DESCRIPTION

TITLE OF INVENTION: ASSISTANCE DEVICE, ASSISTANCE METHOD, AND PROGRAM

TECHNICAL FIELD

[0001]

The present disclosure relates to an assistance device, an assistance method, and a program.

Priority is claimed on Japanese Patent Application No. 2022-117992, filed July 25, 2022, the content of which is incorporated herein by reference.

BACKGROUND ART

[0002]

By performing columnar travel (hereinafter, also referred to as "following travel") in which a plurality of vehicles travel in a column in the same direction or toward the same destination, there are advantages such as a reduction in driving burden on a driver and improvement in fuel economy due to improvement in aerodynamic performance. As the technology for assisting in the following travel, Patent Document 1 discloses that, among vehicles present within a communication range of vehicle-to-vehicle communication, vehicles having the same route to a destination or the same desired vehicle type automatically perform following travel request and permission.

Citation List

Patent Document

[0003]

Patent Document 1: Japanese Unexamined Patent Application, First Publication No. 2022-32673

SUMMARY OF INVENTION

Technical Problem

[0004]

However, in the related art, in a case where a following travel target vehicle is not present within a communication range of vehicle-to-vehicle communication or in a case where a following travel non-target vehicle is present between the target vehicles, it may be difficult to find a matching partner (a preceding vehicle or a following vehicle) for the following travel.

[0005]

An object of the present disclosure is to provide an assistance device, an assistance method, and a program that can match following travel target vehicles with each other without being affected by a communication range of vehicle-to-vehicle communication or the presence of a following travel non-target vehicle.

Solution to Problem

[0006]

According to an aspect of the present disclosure, an assistance device assists in following travel of a vehicle, the assistance device includes a bubble generation unit configured to, in a case where a bubble registration request is received from the vehicle, generate a bubble which is a following travel vehicle group with the vehicle as a leader and register bubble information in which vehicle information of the vehicle and identification information of the generated bubble are associated with each other; a matching processing unit configured to, in a case where a following travel request is received from the vehicle included in the bubble, select a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request; an integration

instruction unit configured to instruct the leader of each of the request source bubble and the matching candidate to perform bubble integration; and an update processing unit configured to, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrate the bubble information of the integration bubble with bubble information of an integrated bubble integrated with the integration bubble to update the bubble information of the integrated bubble.

[0007]

According to an aspect of the present disclosure, an assistance method is a method of assisting in following travel of a vehicle, the assistance method includes a step of, in a case where a bubble registration request is received from the vehicle, generating a bubble which is a following travel vehicle group with the vehicle as a leader and registering bubble information in which vehicle information of the vehicle and identification information of the generated bubble are associated with each other; a step of, in a case where a following travel request is received from the vehicle included in the bubble, selecting a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request; a step of instructing the leader of each of the request source bubble and the matching candidate to perform bubble integration; and a step of, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrating the bubble information of the integration bubble with bubble information of an integrated bubble integrated with the integration bubble to update the bubble information of the integrated bubble.

[0008]

According to an aspect of the present disclosure, a program causing an assistance device to execute a process includes a step of, in a case where a bubble registration request is received from a vehicle, generating a bubble which is a following travel vehicle group with the vehicle as a leader and registering bubble information in which vehicle information of the vehicle and identification information of the generated bubble are associated with each other; a step of, in a case where a following travel request is received from the vehicle included in the bubble, selecting a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request; a step of instructing the leader of each of the request source bubble and the matching candidate to perform bubble integration; and a step of, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrating the bubble information of the integration bubble with bubble information of an integrated bubble integrated with the integration bubble to update the bubble information of the integrated bubble.

Advantageous Effects of Invention

[0009]

According to the above aspects, it is possible to match following travel target vehicles with each other without being affected by a communication range of vehicle-to-vehicle communication or the presence of a following travel non-target vehicle.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

[FIG. 1] A schematic diagram showing the overall configuration of an assistance system according to a first embodiment.

[FIG. 2] A block diagram showing the functional configuration of an assistance

device according to the first embodiment.

[FIG. 3] A diagram showing bubbles according to the first embodiment.

[FIG. 4] A sequence diagram showing an example of bubble generation processing in the assistance system according to the first embodiment.

[FIG. 5] A view showing an example of vehicle information according to the first embodiment.

[FIG. 6] A view showing an example of the bubble information according to the first embodiment.

[FIG. 7] A view showing an example of update information according to the first embodiment.

[FIG. 8] A sequence diagram showing an example of bubble integration processing in the assistance system according to the first embodiment.

[FIG. 9] A flowchart showing an example of matching processing in the assistance device according to the first embodiment.

[FIG. 10] A flowchart showing an example of speed instruction processing in the assistance device according to the first embodiment.

[FIG. 11] A first view showing an example of bubble information update processing according to the first embodiment.

[FIG. 12] A sequence diagram showing an example of information notification processing in the assistance system according to the first embodiment.

[FIG. 13] A sequence diagram showing an example of bubble separation processing in the assistance system according to the first embodiment.

[FIG. 14] A second view showing an example of the bubble information update processing according to the first embodiment.

[FIG. 15] A sequence diagram showing an example of management of bubble

information between different areas in the assistance system according to the first embodiment.

[FIG. 16] A diagram showing an example of the state transition of a target vehicle according to the first embodiment.

[FIG. 17] A diagram showing an example of the state transition of the assistance device according to the first embodiment.

DESCRIPTION OF EMBODIMENTS

[0011]

<First Embodiment>

(Overall Configuration of Assistance System)

Hereinafter, embodiments will be described in detail with reference to the drawings.

FIG. 1 is a schematic diagram showing the overall configuration of an assistance system according to a first embodiment.

As shown in FIG. 1, the assistance system 1 includes an assistance device 10, a target vehicle 20, traffic information DB 41, and weather information DB 42.

[0012]

The assistance device 10 is provided in a road control center or the like that performs monitoring of a target road R, and provides a following travel assistance service of assisting in the following travel of the target vehicle 20 on the target road R.

[0013]

The target road R is, for example, a highway, and the target vehicle 20 and a non-target vehicle 30 travel in a mixed manner.

[0014]

The target vehicle 20 is a connected car that uses the following travel assistance

service, and performs wireless communication with the assistance device 10 via a communication service provided by a mobile communication operator to transmit and receive various types of information, signals, and the like related to the following travel. In addition, the target vehicle 20 performs wireless communication (vehicle-to-vehicle communication) with other target vehicles 20 to transmit and receive various types of information, signals, and the like related to the following travel. In a case where a user (a passenger such as a driver or a user or manager of a vehicle in the case of an autonomous vehicle) desires, the target vehicle 20 travels (travels in a following manner) with other target vehicles 20 in a vehicle group when traveling on the target road R. The target vehicle 20 may be a vehicle driven by a driver or may be an autonomous vehicle. In addition, during the following travel, the subsequent target vehicle 20 may be electronically towed by the preceding target vehicle 20.

[0015]

The non-target vehicle 30 is a non-connected car that does not use the following travel assistance service.

[0016]

The traffic information of the target road R is recorded in the traffic information DB 41. The traffic information includes, for example, an event such as traffic congestion, an accident, or a road closure, an occurrence position (point or section) of the event, and a start time and an end time (expected time) of the event.

[0017]

The weather information of the target road R is recorded in the weather information DB 42. The weather information includes, for example, information on the weather for each area (region consisting of one or more sections) of the target road R or information on an event (freezing of a road surface) caused by the weather.

[0018]

In addition, the assistance system 1 may further include roadside equipment 50 provided on the roadside of the target road R. The roadside equipment 50 relays communication between the assistance device 10 and the target vehicle 20. The roadside equipment 50 performs wireless communication (road-to-vehicle communication) with the target vehicle 20 to transmit and receive various types of information, signals, and the like. The roadside equipment 50 transmits and receives various types of information, signals, and the like by performing wireless communication or wired communication with the assistance device 10 via a communication service provided by a mobile communication operator.

[0019]

In the present embodiment, an aspect in which the assistance device 10 and the target vehicle 20 directly communicate with each other without using the roadside equipment 50 will be described as an example.

[0020]

(Functional Configuration of Assistance Device)

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

As shown in FIG. 2, the assistance device 10 includes a processor 11, a memory 12, a storage 13, and a communication interface 14.

[0021]

The memory 12 has a memory area necessary for the operation of the processor 11.

[0022]

The storage 13 is a so-called auxiliary storage device and is, for example, a hard

disk drive (HDD) or a solid-state drive (SSD).

[0023]

The communication interface 14 is an interface for performing transmission and reception of various types of information to and from external equipment (the target vehicle 20, the traffic information DB 41, the weather information DB 42, the roadside equipment 50, and the like).

[0024]

The processor 11 operates in accordance with a predetermined program to exhibit functions as a bubble generation unit 110, a matching processing unit 111, an updated information acquisition unit 112, an integration instruction unit 113, an update processing unit 114, a separation processing unit 115, and a notification unit 116.

[0025]

In a case where a bubble registration request is received from the target vehicle 20, the bubble generation unit 110 generates a bubble that is a following travel vehicle group with the target vehicle 20 as a leader, and registers bubble information in which the vehicle information of the target vehicle 20 and the identification information of the generated bubble are associated with each other.

[0026]

In a case where a following travel request is received from one bubble, the matching processing unit 111 selects a bubble satisfying a predetermined matching condition among the plurality of bubbles as a matching candidate for a request source bubble of the following travel request.

[0027]

The updated information acquisition unit 112 acquires update information including the traveling position of each of the plurality of bubbles.

[0028]

The integration instruction unit 113 instructs the leader of each of the request source bubble and the matching candidate to perform bubble integration.

[0029]

In a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is an integration bubble and the other is an integrated bubble integrated with the integration bubble is received, the update processing unit 114 integrates the bubble information of the integration bubble with the bubble information of the integrated bubble to update the bubble information of the integrated bubble. In addition, the update processing unit 114 deletes the bubble information of the integrated bubble.

[0030]

In a case where a separation request for exiting an exit vehicle from the bubble is received, the separation processing unit 115 deletes and updates the vehicle information of the exit vehicle from the bubble information of the bubble, generates an exit bubble having the exit vehicle as a leader, and registers bubble information in which the vehicle information of the exit vehicle and identification information of the generated exit bubble are associated with each other.

