next step S404.

On the other hand, when the “traffic volume” of the vehicle traffic state indicator of the road segment B10a is not included within the range of “equal to or greater than q1 and less than q2”, the danger prediction unit 420 determines that “the degree of danger for the traffic volume of the road segment B10a is less than the reference value r1” (NO
25 in step S403), and the procedure proceeds to a step S407.

[0062]

Next, the danger prediction unit 420 determines whether a “degree of danger for the traffic density” of a target road segment is equal to or greater than the reference value $r1$ on the basis of the vehicle traffic state indicator of the target road segment and the degree of danger correlation data D20 of the target road segment (step S404).

In the degree of danger correlation data D20 (the traffic density-degree of danger correlation data D20b) shown in FIG. 9, a reference value $r1$ of the “degree of danger for a traffic density” of the road segment B10a which is a target road segment is set to, for example, 10%. In addition, a range of a value for the traffic density in which the degree of danger is equal to or greater than the reference value $r1$ (10%) is “equal to or greater than $k1$ and less than $k2$.”

For this reason, when a “traffic density” of the vehicle traffic state indicator of the road segment B10a is within the range of “equal to or greater than $k1$ and less than $k2$ ”, the danger prediction unit 420 determines that “the degree of danger for the traffic density of the road segment B10a is equal to or greater than the reference value $r1$ ” (YES in step S404), and the procedure proceeds to a next step S405.

On the other hand, when the “traffic density” of the vehicle traffic state indicator of the road segment B10a is not included within the range of “equal to or greater than $k1$ and less than $k2$ ”, the danger prediction unit 420 determines that “the degree of danger for the traffic density of the road segment B10a is less than the reference value $r1$ ” (NO in step S404), and the procedure proceeds to the step S407.

[0063]

Next, the danger prediction unit 420 determines whether a “degree of danger for an average speed” of a target road segment is equal to or greater than the reference value $r1$ on the basis of the vehicle traffic state indicator of the target road segment and the

degree of danger correlation data D20 of the target road segment (step S405).

In the degree of danger correlation data D20 (the average speed-degree of danger correlation data D20c) shown in FIG. 9, a reference value r1 of the “degree of danger for an average speed” of the road segment B10a which is a target road segment is set to, for example, 10%. In addition, a range of a value for the average speed in which the degree of danger is equal to or greater than the reference value r1 (10%) is “equal to or greater than v1.”

For this reason, when an “average speed” of the vehicle traffic state indicator of the road segment B10a is within the range of “equal to or greater than v1”, the danger prediction unit 420 determines that “the degree of danger for the average speed of the road segment B10a is equal to or greater than the reference value r1” (YES in step S405), and the procedure proceeds to a next step S406.

On the other hand, when the “average speed” of the vehicle traffic state indicator of the road segment B10a is not included within the range of “equal to or greater than v1”, the danger prediction unit 420 determines that “the degree of danger for the average speed of the road segment B10a is less than the reference value r1” (NO in step S405), and the procedure proceeds to the step S407.

[0064]

When the degree of danger for each of the “traffic volume,” “traffic density,” and “average speed” of vehicles in a target road segment is equal to or greater than the reference value r1 (YES in step S403, YES in step S404, and YES in step S405), the danger prediction unit 420 determines the target road segment as “the degree of danger is high” (step S406). Then, the danger prediction unit 420 sets a road segment determined as “the degree of danger is high” as a danger road segment, and outputs it to the portable terminal data extraction unit 430. Specifically, the danger prediction unit 420 outputs

the “link ID” of a danger road segment to the portable terminal data extraction unit 430.
[0065]

In addition, when the degree of danger for any one of the “traffic volume,”
“traffic density,” and “average speed” of vehicles in a target road segment is less than the
5 reference value r1 (NO in step S403, NO in step S404, or NO in step S405), the danger
prediction unit 420 determines the target road segment as “the degree of danger is not
high” (step S407).

As described above, the danger notification device 40 executes the processing
P40 described above on all road segments.

10 [0066]

In addition, the danger notification device 40 performs processing P41 of
transmitting alert information to at least one of a portable terminal T and an on-board unit
A located in each danger road segment determined as “the degree of danger is high” by
the danger prediction unit 420 in the processing P40 as shown in FIG. 13.

15 In the processing P41, the portable terminal data extraction unit 430, first,
extracts the data of the portable terminal T located in a danger road segment from the
traffic state table D10 of the traffic state database 30 (step S410). Specifically, the
portable terminal data extraction unit 430 extracts data in which the data (data in which
the “apparatus type” is a “portable terminal”) of the portable terminal T having the “link
20 ID” of the danger road segment. In addition, the portable terminal data extraction unit
430 further extracts the data of the portable terminal T in which the “alert setting” is
“ON” among the extracted data of the portable terminal T.

When the portable terminal data extraction unit 430 extracts one or more pieces
of the data of the portable terminal T which have the “link ID” of the danger road
25 segment, and in which the “alert setting” is “ON,” the portable terminal data extraction

unit 430 outputs the extracted data of the portable terminal T to the alert information transmission unit 450.

[0067]

Next, the on-board unit data extraction unit 440 extracts data of an on-board unit
5 A located in the danger road segment from the traffic state table D10 of the traffic state database 30 (step S411).

Specifically, the on-board unit data extraction unit 440 identifies, first, a danger road segment in which a pedestrian is present among danger road segments output from the danger prediction unit 420. For example, the on-board unit data extraction unit 440
10 acquires the “link ID” of a danger road segment in which a pedestrian (the data of a portable terminal T) having the “alert setting” of a portable terminal T set to “ON” from the portable terminal data extraction unit 430, thereby identifying such a danger road segment. Then, the on-board unit data extraction unit 440 extracts the data (data in which the “apparatus type” is a “on-board unit”) of an on-board unit A having the same
15 “link ID” as the “link ID” of the identified danger road segment. In addition, the on-board unit data extraction unit 440 further extracts the data of an on-board unit A in which the “alert setting” is “ON” among the extracted data of an on-board unit A.

When the on-board unit data extraction unit 440 extracts one or more pieces of the data of an on-board unit A which have the “link ID” of a danger road segment in
20 which a pedestrian is present, and in which the “alert setting” is “ON,” the on-board unit data extraction unit 440 outputs the extracted data of an on-board unit A to the alert information transmission unit 450.

[0068]

Next, the alert information transmission unit 450 transmits alert information to
25 at least one of the portable terminal T and the on-board unit A via the network NW on the

basis of the data of the portable terminal T and the on-board unit A extracted by the portable terminal data extraction unit 430 and the on-board unit data extraction unit 440 (step S412).

If the alert information transmission unit 450 completes the transmission of alert
5 information to each portable terminal T and each on-board unit A, the danger notification device 40 ends processing for a target road segment (the road segment B10a).

As described above, the danger notification device 40 executes the processing P41 with respect to all danger road segments.

[0069]

10 (Hardware configuration of danger notification device)

FIG. 14 is a diagram which shows an example of a hardware configuration of the danger notification device according to the first embodiment of the present invention.

Hereinafter, an example of hardware configuration of the danger notification device 40 in the present embodiment will be described with reference to FIG. 14.

15 [0070]

A computer 900 includes a CPU 901, a main storage device 902, an auxiliary storage device 903, an input/output interface 904, and a communication interface 905.

The danger notification device 40 described above is implemented in the computer 900. Then, an operation of each processing unit described above is stored in
20 the auxiliary storage device 903 in a form of program. The CPU 901 develops a program in the main storage device 902 by reading it from the auxiliary storage device 903, and executes the processing described above according to the program. In addition, the CPU 901 secures a storage region corresponding to the recording medium 460 in the main storage device 902 according to the program. In addition, the CPU 901 secures a
25 storage region for storing data being processed in the auxiliary storage device 903

according to the program. Note that the computer 900 may be connected to an external storage device 910 via the input/output interface 904 and the storage region corresponding to the recording medium 460 may also be secured in the external storage device 910. In addition, the computer 900 may be connected to an external storage device 920 via the communication interface 905, and the storage region corresponding to the recording medium 460 may also be secured in the external storage device 920.

[0071]

Note that the auxiliary storage device 903 is an example of a non-transitory tangible medium in at least one embodiment. Other examples of the non-transitory tangible medium include a magnetic disk, a magneto-optical disc, a CD-ROM, a DVD-ROM, a semiconductor memory, and the like connected via the input/output interface 904. Moreover, when this program is delivered to the computer 900 via a communication line, the computer 900 which receives the delivery may develop the program in the main storage device 902 and execute the processing described above.