[0031]

The notification unit 116 notifies the matching candidate of the update information of the request source bubble and notifies the request source bubble of the update information of the matching candidate. In addition, in a case where an abnormal event is detected ahead in the traveling direction of a bubble from the traffic information of the traffic information DB 41 or the weather information of the weather information DB 42, the notification unit 116 notifies the bubble of abnormality information related to

the abnormal event. The abnormal event is, for example, an event that may affect the following travel, such as an accident or freezing of a road surface.

[0032]

The assistance device 10 may be configured by a single computer, or may be configured by distributing the configuration of the assistance device 10 to a plurality of computers and functioning as the assistance device 10 by the plurality of computers cooperating with each other.

[0033]

In addition, the predetermined program executed by the processor 11 of the assistance device 10 is stored in a computer-readable recording medium. The computer-readable recording media include magnetic disks, magneto-optical disks, CD-ROMs, DVD-ROMs, semiconductor memories, and the like. Alternatively, this computer program may be distributed to a computer via a communication line, and the computer receiving the distribution may execute the program. Furthermore, this program may be for realizing some of the above-described functions. Further, the program may be a so-called difference file (difference program) capable of realizing the functions described above in combination with a program recorded in advance in the computer system.

[0034]

(Bubble)

FIG. 3 is a diagram showing the bubbles according to the first embodiment.

The assistance device 10 according to the present embodiment manages a vehicle group that travels in a following manner on the target road R in units of “bubbles”. Hereinafter, the concept of the bubbles will be described with reference to FIG. 3.

[0035]

As shown in FIG. 3, the bubbles include at least one target vehicle 20. In addition, one of the target vehicles 20 included in the respective bubbles is a leader. The leader is a vehicle that representatively performs communication between the assistance device 10 and the bubbles. Since the leader vehicle has a function of developing information to the assistance device 10 and the target vehicle 20 other than the leader or relaying information to the assistance device 10 and the target vehicle 20 other than the leader, the vehicle other than the leader may not communicate with the assistance device 10 individually. The leader performs vehicle-to-vehicle communication with the other target vehicle 20 in the same bubble to perform transmission of various types of information and signals related to the following travel or information notified from the assistance device 10.

[0036]

(a) of FIG. 3 shows an example of single bubbles B1 and B2 in which only one target vehicle 20 (20A, 20B) is included in one bubble. Each of the leaders of the single bubbles B1 and B2 is each of the target vehicles 20A and 20B.

[0037]

In addition, the bubbles can be integrated to form one bubble including a plurality of target vehicles 20. (b) of FIG. 3 shows an example of an integration bubble B1 that integrates the single bubbles B1 and B2 and includes two target vehicles 20A and 20B. In the example of (b) of FIG. 3, the single bubble B1 absorbs the single bubble B2 to become the integration bubble B1, and the single bubble B2 is absorbed into the integration bubble B1 and disappears, becoming an integrated bubble B2. The leader of the integration bubble B1 is determined by adjustment between the target vehicles 20A and 20B. In the example of (b) of FIG. 3, the target vehicle 20A is a leader of the

integration bubble B1.

[0038]

The upper limit of the number of target vehicles 20 included in one bubble can be set in advance. In this case, the bubble that has reached the upper limit of the number cannot be integrated with other bubbles. In addition, even bubbles which do not reach the upper limit of the number cannot be integrated with each other in a case where the bubbles exceed the upper limit of the number through the integration. In addition, until the upper limit of the number is reached, the integration bubble may be further integrated with another single bubble or another integration bubble.

[0039]

The traveling formation (traveling lane, traveling order, and the like) of each target vehicle 20 included in the integration bubble is optional. As in the example of (b) of FIG. 3, the target vehicles 20A and 20B of the integration bubble B1 may travel side by side in the same lane. In this case, the subsequent target vehicle 20B may be electronically towed by the preceding target vehicle 20A. In addition, the target vehicles 20A and 20B of the integration bubble B1 may travel on different lanes. In addition, for the purpose of avoiding danger or the like, lane change may be temporarily performed by the driver of each of the target vehicles 20A and 20B or a built-in automatic driving control device in the case of the autonomous vehicle. The leader vehicle may not necessarily travel at the head. Formation or lane change is performed while performing mutual adjustment between the target vehicles 20A and 20B through vehicle-to-vehicle communication.

[0040]

Furthermore, the integration bubble B1 including the plurality of target vehicles 20 can be separated into two bubbles. For example, as shown in (c) FIG. 3, in a case

where one of the target vehicles 20A and 20B exits from the following travel at a branch, an exit, or the like, the integration bubble B1 is separated into two bubbles B1 and B3. In the example of (c) of FIG. 3, the integration bubble B1 is separated into a continuation bubble B1 that continues the traveling on the target road R and an exit bubble B3 that exits from the target road R. A new leader is set in each of the continuation bubble B1 and the exit bubble B3. In the example of (c) of FIG. 3, the leader of the continuation bubble B1 is the target vehicle 20A, and the leader of the exit bubble B3 is the target vehicle 20B. In a case where a plurality of target vehicles 20 are included in each bubble, the leader is determined by adjustment between the target vehicles 20 in the bubble.

[0041]

(Processing 1 of Assistance Device: Bubble Generation Processing)

FIG. 4 is a sequence diagram showing an example of bubble generation processing in the assistance system according to the first embodiment.

Hereinafter, a flow of the bubble generation processing will be described in detail with reference to FIG. 4. Here, an example of generating the bubble of the target vehicle 20A shown in (a) of FIG. 3 will be described.

[0042]

First, in a case where it is determined to start the following travel assistance service (step S10), the target vehicle 20A transmits the bubble registration request to the assistance device 10 (step S11).

[0043]

The target vehicle 20A determines that the service is started, for example, in a case where a user has performed an operation to start the service. In addition, in a case where the target vehicle 20A detects that the target vehicle 20A has entered the target

road R by using a known position detection technique such as GNSS, the target vehicle 20A may determine to start the service. Alternatively, the start may be determined by using communication with a road-to-vehicle communication device installed on the roadside as a trigger.

[0044]

FIG. 5 is a view showing an example of the vehicle information according to the first embodiment.

The bubble registration request transmitted by the target vehicle 20 to the assistance device 10 includes vehicle information D1 (FIG. 5). As shown in FIG. 5, the vehicle information D1 includes information such as identification information (vehicle ID), vehicle attribute, destination, stopover, destination arrival deadline, accompanying vehicle information, and traveling position of the target vehicle 20. The vehicle attribute is information indicating a category according to the external feature, use, or the like of a vehicle, such as a large vehicle, an extra-large vehicle, or a bus.

The destination and the stopover are, for example, an exit IC of the target road R. The accompanying vehicle information includes the number of accompanying vehicles accompanying the target vehicle 20 and the identification information (vehicle ID) of the accompanying vehicles. The accompanying vehicle is, for example, a vehicle that has been performing the following travel along with the target vehicle 20 before entering the target road R, or a towed vehicle that is towed by the target vehicle 20 by electronic towing or the like. In the examples of FIGS. 3 and 5, the target vehicle 20B is a vehicle that travels alone, and the number of accompanying vehicles is 0.

[0045]

Next, the bubble generation unit 110 of the assistance device 10 generates a new bubble based on the vehicle information D1 included in the bubble registration request

(step S12). In addition, the bubble generation unit 110 generates bubble information D2 (FIG. 6) of a newly generated bubble and records the bubble information D2 in the storage 13.

[0046]

FIG. 6 is a diagram showing an example of the bubble information according to the first embodiment.

As shown in FIG. 6, the bubble information D2 includes bubble identification information (bubble ID).

Information such as a leader, the number of vehicles included, a traveling direction, a common destination, and individual vehicle information are included. The leader is a vehicle ID of the target vehicle 20 which is a leader of the bubble. The number of vehicles included is the total number of target vehicles 20 included in the bubble. The common destination is a destination (exit IC) to which the target vehicles 20 included in the bubble commonly are heading. The individual vehicle information is vehicle information D1 (FIG. 5) of each target vehicle 20 included in the bubble. In addition, the bubble information D2 may include information on a final destination indicating the farthest destination among the destinations of the target vehicles 20 included in the bubble.

[0047]

In the examples of FIGS. 3, 5, and 6, the target vehicle 20A has no accompanying vehicle (accompanying vehicle information = 0). In this case, the bubble generation unit 110 generates a single bubble B1 including only the target vehicle 20A. The leader of the single bubble B1 is the target vehicle 20A, and the number of vehicles included is “1”. The traveling direction and the common destination are the traveling direction (upward, downward, a certain direction, or the like) and the destination (exit

IC) of the target vehicle 20A. Only the vehicle information D1 of the target vehicle 20A is recorded in the individual vehicle information.

[0048]

In a case where the bubble registration request is received from the target vehicle 20 with an accompanying vehicle, the bubble generation unit 110 generates a bubble including a plurality of vehicles of the target vehicle 20 and the accompanying vehicle. In this case, the target vehicle 20 acquires the vehicle information D1 of the accompanying vehicle by performing vehicle-to-vehicle communication with the accompanying vehicle. In addition, the target vehicle 20 transmits the vehicle information D1 of the target vehicle 20 itself and the accompanying vehicle to the assistance device 10 together with the bubble registration request in step S11. The bubble generation unit 110 of the assistance device 10 generates the bubble information D2 including the vehicle information D1 of each of the target vehicle 20 and the accompanying vehicle thereof. The total number of the target vehicle 20 and the accompanying vehicle is input to the total number of vehicles included, of the bubble information D2.

[0049]

In addition, the bubble generation unit 110 of the assistance device 10 notifies the target vehicle 20A, which is a transmission source of the bubble registration request, of the bubble ID by transmitting the bubble information D2 of the generated bubble B1 (step S13).

[0050]

In a case where the target vehicle 20A receives the bubble information D2 (bubble ID), the target vehicle 20A transmits an ACK notification (step S14). In addition, the ACK notification includes update information D3 (FIG. 7) of the bubble B1

of the target vehicle 20A.

[0051]

FIG. 7 is a diagram showing an example of the update information according to the first embodiment.