[0072]

In addition, the program may be used to realize a part of the function described above.

Furthermore, the program may be a so-called difference file (difference program) which realizes the function described above by combining it with another program already stored in the auxiliary storage device 903.

[0073]

In addition, the danger notification device 40 may be constituted by one computer 900, and may also be constituted by a plurality of computers connected to be communicable. For example, each function of the danger notification device 40 may also be provided by the traffic state indicator generation unit 20.

[0074]

(Operational effect)

As described above, the danger notification device 40 according to the present embodiment includes the traffic state indicator acquisition unit 410 which acquires a
5 vehicle traffic state indicator of each road segment from the traffic state database 30, the danger prediction unit 420 which predicts a degree of danger indicating the probability of the occurrence of a traffic accident in each road segment on the basis of a vehicle traffic state indicator, and the alert information transmission unit 450 which, when the danger prediction unit determines that the degree of danger of a road segment is equal to or
10 greater than a predetermined reference value $r1$, transmits alert information to at least one of an on-board unit A mounted on a vehicle located in the road segment and a portable terminal T carried by a pedestrian.

The degree of danger of a road segment may be different depending on the traffic volume, traffic density, and average speed of an actual vehicle in the road segment.
15 For example, when a plurality of vehicle traveling at high speeds in the road segment B10a (FIG. 2), that is, when the degree of danger for each of the traffic volume, traffic density, and average speed of vehicles in the road segment B10a is equal to or greater than the predetermined reference value $r1$, there is a possibility that the probability of the occurrence of a traffic accident may increase in the road segment B10a. On the other
20 hand, when a lot of vehicles with low speeds due to congestion and the like are traveling in the road segment B10a, that is, the degrees of danger for the traffic volume and traffic density of vehicles are equal to or greater than the predetermined reference value $r1$, but, when the degree of danger for the average speed of vehicles is less than the predetermined reference value $r1$, there is a possibility that the probability of the
25 occurrence of a traffic accident may decrease.

However, even if a degree of danger is different depending on an actual situation of a road segment in this manner, the danger prediction unit 420 of the present embodiment predicts a degree of danger according to a vehicle traffic state indicator for each road segment, and thus can improve accuracy in prediction of the degree of danger of each road segment. In addition, the alert information transmission unit 450 can perform an alert operation by transmitting alert information to at least one of an on-board unit A and a portable terminal T located in a danger road segment which is determined that “the degree of danger is high” by the danger prediction unit 420, and can suppress transmission of unnecessary alert information to an on-board unit A and a portable terminal T located in a road segment which is determined that “the degree of danger is low” by the danger prediction unit 420.

[0075]

In addition, the danger prediction unit 420 predicts a degree of danger on the basis of a vehicle traffic state indicator acquired by the traffic state indicator acquisition unit 410, and the degree of danger correlation data D20 in which the probability of the occurrence of a traffic accident for each of the traffic volume, traffic density, and average speed in the past vehicle traffic state indicator is associated with each road segment.

In this manner, the danger prediction unit 420 refers to both a current vehicle traffic state indicator acquired by the traffic state indicator acquisition unit 410 and the degree of danger correlation data D20 which shows the probability of the occurrence of a traffic accident for the past vehicle traffic state indicator, and thereby it is possible to further improve accuracy in prediction of a degree of danger.

[0076]

In addition, when the danger prediction unit 420 determines that the degree of danger of a road segment is equal to or greater than a predetermined reference value r1,

and when a pedestrian is present in the road segment, the alert information transmission unit 450 transmits alert information to an on-board unit A mounted on a vehicle which is traveling the road segment.

Specifically, when the danger prediction unit 420 determines that the degree of
 5 danger of a road segment is equal to or greater than a predetermined reference value r_1 ,
 the danger prediction unit 420 outputs the road segment to the on-board unit data
 extraction unit 440 as a danger road segment in which the “degree of danger is high.”
 The on-board unit data extraction unit 440 extracts the data of an on-board unit A
 mounted on a vehicle which is traveling a danger road segment in which a pedestrian is
 10 present. Then, the alert information transmission unit 450 transmits alert information to
 the on-board unit A on the basis of the data of the on-board unit A extracted by the
 on-board unit data extraction unit 440.