As shown in FIG. 7, the update information D3 includes identification information (bubble ID) of a bubble, an update time of the update information, a traveling position, a bubble speed, and the like. In the case of the bubble B1 of the target vehicle 20A, the traveling position and the bubble speed of the update information D3 are the position and the traveling speed of the target vehicle 20A at the update time.

[0052]

Next, in a case where the user desires the target vehicle 20A to perform the following travel with another target vehicle 20 (matching with another bubble), the target vehicle 20A transmits a following travel request to the assistance device 10 (step S15). The target vehicle 20A transmits the following travel request, for example, in a case where the user performs the operation of searching for a matching candidate for the following travel. In addition, the target vehicle 20A may automatically transmit the following travel request in a case where the target vehicle 20A has received a function setting indicating that the target vehicle 20A desires the following travel from in advance. In addition, the following travel request may include update information D3 for giving the notification of the current position or the traveling speed of the target vehicle 20A.

[0053]

In a case where the bubble includes a plurality of target vehicles 20 (or accompanying vehicles), the target vehicle 20 of the leader transmits the following travel request on behalf of the plurality of target vehicles 20. In this case, in a case where the number of vehicles included in the bubble has already reached the upper limit of the

number, the target vehicle 20 does not transmit the following travel request.

[0054]

In a case where the matching processing unit 111 of the assistance device 10 receives the following travel request from the bubble B1, the matching processing unit 111 searches for a matching candidate capable of being integrated with the request source bubble B1 from among the other bubbles recorded in the storage 13 (step S16).

Details of the search processing of the matching candidates will be described below.

[0055]

In addition, in the example of FIG. 4, a case where no matching candidate for the request source bubble B1 is found will be described. In a case where a matching candidate for the request source bubble B1 is not found, the matching processing unit 111 transmits a "wait for matching candidate" instruction to the target vehicle 20A which is the leader of the request source bubble B1 (step S17).

[0056]

In a case where the target vehicle 20A, which is the leader of the bubble B1, receives the "wait for matching candidate" instruction, the following travel is set to a hold state. In addition, thereafter, the target vehicle 20A transmits the update information D3 to the assistance device 10 every predetermined time (step S18). In a case where the updated information acquisition unit 112 of the assistance device 10 receives the update information D3 from the bubble B1 (target vehicle 20A), the update information D3 is recorded and accumulated in the storage 13. Accordingly, the assistance device 10 can ascertain the position and speed at which the request source bubble B1 is traveling on the target road R.

[0057]

(Processing 2 of Assistance Device: Bubble Integration Processing)

FIG. 8 is a sequence diagram showing an example of bubble integration processing in the assistance system according to the first embodiment.

Hereinafter, a flow of the processing of integrating two bubbles will be described in detail with reference to FIG. 8. Here, an example of integrating the bubbles B1 and B2 shown in (a) and (b) of FIG. 3 will be described. In addition, it is assumed that the bubble B1 transmits the following travel request in step S15 of FIG. 4 and is in a "wait for matching candidate" state.

[0058]

Each of the leaders (target vehicles 20A and 20B; hereinafter, also referred to as leaders 20A and 20B) of the bubbles B1 and B2 transmits the update information D3 to the assistance device 10 every predetermined time (step S20). In a case where the updated information acquisition unit 112 of the assistance device 10 receives the update information D3 from each of the bubbles B1 and B2, the updated information acquisition unit 112 records and accumulates the update information D3 in the storage 13. This processing is the same processing as in step S18 in FIG. 4.

[0059]

The matching processing unit 111 of the assistance device 10 searches for a matching candidate to be integrated with the bubble B1 based on the update information D3 of each bubble recorded in the storage 13 (step S21).

[0060]

FIG. 9 is a flowchart showing an example of matching processing in the assistance device according to the first embodiment.

A flow of the processing of searching for the matching candidate for the bubble B1 by the assistance device 10 will be described with reference to FIG. 9. Each

processing (steps S211 to S216) shown in FIG. 9 is processing common to step S16 of FIG. 4 and step S21 of FIG. 8.

[0061]

First, the matching processing unit 111 extracts a bubble within the range of the operational design domain (ODD) related to the following travel based on the update information D3 of each bubble (step S211). For example, the matching processing unit 111 extracts a bubble of which the bubble speed is equal to or lower than a predetermined following travel upper limit speed (for example, 80 km/h) among a plurality of bubbles registered in the storage 13. The matching processing unit 111 excludes a bubble of which the bubble speed exceeds the following travel upper limit speed as a non-matching target. The following travel upper limit speed is set to be within a range of equal to or higher than a minimum speed and equal to or lower than a maximum speed defined for the target road R. In addition, the following travel upper limit speed may be set differently for each vehicle attribute.

[0062]

Next, the matching processing unit 111 determines whether or not a non-integratable bubble, that is, a bubble in which the number of vehicles included has reached the upper limit of the number is present within a predetermined following travel restriction section (for example, 1 km) before and after the traveling position of the request source bubble B1 (step S212).

[0063]

In a case where a bubble is present in which the number of vehicles included has reached the upper limit of the number within a set section of the request source bubble B1 (step S212; NO), the matching processing unit 111 determines that there is no matching candidate capable of being integrated with which the request source bubble B1

(step S216). In this case, the matching processing unit 111 temporarily ends the search processing for the matching candidates and proceeds to step S17 in FIG. 4. Accordingly, the matching processing unit 111 secures the spacing between the bubbles and prevents the bubbles from approaching each other, which could hinder the following travel.

[0064]

Next, the matching processing unit 111 determines whether or not a bubble satisfying a predetermined matching condition is present within a search distance (for example, 1 km) ahead in the traveling direction from the traveling position of the request source bubble B1 among the bubbles extracted in step S211 (step S213). For example, the matching conditions are conditions such as the following (1) to (4).

[0065]

(1) The traveling direction matches that of the request source bubble B1.

[0066]

(2) The vehicle attribute matches that of the request source bubble B1. The vehicle attributes may not be always the same. For example, combinations of vehicle attributes that can be integrated may be set in advance in a table or the like, and in a case where a vehicle attribute (for example, a large vehicle or a bus) that can be integrated with the vehicle attribute (for example, a large vehicle) of the request source bubble B1 is given, it may be determined that the vehicle attributes match each other.

[0067]

(3) The total number of the number of vehicles included in the request source bubble B1 and the number of vehicles included in an extracted bubble is equal to or less than the upper limit of the number (that is, the target vehicles included in the request source bubble B1 can be added).

[0068]

(4) At least a partial travel route is common to a travel route to the common destination of the request source bubble B1 and a travel route to the common destination of the extracted bubble are common, and the length of the common travel route is equal to or longer than a predetermined distance (for example, 40 km). Alternatively, in a case where the bubble speed is set as the following travel upper limit speed, the travel time of the common travel route is equal to or longer than a predetermined time (for example, 30 minutes).

[0069]

In a case where a bubble satisfying the above-described matching conditions (1) to (4) is present ahead in the traveling direction of the request source bubble B1 (step S213; YES), the matching processing unit 111 selects the bubble as a matching candidate (step S215).

[0070]

In addition, in a case where no bubble satisfying the matching condition is present ahead in the traveling direction of the request source bubble B1 (step S213; NO), the matching processing unit 111 searches for a matching candidate behind in the traveling direction of the request source bubble B1.

Specifically, the matching processing unit 111 determines whether or not a bubble satisfying the above-described matching conditions (1) to (4) is present within a search distance (for example, 1 km) behind in the traveling direction from the traveling position of the request source bubble B1 (step S214).

[0071]

In a case where a bubble satisfying the above-described matching condition is present behind in the traveling direction of the request source bubble B1 (YES in step

S214), the matching processing unit 111 selects the bubble as a matching candidate (step S215). In the example of FIG. 3, the matching processing unit 111 selects the bubble B2 present behind in the traveling direction of the request source bubble B1 as the matching candidate.

[0072]

On the other hand, in a case where no bubble satisfying the matching condition is present behind in the traveling direction of the request source bubble B1 (step S214; NO), the matching processing unit 111 determines that there is no matching candidate for the request source bubble B1 (step S216).

In this case, the matching processing unit 111 temporarily ends the search processing for the matching candidates and proceeds to step S17 in FIG. 4.

[0073]

The matching processing unit 111 can exclude bubbles that take time to join (integrate) from the matching candidates by limiting the search distance of the matching candidates as described above.

[0074]

In addition, even in a case where there is no matching candidate (step S216), the matching processing unit 111 executes the series of processing of searching for a matching candidate in FIG. 9 again each time the update information D3 is received from the request source bubble B1 or each time the predetermined search standby time elapses. Accordingly, even in a case where no matching candidate is found within the search distance, for example, in a case where a new bubble that has entered the target road R is generated later and this bubble satisfies the matching condition, the new bubble can be selected as a matching candidate for the request source bubble B1.

[0075]

In addition, in each of the above-described items of processing, in a case where there is a time difference between the update time of the update information D3 and the current time, the matching processing unit 111 may estimate the traveling position of each bubble at the current time based on the time difference and the bubble speed.

[0076]

Next, returning to FIG. 8, the processing after the matching processing unit 111 of the assistance device 10 selects the bubble B2 as a matching candidate for the request source bubble B1 in step S21 will be described. The integration instruction unit 113 of the assistance device 10 transmits an integration standby instruction to the leader 20A or 20B of each of the request source bubble B1 and the matching candidate bubble B2 (step S22). The integration standby instruction includes a bubble ID of a bubble that is each matching partner. For example, the bubble ID of the matching candidate bubble B2 is transmitted to the request source bubble B1 together with the integration standby instruction. In addition, the bubble ID of the request source bubble B1 is transmitted to the matching candidate bubble B2 together with the integration standby instruction.

[0077]

In addition, in a case where each of the leader 20A and 20B of the bubbles B1 and B2 to be integrated receives the integration standby instruction, the leader 20A or 20B transmits an ACK notification (step S23).

In addition, the ACK notification includes the update information D3 of each of the bubbles B1 and B2.

[0078]

The integration instruction unit 113 of the assistance device 10 generates and transmits the integration instruction for each of the bubbles B1 and B2 to be integrated, based on the update information D3 of each of the bubbles B1 and B2 included in the

ACK notification (step S24).

[0079]

The integration instruction is, for example, an instruction to change the bubble speed. The integration instruction unit 113 provides an instruction for the bubble speed of each bubble such that a subsequent bubble (in the example of FIG. 3, the bubble B2) traveling behind in the traveling direction out of the bubbles B1 and B2 to be integrated catches up with a preceding bubble (in the example of FIG. 3, the bubble B1) traveling ahead in the traveling direction or the preceding bubble B1 is caught up with the subsequent bubble B2.

[0080]

FIG. 10 is a flowchart showing an example of speed instruction processing in the assistance device according to the first embodiment.

The processing in which the assistance device 10 performs speed instructions for the subsequent bubble B2 and the preceding bubble B1 will be described in detail with reference to FIG. 10.

[0081]

First, in a case where the current bubble speed of the subsequent bubble B2 is less than the upper limit speed (YES in step S241), the integration instruction unit 113 sets the speed instruction of the subsequent bubble B2 to "accelerate to upper limit speed" (step S242).

[0082]

The upper limit speed is the following travel upper limit speed. For example, in a case where the current bubble speed of the subsequent bubble B2 is 70 km/h and the following travel upper limit speed is 80 km/h, the integration instruction unit 113 sets a speed instruction for the subsequent bubble B2 to "accelerate to of the following travel

upper limit speed 80 km/h".

[0083]

In addition, the integration instruction unit 113 may change the upper limit speed with reference to the traffic information of the traffic information DB 41 or the weather information of the weather information DB 42. For example, in a case where there is a temporary speed regulation on the target road R due to rain or the like and the speed limit in the temporary speed regulation is lower than the following travel upper limit speed, the speed limit in the temporary speed regulation is considered as the upper limit speed. In a case where the current bubble speed of the subsequent bubble B2 is 70 km/h, the following travel upper limit speed is 80 km/h, and the speed limit in the temporary speed regulation is 75 km/h, the integration instruction unit 113 sets the speed limit 75 km/h in the temporary speed regulation as the upper limit speed. In addition, in this case, the integration instruction unit 113 sets a speed instruction for the subsequent bubble B2 to "accelerate to speed limit 75 km/h in temporary speed regulation".

[0084]

On the other hand, in a case where the current bubble speed of the subsequent bubble B2 is the same as the upper limit speed (the following travel upper limit speed or the speed limit in the temporary speed regulation) (NO in step S241), the integration instruction unit 113 sets a speed instruction for the subsequent bubble B2 to "maintain current bubble speed" (step S243).

[0085]

Next, the integration instruction unit 113 sets the speed instruction for the preceding bubble B1 based on the current bubble speed of the preceding bubble B1.

[0086]

In a case where the current bubble speed of the preceding bubble B1 exceeds a

predetermined speed (step S244; YES), the integration instruction unit 113 sets a speed instruction for the preceding bubble B1 to "decelerate to designated speed" (step S245). The predetermined speed is a value obtained by subtracting a predetermined margin α from the upper limit speed, and for example, the upper limit speed = 80 km.

h is 75 km/h in a case where the predetermined margin α is 5 km/h. The value of the predetermined margin α may be optionally changed. In addition, the designated speed is, for example, a value obtained by subtracting the predetermined margin α from the upper limit speed. For example, in a case where the current bubble speed of the preceding bubble B1 is 80 km/h, the integration instruction unit 113 sets a speed instruction for the preceding bubble B1 to "decelerate to 75 km/h". In this case, in a case where the distance between the preceding bubble B1 and the subsequent bubble B2 is 1 km and the speed difference between the bubbles B1 and B2 after the instruction is 5 km/h, the subsequent bubble B2 can catch up with (join) the preceding bubble B1 after about 12 minutes (after traveling about 16 km).

[0087]

In addition, in a case where the current bubble speed of the preceding bubble B1 is equal to or less than the predetermined speed (step S244; YES), the integration instruction unit 113 sets a speed instruction for the preceding bubble B1 to "maintain current bubble speed" (step S245). For example, in a case where the current bubble speed of the preceding bubble B1 is 75 km/h, an instruction is given to maintain this speed.

[0088]

In addition, in a case where a speed instruction for each bubble is determined, the integration instruction unit 113 transmits the speed instruction to each of the subsequent bubble B2 and the preceding bubble B1 (Step S247). Then, the leaders 20A

and 20B of the bubbles B1 and B2 travel according to the received speed instructions. In addition, in a case where each of the bubbles B1 and B2 consists of two or more target vehicles 20, the leaders 20A and 20B transmit speed instructions to the other target vehicles 20 (non-leader) via vehicle-to-vehicle communication. The other target vehicles 20 (non-leader) travel in accordance with the speed instructions transmitted from the leaders 20A and 20B. In a case where each target vehicle 20 is a manned vehicle, the target vehicle 20 presents a speed instruction to a driver, and the driver drives the target vehicle 20 in accordance with a speed instruction presented to the target vehicle 20. In addition, in a case where the target vehicle 20 has a cruise control device or is an autonomous vehicle, the cruise control device or the automatic driving control device may automatically perform acceleration and deceleration control in accordance with a speed instruction.

[0089]

Next, the processing after the integration instruction (speed instruction) is transmitted to the bubbles B1 and B2 to be integrated in step S24 by the integration instruction unit 113 of the assistance device 10 will be described with reference to FIG. 8. Each of the bubbles B1 and B2 transmits the update information D3 to the assistance device 10 every predetermined time from the reception of the integration instruction to the completion of the integration (step S25).

[0090]

In a case where the notification unit 116 of the assistance device 10 receives the update information D3 from the bubbles B1 and B2, the notification unit 116 notifies (transmits) the update information D3 to each matching partner (step S26). That is, the notification unit 116 notifies the bubble B2 of the update information D3 received from the bubble B1, and notifies the bubble B1 of the update information D3 received from the

bubble B2. The target vehicles 20A and 20B of the bubbles B1 and B2 may present the traveling position of the matching partner, the distance to the matching partner, and the like to each user based on the update information D3 of the matching partner, or may be used as information for automatic driving control.

[0091]

Next, in a case where the leaders 20A and 20B of the bubbles B1 and B2 approach a distance at which vehicle-to-vehicle communication is possible, the leaders 20A and 20B transmit and receive bubble IDs to confirm that the leaders 20A and 20B are matching partners with each other, and then perform the integration processing of the bubbles B1 and B2 (step S27).

[0092]

In the integration processing, a target vehicle 20 to be a leader of an integration bubble is determined by the adjustment between the bubbles B1 and B2. In the example of FIG. 3, the target vehicle 20A is the leader of the integration bubble B1. In this case, the preceding bubble B1 of the target vehicle 20A is integrated with the subsequent bubble B2 to become an integration bubble B1, and the subsequent bubble B2 becomes an integrated bubble B1 to be integrated with the preceding bubble B1. In addition, each target vehicle 20 of the integration bubbles B1 acquires each other's vehicle information D1 via vehicle-to-vehicle communication. Accordingly, each target vehicle 20 can share information such as a final destination (the farthest destination among the destinations of the target vehicles 20) of the integration bubble B1 or a common destination (the closest destination among the destinations of the target vehicles 20).

[0093]

In addition, in the integration processing, each of the target vehicles 20 of the bubbles B1 and B2 checks the position of the target vehicle 20 and the presence or

absence of the non-target vehicle 30 present in the vicinity of the target vehicle 20 by using a sensor such as a camera, and changes the formation as necessary such that the target vehicles 20 can communicate with each other directly by vehicle-to-vehicle communication or indirectly through another target vehicle 20. The specific formation depends on the determination of the driver of each target vehicle 20 or the automatic driving control device. In a case where the target vehicles 20 of both the bubbles B1 and B2 transit to a state in which the target vehicles 20 can travel while communicating, that is, the following travel is possible, the integration processing is completed.

[0094]

In a case where the integration processing is completed, the leader 20B of the integrated bubble B1 and the leader 20A of the integration bubble B1 each transmit an integration completion notification to the assistance device 10 (Step S28). The leader 20B of the integrated bubble B1 gives a notification for both the bubble ID of itself (the integrated bubble B2) and the bubble ID of the integration bubble B1 that is the integration destination of the integrated bubble B2 itself in the integration completion notification. In addition, in the integration completion notification, the leader 20A of the integration bubble B1 gives a notification for the bubble ID of itself (the integration bubble B1) and the vehicle information D1 of each of the target vehicles 20 (the leader 20A and the non-leader 20B) of the integration bubble B1. Hereinafter, the target vehicle 20A as the leader of the integration bubble B1 and the target vehicle 20B as the non-leader of the integration bubble B1 perform the following travel while performing vehicle-to-vehicle communication.

[0095]

In addition, the update processing unit 114 of the assistance device 10 updates the bubble information D2 based on the integration completion notification received from

the integrated bubble B1 and the integration bubble B1 (step S29).

[0096]

FIG. 11 is a first view showing an example of bubble information update processing according to the first embodiment.

As shown in FIG. 11, the update processing unit 114 updates the bubble information D2 of the integration bubble B1 by adding the bubble information D2 of the integrated bubble B2 to the bubble information D2 of the integration bubble B1, based on the integration completion notification of the integration bubble B1 and the integrated bubble B2. Since the bubble ID of the integration bubble B1 is inherited from the bubble ID of the bubble B2 before the integration, there is no change. The leader of the integration bubble B1 is the vehicle ID of a new leader after adjustment between the bubbles B1 and B2. In the example of FIG. 11, the leader of the integration bubble B1 is the target vehicle 20A. The number of vehicles included is the total number of target vehicles 20 (and accompanying vehicles) included in the bubbles B1 and B2. The common destination is a destination reached by both the bubbles B1 and B2, and the closer one of the common destinations of the bubbles B1 and B2 is recorded. The vehicle information D1 of each of all the target vehicles 20A and 20B included in the integration bubble B1 is recorded in the individual vehicle information.

[0097]

In addition, the update processing unit 114 deletes the bubble information D2 of the integrated bubble B1.

[0098]

(Processing 3 of Assistance Device: Information Notification Processing)

FIG. 12 is a sequence diagram showing an example of information notification processing in the assistance system according to the first embodiment.