In this manner, the alert information transmission unit 450 can alert a vehicle
 traveling in a road segment in which the degree of danger is high and a pedestrian is
 15 present by transmitting alert information to an on-board unit A, and can suppress
 transmission of unnecessary alert information to an on-board unit A located in a road
 segment in which the degree of danger is high but there is no pedestrian.

[0077]

In addition, the portable terminal data extraction unit 430 and the on-board unit
 20 data extraction unit 440 extract data of a portable terminal T and an on-board unit A in
 which the “alert setting” is “ON.” As a result, the alert information transmission unit
 450 transmits alert information to the portable terminal T and the on-board unit A in
 which the “alert setting” is “ON,” thereby performing an alert operation only on a
 pedestrian, the driver of a vehicle, and the like that desire to receive the alert information.
 25 In addition, it is possible to suppress transmission of unnecessary alert information to a

portable terminal T and an on-board unit A that do not desire to receive the alert information.

For example, a pedestrian who may not be aware of the approach of a vehicle such as a person with visual and hearing disabilities sets the “alert setting” of a portable terminal T to “ON,” thereby recognizing that the degree of danger of a road segment in which traveling is high via alert information transmitted to the portable terminal T.

In addition, the on-board unit data extraction unit 440 extracts the data of an on-board unit A located in a danger road segment in which a pedestrian having the “alert setting” of a portable terminal T set to “ON” is present. For this reason, the alert information transmission unit 450 transmits alert information that a pedestrian having the “alert setting” of a portable terminal set to “ON”, that is, a pedestrian who may not be aware of the approach of a vehicle such as a person with visual and hearing disabilities, is traveling the same road segment to a vehicle on which an on-board unit A is mounted, and thereby it is possible to perform an alert operation on the vehicle.

[0078]

In addition, the danger notification system 1 according to the present embodiment includes the danger notification device 40 described above, the probe data collection unit 10 which collects on-board unit probe data including the position information of an on-board unit A mounted on each of a plurality of vehicles and portable terminal probe data including the position information of a portable terminal T carried by each of a plurality of pedestrians, and the traffic state indicator generation unit 20 which generates a traffic state indicator for each road segment and records it in the traffic state database 30 on the basis of the on-board unit probe data and the portable terminal probe data.

In this manner, the traffic state indicator generation unit 20 can generate a traffic

state indicator in accordance with a situation of an actual road segment on the basis of the on-board unit probe data and the portable terminal probe data successively collected by the probe data collection unit 10. For this reason, the traffic state indicator generation unit 20 can improve the accuracy in traffic state indicator. In addition, the danger notification device 40 can improve accuracy in prediction of a degree of danger of each road segment on the basis of a traffic state indicator with higher accuracy in this manner.

[0079]

<Modified example of first embodiment>

Next, a danger notification system 1 according to a modified example of the first embodiment of the present invention will be described with reference to FIGS.15 and 16.

Components common to those in the first embodiment will be denoted by the same reference numerals and detailed description thereof will be omitted.

In the first embodiment, an aspect in which the danger prediction unit 420 of the danger notification device 40 performs the prediction of a degree of danger on the basis of the “vehicle traffic state indicator” and “degree of danger correlation data” has been described. In the present modified example, the danger prediction unit 420 of the danger notification device 40 is different from that in the first embodiment in that the prediction of a degree of danger is performed on the basis of the “vehicle traffic state indicator”, the “pedestrian traffic state indicator”, and “degree of danger correlation data.”

[0080]

(Processing flow of danger notification device)

FIG. 15 is a diagram which shows a processing flow of a danger notification device according to a modified example of the first embodiment of the present invention.

FIG. 16 is a diagram which shows an example of degree of danger correlation

data according to the modified example of the first embodiment of the present invention.

The danger notification device 40 according to the present modified example performs processing P42 of predicting a degree of danger indicating the probability of the occurrence of a traffic accident of each road segment instead of the processing P40 of the first embodiment (FIG. 12) as shown in FIG. 15.