Hereinafter, a flow of the processing of notifying each bubble of various types of information by the assistance device 10 will be described with reference to FIG. 12.

[0099]

First, the leader 20A of the integration bubble B1 transmits the update information D3 of the integration bubble B1 to the assistance device 10 every predetermined time (step S30).

[0100]

The notification unit 116 of the assistance device 10 refers to the traffic information DB 41 and the weather information DB 42 to check whether or not an abnormal event or regulation information that affects the following travel is present ahead in the traveling direction than the traveling position included in the update information D3 of the integration bubble B1. In a case where an abnormal event or regulation information that affects the following travel is detected (step S31), the notification unit 116 transmits abnormality information or a speed instruction corresponding to the detected content to the leader 20A of the integration bubble B1 (step S32).

[0101]

For example, it is assumed that the notification unit 116 detects an abnormal event in a section present ahead in the traveling direction of the integration bubble B1 from the traffic information of the traffic information DB 41 or the weather information of the weather information DB 42. The abnormal event is, for example, road surface freezing, an accident, or the like. In this case, the notification unit 116 generates abnormality information including the content (road surface freezing) of the abnormal event and a section in which the abnormal event has occurred (or is expected to occur), and transmits the abnormality information to the leader 20A of the integration bubble B1

(step S32). In addition, in a case where the traffic information or the weather information includes the end prediction time of the abnormal event, or in a case where the end prediction time of the abnormal event can be estimated from the abnormal event, the abnormality information may include the end prediction time of the abnormal event.

[0102]

In addition, for example, it is assumed that the notification unit 116 detects that the temporary speed regulation is set in a section present ahead in the traveling direction of the integration bubble B1 from the traffic information of the traffic information DB 41. In this case, the notification unit 116 generates a speed instruction to reduce the bubble speed of the integration bubble B1 to the speed limit in the temporary speed regulation, and transmits the speed instruction to the leader 20A of the integration bubble B1 (Step S32).

[0103]

In a case where both the abnormal event and the regulation information are detected, the notification unit 116 may transmit both the abnormality information and the speed instruction to the leader 20A of the integration bubble B1.

[0104]

Next, in a case where the leader 20A of the integration bubble B1 receives the abnormality information or the speed instruction from the assistance device 10, the leader 20A transmits the abnormality information or the speed instruction to the other target vehicle 20 (non-leader 20B) of the integration bubble B1 by vehicle-to-vehicle communication (step S33).

[0105]

In addition, each of the leader 20A and the non-leader 20B performs processing corresponding to the abnormality information or the speed instruction. The processing

according to the abnormality information depends on the drivers of the leader 20A and the non-leader 20B or the determination of the automatic driving control device. In addition, the leader 20A and the non-leader 20B travel according to the received speed instruction. The control of the speed is performed by the drivers, the cruise control device, or the automatic driving control device.

[0106]

In this way, in a case where an abnormal event, regulation information, or the like is detected, the assistance device 10 does not need to individually communicate with each of the plurality of target vehicles 20A and 20B, and only needs to communicate with the leader 20A of the integration bubble B1. Thus, it is possible to reduce the amount of communication between the assistance device 10 and the target vehicle 20. In addition, since the traveling position may be monitored for each bubble without monitoring the traveling position of each of an individual target vehicle 20A or 20B, the processing load and resources required for monitoring can be reduced. Regarding the communication of the abnormal event or the regulation information via the leader vehicle shown here, in a case where the communication processing between the assistance device 10 and an individual target vehicle can be allowed in terms of the processing load or resources, individual transmission may also be a method.

[0107]

(Processing 3 of Assistance Device: Bubble Separation Processing)

FIG. 13 is a sequence diagram showing an example of bubble separation processing in the assistance system according to the first embodiment.

Hereinafter, a flow of the processing of separating a bubble into two will be described in detail with reference to FIG. 13. Here, an example in which the integration bubble B1 shown in (b) and (c) of FIG. 3 is separated into bubbles B2 and B3 will be

described. In addition, in the examples of FIGS. 3 and 13, an example in which the non-leader 20B exits from the integration bubble B1 has been described, but the leader 20A may exit from the integration bubble B1.

[0108]

First, in a case where the target vehicle 20B of the integration bubble B1 needs to exit from the integration bubble B1 at a branch or an exit, the target vehicle 20B transmits an exit notification to the other target vehicle 20A via vehicle-to-vehicle communication (step S40). For example, the target vehicle 20B transmits the exit notification to the other target vehicle 20A in a case where its own destination (exit IC) is before the final destination of the integration bubble B1 (the destination of the other target vehicle 20A) and the target vehicle 20B reaches a position a predetermined distance (for example, 5 km before) before its own destination.

[0109]

Next, each target vehicle 20 of the integration bubble B1 performs vehicle-to-vehicle communication to perform exit negotiation processing (step S41). In the exit negotiation processing, for example, the leader 20A acquires the vehicle ID and exit position (exit IC) from the target vehicle 20B (hereinafter, also referred to as an exit vehicle 20B) that is an exit notification transmission source. In addition, an adjustment is performed between the target vehicles 20 remaining in the continuation bubble B1 (integration bubble B1) that continues traveling on the target road R, and a target vehicle that is a new leader of the continuation bubble B1 is determined. In the examples of FIGS. 3 and 13, since only the target vehicle 20A remains in the continuation bubble B1, the target vehicle 20A continues to be the leader. In a case where two or more target vehicles 20 remain in the continuation bubble B1, the target vehicle 20A may continue to be the leader, or the leader may be alternated with another target vehicle 20. In

addition, in a case where a plurality of exit vehicles are present, the leader of a bubble to be separated from the integration bubble B1 is determined from the exit vehicles. In the examples of FIGS. 3 and 13, since the exit vehicle is only the target vehicle 20B, the target vehicle 20B is the leader of the exit bubble.

[0110]

In addition, in a case where the exit negotiation processing is completed, the leader 20A of the continuation bubble B1 transmits an exit bubble ID request to the assistance device 10 (step S42). The exit bubble ID request includes a bubble ID of the continuation bubble B1 (integration bubble B1), the vehicle ID of the exit vehicle 20B that exits from the continuation bubble B1, and the like.

[0111]

Next, the separation processing unit 115 of the assistance device 10 generates a new exit bubble B3 for the exit vehicle 20B (step S43).

[0112]

FIG. 14 is a second view showing an example of the bubble information update processing according to the first embodiment.

As shown in FIG. 14, the separation processing unit 115 generates bubble information D2 of the newly generated exit bubble B3 and records the bubble information D2 in the storage 13. The vehicle information D1 of the exit vehicle 20B of the exit bubble B3 may be copied from the bubble information D2 of the integration bubble B1 that is an exit source, or may be acquired from the leader 20A of the continuation bubble B1. In addition, the separation processing unit 115 performs update processing such as deletion of the vehicle information D1 of the exit vehicle 20B or subtraction of the number of exit vehicles from the number of vehicles included, on the bubble information D2 of the continuation bubble B1.

[0113]

In a case where the separation processing unit 115 of the assistance device 10 generates the exit bubble B3, the separation processing unit 115 notifies the leader 20A of the continuation bubble B1 of the bubble ID of the exit bubble B3 and the vehicle ID of the exit vehicle 20B included in the exit bubble B3 (step S44).

[0114]

In a case where the leader of the continuation bubble B1 receives the bubble ID of the exit bubble B3, the leader notifies the exit vehicle 20B of the bubble ID of the exit bubble B3 received from the assistance device 10 (step S45). In response to this notification, the exit vehicle 20B changes from the non-leader of the integration bubble B1 to the leader of the exit bubble B3.

[0115]

In addition, after the integration bubble B1 is separated into the continuation bubble B1 and the exit bubble B3, the leader 20A of the continuation bubble B1 and the leader 20B of the exit bubble B3 each transmit the update information D3 to the assistance device 10 every predetermined time (Step S46).

[0116]

Next, in a case where the leader 20B of the exit bubble B3 determines to end a following travel service (step S47), the leader 20B transmits a service exit notification to the assistance device 10 (step S48). The service exit notification includes the bubble ID of the exit bubble B3.

[0117]

The leader 20B of the exit bubble B3 determines to end the service, for example, in a case where the user performs an operation to end the service. In addition, the leader 20B may determine to end the service in a case where the leader 20B detects that the

leader 20B has exited from the target road R. Alternatively, the end may be determined by using communication with the road-to-vehicle communication device (roadside equipment 50) installed on the roadside as a trigger.

[0118]

In addition, in a case where the update processing unit 114 of the assistance device 10 receives the service exit notification from the exit bubble B3, the update processing unit 114 deletes the bubble information D2 of the exit bubble B3 from the storage 13 (step S49). Accordingly, the assistance device 10 ends the processing of managing, monitoring, and the like the bubble that has ended the following travel assistance service.

[0119]

(Processing 4 of Assistance Device: Management of Bubble Information between Different Areas)

FIG. 15 is a sequence diagram showing an example of management of bubble information between different areas in the assistance system according to the first embodiment.

FIG. 1 shows an example in which the assistance system 1 includes one assistance device 10, but the present invention is not limited thereto. In a case where the target road R spans a plurality of areas, the assistance system 1 may provide a plurality of assistance devices 10 for each area.

In addition, the target road R is operated by different road operators for each area, and the assistance device 10 in each area may be operated by each road operator. Here, as shown in FIG. 15, an example in which the target road R has two areas A and B and two assistance devices, that is, assistance device 10A for the area A and assistance device 10B for the area B are provided will be described.

[0120]

First, in the area A, it is assumed that the assistance device 10A executes the bubble generation processing (steps S10 to S17 in FIG. 4) of the target vehicle 20A, and the bubble B1 having the target vehicle 20A as a leader is registered. In addition, the leader 20A of the bubble B1 transmits the update information to the assistance device 10A of the area A every predetermined time while traveling in the area A (step S50).

[0121]

In a case where the updated information acquisition unit 112 of the assistance device 10A receives the update information D3 from the bubble B1, the updated information acquisition unit 112 checks whether or not the bubble ID (bubble information D2) of the bubble B1 is registered (step S51). In a case where the bubble information D2 of the bubble B1 is already registered in the assistance device 10A, the updated information acquisition unit 112 of the assistance device 10A records the update information D3 in the storage 13 as information for managing the traveling position or the like of the bubble B1 (step S52).