[0081]

In the processing P42, the traffic state indicator acquisition unit 410, first, selects a road segment in which the prediction of a degree of danger is performed as a “target road segment” (step S420).

The traffic state indicator acquisition unit 410 selects a road segment having the link ID with the smallest value as a target road segment. In the example of FIG. 2, the traffic state indicator acquisition unit 410 selects a road segment B10a having the smallest value “B10a” among a plurality of “link IDs” as a target road segment.

[0082]

Next, the traffic state indicator acquisition unit 410 acquires the vehicle traffic state indicator and pedestrian traffic state indicator of the target road segment from the traffic state database 30 via the network NW (step S421). Specifically, the traffic state indicator acquisition unit 410 acquires a vehicle traffic state indicator having the same “link ID” as the “link ID” of the target road segment from the traffic state database 30 by searching for it among a plurality of vehicle traffic state indicators. In addition, the traffic state indicator acquisition unit 410 acquires a pedestrian traffic state indicator having the same “link ID” as the “link ID” of the target road segment from the traffic state database 30 by searching for it among a plurality of pedestrian traffic state indicators.

[0083]

Next, the danger prediction unit 420 acquires the degree of danger correlation data D21 of a target road segment (FIG. 16) from the recording medium 460 (step S422). Specifically, the danger prediction unit 420 acquires a degree of danger correlation data D21 having the same “link ID” as the “link ID” of a target road segment from a plurality of pieces of degree of danger correlation data D21 recorded in the recording medium 460 by searching for it.

[0084]

The degree of danger correlation data D21 is data which indicates a correlation between each of the traffic volume, traffic density, and average speed of vehicles and pedestrians and a degree of danger indicating the probability of the occurrence of a traffic accident for each road segment. Each piece of degree of danger correlation data D21 has “traffic volume-degree of danger correlation data D21a,” “traffic density-degree of danger correlation data D21b,” and “average speed-degree of danger correlation data D21c” as shown in FIG. 16.

The “traffic volume-degree of danger correlation data D21a” shows the traffic volume of vehicles (vehicles/second) and the traffic volume of pedestrians (people/second) on the horizontal axis, and shows the degree of danger (%) for the traffic volume of vehicles and the degree of danger (%) for the traffic volume of pedestrians on the vertical axis. A solid line indicates the degree of danger for the traffic volume of vehicles, and a broken line indicates the degree of danger for the traffic volume of pedestrians. The degree of danger for the traffic volume of vehicles is the same as in the first embodiment. In addition, the degree of danger for the traffic volume of pedestrians is data expressed as the occurrence probability (%) of a traffic accident with respect to the traffic volume of pedestrians by statistically calculating the number of traffic accidents which have occurred with respect to the traffic volume of pedestrians in

each road segment in the past, and the like.

“Traffic density-degree of danger correlation data D21b” shows the traffic density of vehicles (vehicles/m) and the traffic density of pedestrians (people/m) on the horizontal axis, and shows the degree of danger (%) for the traffic density of vehicles and the degree of danger (%) for the traffic density of pedestrians on the vertical axis. A solid line indicates the degree of danger for the traffic density of vehicles, and a broken line indicates the degree of danger for the traffic density of pedestrians. The degree of danger for the traffic density of vehicles is the same as in the first embodiment. In addition, the degree of danger for the traffic density of pedestrians is data expressed as the occurrence probability (%) of a traffic accident with respect to the traffic density of pedestrians by statistically calculating the number of traffic accidents which have occurred with respect to the traffic density of pedestrians in each road segment in the past, and the like.

“Average speed-degree of danger correlation data D21c” shows the average speed of vehicles (m/s) and the average speed of pedestrians (m/s) on the horizontal axis, and shows the degree of danger (%) for the average speed of vehicles and the degree of danger (%) for the average speed of pedestrians on the vertical axis. A solid line indicates the degree of danger for the average speed of vehicles, and a broken line indicates the degree of danger for the average speed of pedestrians. The degree of danger for the average speed of vehicles is the same as in the first embodiment. In addition, the degree of danger for the average speed of pedestrians is data expressed as the occurrence probability (%) of a traffic accident with respect to the average speed of pedestrians by statistically calculating the number of traffic accidents which have occurred with respect to the average speed of pedestrians in each road segment in the past, and the like.