[0122]

In addition, it is assumed that the bubble B1 moves from the area A to the area B. After the movement to the area B, the leader 20A of the bubble B1 transmits the update information D3 to the assistance device 10B every predetermined time (Step S50).

[0123]

In a case where the updated information acquisition unit 112 of the assistance device 10B receives the update information D3 from the bubble B1, the updated information acquisition unit 112 checks whether or not the bubble ID (bubble information D2) of the bubble B1 is registered (step S51). Since the bubble information D2 of the bubble B1 is registered in the area A, the bubble information D2 is not

registered in the assistance device 10B of the area B. Therefore, the updated information acquisition unit 112 of the assistance device 10A requests the transmission of the bubble information D2 to the bubble B1 (step S53).

[0124]

In a case where the leader 20A of the bubble B1 receives a transmission request for the bubble information D2, the leader 20A transmits the bubble information D2 (step S13 in FIG. 3) received from the assistance device 10A together with the bubble ID to the assistance device 10B (step S54).

[0125]

The updated information acquisition unit 112 of the assistance device 10B records the bubble information D2 received from the bubble B1 in the storage 13 (step S55).

[0126]

In addition, the leader 20A of the bubble B1 transmits the update information D3 to the assistance device 10B every predetermined time while traveling in the area B (step S50).

[0127]

In a case where the updated information acquisition unit 112 of the assistance device 10B receives the update information D3 from the bubble B1, the updated information acquisition unit 112 checks whether or not the bubble ID of the bubble B1 is registered (step S51). Since the bubble information D2 of the bubble B1 is registered in the assistance device 10B by the processing of steps S53 to S55, the updated information acquisition unit 112 of the assistance device 10B records the update information D3 in the storage 13 as information for managing the traveling position or the like of the bubble B1 (step S52).

[0128]

In this way, the assistance device 10B can inherit the management of the bubble B1 from the assistance device 10A in the area A by acquiring the bubble information D2 of the bubble B1 generated by the assistance device 10A via the bubble B1. Here, the processing in a case where the assistance device 10A and the assistance device 10B do not share the information on a bubble has been described, but the plurality of assistance devices 10 may share and process the bubble information.

[0129]

(State Transition of Target Vehicle)

FIG. 16 is a diagram showing an example of the state transition of a target vehicle according to the first embodiment.

While referring to FIG. 16, the state and the role (leader or non-leader) of the target vehicle 20 will be described using the target vehicle 20A in FIG. 3 as an example.

[0130]

“V11: wait for start” indicates a state in which the target vehicle 20A has not started the following travel assistance service using a bubble.

[0131]

“V12: wait for bubble ID issuance” is a state in which the target vehicle 20A is waiting for a bubble ID notification from the assistance device 10 after the target vehicle 20A has started (C101) the following travel assistance service.

[0132]

“V13: single bubble (leader)” is a state in which the target vehicle 20A has been issued the bubble ID of the single bubble B1 (C102) from the assistance device 10. The target vehicle 20A transmits the update information D3 to the assistance device 10 after the transition to this state. Since the single bubble B1 does not include other target

vehicles, the target vehicle 20A is the leader of the single bubble B1.

[0133]

"V14: wait for matching candidate (leader)" is a state in which a "following travel request" has been made to the assistance device 10 (C103) and the leader waits for notification of the selection of a matching candidate by the assistance device 10. In this state, the matching can be canceled (C105). Then, the process returns to an original state before the transition (V13).

[0134]

“V15: negotiation state (leader)” is a state during the integration processing of the bubbles or during the separation processing of the bubbles.

The state during the integration processing of the bubbles is a state from the notification (C106) of the bubble ID of the matching candidate from the assistance device 10 to the completion of the integration processing between the bubbles (steps S21 to S28 in FIG. 8). The selection of the leader is performed by adjustment between the target vehicles 20. In a case where the matching is canceled (C107), the process returns to an original state before the transition (V13).

The state during the bubble separation processing is a state until an exit request is made from the leader of the integration bubble and the separation of the bubbles is completed (steps S40 to S45 of FIG. 13). There are a case (C114) in which the target vehicle 20A itself is a leader and performs an exit request, and a case (C115) in which the target vehicle 20A is a non-leader and is promoted to the leader instead of the exit leader.

[0135]

“V16: complete integration (leader)” is a state in which the target vehicle 20A can maintain the position of the leader of the integration bubble B1 as a result of the integration processing between the bubbles (C109).

In a case where there is no empty seat in the integration bubble B1 (number of vehicles included = upper limit of the number) (C112), the target vehicle 20A travels while continuing this state.

In a case where there is an empty seat in the integration bubble B1 (number of vehicles included < upper limit of the number) or in a case where an empty seat is generated due to the exit of another vehicle (non-leader) (C113), the target vehicle 20A transits to "V13: single bubble (leader)".

In addition, in a case where the target vehicle 20A itself, which is the leader, desires to exit from the integration bubble B1 or to be demoted from the leader to the non-leader (C114), the process transits to "V15: negotiation state (leader)". In this case, the target vehicle 20A, which is the leader, instructs the other target vehicles 20 in the integration bubble B1 to perform readjustment (exit negotiation) such as new leader selection.

[0136]

"V17: complete integration (non-leader)" is a state in which the target vehicle 20A does not become the leader of the integration bubble (is demoted) as a result of the integration processing between the bubbles (C110). In a case where the target vehicle 20A, which is a non-leader, desires to exit from the target road R or to proceed to the SA/PA, the target vehicle 20A can exit from the integration bubble by making an exit request to the leader of the integration bubble (C116).

In addition, in a case where the leader makes an exit request or the leader desires to be demoted to a non-leader, a readjustment instruction is received from the leader. In a case where the vehicle-to-vehicle communication with the leader is interrupted during the readjustment, it is determined that the leader has disappeared (C117), and the process transits to a “V18: wait for exit“ state. Accordingly, the target vehicle 20A resets the

state once and performs the processing such as the generation and integration of the bubbles again.

In a case where the target vehicle 20A itself becomes the leader due to the readjustment, the process transits to "V15: negotiation state (leader)".

[0137]

“V18: wait for exit” is a state in which the target vehicle 20A (non-leader) transmits the exit request to the leader of the integration bubble (C116). In a case where a response (an exit bubble ID notification) to the exit request is obtained from the leader, the target vehicle 20A travels as a single bubble (exit bubble), and after the determination of service end (C118), the process transits to a “V19: end” state. The target vehicle 20A determines that the service ends, for example, in a case where the end operation is performed by the user, the exit from the target road R is detected, or a predetermined timeout period has elapsed after the transition to this state.

In addition, the target vehicle 20A may also transit to this state in a case where the exit request to the leader is not reached (no response).

[0138]

The “V19: end” is a state after the target vehicle 20A ends the following travel assistance service using a bubble (C104, C118).

[0139]

(State Transition of Assistance Device)

FIG. 17 is a diagram showing an example of the state transition of the assistance device according to the first embodiment.

A change in the management state in a case where the assistance device 10 manages the bubble B1 of the target vehicle 20A will be described with reference to FIG. 17.

[0140]

“V21: wait for bubble ID request” is an initial state of the assistance device 10, which waits for a bubble registration request (bubble ID issuance request) from the target vehicle 20A.

[0141]

“V22: wait for bubble service request” is a state in which the assistance device 10 issues a bubble ID in response to the bubble registration request from the target vehicle 20A (C201) and then waits for the following travel request (matching request) from the bubble B1 of the target vehicle 20A.

In addition, in a case where the update information D3 of the bubble B1 is received (C202), the assistance device 10 continues this state and performs processing such as monitoring of the position and the speed of the bubble B1.

[0142]

“V23: wait for confirmation of matching candidate” is a state in which the assistance device 10 receives the matching request from the bubble B1 (C203) and selects a matching candidate for the request source bubble B1. In a case where the update information D3 is received from the request source bubble B1 (C204), the assistance device 10 continues this state and performs the reselection of the matching candidate.

In a case where the request source bubble B1 cancels the matching request (C205), the assistance device 10 returns to "V22: wait for bubble service request".

In a case where the request source bubble B1 ends the service (cancels the service) (C206), the assistance device 10 enters the state of “V26: end bubble management” for the request source bubble B1.

[0143]

"V24: wait for bubble integration completion" is a state in which the assistance device 10 waits for the integration completion notification from the request source bubble B1 and a matching candidate after the matching candidate for the request source bubble B1 is selected (C207). In a case where the update information D3 is received from the request source bubble B1 (C208), the assistance device 10 continues this state and performs processing such as monitoring of the position and the speed of the request source bubble B1 and transmission of the update information D3 of the request source bubble B1 to the matching candidate.

[0144]

“V25: wait for bubble integration update” is a state in which, in a case where the integration completion notification indicating that the request source bubble B1 remains as the integration bubble B1 is received (C209), the assistance device 10 waits for the update information D3 from the integration bubble B1, assuming that each target vehicle continues the following travel in the integration bubble B1. In a case where the assistance device 10 receives the update information D3 from the integration bubble B1 (C210), the assistance device 10 continues this state and performs processing such as monitoring of the position and the speed of the integration bubble B1.

[0145]

“V26: end bubble management” is a state in which the assistance service for the bubble B1 is not required and the management of the bubble B1 is ended.

In a case where the assistance device 10 receives the integration completion notification indicating that the request source bubble B1 for which matching is desired disappears as a non-integration bubble B1 (C211) or in a case where a bubble is no longer needed due to the end of the service (the exit bubble exits from the target road R, or the like) (C212, C213), the process transits to this state and the management of the

bubble B1 is ended.

In addition, in a case where the assistance device 10 receives the bubble separation request (the exit bubble ID request) from the integration bubble B1 (C214), the assistance device 10 separates the integration bubble B1 into two bubbles of a continuation bubble and an exit bubble. In this case, the assistance device 10 transits to "V21: wait for bubble ID request" in order to issue the ID of the exit bubble, and returns to "V26: end bubble management " to end the management of the exit bubble in a case where the notification of the service end is received from the exit bubble after the ID of the exit bubble is issued (C215) (after the transition to "V22: wait for matching request").

[0146]

(Operation and Effects)

As described above, the assistance device 10 according to the present embodiment includes the bubble generation unit 110 that, in a case where a bubble registration request is received from the target vehicle 20, generates a bubble which is a following travel vehicle group having the target vehicle 20 as a leader and registers the bubble information D2 in which the vehicle information D1 of the target vehicle 20 and the bubble ID (identification information) of the generated bubble are associated with each other; the matching processing unit 111 that, in a case where a following travel request is received from the bubble, selects a bubble satisfying a predetermined matching condition as a matching candidate for a request source bubble of the following travel request; the integration instruction unit 113 that gives an instruction to the leader of each of the request source bubble and the matching candidate to perform bubble integration; and the update processing unit 114 that, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as the integration bubble is received, integrates the bubble

information D2 of the integration bubble with the bubble information D2 of an integrated bubble to update the information D2 of the integrated bubble.

[0147]

By doing this, since the assistance device 10 can start the processing of searching for the matching candidate for the following travel without relying on the mutual connection between the target vehicles 20 via the vehicle-to-vehicle communication, it is possible to suppress the hindrance to the search processing of the matching candidate caused by the communication range of the vehicle-to-vehicle communication, the presence of the other non-target vehicle 30, or the like. In addition, since the assistance device 10 collectively manages a vehicle group (a plurality of target vehicles 20) that performs the following travel in units of bubbles and performs the transmission and reception of a bubble integration instruction or the like with the leader of each bubble, it is possible to reduce the management resources and the communication amount compared to individually managing each target vehicle 20.

[0148]

In addition, the matching processing unit 111 selects, as the matching candidate, a bubble which has a travel route that is at least partially common to a travel route up to a destination of the request source bubble and in which a length of the common travel route is equal to or longer than a predetermined distance or a travel time of the common travel route is equal to or longer than a predetermined time.

[0149]

In a case where the distance or time for the following travel is short, the effects (the effect of reducing driving burden, the effect of improving fuel economy, and the like) obtained by the following travel are reduced. However, the assistance device 10 according to the present embodiment can match the bubbles that can continue the

following travel for the predetermined distance or the predetermined time or longer, thereby suppressing shortening of the distance or time for performing the following travel and increasing the effect of the following travel.

[0150]

In addition, the matching processing unit 111 selects a bubble having a vehicle attribute matching the vehicle attribute of the request source bubble as the matching candidate.

[0151]

In a case where vehicle attributes (such as vehicle size) are significantly different, there is a possibility that the effects of the following travel, such as improvement in fuel economy due to improvement in aerodynamic performance, are reduced. However, the assistance device 10 according to the present embodiment can match bubbles having the matched vehicle attributes with each other, thereby suppressing the reduction in the effects obtained by the following travel.

[0152]

In addition, the matching processing unit 111 selects, as the matching candidate, a bubble having the number of vehicles such that the total number of vehicles, which is a sum of vehicles included in the request source bubble and the bubble, is equal to or less than an upper limit of the number is equal to or less than an upper limit of the number.

[0153]

By doing this, the assistance device 10 can suppress a situation in which a bubble after the integration becomes too large, making it difficult to perform the following travel, or suppress the influence on the traveling of the other surrounding vehicles (non-target vehicle 30).

[0154]

In addition, the assistance device 10 further includes the updated information acquisition unit 112 that acquires the update information D3 including a traveling position of each of the plurality of bubbles. The matching processing unit 111 selects a bubble located within a predetermined search distance from the traveling position of the request source bubble as the matching candidate based on the update information D3.

[0155]

By doing this, the assistance device 10 can exclude a bubble that takes substantial time to integrate from the matching candidate. Accordingly, it is possible to shorten the distance or time for performing the following travel after the integration, thereby suppressing the reduction in the effects obtained by the following travel.

[0156]

In addition, in order for a subsequent bubble traveling behind out of two matched bubbles to catch up with a preceding bubble traveling ahead, the integration instruction unit 113 gives an instruction for at least one of deceleration of the preceding bubble and acceleration of the subsequent bubble.

[0157]

By doing this, the assistance device 10 can adjust the speeds of the two matched bubbles to cause the bubbles to join each other more reliably. In addition, since a driver of each bubble does not need to determine acceleration and deceleration by himself/herself in consideration of the position and speed of the other bubble, it is possible to reduce the burden associated with driving.

[0158]

In addition, the assistance device 10 further includes a separation processing unit 115 that, in a case where a separation request for exiting the exit vehicle from the bubble is received, deletes and updates the vehicle information D1 of the exit vehicle from the

bubble information D2 of the bubble, generates an exit bubble having the exit vehicle as a leader, and registers the bubble information D2 of the exit bubble.

[0159]

By doing this, since the assistance device 10 can perform the integration and separation of the bubbles as necessary, the target vehicles 20 having different destinations can be combined and caused to perform the following travel as one bubble.

[0160]

<Other Embodiments>

In the above-described embodiment, the aspect in which, in a case where a bubble satisfying a matching condition is present within the search distance (for example, 1 km) before or behind the traveling direction of the request source bubble B1 which requests the following travel, the matching processing unit 111 of the assistance device 10 selects the bubble as a matching candidate has been described. However, the present invention is not limited thereto. In another embodiment, the matching processing unit 111 may set a time limit for the matching of the bubbles, and may use, as a matching candidate, a bubble that can be matched within the time limit.

[0161]

The request source bubble B1 which requests the following travel receives the operation of the user of the leader 20A and sets a time limit indicating when the bubble integration with the matching candidate is desired to be completed. In addition, the request source bubble B1 transmits the time limit set together with the following travel request (step S15 in FIG. 4) and the update information D3 to the assistance device 10 (step S15 in FIG. 4).

[0162]

In addition, in the matching candidate search processing (step S21 in FIG. 8),

the matching processing unit 111 of the assistance device 10 selects a bubble that satisfies the above-described matching conditions (1) to (4) and is capable of joining the request source bubble B1 within the time limit time as a matching candidate.

[0163]

The matching processing unit 111 determines that a bubble satisfying "DL ÷ DV < RT" is capable of joining the request source bubble B1, where RT is the time limit, DL is the distance between the position of the request source bubble B1 and a partner bubble in latest update information D3, and DV is a bubble speed difference between the request source bubble B1 and the partner bubble in the latest update information D3.

[0164]

For example, it is assumed that the time limit set by the request source bubble B1 is 10 minutes and there are bubbles B2 and B3 that satisfy the matching condition. In a case where the distance between the request source bubble B1 and the bubble B2 is 0.5 km and the speed difference is 5 km/h, "0.5 km ÷ 5 km/h = 6 minutes". Then, since the time taken for joining is less than the time limit, the matching processing unit 111 selects the bubble B2 as a matching candidate. On the other hand, in a case where the distance between the request source bubble B1 and the bubble B3 is 1 km and the speed difference is 5 km/h, "1 km ÷ 5 km/h = 12 minutes". Then, since the time taken for joining exceeds the time limit, the matching processing unit 111 excludes the bubble B3 from the matching candidates.

[0165]

In addition, in a case where there are a plurality of bubbles that satisfy the matching information and are capable of being joined within the time limit, the matching processing unit 111 selects, as a matching candidate, a bubble closest to the distance to the request source bubble B1. Accordingly, the matching processing unit 111 can select,

as a matching candidate, a bubble that is capable of being joined in the shortest time.

[0166]

By doing this, since the assistance device 10 can shorten the time until the bubble integration is completed, it is possible to shorten the distance or time for which the target vehicle 20 travels alone until a bubble of an integration partner is found. Accordingly, it is possible to shorten the distance or time for performing the following travel after the integration, thereby suppressing the reduction in the effects obtained by the following travel.

[0167]

Although one embodiment has been described in detail with reference to the drawings, the specific configuration is not limited to the above-described one, and various design changes and the like can be made. That is, in other embodiments, the order of the processing described above may be appropriately changed. Additionally, some processing may be executed in parallel.

[0168]

<Supplementary Note>

The assistance device, the assistance method, and the program according to the above-described embodiment are understood as follows, for example.

[0169]

(1) According to the first aspect, an assistance device 10 that assists in following travel of a vehicle, the assistance device including a bubble generation unit 110 configured to, in a case where a bubble registration request is received from the vehicle, generate a bubble which is a following travel vehicle group with the vehicle as a leader and register bubble information D2 in which vehicle information D1 of the vehicle and identification information of the generated bubble are associated with each other; a

matching processing unit 111 configured to, in a case where a following travel request is received from the vehicle included in the bubble, select a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request; an integration instruction unit 113 configured to instruct the leader of each of the request source bubble and the matching candidate to perform bubble integration; and an update processing unit 114 configured to, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrate the bubble information D2 of the integration bubble with bubble information D2 of an integrated bubble integrated with the integration bubble to update the bubble information D2 of the integrated bubble.

[0170]

By doing this, since the assistance device 10 can start the processing of searching for the matching candidate for the following travel without relying on the mutual connection between the target vehicles 20 via the vehicle-to-vehicle communication, it is possible to suppress the hindrance to the search processing of the matching candidate caused by the communication range of the vehicle-to-vehicle communication, the presence of the other non-target vehicle 30, or the like. In addition, since the assistance device 10 collectively manages a vehicle group (a plurality of target vehicles 20) that performs the following travel in units of bubbles and performs the transmission and reception of a bubble integration instruction or the like with the leader of each bubble, it is possible to reduce the management resources and the communication amount compared to individually managing each target vehicle 20.

[0171]

(2) According to a second aspect, in the assistance device 10 according to the

first aspect, the vehicle information D1 includes a destination of the vehicle, and the matching processing unit 111 is configured to select, as the matching candidate, a bubble which has a travel route that is at least partially common to a travel route up to a destination of the request source bubble and in which a length of the common travel route is equal to or longer than a predetermined distance or a travel time of the common travel route is equal to or longer than a predetermined time.

[0172]

By doing this, the assistance device 10 can suppress shortening of the distance or time for performing the following travel and can enhance the effect of the following travel.