[0085]

Next, the danger prediction unit 420 determines whether a “degree of danger for the traffic volume of vehicles” of a target road segment is equal to or greater than a reference value r1, and whether a “degree of danger for the traffic volume of pedestrians” of the target road segment is equal to or greater than the reference value r1 on the basis of the vehicle traffic state indicator and pedestrian traffic state indicator of the target road segment, and the degree of danger correlation data D21 of the target road segment (step S423).

In the degree of danger correlation data D21 (the traffic volume-degree of danger correlation data D21a) shown in FIG. 16, the reference value r1 of the “degree of danger for a traffic volume” of the road segment B10a which is a target road segment is set to, for example, 10%. In addition, the range of a value for the traffic volume of vehicles in which the degree of danger is equal to or greater than the reference value r1 (10%) is “equal to or greater than q1 and less than q2,” and a range of a value for the traffic volume of pedestrians is “equal to or greater than q3 and less than q4.”

For this reason, when the “traffic volume” of the vehicle traffic state indicator of the road segment B10a is within the range of “equal to or greater than q1 and less than q2”, and the “traffic volume” of the pedestrian traffic state indicator thereof is within the range of “equal to or greater than q3 and less than q4,” the danger prediction unit 420 determines that “the degree of danger for the traffic volume of the road segment B10a is equal to or greater than the reference value r1” (YES in step S423), and the procedure proceeds to a next step S424.

On the other hand, when the “traffic volume” of the vehicle traffic state indicator of the road segment B10a is not included within the range of “equal to or greater than q1 and less than q2”, or when the “traffic volume” of the pedestrian traffic state indicator

thereof is not included within the range of “equal to or greater than q_3 and less than q_4 ,” the danger prediction unit 420 determines that “the degree of danger for the traffic volume of the road segment B10a is less than the reference value r_1 ” (NO in step S423), and the procedure proceeds to the step S427.

5 [0086]

Next, the danger prediction unit 420 determines whether a “degree of danger for the traffic density of vehicles” of a target road segment is equal to or greater than a reference value r_1 , and whether a “degree of danger for the traffic density of pedestrians” of the target road segment is equal to or greater than the reference value r_1 on the basis of
 10 the vehicle traffic state indicator and pedestrian traffic state indicator of the target road segment, and the degree of danger correlation data D21 of the target road segment (step S424).

In the degree of danger correlation data D21 (the traffic density-degree of danger correlation data D21b) shown in FIG. 16, the reference value r_1 of the “degree of
 15 danger for a traffic density” of the road segment B10a which is a target road segment is set to, for example, 10%. In addition, the range of a value for the traffic density of vehicles in which the degree of danger is equal to or greater than the reference value r_1 (10%) is “equal to or greater than k_1 and less than k_2 ,” and a range of a value for the traffic density of pedestrians is “equal to or greater than k_3 and less than k_4 .”

20 For this reason, when the “traffic density” of the vehicle traffic state indicator of the road segment B10a is within the range of “equal to or greater than k_1 and less than k_2 ”, and the “traffic density” of the pedestrian traffic state indicator thereof is within the range of “equal to or greater than k_3 and less than k_4 ,” the danger prediction unit 420 determines that “the degree of danger for the traffic density of the road segment B10a is
 25 equal to or greater than the reference value r_1 ” (YES in step S424), and the procedure

proceeds to a next step S425.

On the other hand, when the “traffic density” of the vehicle traffic state indicator of the road segment B10a is not included within the range of “equal to or greater than k_1 and less than k_2 ”, or when the “traffic density” of the pedestrian traffic state indicator thereof is not included within the range of “equal to or greater than k_3 and less than k_4 ,” the danger prediction unit 420 determines that “the degree of danger for the traffic density of the road segment B10a is less than the reference value r_1 ” (NO in step S424), and the procedure proceeds to the step S427.

[0087]

Next, the danger prediction unit 420 determines whether a “degree of danger for the average speed of vehicles” of a target road segment is equal to or greater than a reference value r_1 , or whether a “degree of danger for the average speed of pedestrians” of the target road segment is equal to or greater than the reference value r_1 on the basis of the vehicle traffic state indicator and pedestrian traffic state indicator of the target road segment, and the degree of danger correlation data D21 of the target road segment (step S425).