[0173]

(3) According to a third aspect, in the assistance device 10 according to the first or second aspect, the vehicle information D1 includes a vehicle attribute of the vehicle, and the matching processing unit 111 is configured to select, as the matching candidate, a bubble having a vehicle attribute that matches the vehicle attribute of the request source bubble.

[0174]

By doing this, the assistance device 10 can suppress the reduction in the effects obtained by the following travel due to the mismatch of the vehicle attributes.

[0175]

(4) According to a fourth aspect, in the assistance device 10 according to any one of the first to third aspects, the matching processing unit 111 is configured to select, as the matching candidate, a bubble having the number of vehicles such that the total number of vehicles, which is a sum of vehicles included in the request source bubble and the bubble, is equal to or less than an upper limit of the number is equal to or less than an

upper limit of the number.

[0176]

By doing this, the assistance device 10 can suppress a situation in which a bubble after the integration from becoming too large, making it difficult to perform the following travel, or suppress the influence on the traveling of the other surrounding vehicles.

[0177]

(5) According to a fifth aspect, the assistance device 10 according to any one of the first to fourth aspects further includes an updated information acquisition unit 112 configured to acquire update information D3 including a traveling position of each of a plurality of the bubbles, and the matching processing unit 111 is configured to select, as the matching candidate, a bubble that is located within a predetermined search distance from the traveling position of the request source bubble based on the update information D3.

[0178]

By doing this, the assistance device 10 can exclude a bubble that takes substantial time to integrate from the matching candidate. Accordingly, it is possible to shorten the distance or time for performing the following travel after the integration, thereby suppressing the reduction in the effects obtained by the following travel.

[0179]

(6) According to a sixth aspect, the assistance device 10 according to any one of the first to fourth aspects further includes an updated information acquisition unit 112 configured to acquire update information D3 including a traveling position and a bubble speed of each of a plurality of the bubbles, and the matching processing unit 111 is configured to select, as the matching candidate, a bubble that is enabled to join within a

set time designated by the request source bubble based on the update information D3.

[0180]

By doing this, since the assistance device 10 can shorten the time until the bubble integration is completed, it is possible to shorten the distance or time for which the target vehicle 20 travels alone until a bubble of an integration partner is found. Accordingly, it is possible to shorten the distance or time for performing the following travel after the integration, thereby suppressing the reduction in the effects obtained by the following travel.

[0181]

(7) According to a seventh aspect, in the assistance device 10 according to any one of the first to sixth aspects, the integration instruction unit 113 is configured to, in order for a subsequent bubble traveling behind out of the request source bubble and the matching candidate to catch up with a preceding bubble traveling ahead, give an instruction for at least one of deceleration of the preceding bubble and acceleration of the subsequent bubble.

[0182]

By doing this, the assistance device 10 can adjust the speeds of the two matched bubbles to cause the bubbles to join each other more reliably. In addition, since a driver of each bubble does not need to determine acceleration and deceleration by himself/herself in consideration of the position and speed of the other bubble, it is possible to reduce the burden associated with driving.

[0183]

(8) According to an eighth aspect, the assistance device 10 according to any one of the first to seventh aspects further includes a separation processing unit 115 configured to, in a case where a separation request for exiting the exit vehicle from the bubble is

received, delete and update the vehicle information D1 of the exit vehicle from the bubble information D2 of the bubble, generate an exit bubble having the exit vehicle as a leader to register bubble information D2 in which the vehicle information D1 of the exit vehicle and identification information of the generated exit bubble are associated with each other.

[0184]

By doing this, since the assistance device 10 can perform the integration and separation of the bubbles as necessary, the target vehicles 20 having different destinations can be combined and caused to perform the following travel as one bubble.

[0185]

(9) According to the ninth aspect, there is provided an assistance method of assisting in following travel of a vehicle, the assistance method including a step of, in a case where a bubble registration request is received from the vehicle, generating a bubble which is a following travel vehicle group with the vehicle as a leader and registering bubble information in which vehicle information D1 of the vehicle and identification information D2 of the generated bubble are associated with each other; a step of, in a case where a following travel request is received from the vehicle included in the bubble, selecting a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request; a step of instructing the leader of each of the request source bubble and the matching candidate to perform bubble integration; and a step of, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrating the bubble information of the integration bubble with bubble information D2 of an integrated bubble integrated with the integration bubble to update the bubble information

D2 of the integrated bubble.

[0186]

(10) According to a tenth aspect, there is provided a program causing an assistance device to execute a process including a step of, in a case where a bubble registration request is received from the vehicle, generating a bubble which is a following travel vehicle group with the vehicle as a leader and registering bubble information D3 in which vehicle informationD1 of the vehicle and identification information of the generated bubble are associated with each other; a step of, in a case where a following travel request is received from the vehicle included in the bubble, selecting a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request; a step of instructing the leader of each of the request source bubble and the matching candidate to perform bubble integration; and a step of, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrating the bubble information D2 of the integration bubble with bubble information D2 of an integrated bubble integrated with the integration bubble to update the bubble information D2 of the integrated bubble.

INDUSTRIAL APPLICABILITY

[0187]

According to the above aspects, it is possible to match following travel target vehicles with each other without being affected by a communication range of vehicle-to-vehicle communication or the presence of a following travel non-target vehicle.

REFERENCE SIGNS LIST

[0188]

1 Assistance system

10, 10A, 10B Assistance device

11 Processor

110 Bubble generation unit

111 Matching processing unit

112 Updated information acquisition unit

113 Integration instruction unit

114 Update processing unit

115 Separation processing unit

116 Notification unit

12 Memory

13 Storage

14 Communication interface

20, 20A, 20B Target vehicle

30 Non-target vehicle

50 Roadside equipment

CLAIMS

[Claim 1] An assistance device that assists in following travel of a vehicle, the assistance device comprising:

a bubble generation unit configured to, in a case where a bubble registration request is received from the vehicle, generate a bubble which is a following travel vehicle group with the vehicle as a leader and register bubble information in which vehicle information of the vehicle and identification information of the generated bubble are associated with each other;

a matching processing unit configured to, in a case where a following travel request is received from the vehicle included in the bubble, select a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request;

an integration instruction unit configured to instruct the leader of each of the request source bubble and the matching candidate to perform bubble integration; and

an update processing unit configured to, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrate the bubble information of the integration bubble with bubble information of an integrated bubble integrated with the integration bubble to update the bubble information of the integrated bubble<u>; and</u>

<u>a notification unit configured to transmit a start time and an end prediction time of an abnormal event to the leader of the integration bubble in a case where the abnormal event from a traffic information of a target road and a weather information of the target road is detected</u>.

[Claim 2] The assistance device according to Claim 1,

wherein the vehicle information includes a destination of the vehicle, and

the matching processing unit is configured to select, as the matching candidate, a bubble which has a travel route that is at least partially common to a travel route up to a destination of the request source bubble and in which a length of the common travel route is equal to or longer than a predetermined distance or a travel time of the common travel route is equal to or longer than a predetermined time.

[Claim 3] The assistance device according to Claim 1,

wherein the vehicle information includes a vehicle attribute of the vehicle, and

the matching processing unit is configured to select, as the matching candidate, a bubble having a vehicle attribute that matches the vehicle attribute of the request source bubble.

[Claim 4] The assistance device according to Claim 1,

wherein the matching processing unit is configured to select, as the matching candidate, a bubble having the number of vehicles such that the total number of vehicles, which is a sum of vehicles included in the request source bubble and the bubble, is equal to or less than an upper limit of the number is equal to or less than an upper limit of the number.

[Claim 5] The assistance device according to Claim 1, further comprising:

an updated information acquisition unit configured to acquire update information including a traveling position of each of the plurality of bubbles,

wherein the matching processing unit is configured to select, as the matching candidate, a bubble that is located within a predetermined search distance from the traveling position of the request source bubble based on the update information.

[Claim 6] The assistance device according to Claim 1, further comprising:

an updated information acquisition unit configured to acquire update

information including a traveling position and a bubble speed of each of the plurality of bubbles,

wherein the matching processing unit is configured to select, as the matching candidate, a bubble that is enabled to join within a set time designated by the request source bubble based on the update information.

[Claim 7] The assistance device according to Claim 1,

wherein the integration instruction unit is configured to, in order for a subsequent bubble traveling behind out of the request source bubble and the matching candidate to catch up with a preceding bubble traveling ahead, give an instruction for at least one of deceleration of the preceding bubble and acceleration of the subsequent bubble.

[Claim 8] The assistance device according to any one of Claims 1 to 7, further comprising:

a separation processing unit configured to, in a case where a separation request for exiting an exit vehicle from the bubble is received, delete and update the vehicle information of the exit vehicle from the bubble information of the bubble, generate an exit bubble having the exit vehicle as a leader to register bubble information in which the vehicle information of the exit vehicle and identification information of the generated exit bubble are associated with each other.

[Claim 9] An assistance method of assisting in following travel of a vehicle, the assistance method comprising:

a step of, in a case where a bubble registration request is received from the vehicle, generating a bubble which is a following travel vehicle group with the vehicle as a leader and registering bubble information in which vehicle information of the vehicle and identification information of the generated bubble are associated with each other;

a step of, in a case where a following travel request is received from the vehicle included in the bubble, selecting a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request;

a step of instructing the leader of each of the request source bubble and the matching candidate to perform bubble integration; and

a step of, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrating the bubble information of the integration bubble with bubble information of an integrated bubble integrated with the integration bubble to update the bubble information of the integrated bubble.

[Claim 10] A program causing an assistance device to execute a process comprising:

a step of, in a case where a bubble registration request is received from a vehicle, generating a bubble which is a following travel vehicle group with the vehicle as a leader and registering bubble information in which vehicle information of the vehicle and identification information of the generated bubble are associated with each other;

a step of, in a case where a following travel request is received from the vehicle included in the bubble, selecting a bubble satisfying a predetermined matching condition among a plurality of the bubbles as a matching candidate for a request source bubble of the following travel request;

a step of instructing the leader of each of the request source bubble and the matching candidate to perform bubble integration; and

a step of, in a case where an integration completion notification for notifying that one of the request source bubble and the matching candidate is designated as an integration bubble is received, integrating the bubble information of the integration

bubble with bubble information of an integrated bubble integrated with the integration bubble to update the bubble information of the integrated bubble.