In the degree of danger correlation data D21 (the average speed-degree of danger correlation data D21c) shown in FIG. 16, the reference value r_1 of the “degree of danger for an average speed” of the road segment B10a which is a target road segment is set to, for example, 10%. In addition, the range of a value for the average speed of vehicles in which the degree of danger is equal to or greater than the reference value r_1 (10%) is “equal to or greater than v_1 ,” and a range of a value for the average speed of pedestrians is “equal to or greater than v_2 .”

For this reason, when the “average speed” of the vehicle traffic state indicator of the road segment B10a is within the range of “equal to or greater than v_1 ”, and the

“average speed” of the pedestrian traffic state indicator thereof is within the range of “equal to or greater than v_2 ,” the danger prediction unit 420 determines that “the degree of danger for the average speed of the road segment B10a is equal to or greater than the reference value r_1 ” (YES in step S425), and the procedure proceeds to a next step S426.

5 On the other hand, when the “average speed” of the vehicle traffic state indicator of the road segment B10a is not included within the range of “equal to or greater than v_1 ”, or when the “average speed” of the pedestrian traffic state indicator thereof is not included within the range of “equal to or greater than v_2 ,” the danger prediction unit 420 determines that “the degree of danger for the average speed of the road segment B10a is less than the reference value r_1 ” (NO in step S425), and the procedure proceeds to the step S427.

[0088]

When the degree of danger for each of the “traffic volume,” “traffic density,” and “average speed” of vehicles and pedestrians in a target road segment is equal to or greater than the reference value r_1 (YES in step S423, YES in step S424, and YES in step 15 S425), the danger prediction unit 420 determines the target road segment as “the degree of danger is high” (step S426). Then, the danger prediction unit 420 sets a road segment determined as “the degree of danger is high” as a danger road segment, and outputs it to the portable terminal data extraction unit 430. Specifically, the danger 20 prediction unit 420 outputs the “link ID” of a danger road segment to the portable terminal data extraction unit 430.

[0089]

In addition, when the degree of danger for any one of the “traffic volume,” “traffic density,” and “average speed” of vehicles and pedestrians in a target road 25 segment is less than the reference value r_1 (NO in step S423, NO in step S424, or NO in

step S425), the danger prediction unit 420 determines the target road segment as “the degree of danger is low” (step S427).

As described above, the danger notification device 40 executes the processing P42 described above on all road segments.

5 [0090]

(Operational effect)

As described above, in the danger notification device 40 according to the present modified example, the traffic state indicator acquisition unit 410 acquires a vehicle traffic state indicator and a pedestrian traffic state indicator of each road segment from the
10 traffic state database 30. The danger prediction unit 420 predicts a degree of danger indicating the occurrence probability of a traffic accident in each road segment on the basis of the vehicle traffic state indicator and the pedestrian traffic state indicator of each road segment.

The degree of danger of a road segment may be different depending on the
15 actual traffic volume, traffic density, average speed of vehicles, and the actual traffic volume, traffic density, and average speed of pedestrians in a corresponding road segment. For example, when there are a lot of vehicles traveling at high speed in the road segment B10a (FIG. 2), that is, when the traffic volume or traffic density of pedestrians is low even though the degree of danger for each of the traffic volume, traffic
20 density, and average speed of vehicles in the road segment B10a is equal to or greater than a predetermined reference value r_1 , the degree of danger may be low.

However, even when the degree of danger is different depending on situations of vehicles and pedestrians in a road segment in this manner, the danger prediction unit 420 of the present embodiment predicts a degree of danger according to both a vehicle traffic
25 state indicator and a pedestrian traffic state of each road segment, thereby improving

accuracy in prediction of the degree of danger in each road segment.

[0091]

As described above, the embodiments of the present invention have been described in details, but the present invention is not limited thereto as long as not departing from a technical concept of the present invention, and some design changes and the like can be made.

For example, an aspect in which a pedestrian carries a portable terminal T has been described in the embodiments, but the present invention is not limited thereto. For example, a portable terminal T may be attached to a light vehicle such as a bicycle. In this case, the alert information transmission unit 450 may transmit alert information indicating that a light vehicle is present in a corresponding danger road segment to one or both of a portable terminal T carried by a pedestrian traveling in the danger road segment and an on-board unit A mounted on a traveling vehicle traveling in the danger road segment. In addition, the alert information transmission unit 450 may transmit alert information indicating that a pedestrian and a vehicle are present in a corresponding danger road segment to a portable terminal T attached to a light vehicle traveling the danger road segment.

[Industrial Applicability]

[0092]

According to the danger notification device, the danger notification system, the danger notification method, and the program described above, it is possible to notify of danger prediction information of traffic accidents in accordance with a traffic state of each road segment.

[Reference Signs List]

[0093]

	1: Danger notification system
	10: Probe data collection unit
	20: Traffic state indicator generation unit
	30: Traffic state database
5	40: Danger notification device
	410: Traffic state indicator acquisition unit
	420: Danger prediction unit
	430: Portable terminal data extraction unit
	440: On-board unit data extraction unit
10	450: Alert information transmission unit
	460: Recording medium
	900: Computer
	901: CPU
	902: Main storage device
15	903: Auxiliary storage device
	904: Input/output interface
	905: Communication interface
	910: External storage device
	920: External storage device
20	A: On-board unit
	NW: Network
	T: Portable terminal

[CLAIMS]

[Claim 1]

A danger notification device comprising:
 a traffic state indicator acquisition unit configured to acquire a traffic state indicator of a road segment from a traffic state database;
 a danger prediction unit configured to predict a degree of danger indicating occurrence probability of a traffic accident in the road segment on the basis of the traffic state indicator; and
 an alert information transmission unit configured to transmit alert information to at least one of an on-board unit mounted on a vehicle and a portable terminal carried by a pedestrian located in the road segment when the danger prediction unit determines that the degree of danger of the road segment is equal to or greater than a predetermined reference value,

wherein the alert information transmission unit is configured to transmit the alert information to the on-board unit when the danger prediction unit determines that the degree of danger of the road segment is equal to or greater than the predetermined reference value and the pedestrian exists in the road segment.

[Claim 2]

The danger notification device according to claim 1,
 wherein the danger prediction unit predicts the degree of danger on the basis of the traffic state indicator acquired by the traffic state indicator acquisition unit and degree of danger correlation data in which the occurrence probability of a traffic accident with respect to a past traffic state indicator is associated with each road segment.

[Claim 3]

A danger notification system comprising:
 the danger notification device according to claim 1 or 2;
 a probe data collection unit configured to collect on-board unit probe data including position information of an on-board unit mounted on each of a plurality of vehicles and portable terminal probe data including position information of a portable terminal carried by each of a plurality of pedestrians; and
 a traffic state indicator generation unit configured to generate a traffic state indicator for each road segment and record it in a traffic state database on the basis of the on-board unit probe data and the portable terminal probe data.

[Claim 4]

A danger notification method comprising:
 a traffic state indicator acquisition step of acquiring a traffic state indicator of a road segment from a traffic state database;
 a danger prediction step of predicting a degree of danger in the road segment on the basis of the traffic state indicator; and
 an alert information transmission step of transmitting alert information to at least one of an on-board unit mounted on a vehicle and a portable terminal carried by a pedestrian located in the road segment when it is determined that a degree of danger of the road segment is equal to or greater than a predetermined reference value in the danger prediction step,
 wherein in the alert information transmission step, the alert information is transmitted to the on-board unit when the danger prediction unit determines that the degree of danger of the road segment is equal to or greater than the predetermined reference value and the pedestrian exists in the road segment.

[Claim 5]

A program which causes a computer of a danger notification device to function as:
a traffic state indicator acquisition unit configured to acquire a traffic state indicator of a road segment from a traffic state database,
a danger prediction unit configured to predict a degree of danger in the road segment on the basis of the traffic state indicator, and
an alert information transmission unit configured to transmit alert information to at least one of an on-board unit mounted on a vehicle and a portable terminal carried by a pedestrian located in the road segment when the danger prediction unit determines that a degree of danger of the road segment is equal to or greater than a predetermined reference value,
wherein the alert information transmission unit is configured to transmit the alert information to the on-board unit when the danger prediction unit determines that the degree of danger of the road segment is equal to or greater than the predetermined reference value and the pedestrian exists in the road segment.